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(54) **ULTRASONIC DIAGNOSTIC DEVICE, ULTRASONIC IMAGING DEVICE, AND RECORDING MEDIUM FOR RECORDING ULTRASONIC IMAGING PROGRAM**

ULTRASCHALLDIAGNOSEVORRICHTUNG, ULTRASCHALLABBILDUNGSVORRICHTUNG UND AUFZEICHNUNGSMEDIUM FÜR EIN ULTRASCHALLABBILDUNGSPROGRAMM

DISPOSITIF DE DIAGNOSTIC ULTRASONIQUE, DISPOSITIF D'IMAGERIE ULTRASONIQUE, ET SUPPORT D'ENREGISTREMENT POUR L'ENREGISTREMENT DE PROGRAMME D'IMAGERIE ULTRASONIQUE

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Description

Technical Field

[0001] The present invention relates to a technique in a case in which tissue strain imaging (TSI) is applied to elastic imaging to estimate a local hardness distribution from the strain state of a biological soft tissue.

Background Art

[0002] In ultrasonic diagnosis, the pulsation of the heart or the movement of a fetus can be displayed in real time by the simple operation of bringing an ultrasonic probe into contact with the surface of the body. In addition, this technique is highly safety, and hence allows repetitive examination. Furthermore, the size of this system is smaller than those of other diagnosis apparatuses such as X-ray, CT, and MRI apparatuses, and hence can be said to be a simple diagnosis technique which facilitates examination to be performed by moving the apparatus to the bed side. Ultrasonic diagnosis apparatuses used in this ultrasonic diagnosis vary in type depending on the functions which they have. Some compact apparatuses which have already been developed are small enough to be carried with one hand. Ultrasonic diagnosis is free from the influence of radiation exposure such as X-ray exposure, and hence can be used in obstetric treatment, treatment at home, and the like.

[0003] It is very important for tissue diagnosis to objectively and quantitatively evaluate the function of a living tissue such as cardiac muscle by using such an ultrasonic diagnosis apparatus. For example, there has recently been commercialized, as a quantitative evaluation method for the heart, a technique of calculating local myocardial wall motion information such as displacement or strain while performing local pattern matching in images (see, for example, Jpn. Pat. Appln. KOKAI Publication No. 2003-175041). There is available a technique of accurately computing the three-dimensional distribution of myocardial wall motion information by using an ultrasonic diagnosis apparatus capable of acquiring three-dimensional images (see Jpn. Pat. Appln. KOKAI Publication No. 2003-175041). These techniques allow to acquire three-dimensional myocardial wall motion information and the like and quantitatively evaluate the function of a tissue.

[0004] As an image diagnosis technique using an ultrasonic diagnosis apparatus, a technique called elastic imaging is available. This technique applies a dynamic load to a tissue to compress/expand it, and measures a motion (dynamic response) in response to the application of the load, thereby acquiring and visualizing elastic information. Recently, there has been developed a technique of determining and displaying the current pressed state (pressing strength) by using displacement information obtained from between two frames when performing this elastic imaging (i.e., a technique which applies TSI to elastic imaging) (see, for example, Jpn. Pat. Appln. KOKAI Publication No. 2004-351062). Reference is further made to EP 1 652 477 A1 which discloses an ultrasonograph.

[0005] When TSI is applied to elastic imaging by using a conventional ultrasonic diagnosis apparatus, for example, the following problems arise.

[0006] First of all, when elastic imaging based on TSI is to be performed for a soft tissue such as mammary glands, the deformation of the soft tissue is induced by, for example, repeating compression and release using a probe. In this case, since there is no guarantee that a time phase suitable for the start of strain computation is synchronous with deformation motion, an optimal strain image which produces the maximum strain relative to the strain before deformation cannot sometimes be obtained after deformation.

[0007] In addition, when the compression and release are performed by using the probe, it is not possible to recognize the time phase of deformation (for example, the extent to which the tissue is currently compressed or released).

[0008] These problems arise from the fact that there is no proper reference (synchronization) signal in the case of induction of deformation, in which compression and release are repeated by the probe, unlike the case of the heart in which a biological signal such as an ECG signal is synchronous with the motion of a target tissue and hence serves as a reference signal.

Disclosure of Invention

[0009] The present invention has been made in consideration of the above situation, and has as its object to provide an ultrasonic diagnosis apparatus, an ultrasonic image processing apparatus, and a recording medium on which an ultrasonic image processing program is recorded, which can generate and display reference information serving as a suitable reference in a case in which a time phase suitable for the start of strain computation is determined and a dynamic load is applied to a tissue in elastic imaging using TSI.

[0010] This object is achieved by the ultrasonic diagnosis apparatus according to claim 1, the ultrasonic image processing apparatus according to claim 14, and the recording medium according to claim 15. The other claims relate to further developments.

[0011] According to a first aspect of the present invention, an ultrasonic diagnosis apparatus comprising: an image data acquisition unit which acquires ultrasonic image data corresponding to each time phase in a first period including at least one contraction and one expansion by ultrasonic scanning throughout the first period for an observation region of an object to be examined which repeats contracting motion and expanding motion upon application of a dynamic load including repetition of compression and release; a velocity information generating unit which generates velocity information concerning a tissue in the observation region in each time phase in the first period; a reference information generating unit which generates reference information indicating a change in the contracting motion and the expanding motion with time; a strain information generating unit which generates strain information concerning the tissue in the observation region based on the reference information and velocity information in said each time phase; an image generating unit which generates, based on strain information, a strain image indicating a strain distribution of the observation region; and a display unit which displays the strain image in a predetermined form.

[0012] According to a second aspect of the present invention, an ultrasonic image processing apparatus comprising: a storage unit which stores ultrasonic image data corresponding to each time phase in a first period including at least one contraction and one expansion by ultrasonic scanning throughout the first period for an observation region of an object to be examined which repeats contracting motion and expanding motion upon application of a dynamic load including repetition of compression and release; a velocity information generating unit which generates velocity information concerning a tissue in the observation region in each time phase in the first period; a reference information generating unit which generates reference information indicating a change in the contracting motion and the expanding motion with time; a strain information generating unit which generates strain information concerning the tissue in the observation region based on the reference information and velocity information in said each time phase; an image generating unit which generates, based on strain information, a strain image indicating a strain distribution of the observation region; and a display unit which displays the strain image in a predetermined form.

[0013] According to a third aspect of the present invention, a recording medium which records an ultrasonic image processing program which causes a computer to execute a velocity information generating function of generating velocity information concerning a tissue in an observation region in each time phase in a first period including at least one contraction and one expansion by using ultrasonic image data corresponding to each time phase in the first period by ultrasonic scanning throughout the first period for the observation region of an object to be examined which repeats contracting motion and expanding motion upon application of a dynamic load including repetition of compression and release, a reference information generation function of generating reference information indicating a change in the contracting motion and the expanding motion with time, a strain information generating function of generating strain information concerning the tissue in the observation region based on the reference information and velocity information in said each time phase, and an image generating function of generating, based on strain information, a strain image indicating a strain distribution of the observation region.

Brief Description of Drawings

[0014]

FIG. 1 is a block diagram for explaining the arrangement of an ultrasonic diagnosis apparatus according to the first embodiment;
FIG. 2 is a flowchart showing a processing sequence in the execution of elastic imaging using TSI with the use of a reference information generation/display function;
FIG. 3 is a graph showing an example of the reference waveform generated in step S4 in the flowchart shown in FIG. 2;
FIG. 4 is a view showing an example of a suitable display form of a strain image;
FIG. 5 is a block diagram for explaining the arrangement of an ultrasonic diagnosis apparatus 1 according to the second embodiment;
FIG. 6 is a flowchart showing a processing sequence in the execution of elastic imaging using TSI according to the second embodiment;
FIG. 7 is a block diagram showing the arrangement of an ultrasonic diagnosis apparatus 1 according to

third embodiment; and

[0015] FIG. 8 is a block diagram for explaining the arrangement of an ultrasonic diagnosis apparatus 1 according to the fourth embodiment.

Best Mode for Carrying Out the Invention

[0016] The first to fourth embodiments of the present invention will be described with reference to the accompanying drawings. Note that throughout the drawings, the same reference numerals denote constituent elements having same or similar functions, and a repetitive description thereof will be avoided.

(First Embodiment)

[0017] FIG. 1 is a block diagram showing the arrangement of an ultrasonic diagnosis apparatus 1 according to this embodiment. An ultrasonic diagnosis apparatus includes an ultrasonic probe 11, a transmission unit 13, a reception unit 15, a B-mode processing unit 17, a velocity computation unit 19, a display control unit 21, a display unit 23, a strain computation unit 25, and a reference information generating unit 27.

[0018] The ultrasonic probe 11 generates ultrasonic waves based on a driving signal from the transmission unit 13, and includes a plurality of piezoelectric vibrators which convert reflected waves from an object to be examined into electrical signals, a matching layer provided for the piezoelectric vibrators, and a backing member which prevents ultrasonic waves from propagating backward from the piezoelectric vibrators. When ultrasonic waves are transmitted from the ultrasonic probe 11 to the object, various harmonic components are generated due to the nonlinearity of a living tissue upon propagation of ultrasonic waves. Fundamental waves and harmonic components constituting transmission ultrasonic waves are scattered backward by acoustic impedance boundaries of a tissue in the living body, micro-scattering, and the like, and are received as reflected waves (echoes) by the ultrasonic probe 11.

[0019] The transmission unit 13 includes a delay circuit and pulser circuit (not shown). The pulser circuit repetitively generates rate pulses for the formation of transmission ultrasonic waves at a predetermined rate frequency fr Hz (period: 1/fr sec). The delay circuit gives each rate pulse a delay time necessary to focus an ultrasonic wave into a beam and determine transmission directivity for each channel. The transmission unit 13 applies a driving pulse to each vibrator so as to form an ultrasonic beam toward a predetermined scan line at the timing based on this rate pulse.

[0020] The reception unit 15 includes an amplifier circuit, A/D converter, and adder which are not shown. The amplifier circuit amplifies an echo signal received through the probe 11 for each channel. The A/D converter gives the amplified echo signals delay times necessary to determine reception directivities. The adder then performs addition processing for the signals. With this addition, an ultrasonic echo signal corresponding to a predetermined scan line is generated.

[0021] The B-mode processing unit 17 performs envelope detection processing for the ultrasonic echo signal received from the reception unit 15 to generate a B-mode signal corresponding to the amplitude intensity of the ultrasonic echo.

[0022] The velocity computation unit 19 performs quadrature detection processing, autocorrelation processing, and delay/addition processing for the echo signal acquired by tissue Doppler imaging, and obtains, based on the Doppler shift component of the echo signal having undergone delay/addition processing, a tissue Doppler signal corresponding to the velocity, variance, and power of the tissue which moves in the object. The velocity computation unit 19 generates, for each time phase in a predetermined period, a tissue Doppler image representing the two-dimensional distribution of velocities, variances, and power values which is associated with a predetermined slice by using the tissue Doppler signal. Note that the predetermined period is an arbitrary period including repetitive compression/release with respect to a diagnosis target. The velocity computation unit 19 also generates a spatiotemporal distribution image (an image representing the velocity of the diagnosis target tissue at each position, which will be,referred to as velocity distribution information hereinafter) of tissue velocities in the respective time phases in the predetermined period by using a tissue Doppler image in each time phase in the predetermined period.

[0023] The display control unit 21 generates an ultrasonic diagnosis image (a B-mode ultrasonic image, strain image, or the like) or reference waveform as a display image by converting (scan-converting) the scanning line signal string for ultrasonic scanning into a scanning line signal string in a general video format typified by a TV format.

[0024] The display unit 23 displays a B-mode ultrasonic image, strain image, and reference waveform in predetermined forms and at predetermined timings based on video signals from the display control unit 21. The display unit 23 also displays a marker indicating anatomical position on an image and a color bar indicating the magnitude of a color-coded physical quantity.

[0025] The strain computation unit 25 obtains a displacement by time-integrating predetermined motion direction components of velocity associated with a region of interest by using each reference time phase (to be described later) determined by using velocity distribution information and reference information associated with each time phase in a predetermined period. The strain computation unit 25 computes the local strain of the tissue for each time phase by performing predetermined computation using the obtained displacement. The strain computation unit 25 generates a strain image by converting the obtained local strain of the tissue for each time phase into a color code and mapping it at a corresponding position.

[0026] The reference information generating unit 27 computes the average tissue velocity for each frame by using the velocity distribution information associated with each time phase in the predetermined period. In addition, the reference information generating unit 27 generates a reference waveform by plotting the average tissue velocity for each frame in time series.

(Reference Information Generation/Display Function)

[0027] The reference information generation/display function of the ultrasonic diagnosis apparatus 1 will be described next. In elastic imaging using TSI, this function serves to generate reference information as a proper reference and display it in a predetermined form when a time phase suitable for the start of strain computation is determined or a dynamic load is applied to the tissue. Assume that in this embodiment, for a concrete description, a waveform (reference waveform) indicating a temporal change in the average tissue velocity for each frame is generated as reference information.

[0028] FIG. 2 is a flowchart showing a processing sequence in the execution of elastic imaging using TSI with the use of the reference information generation/display function. This sequence will be described below with reference to FIG. 2.

[Acquisition of Tissue Doppler Image in Each Time Phase in Predetermined Period: Step S1]

[0029] First of all, a tissue Doppler image is acquired in each time phase in a predetermined period for a desired observation region of a soft tissue (e.g., a breast) of a given object by the tissue Doppler method (step S1).

[Generation of Velocity Distribution Information in Each Time Phase in Predetermined Period: Step S2]

[0030] The velocity computation unit 19 then generates velocity distribution information in each time phase in the predetermined period by using the tissue Doppler image associated with each time phase in the predetermined period and the motion field set by a predetermined technique (step S2). As a technique of generating this velocity distribution information, for example, the technique disclosed in
Jpn. Pat. Appln. KOKAI Publication No. 2003-175041 can be used.

[Calculation of Average Tissue Velocity for Each Frame: Step S3]

[0031] The reference information generating unit 27 then calculates an average tissue velocity for each frame by using velocity distribution information in each time phase in the predetermined period (step S3). In this case, in a period during which the observation region is compressed by the ultrasonic probe 11, the observation region and the ultrasonic probe 11 relatively come close to each other. The moving direction of the tissue (i.e., the direction of velocity) in this period is defined as positive. On the other hand, in a period during which the ultrasonic probe 11 stops compressing (i.e., releases) the observation region, the observation region and the ultrasonic probe 11 relatively separate from each other. The moving direction of the tissue (i.e., the direction of velocity) in this period is defined as negative.

[Generation of Reference Waveform: Step S4]

[0032] The reference information generating unit 27 then plots the average tissue velocity for each frame in the predetermined period in time series, and performs predetermined interpolation processing as needed, thereby generating a reference waveform indicating a change in average tissue velocity with time (step S4).

[0033] FIG. 3 is a graph showing an example of the reference waveform generated in step S4. As shown in FIG. 3, when the observation region is repeatedly compressed and released by the ultrasonic probe 11, the average tissue velocity periodically changes positively and negatively. Note that the expression "V = 0+" in this graph indicates a time point corresponding to velocity V = 0 in the process of a change in average tissue velocity from a negative value to a positive value (i.e., the process of a change from a released state to a compressed state), and the expression "V = 0-" indicates a time point corresponding to velocity V = 0 in the process of a change in average tissue velocity from a positive value to a negative value (i.e., the process of a change from a compressed state to a released state). Therefore, on the reference waveform, the period from time t(V = 0+) corresponding to V = 0+ to time t(V = 0-) corresponding to V = 0- corresponds to a compression period, and the period from time t(V = 0-) corresponding to V = 0- to time t(V = 0+) corresponding to V = 0+ corresponds to a release period.

[Determination of Reference Time Phase: Step S5]

[0034] The strain computation unit 25 then determines the first and second reference time phases used in strain computation based on the reference waveform (step S5). In this case, the first reference time phase is a time phase corresponding to the lower limit of the integral interval of time integration executed in strain computation. The second reference time phase is a time phase corresponding to the end of the updating of the upper limit of the integral interval in the time integration in strain computation.

[0035] That is, when generating a strain image in each compression period, the strain computation unit 25 determines, based on the reference waveform, time t(V = 0+) corresponding to V = 0+ in each compression period as the first reference time phase, and time t(V = 0-) corresponding to V = 0- in each compression period as the second reference time phase. When generating a strain image in each release period, the strain computation unit 25 determines, based on the reference waveform, time t(V = 0-) corresponding to V = 0- in each compression period as the first reference time phase, and time t(V = 0+) corresponding to V = 0+ in each compression period as the second reference time phase.

[Step S6: Generation of Strain Image]

[0036] The strain computation unit 25 then obtains a displacement by time-integrating predetermined motion direction components of velocity associated with a region of interest by using the determined first and second reference time phases, and computes the local strain of the tissue by performing predetermined computation using the obtained displacement. That is, the strain computation unit 25 sets the lower limit of an integral interval in a compression period or a release period as the first reference time phase, and resets a strain value. The strain computation unit 25 then calculates a strain associated with the region of interest for each time phase by accumulatively executing time integration while sequentially updating the upper limit of an integral interval to a new time phase. In this calculation, when the updated time phase becomes the second reference time phase, the strain computation unit 25 performs time integration with the second reference time phase being the upper limit of an integral interval. A series of these processes is repeatedly executed as needed every time an interval is updated. In this case, the strain computation unit 25 computes the local strain of the tissue for each time phase by performing predetermined computation using the displacement obtained for each time phase, and generates a strain image for each time phase by color-coding and mapping each strain at a corresponding position (step S6).

[0037] A preferable form of use of the ultrasonic diagnosis apparatus 1, from the point of view of convenience of observation, is that it is determined in advance whether to generate a strain image in one of a compression period and a release period. If, for example, it is determined that a strain image is generated in a compression period, the processing in the steps is repeatedly executed for each compression period.

[Step S7: Display of Strain Image]

[0038] The display control unit 21 then controls the display unit 23 to display the generated strain image in a predetermined form (step S7).

[0039] FIG. 4 shows an example of a preferred display form of a strain image. In this form, a B-mode image and a strain image are displayed side by side. In this case, the B-mode image is sequentially updated with an image in a new time phase and dynamically displayed. On the other hand, the strain image is dynamically displayed in synchronism with the B-mode image in each compression period, while the strain image (i.e., the image generated by using time integration with the lower and upper limits of an integral interval being the first and second time phases, respectively) corresponding to last time phase t(V = 0+) in the compression period is held/displayed until the next compression period (i.e., during a release period). According to this display form, even in a time phase in which a TSI image is held, the operator can always grasp the contact state of the probe or the state of a slice by using a B-mode image.

[0040] For example, in each compression period, the displacement amount (contraction amount) of the tissue cumulatively increases from start time t(V = 0-) of compression, and becomes maximum at end time t(V = 0+). Therefore, holding and displaying a strain image corresponding to the last time phase t(V = 0+) in each compression period up to the next compression period allows to observe the stain image having the maximum strain difference concerning the contraction of the tissue.

[0041] The display control unit 21 also displays the reference waveform on the display unit 23 in real time, together with the B-mode image and the strain image. At this time, the reference waveform is preferably displayed in a form similar to that of, for example, a pulse Doppler waveform or ECG waveform, while indicating to which time phase on the waveform the B-mode image and strain image correspond. In addition, when the reference waveform is to be displayed, it is preferable to set the display scale in accordance with, for example, a compression strength.

(Effects)

[0042] According to the above arrangement, the following effects can be achieved.

[0043] This ultrasonic diagnosis apparatus calculates the average velocity of the tissue corresponding to compression/release for each frame, and generates a reference waveform by using each average velocity. The apparatus specifies a time phase corresponding to an average velocity of 0 (i.e., a stationary time phase of the tissue) by using this reference waveform. In strain computation, the apparatus then performs time integration for the strain computation in a compression period or a release period with reference to the specified stationary time phase. It is therefore possible to properly and automatically visualize how the contraction of the tissue is accumulated from the start of compression (i.e., a time phase corresponding to V = 0+) or the contraction of the tissue in a compression end time phase (i.e., a time phase corresponding to V = 0+) becomes maximum in a compression period, or how the tissue expands from the start of release (i.e., a time phase corresponding to V = 0-) or the expansion of the tissue in a release end time phase (i.e., a time phase corresponding to V = 0+) becomes maximum in a release time phase. The observer can perform image diagnosis with higher quality by observing strain images in which these states are visualized.

[0044] This ultrasonic diagnosis apparatus displays the generated reference waveform in synchronism with an ultrasonic image displayed in real time as in the case of a pulse Doppler waveform, ECG waveform, or the like. This allows the probe operator to easily grasp the whereabout of the current time phase in a compression period or release period by observing a displayed reference waveform. In addition, when a strain image is held and displayed (freeze-displayed), the operator can easily grasp the whereabout of the current time phase of the strain image in a compression period or release period by referring to the position of a time phase corresponding to the image held and displayed on the reference waveform.

[0045] This ultrasonic diagnosis apparatus sets a display scale in accordance with a compression strength when displaying a reference waveform. The probe operator can monitor a compression strength by referring to the reference waveform displayed in this manner. For example, when a waveform is saturated and discontinuously displayed, the operator can monitor that the compression strength is large. When a waveform is displayed with an amplitude which is too small relative to a display scale, the operator can monitor that the compression strength is small.

(Second Embodiment)

[0046] The second embodiment of the present invention will be described next. An ultrasonic diagnosis apparatus according to this embodiment obtains a region of interest which is a characteristic region (e.g., a region with the highest luminance or a spatial edge region whose spatial differential coefficient value is high) from a B-mode image up to a predetermined period, and obtains the moving vector information and moving velocity information of the tissue by pattern matching processing between two frames.

[0047] FIG. 5 is a block diagram for explaining the arrangement of the ultrasonic diagnosis apparatus according to the second embodiment. In comparison with the arrangement shown in FIG. 1, the arrangement in FIG. 5 mainly differs in the function of a strain computation unit 25.

[0048] That is, the strain computation unit 25 detects the moving position of the tissue by using pattern matching processing between two two-dimensional image data in different time phases or two volume data in different time phases, and obtains the moving vector (or the velocity) of each tissue based on the moving position. More specifically, the strain computation unit 25 can obtain the moving vector of the tissue by obtaining, with regard to a region of interest in one two-dimensional image data, a region of interest in the other two-dimensional image data which has the highest similarity and obtaining the distance between the regions of interest. The strain computation unit 25 can also obtain the moving velocity of the tissue by dividing the magnitude of this moving vector (i.e., the moving amount) by the time difference between the frames of the two-dimensional image data. Performing this processing at each position on two-dimensional image data frame by frame can acquire spatiotemporal distribution data (moving vector information) associated with the displacement (moving vector) of the tissue or the velocity of the tissue.

[0049] FIG. 6 is a flowchart showing a processing sequence in the execution of elastic imaging using TSI according to the second embodiment. This flowchart differs from that of FIG. 2 in steps S11 and S12. Processing in these steps will be described below.

[Acquisition of B-Mode Image in Each Time Phase in Predetermined Period: Step S11]

[0050] First of all, an ultrasonic image in each time phase in a predetermined period is acquired from a desired observation region of a soft tissue (e.g., mammary glands) of an object by the B-mode imaging method (step S11).

[Generation of Velocity Distribution Information in Each Time Phase in Predetermined Period: Step S12]

[0051] Each tissue motion information is then generated (step S12). That is, the strain computation unit 25 extracts a region of interest of a myocardial region, based on an instruction or the like from the user, from two-dimensional image data which constitute an acquired time-series two-dimensional image data group. The strain computation unit 25 then computes spatiotemporal moving vector information by temporally tracking the extracted region of interest by two-dimensional pattern matching processing. In addition, the strain computation unit 25 obtains tissue distribution information indicating the moving velocity distribution of the tissue for each time phase by dividing this moving vector by the time difference between the frames of the two-dimensional image data.

[0052] The above arrangement can also achieve the same effects as those of the first embodiment.

(Third Embodiment)

[0053] The third embodiment of the present invention will be described next. An ultrasonic diagnosis apparatus 1 according to this embodiment measures a temporal change in the position of an ultrasonic probe 11 upon application of a dynamic load such as compression/release or a temporal change in pressure on the contact surface between the ultrasonic probe 11 and an object upon compression, and generates a reference waveform by using the measured change.

[0054] FIG. 7 is a block diagram showing the arrangement of the ultrasonic diagnosis apparatus 1 according to this embodiment. As shown in FIG. 7, the ultrasonic diagnosis apparatus 1 further includes a sensor 30. The sensor 30 is a magnetic induction type position sensor which measures a temporal change in the position of the ultrasonic probe 11 upon application of a dynamic load such as compression/release or a pressure sensor which measures a temporal change in pressure on the contact surface between the ultrasonic probe 11 (or a compression attachment attached to the probe 11) and the object upon compression.

[0055] A reference information generating unit 27 receives the spatial position of the ultrasonic probe 11 or the pressure on the contact surface between the probe and the object in each time phase in a predetermined period, and plots it in time series. The reference information generating unit 27 then performs predetermined interpolation processing for the resultant data, as needed, to generate a reference waveform indicating a temporal change in average tissue velocity. In the reference waveform generated in this manner, a time phase in which the level of the ultrasonic probe 11 becomes maximal (or a time phase in which the pressure becomes 0 or minimal) corresponds to compression start time phase $t(V = 0+)$, and a time phase in which the level of the ultrasonic probe 11 becomes minimal (or a time phase in which the pressure becomes maximal) corresponds to release start time phase $t(V = 0-)$.

[0056] The above arrangement can also achieve the same effects as those of the first embodiment.

(Fourth Embodiment)

[0057] The fourth embodiment of the present invention will be described next. An ultrasonic diagnosis apparatus

1 according to this embodiment generates and displays a monitoring waveform (strain waveform) for indicating a deformed time phase on the basis of an average strain value for each frame itself which is obtained from a computed strain image.

[0058] FIG. 8 is a block diagram for explaining the arrangement of the ultrasonic diagnosis apparatus 1 according to this embodiment. As shown in FIG. 8, the ultrasonic diagnosis apparatus 1 according to this embodiment further include a strain waveform computation unit 29.

[0059] The strain waveform computation unit 29 calculates an average strain value for each frame by using a strain image in each time phase in a predetermined period. Assume that the positive and negative directions are defined in the same manner as in the case of the generation of velocity information. The strain waveform computation unit 29 generates a strain waveform indicating a temporal change in average strain value by plotting, in time series, an average strain value for each frame in a predetermined period and performing predetermined interpolation processing for the resultant data, as needed. A display unit 23 displays the generated strain waveform instead of the monitoring waveform generated based on the average tissue velocity or together with the monitoring waveform generated based on the average tissue velocity.

[0060] According to this embodiment, a monitoring waveform (strain waveform) is generated by using an average strain value for each frame which is obtained from a computed strain image, and is displayed in the same form as that of an ECG waveform or the like in a scale corresponding to, for example, a compression strength. Therefore, displaying, in this manner, a monitoring waveform including waveforms corresponding to a plurality of number of times of compression/release in the past allows the probe operator to check whether stable compressing/releasing operation is performed. Based on such a monitoring waveform, freeze operation is performed in a time phase regarded as a time phase in which a strain image is properly and stably obtained in elastic imaging. This makes it possible to record the strain image as a diagnosis image. In elastic imaging, therefore, a proper strain image can be selected efficiently by using an objective reference. This can contribute to improvements in the quality of image diagnosis and in the efficiency of operation.

[0061] Note that the present invention is not limited to the above embodiments, and constituent elements can be variously modified and embodied at the execution stage within the spirit and scope of the invention. For example, the following are concrete modifications.

[0062] Each function associated with each embodiment can also be implemented by installing programs for executing the corresponding processing in a computer such as a workstation and mapping them in a memory. In this case, the programs which can cause the computer to execute the corresponding techniques can be distributed by being stored in recording media such as magnetic disks (floppy® disks, hard disks, and the like), optical disks (CD-ROMs, DVDs, and the like), and semiconductor memories.

[0063] Note that the above embodiments are not limited to real-time processing on an ultrasonic diagnosis apparatus, and can also be applied to a case in which after reception signals representing B-mode information and velocity information are stored, analysis is performed by reading stored data. In this case, although the monitoring effect introduced in the embodiments above is not provided, a deformed time phase can be automatically grasped and an optimal strain image synchronous with movement can be automatically obtained in the same manner as described above.

[0064] In addition, various inventions can be formed by proper combinations of a plurality of constituent elements disclosed in the above embodiments. For example, several constituent elements may be omitted from all the constituent elements disclosed in the above embodiments. Furthermore, constituent elements in the different embodiments may be properly combined.

Industrial Applicability

[0065] The present invention described above can implement an ultrasonic diagnosis apparatus, an ultrasonic image processing apparatus, and a recording medium on which an ultrasonic image processing program is recorded, which can determine a time phase suitable for the start of strain computation in elastic imaging using TSI and can generate and display reference information as a suitable reference when applying a dynamic load on a tissue.

Claims

1. An ultrasonic diagnosis apparatus comprising:

an image data acquisition unit (15, 17) adapted to acquire ultrasonic image data corresponding to each time phase in a first period including at least one contraction and one expansion by ultrasonic scanning throughout the first period for an observation region of a soft tissue not having active dynamics as an object to be examined, the observation region repeating contracting motion and expanding motion due to an external dynamic load (11) toward the observation region including repetition of compression and release;

a velocity information generating unit (19) adapted to generate, from the ultrasonic image data, velocity information concerning a tissue in the observation region in each time phase in the first period;

a reference information generating unit (27) adapted to generate, from the velocity informa-

tion, reference information that is represented by a graph on velocities of the observation region with time, over the first period;
a strain information generating unit (25) adapted to determine, from the reference information, a reference time phase, and to generate strain information concerning the tissue in the observation region by executing time integration with respect to the velocity information based on the reference time phase, the reference information and the velocity information, the reference time phase being a time phase corresponding to one of the contracting motion and the expanding motion, wherein the time integration is executed over a second period including at least part of the compression or the release, respectively;
an image generating unit (21) adapted to generate, based on strain information, a strain image indicating elasticity of the soft tissue; and
a display unit (23) adapted to display the strain image in a predetermined form.

2. The ultrasonic diagnosis apparatus according to claim 1, wherein the strain information generating unit (25) is adapted to determine, based on the reference information, an integral interval for calculation of strain information for each time phase in the second period included in the first period, and to generate strain information concerning the tissue in the observation region for each time phase in the second period by executing time integration using the velocity information based on the determined integral interval.

3. The ultrasonic diagnosis apparatus according to claim 2, wherein the strain information generating unit (25) is adapted to set, as lower limit, a time phase in which a velocity associated with the contracting motion or the expanding motion becomes 0 or a time phase in which the velocity gradually becomes closer to 0, while setting, as an upper limit, each time phase in the second period, and to determine an integral interval for said each time phase.

4. The ultrasonic diagnosis apparatus according to claim 2 or 3, wherein the strain information generating unit (25) is adapted to determine, based on the reference information, a period in which the observation region contracts due to a dynamic load including compression or a period in which the observation region expands due to a dynamic load including release, and to set the second period as a period in which the observation region contracts or a period in which the observation region expands.

5. The ultrasonic diagnosis apparatus according to any of claims 1 to 4, wherein
the image data acquisition unit is adapted to acquire the ultrasonic image data by a tissue Doppler method,
the velocity information generating unit (19) is adapted to generate velocity information in each time phase in the first period based on the ultrasonic image data, and
the reference information generating unit (27) is adapted to generate, based on the velocity information in each time phase in the first period, reference information indicating changes in the contracting motion and expanding motion with time.

6. The ultrasonic diagnosis apparatus according to any of claims 1 to 4, wherein
the image data acquisition unit is adapted to acquire the ultrasonic image data in a B mode,
the velocity information generating unit (19) is adapted to generate velocity information in each time phase in the first period by executing pattern matching processing between two frames associated with a region of interest using the ultrasonic image data, and
the reference information generating unit (27) is adapted to generate, based on the velocity information in each time phase in the first period, reference information indicating changes in the contracting motion and expanding motion with time.

7. The ultrasonic diagnosis apparatus according to any of claims 1 to 6, wherein the reference information generating unit (27) is adapted to generate, based on a temporal change in a position of an ultrasonic probe used for acquisition of the ultrasonic image data, reference information indicating changes in the contracting motion and expanding motion with time.

8. The ultrasonic diagnosis apparatus according to any of claims 1 to 6, wherein the reference information generating unit (27) is adapted to generate reference information indicating changes in the contracting motion and expanding motion with time based on a temporal change concerning a pressure on a contact surface between an ultrasonic probe (11) used for acquisition of the ultrasonic image data and the object due to the dynamic load.

9. The ultrasonic diagnosis apparatus according to any of claims 1 to 8, wherein the display unit (23) is adapted to display the strain image while sequentially updating the strain image in a period during which the observation region contracts, and to hold and to display the strain image corresponding to a time phase at a time of an end of compression in a period during which the observation region expands, or
wherein the display unit (23) is adapted to display the strain image while sequentially updating the strain image in a period during which the observation region expands, and to hold and to display the strain

image corresponding to a time phase at a time of an end of release in a period during which the observation region contracts.

10. The ultrasonic diagnosis apparatus according to any of claims 1 to 9, wherein the display unit (23) is adapted to simultaneously display the strain image and a B-mode image associated with the observation region displayed like a moving image, or to simultaneously display the reference information and the strain image.

11. The ultrasonic diagnosis apparatus according to any of claims 1 to 10, wherein the display unit (23) is adapted to display the reference information in a scale corresponding to a strength of the dynamic load or in a form including a plurality of compression periods and a plurality of release periods; and/or wherein the soft tissue includes mammary glands.

12. The ultrasonic diagnosis apparatus according to any of claims 1 to 11, wherein
the reference information generating unit (27) is adapted to generate reference information indicating a change in strain concerning a tissue in the observation region with time by using the strain information, and
the display unit (23) is adapted to display reference information indicating a change in strain concerning a tissue in the observation region with time.

13. The ultrasonic diagnosis apparatus according to claim 1, wherein
the reference information unit is further adapted to extract velocity information in directions of the compression and the release from a tissue motion, and to generate the reference information based on the extracted velocity information.

14. An ultrasonic image processing apparatus comprising:

a storage unit adapted to store ultrasonic image data corresponding to each time phase in a first period including at least one contraction and one expansion by ultrasonic scanning throughout the first period for an observation region of a soft tissue not having active dynamics as an object to be examined, the observation region repeating contracting motion and expanding motion due to an external dynamic load (11) toward the observation region including repetition of compression and release;
a velocity information generating unit (19) adapted to generate, from the ultrasonic image data, velocity information concerning a tissue in the observation region in each time phase in the first period;
a reference information generating unit (27) adapted to generate, from the velocity information, reference information that is represented by a graph on velocities of the observation region with time, over the first period;
a strain information generating unit (25) adapted to determine, from the reference information, a reference time phase, and to generate strain information concerning the tissue in the observation region by executing time integration with respect to the velocity information based on the reference time phase, the reference information and the velocity information, the reference time phase being a time phase corresponding to one of the contracting motion and the expanding motion, wherein the time integration is executed over a second period including at least part of the compression or the release, respectively;
an image generating unit (28) adapted to generate, based on strain information, a strain image indicating elasticity of the soft tissue; and
a display unit (23) adapted to display the strain image in a predetermined form.

15. A recording medium comprising an ultrasonic image processing program which, when run by a computer, causes the computer to execute
a velocity information generating function of generating, from the ultrasonic image data, velocity information concerning a tissue in a soft tissue not having active dynamics as an observation region in each time phase in a first period including at least one contraction and one expansion by using ultrasonic image data corresponding to each time phase in the first period by ultrasonic scanning throughout the first period for the observation region of an object to be examined, the observation region repeating contracting motion and expanding motion due to an external dynamic load (11) toward the observation region including repetition of compression and release,
a reference information generation function of generating, from the velocity information, reference information that is represented by a graph on velocities of the observation region with time, over the first period,
a strain information generating function of determining, from the reference information, a reference time phase, and generating strain information concerning the tissue in the observation region by executing time integration with respect to the velocity information based on the reference time phase, the reference information and the velocity information, the reference time phase being a time phase corresponding to one of the contracting motion and the expanding motion, wherein the time integration is executed over a second period including at least part of the compression or the release, respectively, and
an image generating function of generating, based

on strain information, a strain image indicting elasticity of the soft tissue.

Patentansprüche

1. Ultraschalldiagnosevorrichtung mit einer Bilddatenerfassungseinheit (15, 17), die dazu ausgebildet ist, Ultraschallbilddaten, die zu jeder Zeitphase in einer ersten Periode mit mindestens einer Kontraktion und einer Expansion gehören, durch Ultraschallscannen während der ersten Periode für eine Observationsregion von weichem Gewebe, welches keine aktive Dynamik aufweist, als ein zu untersuchendes Objekt zu erfassen, wobei die Observationsregion kontrahierende Bewegung und expandierende Bewegung aufgrund einer äußeren dynamischen Last (11) auf die Observationsregion mit einer Wiederholung von Kompression und Entlastung wiederholt,
einer Geschwindigkeitsinformationserzeugungseinheit (19), die dazu ausgebildet ist, von den Ultraschallbilddaten Geschwindigkeitsinformation betreffend einem Gewebe in der Observationsregion in jeder Zeitphase in der ersten Periode zu erzeugen,
einer Referenzinformationserzeugungseinheit (27), die dazu ausgebildet ist, von der Geschwindigkeitsinformation Referenzinformation, die durch einen Graph auf Geschwindigkeiten der Observationsregion mit der Zeit dargestellt wird, über die erste Periode zu erzeugen,
einer Belastungsinformationserzeugungseinheit (25), die dazu ausgebildet ist, von der Referenzinformation eine Referenzzeitphase zu bestimmen und Belastungsinformation betreffend dem Gewebe in der Observationsregion durch Ausführen einer Zeitintegration bezüglich der Geschwindigkeitsinformation basierend auf der Referenzzeitphase, der Referenzinformation und der Geschwindigkeitsinformation zu erzeugen, wobei die Referenzzeitphase eine Zeitphase ist, die zu der Kontraktionsbewegung oder der Expansionsbewegung gehört, wobei die Zeitintegration über eine zweite Periode, die jeweils mindestens ein Teil der Kompression oder der Entlastung aufweist, ausgeführt wird,
einer Bilderzeugungseinheit (21), die dazu ausgebildet ist, basierend auf der Belastungsinformation ein Belastungsbild zu erzeugen, welches die Elastizität des weichen Gewebes angibt, und
einer Anzeigeeinheit (23), die dazu ausgebildet ist, das Belastungsbild in einer vorbestimmten Form anzuzeigen.

2. Ultraschalldiagnosevorrichtung nach Anspruch 1, wobei die Belastungsinformationserzeugungseinheit (25) dazu ausgebildet ist, basierend auf der Referenzinformation ein Integralintervall zur Berechnung der Belastungsinformation für jede Zeitphase in der zweiten Periode, die in der ersten Periode enthalten ist, zu bestimmen, und Belastungsinformation betreffend dem Gewebe in der Observationsregion für jede Zeitphase in der zweiten Periode durch Ausführen der Zeitintegration unter Verwendung der Geschwindigkeitsinformation basierend auf dem bestimmten Integralintervall zu erzeugen.

3. Ultraschalldiagnosevorrichtung nach Anspruch 2, wobei die Belastungsinformationserzeugungseinheit (25) dazu ausgebildet ist, als eine untere Grenze eine Zeitphase, in der eine Geschwindigkeit, die mit der Kontraktionsbewegung oder der Expansionsbewegung in Bezug steht, Null wird, oder eine Zeitphase, in der die Geschwindigkeit graduell näher auf Null zugeht, festzulegen, während als eine obere Grenze jeder Zeitphase in der zweiten Periode festgesetzt wird, und ein Integralintervall für jede Zeitphase zu bestimmen.

4. Ultraschalldiagnosevorrichtung nach Anspruch 2 oder 3, wobei die Belastungsinformationserzeugungseinheit (25) dazu ausgebildet ist, basierend auf der Referenzinformation eine Periode, in der die Observationsregion aufgrund einer dynamischen Last mit Kompression kontrahiert, oder eine Periode, in der die Observationsregion aufgrund einer dynamischen Last mit Entlastung expandiert, zu bestimmen und die zweite Periode als eine Periode, in der die Observationsregion kontrahiert, oder als eine Periode, in der die Observationsregion expandiert, festzusetzen.

5. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 4, wobei die Bilddatenerfassungseinheit dazu ausgebildet ist, die Ultraschallbilddaten mit einer Gewebe-Doppler-Methode zu erfassen,
die Geschwindigkeitsinformationserzeugungseinheit (19) dazu ausgebildet ist, die Geschwindigkeitsinformation in jeder Zeitphase in der ersten Periode basierend auf den Ultraschallbilddaten zu erzeugen, und
die Referenzinformationserzeugungseinheit (27) dazu ausgebildet ist, basierend auf der Geschwindigkeitsinformation in jeder Zeitphase in der ersten Periode Referenzinformation zu erzeugen, die Änderungen in der Kontraktionsbewegung und der Expansionsbewegung mit der Zeit angibt.

6. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 4, wobei die Bilddatenerfassungseinheit dazu ausgebildet ist, Ultraschallbilddaten in einem B-Modus zu erfassen,
die Geschwindigkeitsinformationserzeugungseinheit (19) dazu ausgebildet ist, die Geschwindigkeitsinformation in jeder Zeitphase in der ersten Periode durch Ausführen eines Musterabgleichprozesses zwischen zwei Rahmen, die mit einer Region von

Interesse in Bezug stehen, unter Verwendung der Ultraschallbilddaten zu erzeugen, und
die Referenzinformationserzeugungseinheit (27) dazu ausgebildet ist, basierend auf der Geschwindigkeitsinformation in jeder Zeitphase in der ersten Periode Referenzinformation, welche im Wechsel in der Kontraktionsbewegung und der Expansionsbewegung mit der Zeit anzeigt, zu erzeugen.

7. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 6, wobei die Referenzinformationserzeugungseinheit (27) dazu ausgebildet ist, basierend auf einem zeitlichen Wechsel in einer Lage einer Ultraschallprobe, die zum Erfassen der Ultraschallbilddaten verwendet wird, Referenzinformationen zu erzeugen, die Änderungen in der Kontraktionsbewegung und der Expansionsbewegung mit der Zeit anzeigt.

8. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 6, wobei die Referenzinformationserzeugungseinheit (27) dazu ausgebildet ist, Referenzinformation, welche Änderungen in der Kontraktionsbewegung und der Expansionsbewegung mit der Zeit anzeigt, basierend auf einer zeitlichen Änderung, die einen Druck auf eine Kontaktfläche zwischen einer Ultraschallprobe (11), die zur Erfassung der Ultraschallbilddaten verwendet wird, und dem Objekt aufgrund der dynamischen Last betrifft, zu erzeugen.

9. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 8, wobei die Anzeigeheit (23) dazu ausgebildet ist, ein Belastungsbild anzuzeigen, während das Belastungsbild in einer Periode, während der die Observationsregion kontrahiert, nacheinander erneuert wird, und das Belastungsbild, welches zu einer Zeitphase zu einer Zeit eines Endes der Kompression in einer Periode, während der die Observationsregion expandiert, gehört, still zu halten und anzuzeigen, oder
wobei die Anzeigeeinheit (23) dazu ausgebildet ist, das Belastungsbild anzuzeigen, während das Belastungsbild in einer Periode, während der die Observationsregion expandiert, nacheinander erneuert wird, und das Belastungsbild, welches zu einer Zeitphase bei einer Zeit eines Endes der Endspannung in einer Periode, während welcher die Observationsregion kontrahiert, still zu halten und anzuzeigen.

10. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 9, wobei die Anzeigeeinheit (23) dazu ausgebildet ist, gleichzeitig das Belastungsbild und ein B-Modus-Bild, welches mit der Observationsregion in Bezug steht, wie ein bewegtes Bild dargestellt ist, darzustellen oder die Referenzinformation und das Belastungsbild gleichzeitig darzustellen.

11. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 10, wobei die Anzeigeeinheit (23) dazu ausgebildet ist, die Referenzinformation in einer Skala, die zu einer Stärke der dynamischen Last gehört, oder auf eine Art, die eine Mehrzahl von Kompressionsperioden und einer Mehrzahl von Entlastungsperioden aufweist, darzustellen, und/oder wobei das weiche Gewebe Brustdrüsen aufweist.

12. Ultraschalldiagnosevorrichtung nach einem der Ansprüche 1 bis 11, wobei die Referenzinformationserzeugungseinheit (27) dazu ausgebildet ist, Referenzinformation, welche eine Änderung in der Belastung betreffend einem Gewebe in der Observationsregion mit der Zeit anzeigt, unter Verwendung der Belastungsinformation zu erzeugen, und
die Anzeigeeinheit (23) dazu ausgebildet ist, die Referenzinformation, welche eine Änderung in der Belastung betreffend einem Gewebe in der Observationsregion mit der Zeit anzeigt, anzuzeigen.

13. Ultraschalldiagnosevorrichtung nach Anspruch 1, wobei die Referenzinformationseinheit ferner dazubausgebildet ist, Geschwindigkeitsinformation in Richtungen der Kompression und der Entlastung von einer Gewebebewegung zu extrahieren und Referenzinformation basierend auf der extrahierten Geschwindigkeitsinformation zu erzeugen.

14. Ultraschallbildverarbeitungsvorrichtung mit
einer Speichereinheit, die dazu ausgebildet ist, Ultraschallbilddaten, die zu jeder Zeitphase in einer ersten Periode mit mindestens einer Kontraktion und einer Expansion gehören, durch Ultraschallscannen während der ersten Periode für eine Observationsregion eines weichen Gewebes, welche keine aktive Dynamik aufweist, als ein zu untersuchendes Objekt zu speichern, wobei die Observationsregion Kontraktionsbewegung und Expansionsbewegung aufgrund einer externen dynamischen Last (11) auf die Observationsregion, welche eine Wiederholung der Kompression und der Entlastung aufweist, zu wiederholen,
einer Geschwindigkeitsinformationserzeugungseinheit (19), die dazu ausgebildet ist, von den Ultraschallbilddaten Geschwindigkeitsinformation betreffend einem Gewebe in der Observationsregion in jede Zeitphase in der ersten Periode zu erzeugen,
einer Referenzinformationserzeugungseinheit (27), die dazu ausgebildet ist, von der Geschwindigkeitsinformation Referenzinformationen, die durch einen Graph auf Geschwindigkeiten der Observationsregion mit der Zeit dargestellt wird, über die erste Periode zu erzeugen,
einer Belastungsinformationserzeugungseinheit (25), die dazu ausgebildet ist, von der Referenzinformation eine Referenzzeitphase zu bestimmen und Belastungsinformation betreffend dem Gewebe

in der Observationsregion durch Ausführen einer Zeitintegration bezüglich der Geschwindigkeitsinformation basierend auf der Referenzzeitphase der Referenzinformation und der Geschwindigkeitsinformation zu erzeugen, wobei die Referenzzeitphase eine Zeitphase ist, die zu der Kontraktionsbewegung oder der Expansionsbewegung gehört, wobei die Zeitintegration über eine zweite Periode, die jeweils mindestens einen Teil der Kompression oder der Entlastung aufweist, ausgeführt wird,
einer Bilderzeugungseinheit (28), die dazu ausgebildet ist, basierend auf Belastungsinformation ein Belastungsbild zu erzeugen, welches die Elastizität des weichen Gewebes anzeigt, und
einer Anzeigeeinheit (23), die dazu ausgebildet ist, das Belastungsbild in einer vorbestimmten Form anzuzeigen.

15. Ein Aufnahmemedium mit einem Ultraschallbildverarbeitungsprogramm, welches beim Ablaufen auf einem Computer den Computer zum Ausführen folgender Funktionen veranlasst:

eine Geschwindigkeitsinformationserzeugungsfunktion zur Erzeugung aus den Ultraschallbilddaten einer Geschwindigkeitsinformation, die ein Gewebe in einem weichen Gewebe betrifft, welches keine aktive Dynamik aufweist, als eine Observationsregion in jeder Zeitphase in einer ersten Periode mit mindestens einer Kontraktion und einer Expansion unter Verwendung von Ultraschallbilddaten, die zu jeder Zeitphase in der ersten Zeitperiode gehören, durch Ultraschallscannen während der ersten Periode für die Observationsregion des zu untersuchenden Objekts, wobei die Observationsregion eine Kontraktionsbewegung und eine Expansionsbewegung aufgrund einer externen dynamischen Last (11) auf die Observationsregion mit einer Wiederholung von Kompression und Entlastung wiederholt,
eine Referenzinformationserzeugungsfunktion zu Erzeugung aus der Geschwindigkeitsinformation einer Referenzinformation, die durch einen Graph auf Geschwindigkeiten der Observationsregion mit der Zeit dargestellt wird, über die erste Periode,
einer Belastungsinformationserzeugungsfunktion zum Bestimmen aus der Referenzinformation eine Referenzzeitphase und zum Erzeugen einer Belastungsinformation, die das Gewebe in der Observationsregion betrifft, durch Ausführen einer Zeitintegration bezüglich der Geschwindigkeitsinformation basierend auf der Referenzzeitphase, der Referenzinformation und der Geschwindigkeitsinformation, wobei die Referenzzeitphase eine Zeitphase ist, die zur Kontraktionsbewegung oder der Expansionsbewegung gehört, wobei die Zeitintegration über eine zweite Periode mit jeweils mindestens einem Teil der Kompression und der Entlastung ausgeführt wird, und
einer Bilderzeugungsfunktion zum Erzeugen basierend auf der Belastungsinformation eines Belastungsbildes, das Elastizität des weichen Gewebes angibt.

Revendications

1. Appareil de diagnostic ultrasonique comprenant :

une unité d'acquisition de données d'image (15, 17) adaptée pour acquérir des données d'image ultrasoniques correspondant à chaque phase temporelle dans une première période incluant au moins une contraction et une extension par un balayage ultrasonique pendant toute la première période pour une région d'observation d'un tissu mou n'ayant pas de dynamiques actives en tant qu'objet à examiner, la région d'observation répétant un mouvement de contraction et un mouvement d'extension en raison d'une charge dynamique externe (11) vers la région d'observation incluant une répétition de compressions et de relâchements ;
une unité de génération d'informations de vitesse (19) adaptée pour générer, à partir des données d'image ultrasoniques, des informations de vitesse concernant un tissu dans la région d'observation dans chaque phase temporelle dans la première période ;
une unité de génération d'informations de référence (27) adaptée pour générer, à partir des informations de vitesse, des informations de référence qui sont représentées par un graphe sur des vitesses de la région d'observation en fonction du temps, au cours de la première période ;
une unité de génération d'informations de déformation (25) adaptée pour déterminer, à partir des informations de référence, une phase temporelle de référence et pour générer des informations de déformation concernant le tissu dans la région d'observation par une exécution d'une intégration dans le temps en ce qui concerne les informations de vitesse sur la base de la phase temporelle de référence, des informations de référence et des informations de vitesse, la phase temporelle de référence étant une phase temporelle correspondant à un mouvement parmi le mouvement de contraction et le mouvement d'extension, dans lequel l'intégration dans le temps est exécutée au cours d'une seconde période incluant respectivement au moins une partie de la compression ou du relâchement ;

une unité de génération d'image (21) adaptée pour générer, sur la base d'informations de déformation, une image de déformation indiquant une élasticité du tissu mou ; et
une unité d'affichage (23) adaptée pour afficher l'image de déformation sous une forme prédéterminée.

2. Appareil de diagnostic ultrasonique selon la revendication 1, dans lequel l'unité de génération d'informations de déformation (25) est adaptée pour déterminer, sur la base des informations de référence, un intervalle intégral pour calculer des informations de déformation pour chaque phase temporelle dans la seconde période incluse dans la première période, et pour générer des informations de déformation concernant le tissu dans la région d'observation pour chaque phase temporelle dans la seconde période en exécutant une intégration dans le temps à l'aide des informations de vitesse sur la base de l'intervalle intégral déterminé.

3. Appareil de diagnostic ultrasonique selon la revendication 2, dans lequel l'unité de génération d'informations de déformation (25) est adaptée pour régler, en tant que limite inférieure, une phase temporelle dans laquelle une vitesse associée au mouvement de contraction ou au mouvement d'extension devient nulle ou une phase temporelle dans laquelle la vitesse devient progressivement proche de zéro, tout en réglant, en tant que limite supérieure, chaque phase temporelle dans la seconde période, et pour déterminer un intervalle intégral pour chaque dite phase temporelle.

4. Appareil de diagnostic ultrasonique selon la revendication 2 ou 3, dans lequel l'unité de génération d'informations de déformation (25) est adaptée pour déterminer, sur la base des informations de référence, une période dans laquelle la région d'observation se contracte en raison d'une charge dynamique incluant une compression ou une période dans laquelle la région d'observation s'étend en raison d'une charge dynamique incluant un relâchement, et pour régler la seconde période en tant que période dans laquelle la région d'observation se contracte ou une période dans laquelle la région d'observation s'étend.

5. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 4, dans lequel l'unité d'acquisition de données d'image est adaptée pour acquérir les données d'image ultrasoniques par un procédé Doppler de tissu,
l'unité de génération d'informations de vitesse (19) est adaptée pour générer des informations de vitesse dans chaque phase temporelle dans la première période sur la base des données d'image ultrasoniques, et
l'unité de génération d'informations de référence (27) est adaptée pour générer, sur la base des informations de vitesse dans chaque phase temporelle dans la première période, des informations de référence indiquant des changements du mouvement de contraction et du mouvement d'extension en fonction du temps.

6. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 4, dans lequel
l'unité d'acquisition de données d'image est adaptée pour acquérir les données d'image ultrasoniques dans un mode B,
l'unité de génération d'informations de vitesse (19) est adaptée pour générer des informations de vitesse dans chaque phase temporelle dans la première période en exécutant un traitement de concordance de motifs entre deux trames associées à une région d'intérêt à l'aide des données d'image ultrasoniques, et
l'unité de génération d'informations de référence (27) est adaptée pour générer, sur la base des informations de vitesse dans chaque phase temporelle dans la première période, des informations de référence indiquant des changements du mouvement de contraction et du mouvement d'extension en fonction du temps.

7. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 6, dans lequel l'unité de génération d'informations de référence (27) est adaptée pour générer, sur la base d'un changement temporel d'une position d'une sonde ultrasonique utilisée pour une acquisition des données d'image ultrasoniques, des informations de référence indiquant des changements du mouvement de contraction et du mouvement d'extension en fonction du temps.

8. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 6, dans lequel l'unité de génération d'informations de référence (27) est adaptée pour générer des informations de référence indiquant des changements du mouvement de contraction et du mouvement d'extension en fonction du temps sur la base d'un changement temporel concernant une pression sur une surface de contact entre une sonde ultrasonique (11) utilisée pour une acquisition des données d'image ultrasoniques et l'objet en raison de la charge dynamique.

9. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 8, dans lequel l'unité d'affichage (23) est adaptée pour afficher l'image de déformation tout en mettant à jour séquentiellement l'image de déformation dans une période au cours de laquelle la région d'observation se contracte, et pour conserver et afficher l'image de déformation correspondant à une phase temporelle à un instant d'une fin d'une compression dans une période au cours de laquelle la région d'observation s'étend, ou dans lequel l'unité d'affichage (23) est adaptée pour afficher l'image de déformation tout en mettant à jour séquentiellement l'image de déformation dans une période au cours de laquelle la région d'observation s'étend, et pour conserver et afficher l'image de déformation correspondant à une phase temporelle à un instant d'une fin d'un relâchement dans une période au cours de laquelle la région d'observation se contracte.

10. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 9, dans lequel l'unité d'affichage (23) est adaptée pour afficher simultanément l'image de déformation et une image de mode B associée à la région d'observation affichée comme une image animée, ou pour afficher simultanément les informations de référence et l'image de déformation.

11. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 10,
dans lequel l'unité d'affichage (23) est adaptée pour afficher les informations de référence selon une échelle correspondant à une intensité de la charge dynamique ou sous une forme incluant une pluralité de périodes de compression et une pluralité de périodes de relâchement ; et/ou
dans lequel le tissu mou inclut des glandes mammaires.

12. Appareil de diagnostic ultrasonique selon l'une quelconque des revendications 1 à 11, dans lequel l'unité de génération d'informations de référence (27) est adaptée pour générer des informations de référence indiquant un changement de déformation concernant un tissu dans la région d'observation en fonction du temps à l'aide des informations de déformation, et l'unité d'affichage (23) est adaptée pour afficher des informations de référence indiquant un changement de déformation concernant un tissu dans la région d'observation en fonction du temps.

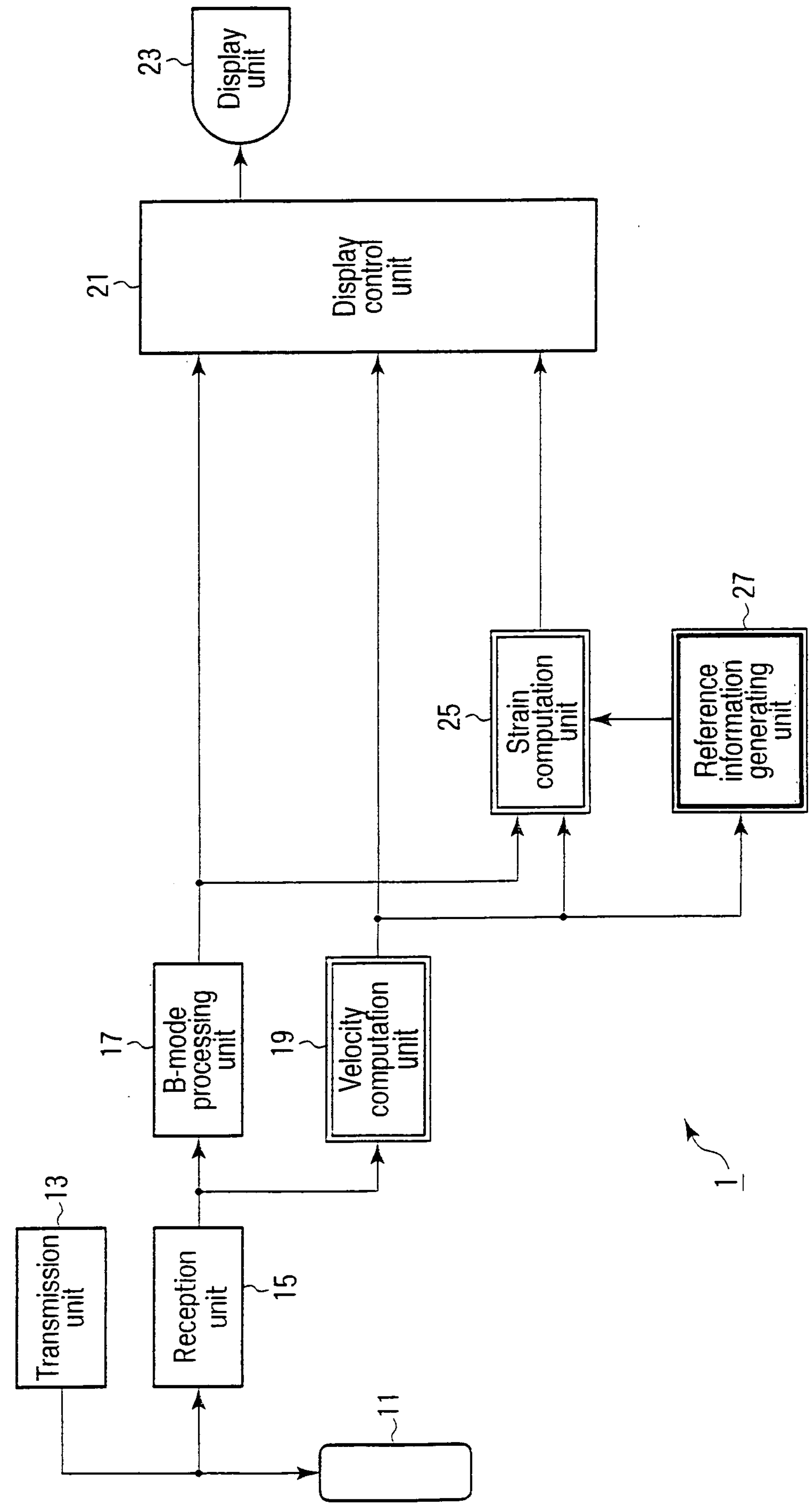
13. Appareil de diagnostic ultrasonique selon la revendication 1, dans lequel l'unité d'informations de référence est en outre adaptée pour extraire des informations de vitesse dans des directions de la compression et du relâchement à partir d'un mouvement du tissu, et pour générer les informations de référence sur la base des informations de vitesse extraites.

14. Appareil de traitement d'image ultrasonique comprenant :

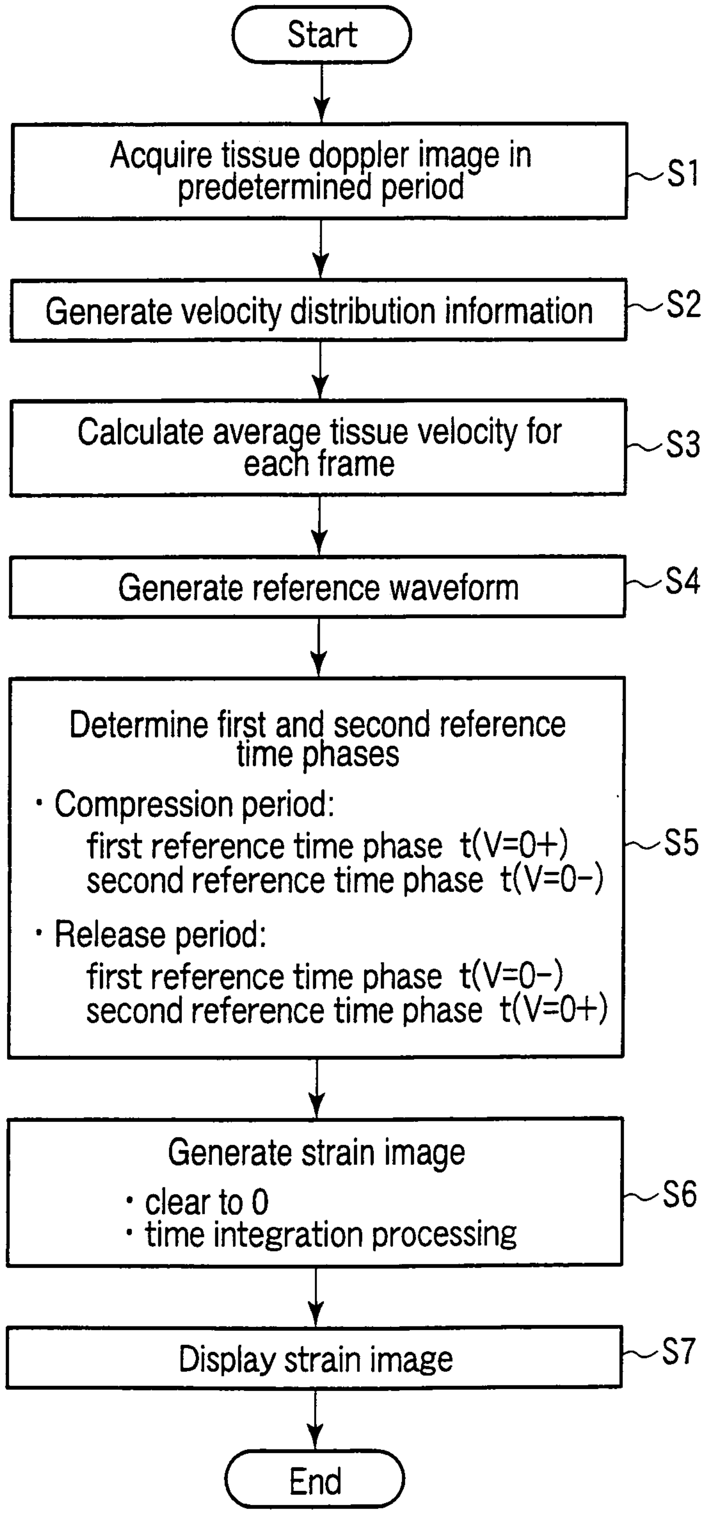
une unité de stockage adaptée pour stocker des données d'image ultrasoniques correspondant à chaque phase temporelle dans une première période incluant au moins une contraction et une extension par balayage ultrasonique pendant toute la première période pour une région d'observation d'un tissu mou n'ayant pas de dynamiques actives en tant qu'objet à examiner, la région d'observation répétant un mouvement de contraction et un mouvement d'extension en raison d'une charge dynamique externe (11) vers la région d'observation incluant une répétition de compressions et de relâchements ;
une unité de génération d'informations de vitesse (19) adaptée pour générer, à partir des données d'image ultrasoniques, des informations de vitesse concernant un tissu dans la région d'observation dans chaque phase temporelle dans la première période ;
une unité de génération d'informations de référence (27) adaptée pour générer, à partir des informations de vitesse, des informations de référence qui sont représentées par un graphe sur des vitesses de la région d'observation en fonction du temps, au cours de la première période ;
une unité de génération d'informations de déformation (25) adaptée pour déterminer, à partir des informations de référence, une phase temporelle de référence, et pour générer des informations de déformation concernant le tissu dans la région d'observation par une exécution d'une intégration dans le temps en ce qui concerne les informations de vitesse sur la base de la phase temporelle de référence, des informations de référence et des informations de vitesse, la phase temporelle de référence étant une phase temporelle correspondant à un mouvement parmi le mouvement de contraction et le mouvement d'extension, dans lequel l'intégration dans le temps est exécutée au cours d'une seconde période incluant respectivement au moins une partie de la compression ou du relâchement ;
une unité de génération d'image (28) adaptée pour générer, sur la base d'informations de déformation, une image de déformation indiquant une élasticité du tissu mou ; et
une unité d'affichage (23) adaptée pour afficher l'image de déformation sous une forme prédéterminée.

15. Support d'enregistrement comprenant un programme de traitement d'image ultrasonique qui, lorsqu'il est mis en oeuvre par un ordinateur, amène l'ordinateur à exécuter
une fonction de génération d'informations de vitesse, générant à partir des données d'image ultrasoniques, des informations de vitesse concernant un

tissu dans un tissu mou n'ayant pas de dynamiques actives en tant que région d'observation dans chaque phase temporelle dans une première période incluant au moins une contraction et une extension à l'aide de données d'image ultrasoniques correspondant à chaque phase temporelle dans la première période par balayage ultrasonique pendant toute la première période pour la région d'observation d'un objet à examiner, la région d'observation répétant un mouvement de contraction et un mouvement d'extension en raison d'une charge dynamique externe (11) vers la région d'observation incluant une répétition de compressions et de relâchements,
une fonction de génération d'informations de référence générant, à partir des informations de vitesse, des informations de référence qui sont représentées par un graphe sur des vitesses de la région d'observation en fonction du temps, au cours de la première période,
une fonction de génération d'informations de déformation déterminant, à partir les informations de référence, une phase temporelle de référence, et générant des informations de déformation concernant le tissu dans la région d'observation par une exécution d'une intégration dans le temps en ce qui concerne les informations de vitesse sur la base de la phase temporelle de référence, des informations de référence et des informations de vitesse, la phase temporelle de référence étant une phase temporelle correspondant à un du mouvement de contraction et du mouvement d'extension, dans lequel l'intégration dans le temps est exécutée au cours d'une seconde période incluant respectivement au moins une partie de la compression ou du relâchement, et une fonction de génération d'image générant, sur la base d'informations de déformation, une image de déformation indiquant une élasticité du tissu mou.


Transmission unit
13
Reception unit
15
11
B-mode processing unit
17
Velocity computation unit
19
Strain computation unit
25
Reference information generating unit
27
Display control unit
21
Display unit
23
1

F I G. 1


Start
Acquire tissue doppler image in predetermined period
S1
Generate velocity distribution information
S2
Calculate average tissue velocity for each frame
S3
Generate reference waveform
S4
Determine first and second reference time phases
· Compression period:
first reference time phase t(V=0+)
second reference time phase t(V=0−)
· Release period:
first reference time phase t(V=0−)
second reference time phase t(V=0+)
S5
Generate strain image
· clear to 0
· time integration processing
S6
Display strain image
S7
End

F I G. 2

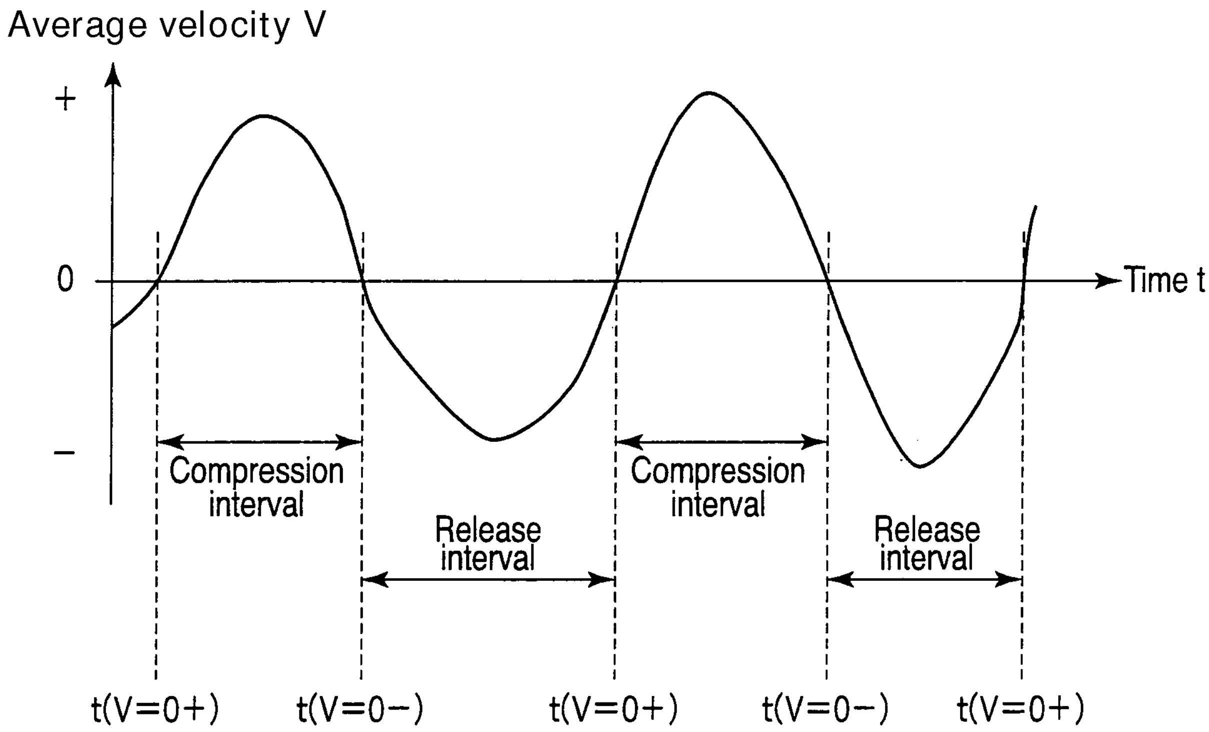
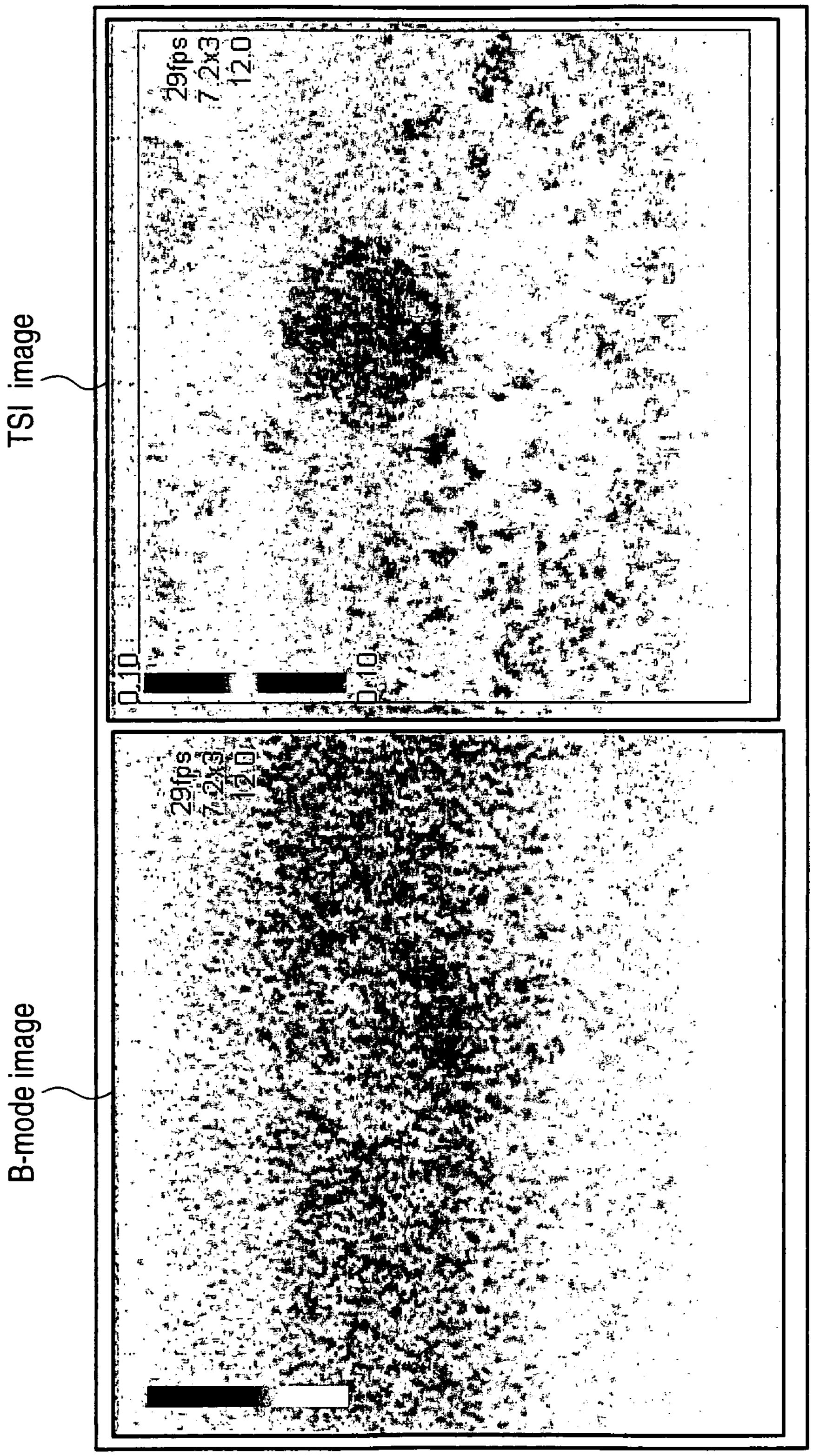
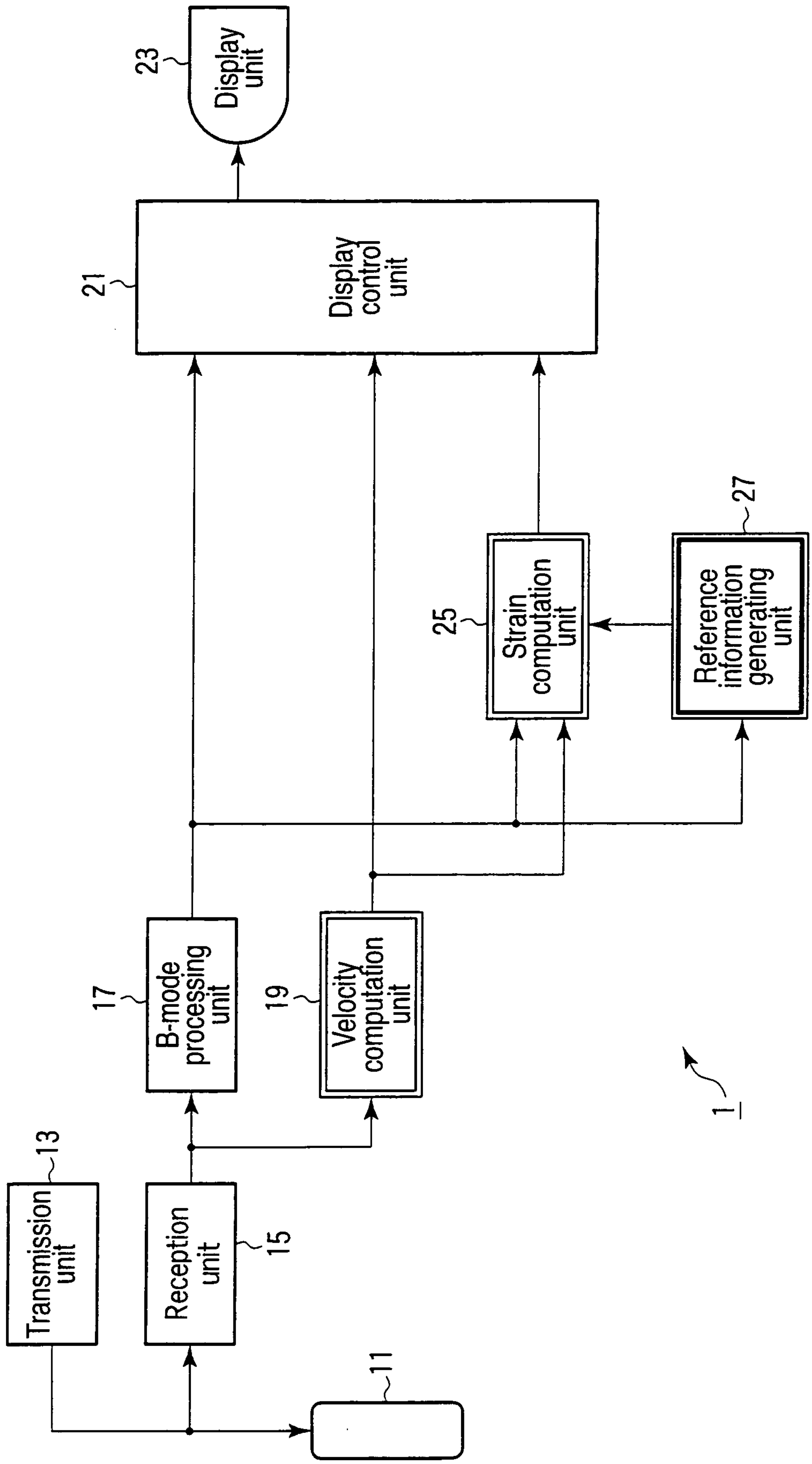

Average velocity V
+
0
−
Time t
Compression interval
Release interval
Compression interval
Release interval
t(V=0+)
t(V=0−)
t(V=0+)
t(V=0−)
t(V=0+)

FIG. 3



F I G. 4



Display unit
23
Display control unit
21
Strain computation unit
25
Reference information generating unit
27
B-mode processing unit
17
Velocity computation unit
19
Transmission unit
13
Reception unit
15
11
1

F I G. 5

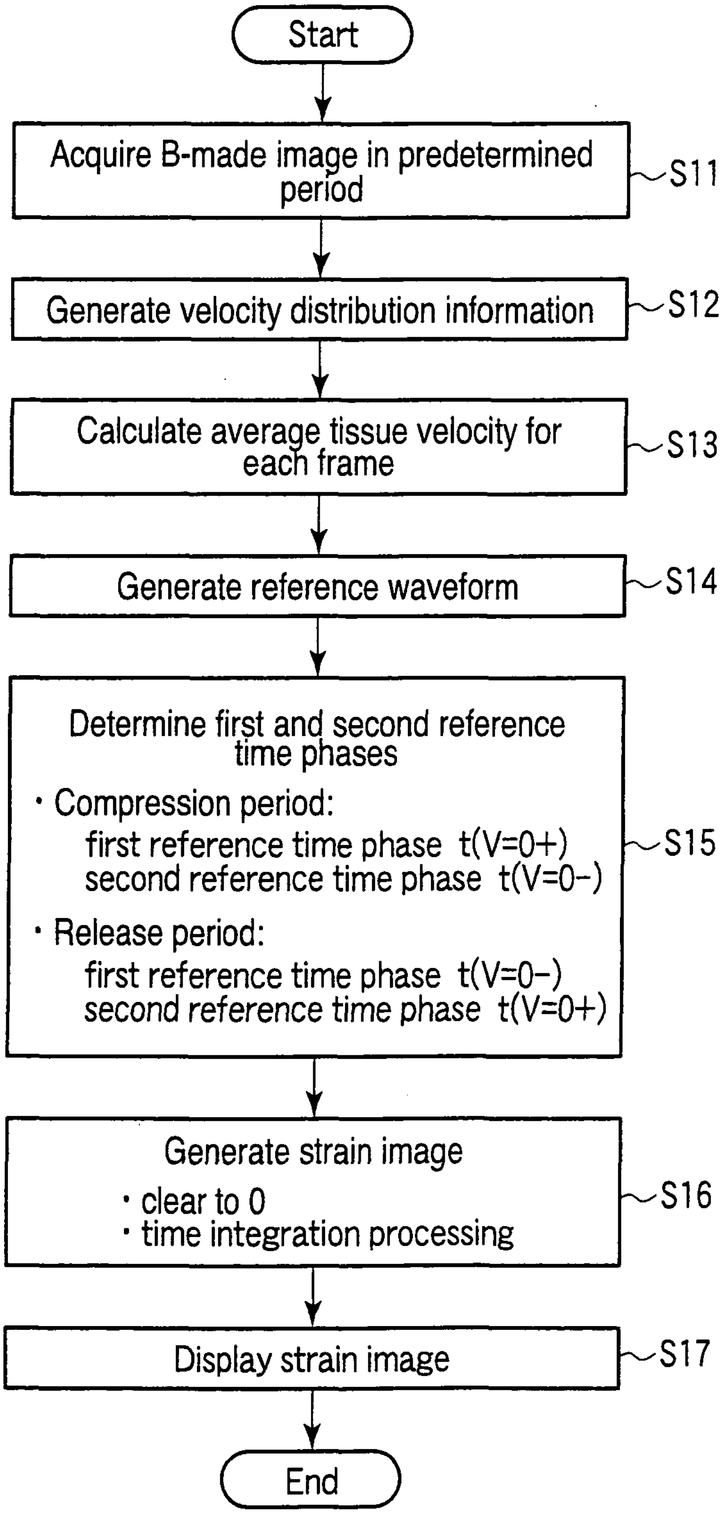

Start
Acquire B-made image in predetermined period
S11
Generate velocity distribution information
S12
Calculate average tissue velocity for each frame
S13
Generate reference waveform
S14
Determine first and second reference time phases
· Compression period:
first reference time phase t(V=0+)
second reference time phase t(V=0-)
· Release period:
first reference time phase t(V=0-)
second reference time phase t(V=0+)
S15
Generate strain image
· clear to 0
· time integration processing
S16
Display strain image
S17
End

FIG.6

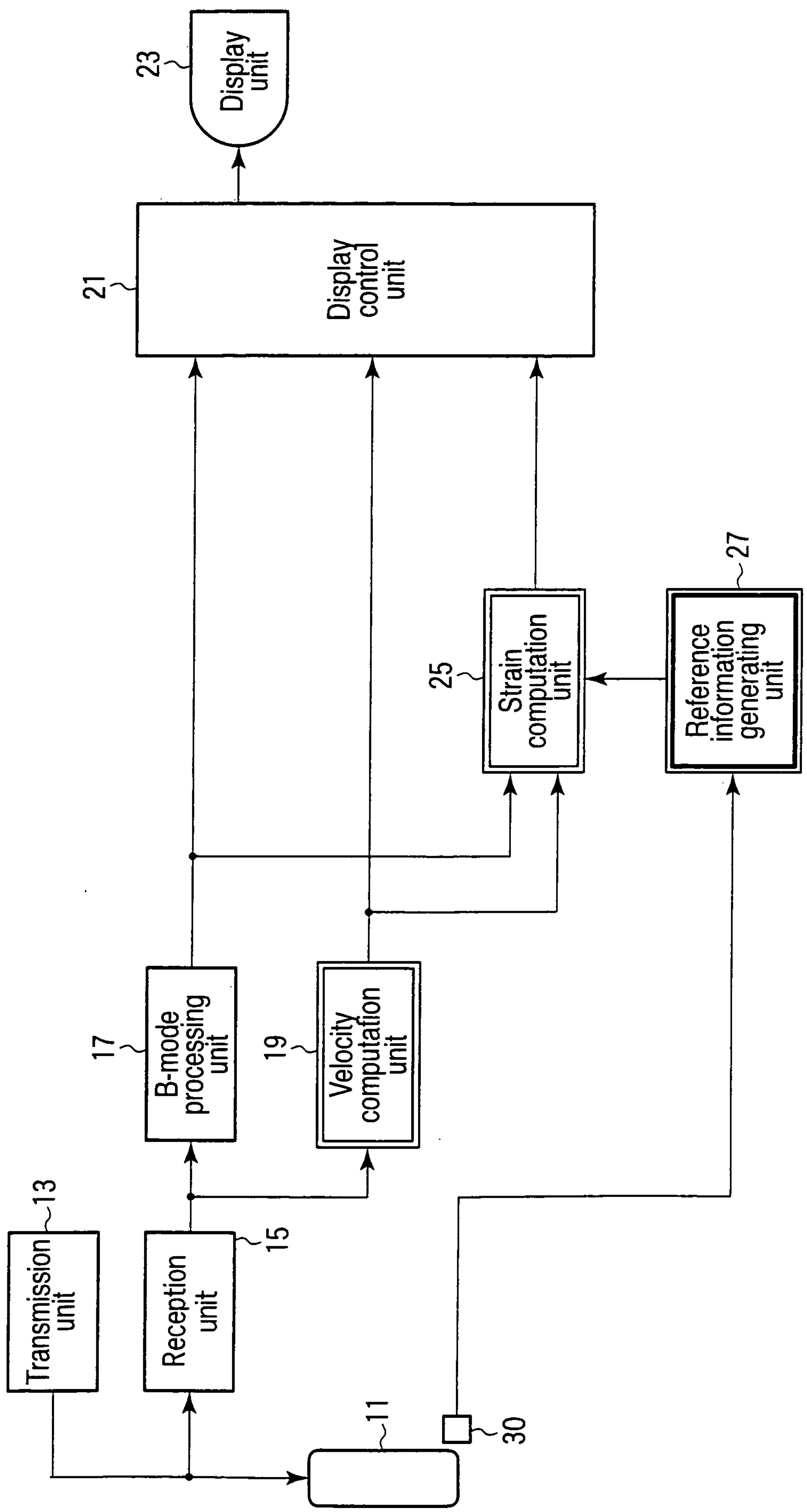

Display unit
23
Display control unit
21
B-mode processing unit
17
Velocity computation unit
19
Strain computation unit
25
Reference information generating unit
27
Transmission unit
13
Reception unit
15
11
30

FIG. 7

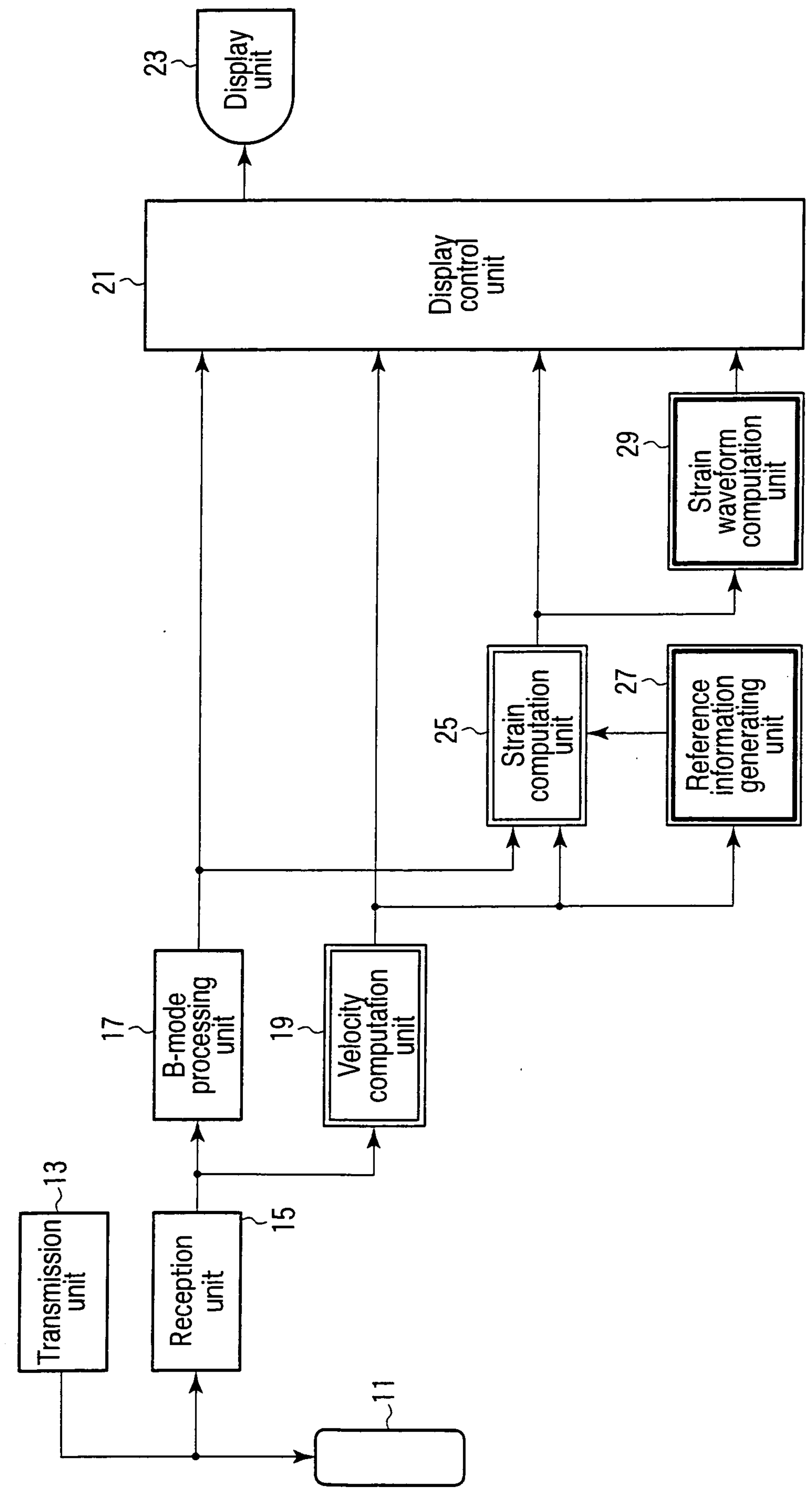

Display unit
23
Display control unit
21
Strain waveform computation unit
29
Strain computation unit
25
Reference information generating unit
27
B-mode processing unit
17
Velocity computation unit
19
Transmission unit
13
Reception unit
15
11

FIG. 8

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2003175041 A **[0003] [0030]**
- JP 2004351062 A **[0004]**
- EP 1652477 A1 **[0004]**

专利名称(译)	超声波诊断装置，超声波成像装置和用于记录超声波成像程序的记录介质		
公开(公告)号	EP2138103B1	公开(公告)日	2016-09-14
申请号	EP2009715919	申请日	2009-02-25
[标]申请(专利权)人(译)	株式会社东芝 东芝医疗系统株式会社		
申请(专利权)人(译)	株式会社东芝 东芝医疗系统公司		
当前申请(专利权)人(译)	东芝医疗系统公司		
[标]发明人	ABE YASUHIKO		
发明人	ABE, YASUHIKO		
IPC分类号	G01S7/52 A61B8/08 G01S15/89 A61B8/00 A61B5/00		
CPC分类号	A61B8/429 A61B5/7242 A61B8/08 A61B8/0883 A61B8/4245 A61B8/463 A61B8/485 A61B8/488 G01S7/52042 G01S15/8979		
优先权	2008043142 2008-02-25 JP		
其他公开文献	EP2138103A1 EP2138103A4		
外部链接	Espacenet		

摘要(译)

根据压缩/释放计算每个帧的组织的平均速度，并且通过使用计算的速度生成参考波形。通过参考波形指定平均速度变为0的时间阶段（即，组织的静止时间相位）。在应变计算中，参考指定的静止时间相对于压缩周期或释放周期中的应变计算执行时间积分。这可以适当且自动地可视化从压缩开始（即，对应于V = 0+的时间相）累积组织的收缩，或者组织的收缩在压缩结束时间阶段中变得最大（即，在压缩时段中对应于V = 0-）的时间相位以及组织如何从释放开始扩展（即，对应于V = 0-的时间相位）或组织的扩张在释放结束时间阶段变为最大（即，对应于V = 0+的时间相位）在释放时间阶段。

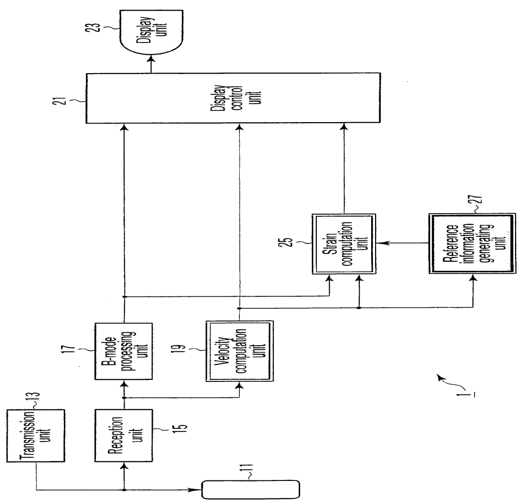


FIG.1