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(54) ULTRASONIC IMAGE CONSTRUCTION METHOD AND DIAGNOSTIC ULTRASOUND APPARATUS

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(57) **ABSTRACT**

An object of the present invention is to make it possible to observe the whole of a diagnostic region covering a wide range and to improve diagnostic efficiency. Based on a first echo signal produced by scanning with ultrasonic waves a three-dimensional field corresponding to a first position on a subject, a first image of the three-dimensional field corresponding to the first position is constructed in the form of a C-mode image. Thereafter, based on a second echo signal produced by scanning a three-dimensional field corresponding to a second position with an ultrasonic probe that is moved from the first position on the subject to the second position, a second image of the three-dimensional field corresponding to the second position is constructed in the form of a C-mode image. Thereafter, the first and second images are joined so that they will be associated with the first and second positions respectively, whereby a joint image is constructed. The joint image is then displayed on a display surface.

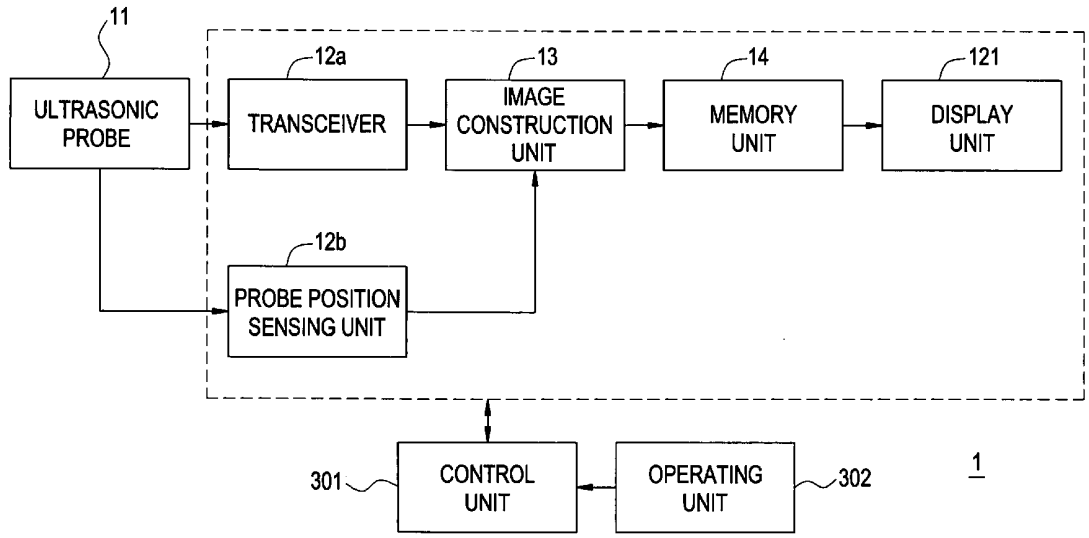


FIG. 1

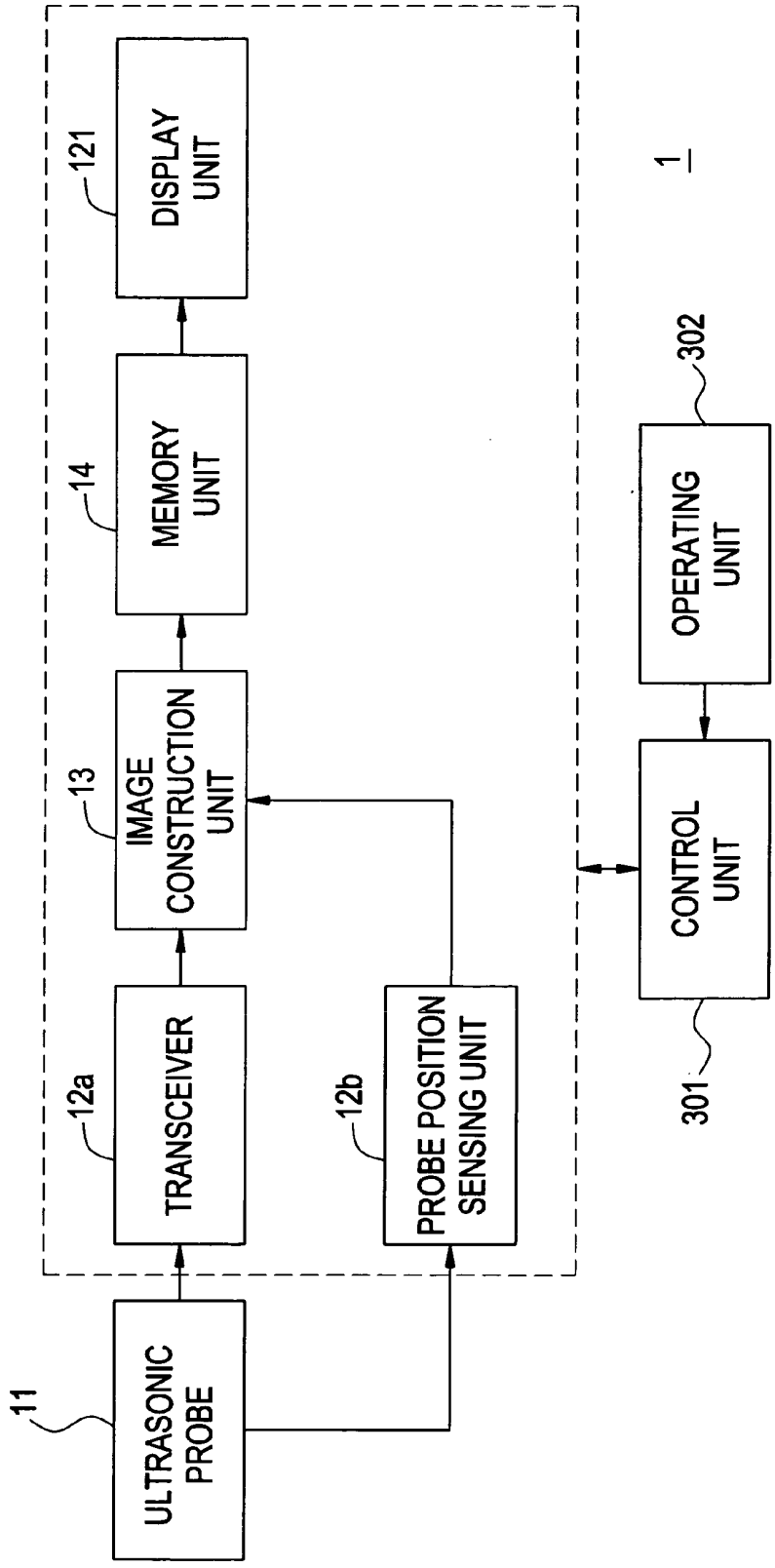

1
11
ULTRASONIC PROBE
12a
TRANSCEIVER
12b
PROBE POSITION SENSING UNIT
13
IMAGE CONSTRUCTION UNIT
14
MEMORY UNIT
121
DISPLAY UNIT
301
CONTROL UNIT
302
OPERATING UNIT

FIG. 2

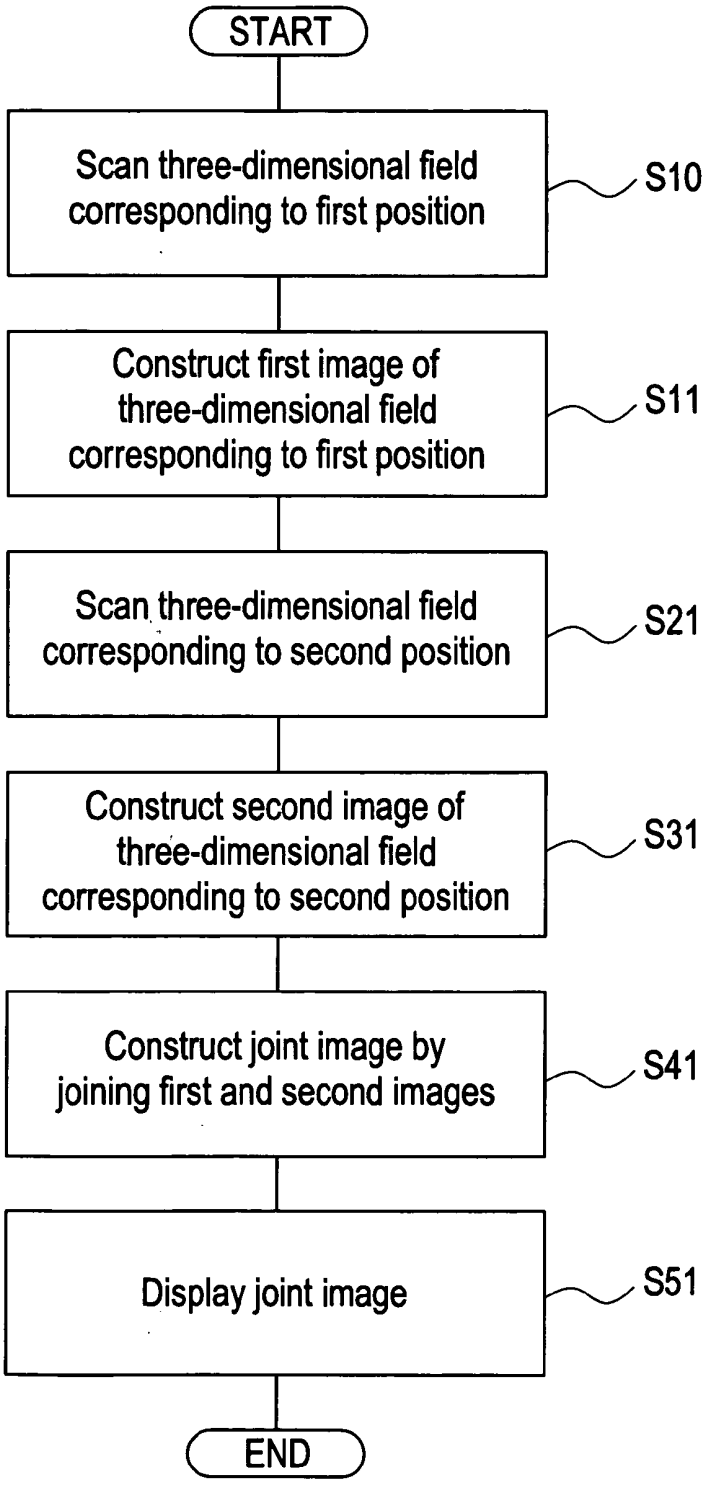

START
Scan three-dimensional field corresponding to first position
S10
Construct first image of three-dimensional field corresponding to first position
S11
Scan three-dimensional field corresponding to second position
S21
Construct second image of three-dimensional field corresponding to second position
S31
Construct joint image by joining first and second images
S41
Display joint image
S51
END

FIG. 3A

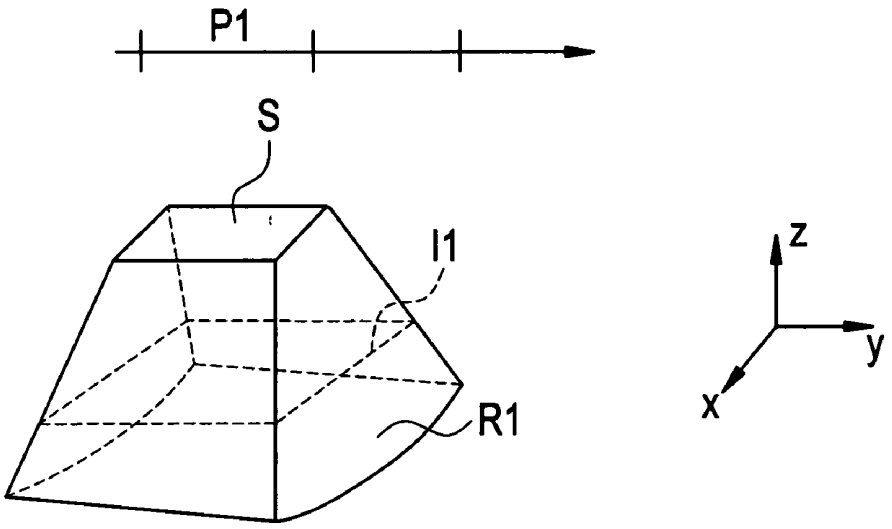


FIG. 3B

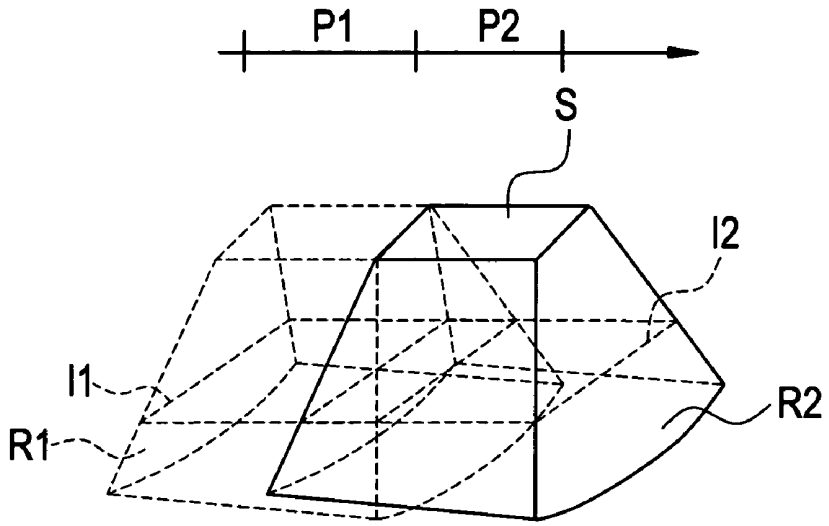


FIG. 4A

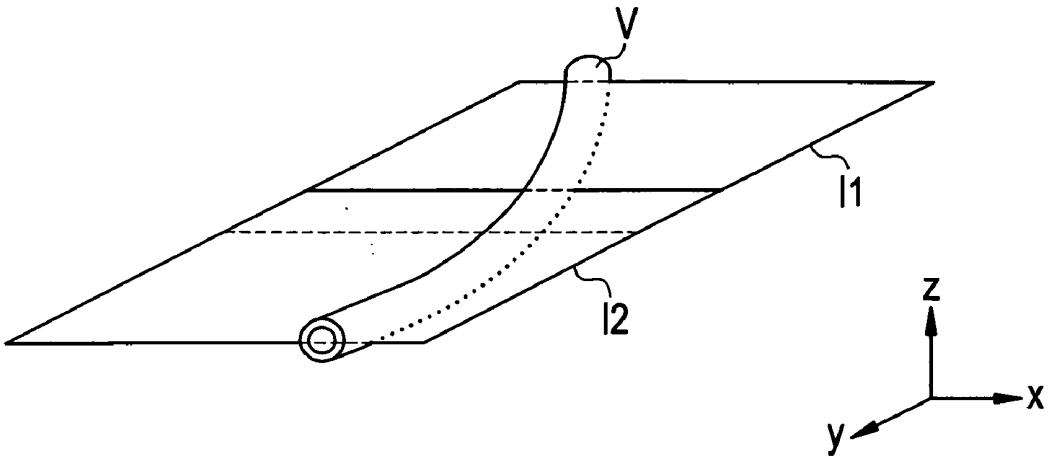


FIG. 4B

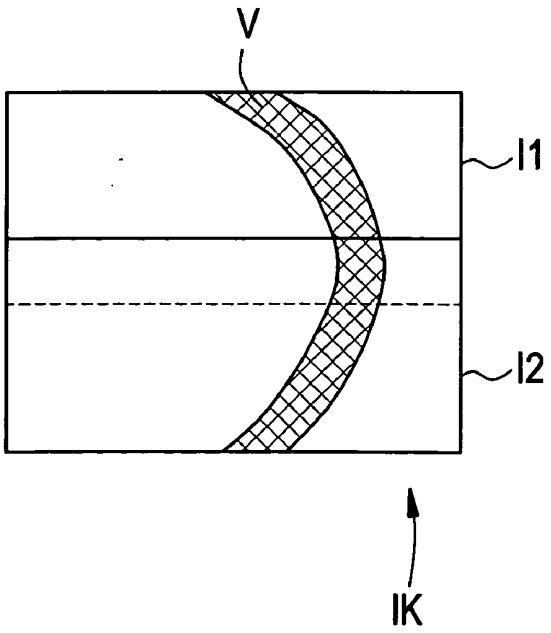
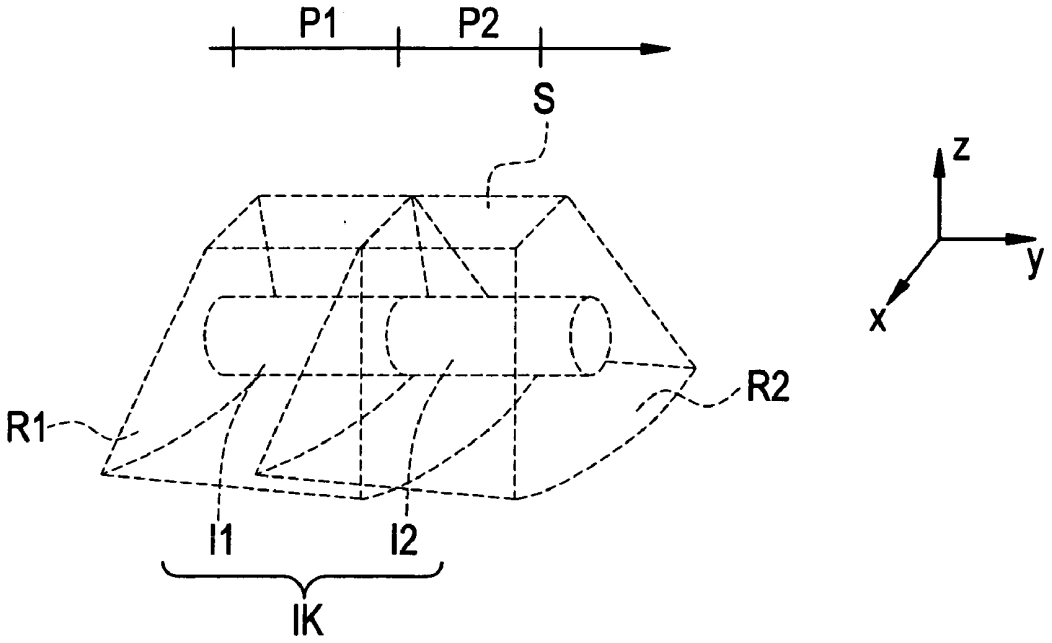


FIG. 5



ULTRASONIC IMAGE CONSTRUCTION METHOD AND DIAGNOSTIC ULTRASOUND APPARATUS

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an ultrasonic image construction method and a diagnostic ultrasound apparatus.

[0002] Diagnostic ultrasound apparatuses produce an echo signal by transmitting ultrasonic waves to a subject and receiving the ultrasonic waves reflected from the subject, construct an image of a subject's section on the basis of the produced echo signal, and then display the image of the section on a screen. The diagnostic ultrasound apparatus supports various imaging modes such as an A mode, a B mode, a C mode, a color flow mapping (CFM) mode, and a pulsed-wave Doppler (PWD) mode. The diagnostic ultrasound apparatus can construct and display an image in real time and is therefore proved useful in the field of medicine, or more particularly, in prenatal screening or cardiac screening.

[0003] The diagnostic ultrasound apparatus produces an echo signal by performing a scan to transmit ultrasonic waves from an ultrasonic probe to a three-dimensional field in a subject and to receive ultrasonic waves reflected from the three-dimensional field, constructs an image of the three-dimensional field in real time on the basis of the echo signal, and then displays the image on a display surface (refer to, for example, Patent Document 1).

[0004] [Patent Document 1] Japanese Unexamined Patent Publication No. 2000-152932

[0005] [Patent Document 2] Japanese Unexamined Patent Publication No. 2001-353150

[0006] However, since only an image of a field corresponding to a section scanned with an ultrasonic probe is constructed and displayed on a display surface, the whole of a diagnostic region covering a wide range cannot be observed. Therefore, a scan must be performed again in some cases. This hinders diagnostic efficiency from improving. For example, when the diagnostic region is a thoracic region or a vascular region, the whole of the diagnostic region cannot be scanned. The drawback of poor diagnostic efficiency becomes outstanding.

SUMMARY OF THE INVENTION

[0007] Therefore, an object of the present invention is to provide an ultrasonic image construction method and a diagnostic ultrasound apparatus making it possible to observe the whole of a diagnostic region covering a wide range and to improve diagnostic efficiency.

[0008] In efforts to accomplish the above object, an ultrasonic image construction method in accordance with the present invention constructs an image of a subject on the basis of an echo signal produced by transmitting ultrasonic waves from an ultrasonic probe to the subject and receiving the ultrasonic waves reflected from the subject using the ultrasonic probe. The ultrasonic image construction method comprises: a first step of constructing a first image of a three-dimensional field corresponding to a first position on the subject on the basis of a first echo signal produced by performing a scan to transmit ultrasonic waves from the ultrasonic probe to the three-dimensional field corresponding to the first position and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the first position; and a second step of constructing a second image of a three-dimensional field corresponding to a second position on the basis of a second echo signal produced by performing a scan to transmit the ultrasonic waves to the three-dimensional field corresponding to the second position from the ultrasonic probe moved from the first position on the subject to the second position, and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the second position, and then constructing a joint image by joining the first image constructed at the first step and the second image so that the images will be associated with the first and second positions respectively.

[0009] In efforts to accomplish the aforesaid object, a diagnostic ultrasound apparatus in accordance with the present invention constructs an image of a subject on the basis of an echo signal produced by transmitting ultrasonic waves to a subject from an ultrasonic probe and receiving ultrasonic waves reflected from the subject using the ultrasonic probe. The diagnostic ultrasound apparatus comprises: a transceiver that acquires a first echo signal produced by performing a scan to transmit the ultrasonic waves to a three-dimensional field corresponding to a first position on the subject from the ultrasonic probe and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the first position, and that then acquires a second echo signal produced by performing a scan to transmit the ultrasonic waves to a three-dimensional field corresponding to a second position from the ultrasonic probe moved to the second position adjoining the first position on the subject and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the second position; and an image construction unit that constructs a first image of the three-dimensional field corresponding to the first position on the basis of the first echo signal, and that constructs a second image of the three-dimensional field corresponding to the second position on the basis of the second echo signal. The image construction unit constructs a joint image by joining the first image and the second image so that the images will be associated with the first and second positions respectively.

[0010] According to the present invention, there is provided an ultrasonic image construction method and a diagnostic ultrasound apparatus making it possible to observe the whole of a diagnostic region covering a wide range and to improve diagnostic efficiency.

[0011] Further objects and advantages of the present invention will be apparent from the following description of the preferred embodiments of the invention as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is a block diagram showing the overall configuration of a diagnostic ultrasound apparatus **1** in accordance with the first embodiment of the present invention.

[0013] **FIG. 2** is a flowchart describing actions to be performed in order to display an image of a subject after scanning the subject using the diagnostic ultrasound apparatus **1** in accordance with the first embodiment of the present invention.

[0014] **FIG. 3** includes perspective views illustrating scans of a subject performed with the ultrasonic probe **11** included in the diagnostic ultrasound apparatus **1** in accordance with the first embodiment of the present invention, **FIG. 3***a* shows a case where a three-dimensional field R**1** corresponding to a first position P**1** on a subject is scanned, and **FIG. 3***b* shows a case where a three-dimensional field R**2** corresponding to the second position P**2** on the subject is scanned.

[0015] **FIG. 4** shows construction of a joint image IK by joining first and second images I**1** and I**2** according to the first embodiment of the present invention, **FIG. 4***a* is a perspective view showing the relationship of a plane associated with the first and second images I**1** and I**2** constructed in the form of C-mode images and a subject's blood vessel visualized in the C-mode images, and **FIG. 4***b* shows the joint image IK constructed by joining the first and second images I**1** and I**2**.

[0016] **FIG. 5** is a perspective view showing the joint image IK constructed by an image construction unit **13** included in the second embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Embodiments of the present invention will be described below.

FIRST EMBODIMENT

[0018] **FIG. 1** is a block diagram showing the overall configuration of a diagnostic ultrasound apparatus **1** in accordance with the first embodiment of the present invention.

[0019] As shown in **FIG. 1**, the diagnostic ultrasound apparatus **1** comprises an ultrasonic probe **11**, a transceiver **12***a*, a probe position sensing unit **12***b*, an image construction unit **13**, a memory unit **14**, a display unit **121**, a control unit **301**, and an operating unit **302**.

[0020] The components of the diagnostic ultrasound apparatus **1** will be described sequentially.

[0021] The ultrasonic probe **11** has a contact surface that is abutted on the surface of a subject, transmits ultrasonic waves to the subject through the contact surface, and receives the ultrasonic waves reflected from the subject through the contact surface. The ultrasonic probe **11** is, for example, a two-dimensional array probe and has a plurality of ultrasonic transducers set in array on the surface thereof that is abutted on the surface of the subject. The ultrasonic transducers included in the ultrasonic probe **11** are made of, for example, a lead zilconate titanate (PZT) ceramic. The ultrasonic transducers convert an electric signal into ultrasonic waves, transmit the ultrasonic waves to a subject, receive ultrasonic waves reflected from the subject, and convert the received ultrasonic waves into an electric signal. Specifically, the ultrasonic probe **11** transmits ultrasonic waves produced by the ultrasonic transducers **11***a* to a subject's intracorporeal region according to a driving signal that is sent from the transceiver **12***a* in response to a command issued from the control unit **301**. Ultrasonic waves reflected from the intracorporeal region to which the ultrasonic waves have been transmitted are received in order to produce an echo signal, and the echo signal is transmitted to the transceiver **12***a*. Moreover, a magnetic sensor (not shown) included in the probe position sensing unit **12***b* that will be described later is disposed in the ultrasonic probe **11**.

[0022] The transceiver **12***a* includes a transmission/reception circuit that transmits or receives ultrasonic waves. The transceiver **12***a* is connected to the ultrasonic probe **11**. The transceiver **12***a* causes the ultrasonic transducers included in the ultrasonic probe **11** to transmit ultrasonic waves to a subject in response to a command issued from the control unit **301**. The transceiver **12***a* causes the ultrasonic transducers included in the ultrasonic probe **11** to receive ultrasonic waves reflected from the subject so as to produce an echo signal. For example, the transceiver **12***a* implements a scan according to an electronic convex scanning method. The transceiver **12***a* acquires a produced echo signal and transfers the echo signal to the image construction unit **13**. Specifically, the transceiver **12***a* sequentially changes the selected ones of the ultrasonic transducers included in the ultrasonic probe **11** and drives the selected ultrasonic transducers so that the selected ultrasonic transducers will receive ultrasonic waves so as to produce an echo signal, and thus causes the ultrasonic probe **11** to move an ultrasonic beam during a scan. The echo signal is subjected to processing such as amplification, delay, and addition, and then transferred to the image construction unit **13**.

[0023] Actions will be detailed later. In the present embodiment, the transceiver **12***a* acquires a first echo signal produced by performing a scan to transmit ultrasonic waves from the ultrasonic probe **11** to a three-dimensional field corresponding to a first position on a subject and to receive ultrasonic waves reflected from the three-dimensional field corresponding to the first position. Thereafter, the transceiver **12***a* acquires a second echo signal produced by performing a scan to transmit ultrasonic waves to a three-dimensional field corresponding to a second position from the ultrasonic probe **11** that is manually moved to the second position adjoining the first position on the subject and to receive ultrasonic waves reflected from the three-dimensional field corresponding to the second position. Thus, the transceiver **12***a* sequentially acquires echo signals produced by performing scans to transmit ultrasonic waves to three-dimensional fields corresponding to different positions on a subject from the ultrasonic probe **11** that is sequentially moved to the different positions, and to receive ultrasonic waves reflected from the three-dimensional fields corresponding to the different moved positions.

[0024] The probe position sensing unit **12***b* senses the position of the ultrasonic probe **11**. The probe position sensing unit **12***b* includes, for example, a magnetic sensor (not shown), a magnetic generator (not shown), and a probe position arithmetic unit (not shown). The magnetic sensor included in the probe position sensing unit **12***b* is disposed in the ultrasonic probe **11**. The magnetic sensor and the magnetic generator each have three coils that are orthogonal to one another. The magnetic generator induces magnetic fields, and the magnetic sensor senses the magnetic fields induced by the magnetic generator. When the magnetic sensor senses the magnetic fields induced by the magnetic generator, the magnetic sensor generates induction fields that inversely correlate the slopes of the coils with respect to the directions of the magnetic fields, and transfers induced currents, whose values are proportional to the field strengths, to the probe position arithmetic unit. The probe position

arithmetic unit calculates the position of the ultrasonic probe **11** and the slope thereof on the basis of the induced currents generated by the magnetic sensor. Thereafter, the probe position sensing unit **12***b* transfers data, which represents the sensed results, to the image construction unit **13**.

[**0025**] According to the present embodiment, the probe position sensing unit **12***b* sequentially senses, for example, a first position on a subject to be scanned with the ultrasonic probe **11**, and a second position to be scanned with the ultrasonic probe **11** manually moved by an operator. Thus, the probe position sensing unit **12***b* sequentially senses a plurality of positions to be scanned with the ultrasonic probe **11** manually moved by an operator. Thereafter, the probe position sensing unit **12***b* transfers positional data, which represents the positions of the ultrasonic probe **11** moved by the operator, to the image construction unit **13**.

[**0026**] The image construction unit **13** constructs an image of a subject on the basis of an echo signal acquired by the transceiver **12***a*. The image construction unit **13** comprises, for example, a computer and a program. In response to a command issued from the control unit **301**, the image construction unit **13** performs image processing on the basis of the echo signals sent from the transceiver **12***a*, and time-sequentially constructs images of subject's sections frame by frame. The image construction unit **13** is connected to the memory unit **14**, and sequentially transfers the constructed frame images to the memory unit **14**.

[**0027**] According to the present embodiment, the image construction unit **13** constructs a first image of a three-dimensional field corresponding to a first position on a subject on the basis of a first echo signal received by the transceiver **12***a*. Herein, the image construction unit **13** constructs the first image in real time with a scan that is performed in order to produce the first echo signal. Furthermore, the image construction unit **13** constructs a second image of a three-dimensional field corresponding to a second position on the basis of a second echo signal received by the transceiver **12***a*. Herein, the image construction unit **13** constructs the second image in real time with a scan that is performed in order to produce the second echo signal.

[**0028**] To be more specific, the image construction unit **13** constructs as the first and second images C-mode images that are images of sections separated from the contact surface of the ultrasonic probe **11**, which is brought into contact with a subject, by substantially the same distance in a direction in which ultrasonic waves are propagated. In other words, images of transverse planes are constructed as the first and second images. Thus, the image construction unit **13** sequentially constructs C-mode images in real time on the basis of echo signals produced by scanning a plurality of positions with the ultrasonic probe **11** that is manually moved by an operator. The image construction unit **13** sequentially transfers the constructed C-mode images as the first and second images to the memory unit **14** so that the images will be stored in the memory unit. Moreover, the image construction unit **13** joins the first and second images constructed in the form of C-mode images so that the images will be associated with the first and second positions which are scanned, and thus constructs joint image. Herein, the image construction unit **13** aligns the first and second images according to data that represents the positions of the ultrasonic probe **11** sensed by the probe position sensing unit **12***b*, and joins the images to construct the joint image. In other words, the image construction unit **13** reads a plurality of C-mode images, which are sequentially constructed as mentioned above, from the memory unit **14**, aligns the C-mode images, and joins them to construct the joint image. Thereafter, the image construction unit **13** transfers the constructed joint image to the memory unit **14** so that the joint image will be stored in the memory unit **14**.

[**0029**] The memory unit **14** comprises, for example, a cine memory and a hard disk drive (HDD), and preserves images constructed by the image construction unit **13**. The memory unit **14** is connected to the image construction unit **13**. In response to a command issued from the control unit **301**, a plurality of frame images constructed by the image construction unit **13** is temporarily stored in the cine memory, and then transferred to and stored in the HDD. For example, the memory unit **14** preserves frame images, which are equivalent to a motion picture that lasts for two min, in the cine memory. The frame images constituting the motion picture that lasts for two min are transferred to and stored in the HDD. Moreover, the cine memory included in the memory unit **14** is connected to the display unit **121**. The frames constituting the motion picture and being stored in the cine memory are sequentially displayed on the display unit **121** in real time. The HDD included in the memory unit **14** is also connected to the display unit **121**. In response to a command an operator enters at the operating unit **302**, image data that represents frame images constituting a motion picture and being stored in the HDD is transmitted to the display unit **121**. Consequently, the images are displayed on the display unit **121** according to the image data.

[**0030**] According to the present embodiment, in the memory unit **14**, the first image which the image construction unit **13** has constructed in the form of a C-mode image on the basis of the first echo signal received by the transceiver **12***a* is stored in the cine memory. Thereafter, the second image which the image construction unit **13** has constructed in the form of a C-mode image on the basis of the second echo signal received by the transceiver **12***a* is stored in the cine memory. Thus, the memory unit **14** preserves a plurality of C-mode images, which the image construction unit **13** has sequentially constructed based on echo signals produced by scanning a plurality of positions with the ultrasonic probe **11** that is manually moved by an operator, sequentially in the cine memory in real time. Moreover, the memory unit **14** preserves a joint image that is constructed by joining the first and second images sequentially constructed as mentioned above by the image construction unit **13**. Namely, the memory unit **14** sequentially updates and preserves the joint image constructed by joining a plurality of C-mode images sequentially constructed by the image construction unit **13**. The image construction unit **13** transmits the constructed joint image to the display unit **121** so that the joint image will be displayed on a display surface.

[**0031**] The display unit **121** receives an image, which is constructed by the image construction unit **13**, from the memory unit **14**, and displays it. The display unit **121** comprises, for example, a graphic display and a digital scan converter (DSC). The display unit **121** is connected to the memory unit **14**. In response to a command issued from the control unit **301**, the DSC converts an image stored in the cine memory included in the memory unit **14** into a display signal, and the image constructed by the image construction

unit **13** is displayed on the display screen of the graphic display in real time. Moreover, the display unit **121** is connected to the HDD included in the memory unit **14**. In response to a command an operator enters at the operating unit **302**, the display unit **121** receives image data representing frame images, which constitute a motion picture and are stored in the HDD, and displays the images on the screen thereof.

[**0032**] In the present embodiment, the display unit **121** displays a joint image, which is constructed by the image construction unit **13**, on the display surface thereof in real time with a scan.

[**0033**] The control unit **301** comprises, for example, a computer and programs, and is connected to the other components. The control unit **301** applies control signals to the components according to an operating signal sent from the operating unit **302** so as to control the components.

[**0034**] The operating unit **302** comprises input devices, for example, a keyboard, a touch panel, a trackball, a footswitch, and an audio input device. An operator enters operational information at the operating unit **302**, and the operating unit **302** transfers a command to the control unit **301** accordingly.

[**0035**] The diagnostic ultrasound apparatus **1** in accordance with the present embodiment is equivalent to a diagnostic ultrasound apparatus in accordance with the present invention. An ultrasonic probe **11** included in the present embodiment is equivalent to an ultrasonic probe included in the present invention. The transceiver **12***a* included in the present embodiment is equivalent to a transceiver included in the present invention. The position sensing unit **12***b* included in the present embodiment is equivalent to a position sensing unit included in the present invention. The image construction unit **13** included in the present embodiment is equivalent to an image construction unit included in the present invention. The display unit **121** included in the present embodiment is equivalent to a display unit included in the present invention.

[**0036**] Now, actions to be performed in the diagnostic ultrasound apparatus **1** in accordance with the present embodiment of the present invention will be described below.

[**0037**] **FIG. 2** and **FIG. 3** are concerned with actions to be performed when the diagnostic ultrasound apparatus **1** scans a subject. **FIG. 2** is a flowchart describing actions to be performed when the diagnostic ultrasound apparatus **1** in accordance with the present embodiment scans a subject and displays an image of the subject. **FIG. 3** includes perspective views showing scans of a subject performed with the ultrasonic probe **11** included in the diagnostic ultrasound apparatus **1**. **FIG. 3***a* shows a scan of a three-dimensional field R**1** corresponding to a first position P**1** on a subject, and **FIG. 3***b* shows a scan of a three-dimensional field R**2** corresponding to a second position P**2** on the subject.

[**0038**] As described in **FIG. 2**, first, the three-dimensional field R**1** corresponding to the first position P**1** on a subject is scanned (S**11**).

[**0039**] As shown in **FIG. 3***a*, an operator brings the contact surface S of the ultrasonic probe **11** into contact with the first position P**1** on a subject. The transceiver **12***a* acquires a first echo signal E**1** produced by performing a scan to transmit ultrasonic waves from the ultrasonic probe **11** to the three-dimensional field R**1** corresponding to the first position P**1** on the subject and to receive the ultrasonic waves reflected from the three-dimensional field R**1** corresponding to the first position P**1**. At this time, the probe position sensing unit **12***b* senses the first position P**1** on the subject scanned with the ultrasonic probe **11**.

[**0040**] Thereafter, as described in **FIG. 2**, a first image I**1** of the three-dimensional field R**1** corresponding to the first position P**1** is constructed (S**21**).

[**0041**] Herein, as shown in **FIG. 3***a*, the image construction unit **13** constructs as the first image I**1** a C-mode image of the three-dimensional field R**1** corresponding to the first position P**1** on the subject according to the first echo signal E**1** received by the transceiver **12***a*. Herein, the image construction unit **13** constructs the first image I**1** in real time with the scan performed in order to produce the first echo signal E**1**. The image construction unit **13** then transfers the first image I**1** to the memory unit **14** so that the first image will be stored in the memory unit.

[**0042**] Thereafter, as described in **FIG. 2**, the three-dimensional field R**2** corresponding to the second position P**2** on the subject is scanned (S**31**).

[**0043**] Herein, as shown in **FIG. 3***b*, the operator slides the ultrasonic probe **11** in the direction y of the major axis of the contact surface S so as to move it from the position P**1**, and then brings the contact surface S of the ultrasonic probe **11** into contact with the position P**2** on the subject. The transceiver **12***a* acquires a second echo signal E**2** produced by performing a scan to transmit ultrasonic waves to the three-dimensional field R**2** corresponding to the second position P**2** on the subject and to receive the ultrasonic waves reflected from the three-dimensional field R corresponding to the second position P**2**. At this time, the probe position sensing unit **12***b* senses the position P**2** on the subject scanned with the ultrasonic probe **11**.

[**0044**] Thereafter, as described in **FIG. 2**, a second image I**2** of the three-dimensional field R**2** corresponding to the second position P**2** is constructed (S**41**).

[**0045**] Herein, as shown in **FIG. 3***b*, the image construction unit **13** constructs as the second image I**2** a C-mode image of the three-dimensional field R**2** corresponding to the second position P**2** on the subject according to the second echo signal E**2** received by the transceiver **12***a*. Herein, the image construction unit **13** constructs the second image I**2** in real time with the scan performed in order to produce the second echo signal E**2**. The image construction unit **13** then transfers the second image I**2** to the memory unit **14** so that the second image will be stored in the memory unit.

[**0046**] Thereafter, as described in **FIG. 2**, the first image I**1** and second image I**2** are joined to construct a joint image IK (S**51**).

[**0047**] Herein, the image construction unit **13** joins the first and second images I**1** and I**2** constructed in the form of C-mode images so that the first and second images will be associated with the first and second positions P**1** and P**2** on the subject, and thus constructs the joint image IK. In the present embodiment, the image construction unit **13** aligns the first and second images I**1** and I**2** according to data that

represents the positions of the ultrasonic probe **11** sensed by the probe position sensing unit **12***b*, and joins the images to construct the joint image.

[**0048**] **FIG. 4** shows construction of the joint image IK by joining the first and second images I**1** and I**2**. Herein, **FIG. 4***a* is a perspective view showing the relationship between a plane associated with the first and second images I**1** and I**2** constructed in the form of C-mode images and a subject's blood vessel visualized in the C-mode images. **FIG. 4***b* shows the joint image IK constructed by joining the first and second images I**1** and I**2**.

[**0049**] As shown in **FIG. 4**, the first and second images I**1** and I**2** are aligned so that the images will be associated with the respective positions on the subject, and then joined to overlap. Thus, the joint image I**1** is constructed. For example, the vascular image portions V of the first and second images I**1** and I**2** are coupled to each other in order to construct the joint image IK. The image construction unit **13** transfers the resultant joint image Ik to the memory unit **14** so that the joint image will be stored in the memory unit.

[**0050**] Thereafter, as described in **FIG. 2**, the joint image IK is displayed (S**61**).

[**0051**] Herein, the display unit **121** fetches the joint image IK constructed by the image construction unit **13** from the memory unit **14**, and displays it on the display screen thereof in real time with the scan.

[**0052**] As described so far, according to the present embodiment, first, the first image I**1** of the three-dimensional field R**1** corresponding to the first position P**1** is constructed based on the first echo signal E**1** produced by performing a scan to transmit ultrasonic waves from the ultrasonic probe **11** to the three-dimensional field R**1** corresponding to the first position P**1** on a subject and to receive the ultrasonic waves reflected from the three-dimensional field R**1** corresponding to the first position P**1**. Herein, a C-mode image is constructed as the first image I**1**. Thereafter, the second image I**2** of the three-dimensional field R**2** corresponding to the second position P**2** is constructed based on the second echo signal E**2** produced by performing a scan to transmit ultrasonic waves to the three-dimensional field R corresponding to the second position P**2** from the ultrasonic probe **11** that is moved from the first position P**1** on the subject to the second position P**2** and to receive the ultrasonic waves reflected from the three-dimensional field R**2** corresponding to the second position P**2**. Herein, a C-mode image is constructed as the second image I**2** in the same manner as the first image I**1**. Thereafter, as mentioned above, the first and second images I**1** and I**2** constructed in the form of C-mode images are joined so that the images will be associated with the first and second positions P**1** and P**2** respectively, whereby the joint image IK is constructed. The joint image IK is then displayed on the display surface of the display unit **121**. The present embodiment constructs and displays the joint image IK that represents three-dimensional fields scanned by moving the ultrasonic probe **11**. Consequently, the present embodiment makes it possible to observe the whole of a diagnostic region covering a wide range and to improve diagnostic efficiency.

SECOND EMBODIMENT

[**0053**] The second embodiment of the present invention will be described below.

[**0054**] The present embodiment is identical to the first embodiment except the action of the image construction unit **13**. An iterative description will be omitted.

[**0055**] According to the present embodiment, the image construction unit **13** constructs as first and second images three-dimensional images that represent a subject three-dimensionally.

[**0056**] To be more specific, the image construction unit **13** constructs as the first and second images three-dimensional images of voluminal fields in a subject juxtaposed in a direction in which ultrasonic waves are transmitted through the contact surface of the ultrasonic probe **11** that is brought into contact with the subject. Namely, so-called voluminal images are constructed as the first and second images. Herein, the image construction unit **13** sequentially constructs three-dimensional images in real time on the basis of echo signals produced by scanning a plurality of positions with the ultrasonic probe **11** that is manually moved by an operator. The image construction unit **13** sequentially transmits the three-dimensional images constructed as the first and second images to the memory unit **14** so that the images will be stored in the memory unit. Moreover, the image construction unit **13** joins the first and second images constructed in the form of the three-dimensional images so that the images will be associated with the first and second positions respectively that are scanned, whereby a joint image is constructed. Herein, similarly to the first embodiment, the image construction unit **13** aligns the first and second images according to data that represents the positions of the ultrasonic probe **11** sensed by the probe position sensing unit **12***b*, and joins the images to construct the joint image. The image construction unit **13** transfers the resultant joint image to the memory unit **14** so that the image will be stored in the memory unit.

[**0057**] **FIG. 5** is a perspective view showing the joint image constructed by the image construction unit **13** included in the present embodiment.

[**0058**] As shown in **FIG. 5**, first, the three-dimensional field R**1** corresponding to the first position P**1** is scanned in order to construct the first image I**1** of the three-dimensional field R**1** in the form of a three-dimensional image. Thereafter, the three-dimensional field R**2** corresponding to the second position P**2** on the subject is scanned in order to construct the second image I**2** of the three-dimensional field R**2** in the form of a three-dimensional image. Herein, for example, the first and second images I**1** and I**2** representing columnar fields in the subject are constructed in the form of three-dimensional images by performing rendering after producing three-dimensional data items on the basis of echo signals produced based on echoes returned from the respective fields. After the first and second images I**1** and I**2** of the columnar fields in the subject are constructed in the form of three-dimensional images, the first and second images I**1** and I**2** are joined to construct the joint image IK that appears three-dimensionally.

[**0059**] As mentioned above, in the present embodiment, similarly to the first embodiment, the first and second images I**1** and I**2** are constructed. Herein, the first and second images I**1** and I**2** are constructed in the form of three-dimensional images. Thereafter, the first and second images I**1** and I**2** are joined to construct the joint image IK. The joint image IK is then displayed on the display surface of the display unit **121**. Consequently, the present embodiment constructs and displays the joint image IK representing three-dimensional fields scanned by moving the ultrasonic probe **11**. Thus, the

present embodiment makes it possible to observe the whole of a diagnostic region covering a wide range and to improve diagnostic efficiency.

[0060] Incidentally, the present invention is not limited to the aforesaid embodiments. Various variant modes can be adopted.

[0061] For example, in the embodiments, a probe capable of mechanically three-dimensionally scanning a subject can be adopted as the ultrasonic probe **11**.

[0062] Moreover, for example, in the embodiments, when the first and second images I**1** and I**2** are joined to construct the joint image IK, the first and second images I**1** and I**2** may be aligned based on the correlational values between the pixels contained in the first image I**1** and those contained in the second image I**2**. Thus, the joint image IK may be constructed.

[0063] Moreover, in the embodiments, the ultrasonic probe **11** is slid rectilinearly in the direction x of the major axis of the contact surface S in order to scan a subject. The present invention is not limited to this mode. The present invention can be applied to a case where, for example, the ultrasonic probe **11** is rectilinearly slid in the direction of the minor axis of the contact surface S in order to scan a subject. Moreover, the present invention can be applied to a case where, for example, the ultrasonic probe **11** is rotationally slid in order to scan a subject.

[0064] Many widely different embodiments of the invention may be configured without departing from the spirit and the scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

1. An ultrasonic image construction method for constructing an image of a subject on the basis of an echo signal produced by transmitting ultrasonic waves from an ultrasonic probe to the subject and receiving the ultrasonic waves reflected from the subject using the ultrasonic probe, comprising:

a first step of constructing a first image of a three-dimensional field corresponding to a first position on a subject on the basis of a first echo signal produced by performing a scan to transmit ultrasonic waves from the ultrasonic probe to the three-dimensional field corresponding to the first position and to receive ultrasonic waves reflected from the three-dimensional field corresponding to the first position;

a second step of constructing a second image of a three-dimensional field corresponding to a second position on the basis of a second echo signal produced by performing a scan to transmit the ultrasonic waves to the three-dimensional field corresponding to the second position from the ultrasonic probe that is moved from the first position on the subject to the second position and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the second position, and then constructing a joint image by joining the first image constructed at the first step and the second image so that the first and second images will be associated with the first and second positions respectively.

2. The ultrasonic image construction method according to claim 1, wherein at the first and second steps, C-mode images are constructed as the first and second images.

3. The ultrasonic image construction method according to claim 1, wherein at the first and second steps, three-dimensional images are constructed as the first and second images.

4. The ultrasonic image construction method according to claim 1, further comprising:

a third step of sensing the first position scanned at the first step; and

a fourth step of sensing the second position scanned at the second step,

wherein at the second step, the first and second images are joined based on pieces of information on the first position sensed at the third step and the second position sensed at the fourth step in order to construct the joint image.

5. The ultrasonic image construction method according to claim 1, further comprising a fifth step of displaying the image constructed at the second step on a display surface.

6. A diagnostic ultrasound apparatus for constructing an image of a subject on the basis of an echo signal produced by transmitting ultrasonic waves from an ultrasonic probe to a subject and receiving the ultrasonic waves reflected from the subject using the ultrasonic probe, the diagnostic ultrasound apparatus comprising:

a transceiver that acquires a first echo signal produced by performing a scan to transmit the ultrasonic waves from the ultrasonic probe to a three-dimensional field corresponding to a first position on the subject and to receive the ultrasonic wave reflected from the three-dimensional field corresponding to the first position, and then acquires a second echo signal produced by performing a scan to transmit the ultrasonic waves to a three-dimensional field corresponding to a second position from the ultrasonic probe that is moved to the second position adjoining the first position on the subject and to receive the ultrasonic waves reflected from the three-dimensional field corresponding to the second position; and

an image construction device that constructs a first image of the three-dimensional field corresponding to the first position on the basis of the first echo signal, and constructs a second image of the three-dimensional field corresponding to the second position on the basis of the second echo signal,

wherein the image construction device joins the first and second images so that the first and second images will be associated with the first and second positions respectively.

7. The diagnostic ultrasound apparatus according to claim 6, wherein the image construction device constructs C-mode images as the first and second images.

8. The diagnostic ultrasound apparatus according to claim 6, wherein the image construction device constructs three-dimensional images as the first and second images.

9. The diagnostic ultrasound apparatus according to claim 6, further comprising a position sensing device that senses the position of the ultrasonic probe,

wherein the image construction device joins the first and second images according to the positions of the ultrasonic probe sensed by the position sensing device, and thus constructs the joint image.

10. The diagnostic ultrasound apparatus according to claim 6, further comprising a display device for displaying the joint image constructed by the image construction device.

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摘要(译)

本发明的目的是使得可以观察覆盖宽范围的整个诊断区域并提高诊断效率。基于通过用超声波扫描产生的第一回波信号，对应于对象上的第一位置的三维场，对应于第一位置的三维场的第一图像以C模式的形式构造图片。此后，基于通过利用从对象上的第一位置移动到第二位置的超声探头扫描对应于第二位置的三维场产生的第二回波信号，对应的三维场的第二图像第二位置以C模式图像的形式构造。此后，第一和第二图像被连接，使得它们将分别与第一和第二位置相关联，从而构成关节图像。然后将关节图像显示在显示表面上。