US 20170105704A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2017/0105704 A1
AKIYAMA (43) Pub. Date: Apr. 20, 2017

(54) ULTRASONIC DIAGNOSTIC APPARATUS AND MEDICAL IMAGE PROCESSING APPARATUS

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(21) Appl. No.: **15/196,176**

(22) Filed: **Jun. 29, 2016**

(30) **Foreign Application Priority Data**

Oct. 15, 2015 (JP) 2015-203757

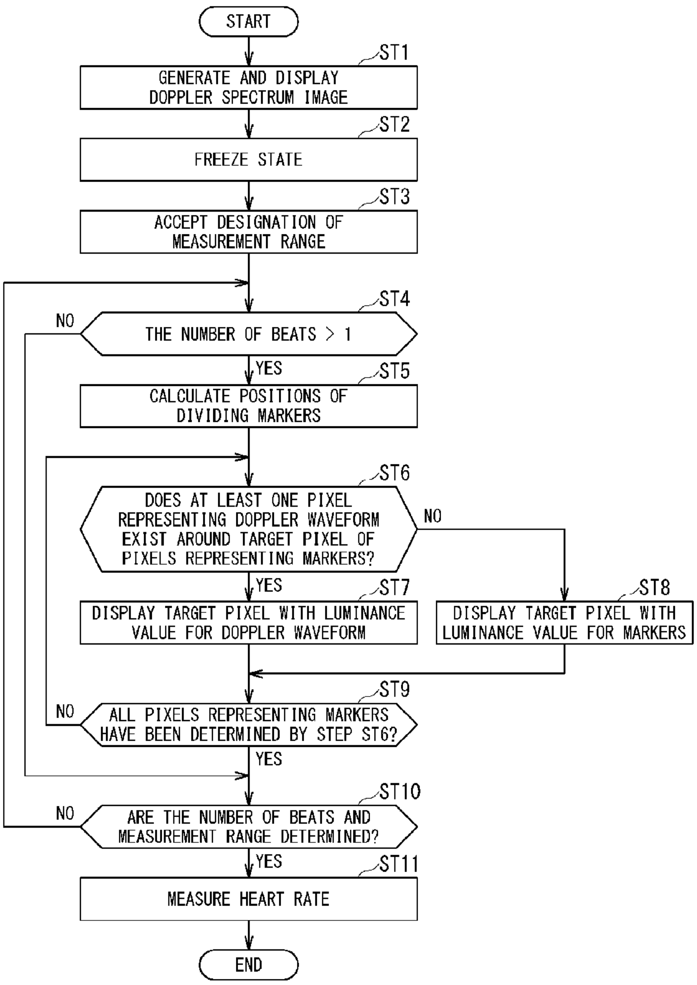
Publication Classification

(51) **Int. Cl.**
A61B 8/08 (2006.01)
A61B 8/02 (2006.01)
A61B 8/00 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 8/5207*** (2013.01); ***A61B 8/461*** (2013.01); ***A61B 8/5223*** (2013.01); ***A61B 8/488*** (2013.01); ***A61B 8/486*** (2013.01); ***A61B 8/02*** (2013.01); ***A61B 8/4483*** (2013.01)

(57) **ABSTRACT**

An ultrasonic diagnostic apparatus according to a present embodiment includes transceiver circuitry, image generating circuitry and processing circuitry. The transceiver circuitry is configured to transmit, to an ultrasonic probe, a transmission signal for transmitting ultrasonic waves, and to receive a received signal based on the ultrasonic waves. The image generating circuitry is configured to generate an ultrasonic image where temporal variation over a given time period is imaged, based on the received signal, and to display the ultrasonic image to a display. The processing circuitry is configured to: (A) set a measurement range on the ultrasonic image; (B) generate a marker for dividing the measurement range, at substantially equal intervals, the number of the marker according to the numerically number of beats; and (C) superimpose the marker on the displayed ultrasonic image.



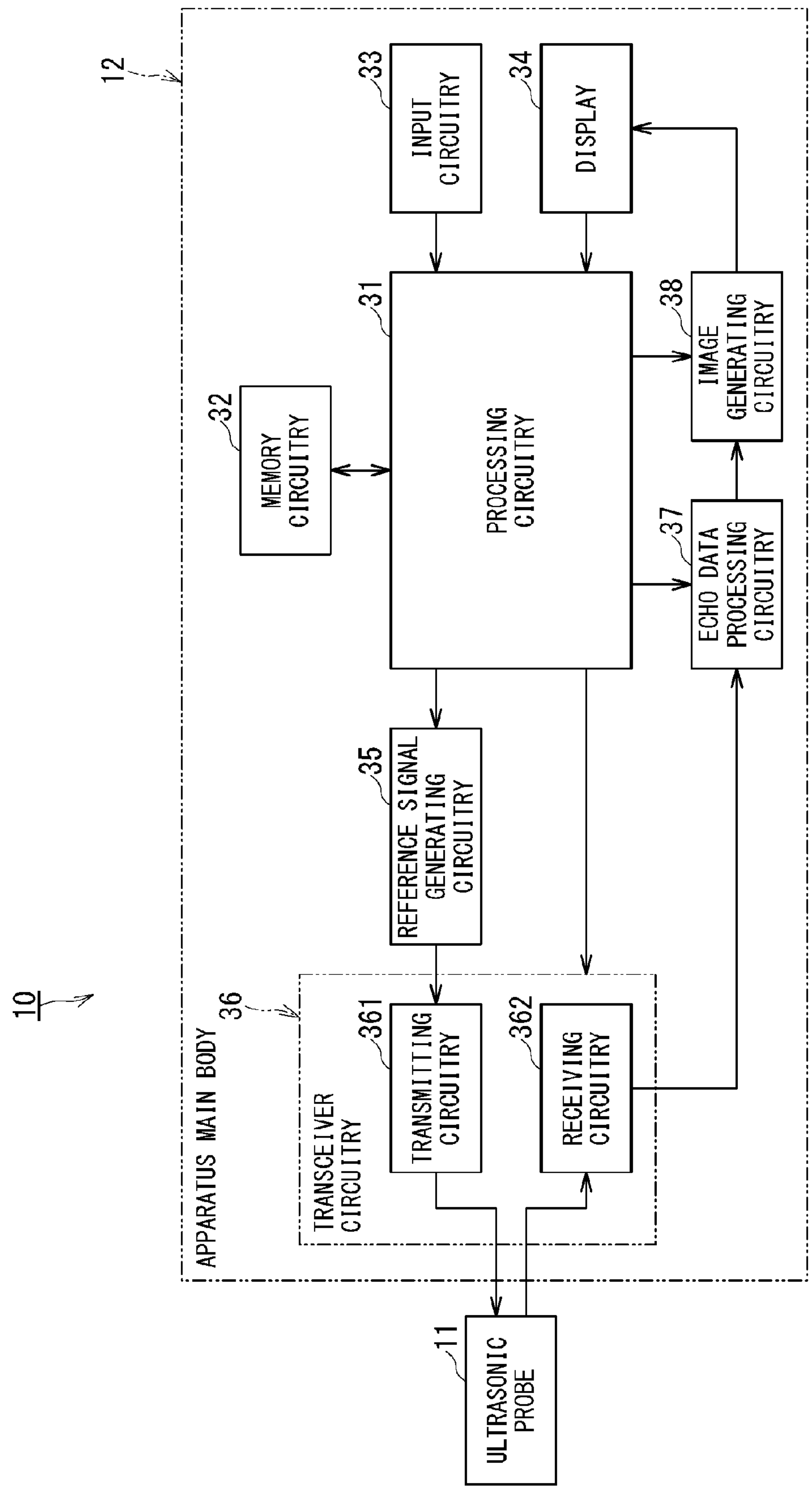

10
12
APPARATUS MAIN BODY
33
INPUT CIRCUITRY
34
DISPLAY
31
PROCESSING CIRCUITRY
32
MEMORY CIRCUITRY
38
IMAGE GENERATING CIRCUITRY
37
ECHO DATA PROCESSING CIRCUITRY
35
REFERENCE SIGNAL GENERATING CIRCUITRY
36
TRANSCEIVER CIRCUITRY
361
TRANSMITTING CIRCUITRY
362
RECEIVING CIRCUITRY
11
ULTRASONIC PROBE

FIG. 1

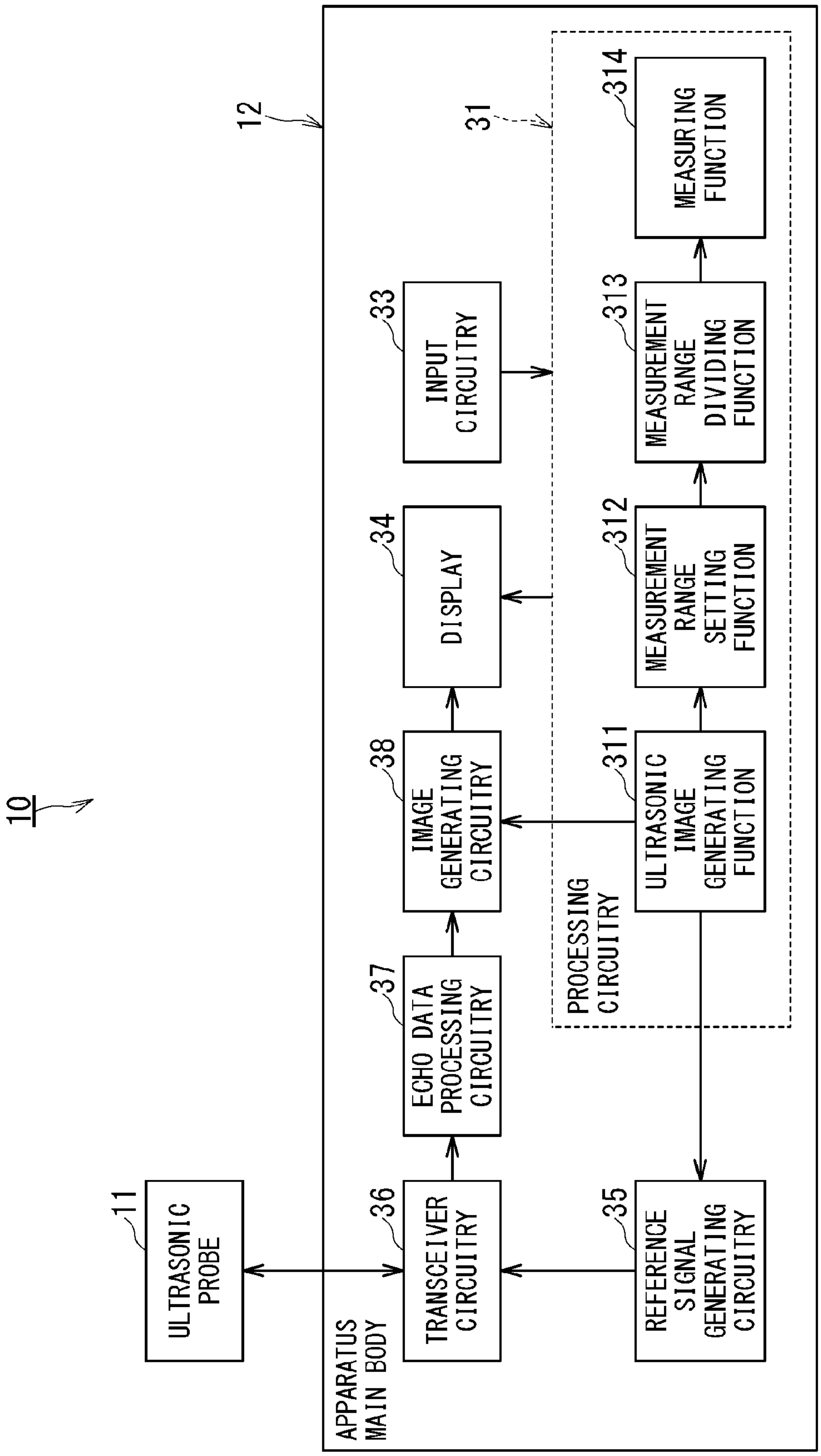

10
11
ULTRASONIC PROBE
12
APPARATUS MAIN BODY
36
TRANSCEIVER CIRCUITRY
37
ECHO DATA PROCESSING CIRCUITRY
38
IMAGE GENERATING CIRCUITRY
34
DISPLAY
33
INPUT CIRCUITRY
35
REFERENCE SIGNAL GENERATING CIRCUITRY
31
PROCESSING CIRCUITRY
311
ULTRASONIC IMAGE GENERATING FUNCTION
312
MEASUREMENT RANGE SETTING FUNCTION
313
MEASUREMENT RANGE DIVIDING FUNCTION
314
MEASURING FUNCTION

FIG. 2

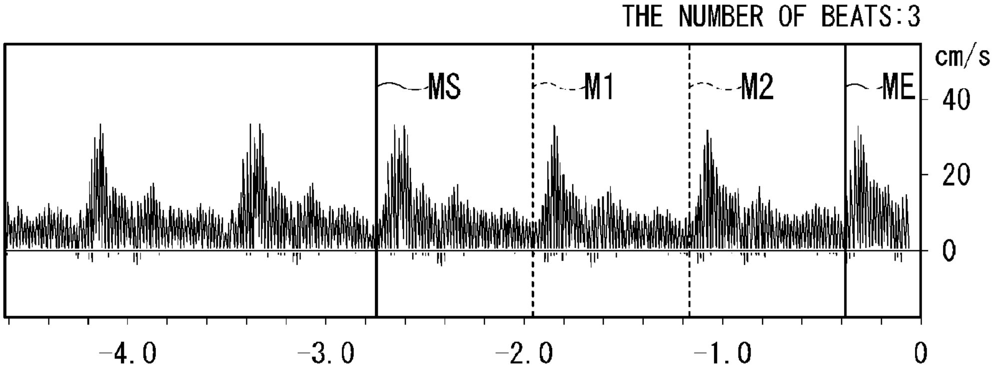

THE NUMBER OF BEATS:3
cm/s
MS
M1
M2
ME
40
20
0
-4.0
-3.0
-2.0
-1.0
0

FIG. 3

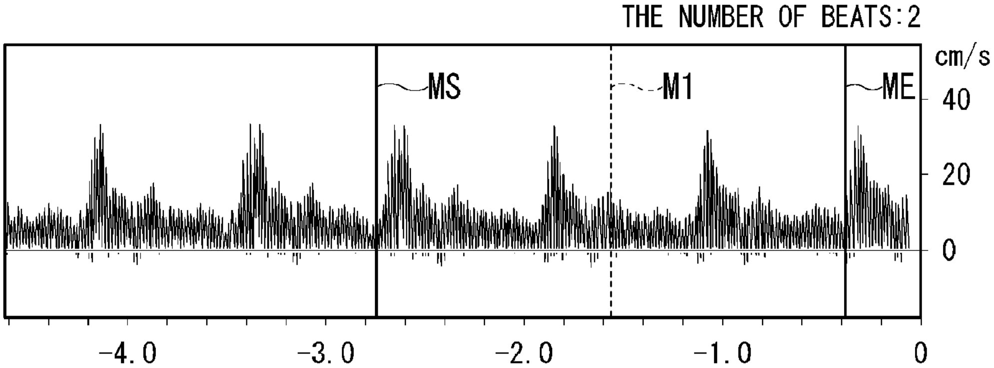

THE NUMBER OF BEATS:2
cm/s
MS
M1
ME
40
20
0
-4.0
-3.0
-2.0
-1.0
0

FIG. 4

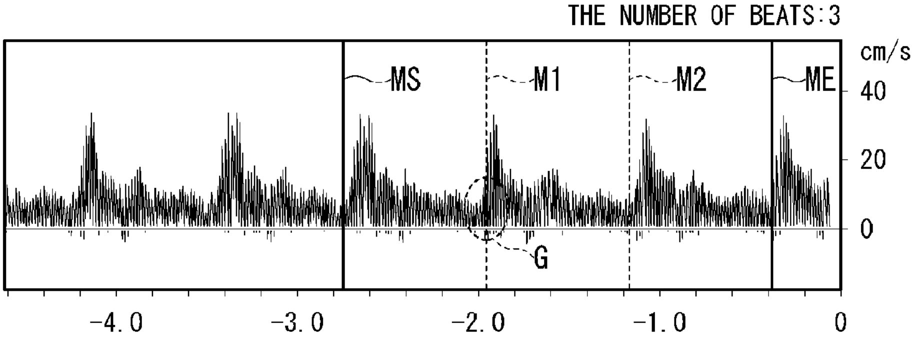

THE NUMBER OF BEATS:3
cm/s
MS
M1
M2
ME
40
20
0
G
-4.0
-3.0
-2.0
-1.0
0

FIG. 5

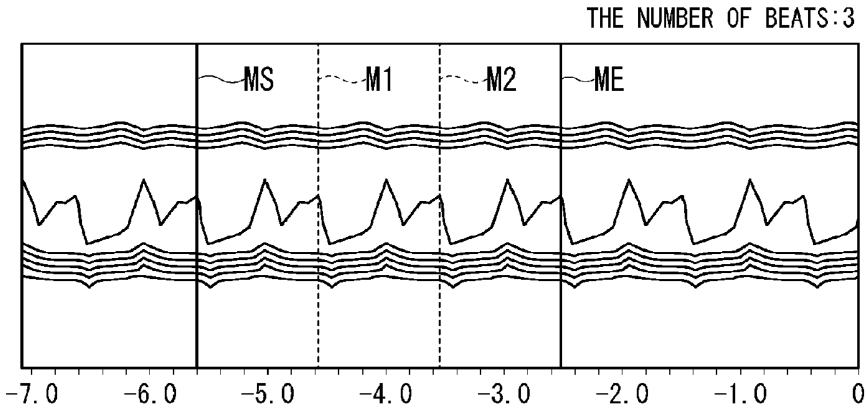

THE NUMBER OF BEATS:3
MS
M1
M2
ME
-7.0
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0

FIG. 6

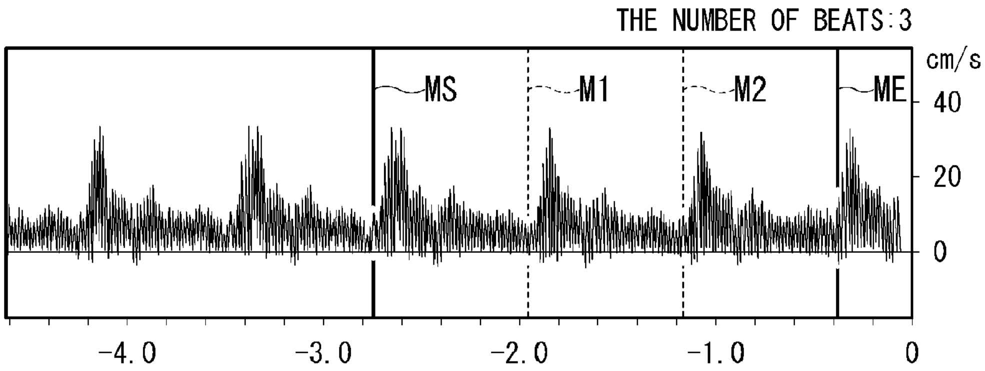


FIG. 7

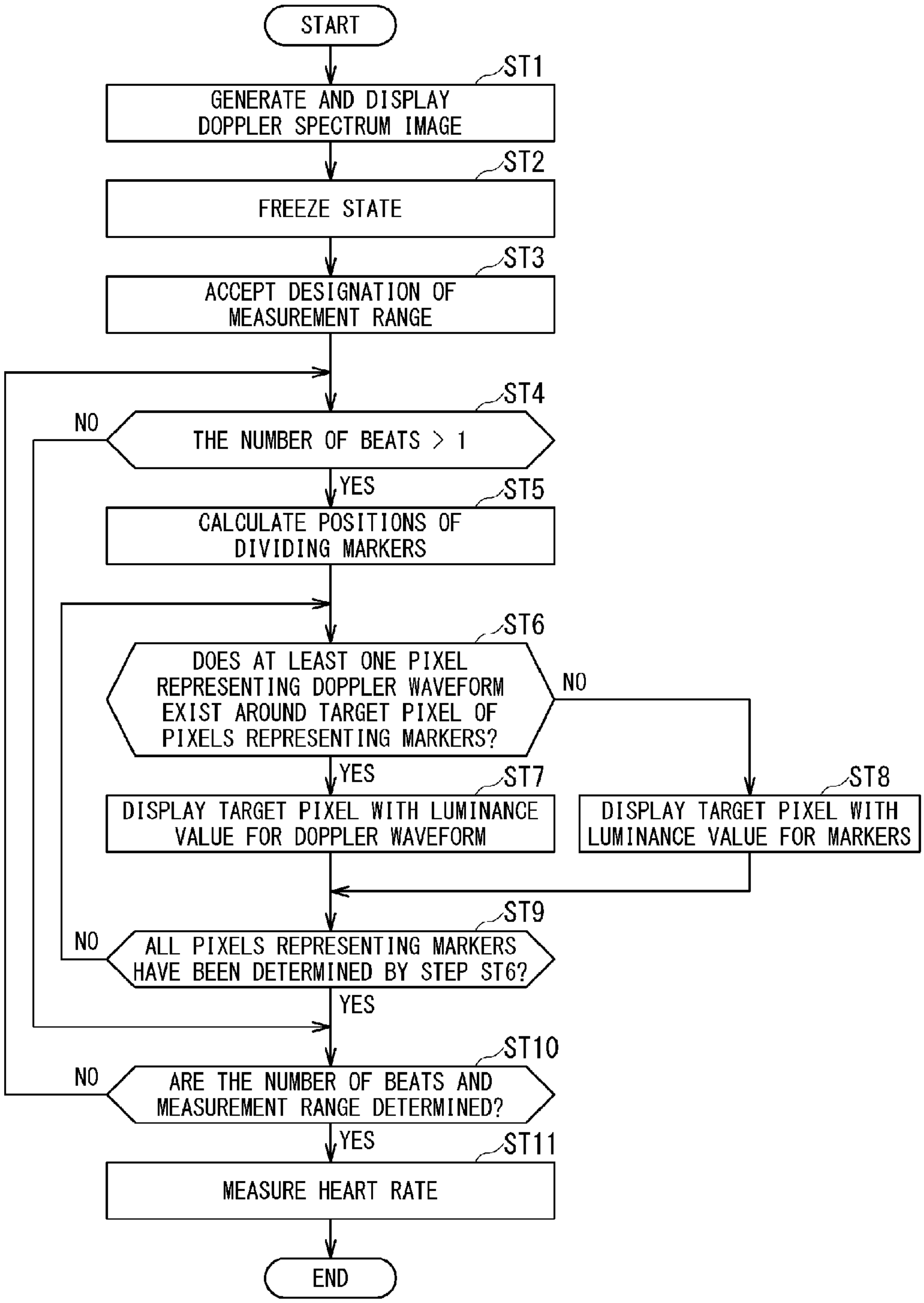

START
ST1
GENERATE AND DISPLAY DOPPLER SPECTRUM IMAGE
ST2
FREEZE STATE
ST3
ACCEPT DESIGNATION OF MEASUREMENT RANGE
ST4
THE NUMBER OF BEATS > 1
NO
YES
ST5
CALCULATE POSITIONS OF DIVIDING MARKERS
ST6
DOES AT LEAST ONE PIXEL REPRESENTING DOPPLER WAVEFORM EXIST AROUND TARGET PIXEL OF PIXELS REPRESENTING MARKERS?
NO
YES
ST7
DISPLAY TARGET PIXEL WITH LUMINANCE VALUE FOR DOPPLER WAVEFORM
ST8
DISPLAY TARGET PIXEL WITH LUMINANCE VALUE FOR MARKERS
ST9
ALL PIXELS REPRESENTING MARKERS HAVE BEEN DETERMINED BY STEP ST6?
NO
YES
ST10
ARE THE NUMBER OF BEATS AND MEASUREMENT RANGE DETERMINED?
NO
YES
ST11
MEASURE HEART RATE
END

FIG. 8

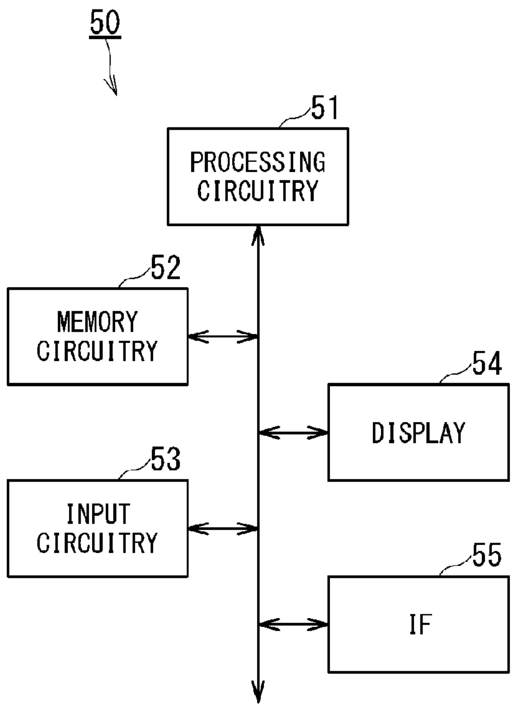

50
51
PROCESSING CIRCUITRY
52
MEMORY CIRCUITRY
54
DISPLAY
53
INPUT CIRCUITRY
55
IF

FIG. 9

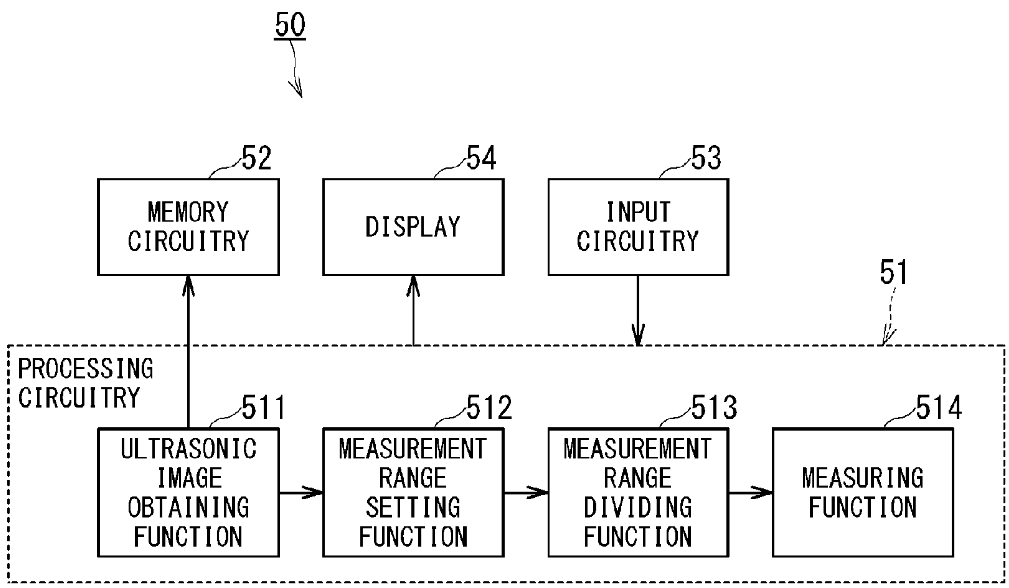

50
52
MEMORY CIRCUITRY
54
DISPLAY
53
INPUT CIRCUITRY
51
PROCESSING CIRCUITRY
511
ULTRASONIC IMAGE OBTAINING FUNCTION
512
MEASUREMENT RANGE SETTING FUNCTION
513
MEASUREMENT RANGE DIVIDING FUNCTION
514
MEASURING FUNCTION

FIG. 10

ULTRASONIC DIAGNOSTIC APPARATUS AND MEDICAL IMAGE PROCESSING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority from Japanese Patent Application No. 2015-203757, filed on Oct. 15, 2015, the entire contents of which are incorporated herein by reference.

FIELD

[0002] An embodiment as an aspect of the present invention relates to an ultrasonic diagnostic apparatus and a medical image processing apparatus.

BACKGROUND

[0003] In the medical field, ultrasonic diagnostic apparatuses are used. The apparatus utilizes ultrasonic waves that are generated using transducers (piezoelectric transducers) of an ultrasonic probe, and images the inside of an object. The ultrasonic diagnostic apparatus causes the ultrasonic probe connected to the ultrasonic diagnostic apparatus to transmit ultrasonic waves into the object to generate a received signal based on reflected waves, and obtains desired ultrasonic images through image processing.

[0004] The ultrasonic images include, for example: a B-mode image, which is sectional information at a given time; an M-mode image, in which temporal variation over a given time period is imaged; and a Doppler spectrum image. At the position of a sample volume (SV) that is set on a B-mode image, a Doppler spectrum image is obtained that represents flow velocities (flow velocity transition) obtained over a given time period.

[0005] When a heart rate and the like are measured using a Doppler spectrum image, two times (a start time and an end time) for determining a measurement range are set on the Doppler spectrum image. These two times are set at a telediastolic point in a cardiac sequence. The heart rate is calculated from the time interval between the two times and the number of beats in the interval. The result is numerically represented as a heart rate of 84 beats per minute.

[0006] For example, in the case where two times including three beats are set and where the interval between the two times, i.e., the measurement range, is 2.5 seconds, the heart rate is (3 [beat]/2.5 [sec.])×60 [sec.]=72 [bpm]. The number of beats is numerically set irrespective of the measurement range, and is preset as a default or set through designation by an operator to change the default value.

[0007] The problem the present invention intends to solve is actually solved by providing an ultrasonic diagnostic apparatus and a medical image processing apparatus that allow an operator to intuitively, visually identify an erroneous setting on the number of beats and the measurement range and reduce the test time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] In accompanying drawings,

[0009] FIG. **1** is a schematic diagram showing a configuration of an ultrasonic diagnostic apparatus according to a present embodiment;

[0010] FIG. **2** is a block diagram showing functions of the ultrasonic diagnostic apparatus **10** according to the present embodiment;

[0011] FIG. **3** is a diagram to illustrate an example of dividing a measurement range;

[0012] FIG. **4** is a diagram to illustrate an example of dividing a measurement range;

[0013] FIG. **5** is a diagram to illustrate an example of dividing a measurement range;

[0014] FIG. **6** is a diagram to illustrate an example of dividing a measurement range;

[0015] FIG. **7** is a diagram to illustrate an example of dividing a measurement range;

[0016] FIG. **8** is a flowchart showing operations of the ultrasonic diagnostic apparatus according to the present embodiment;

[0017] FIG. **9** is a schematic diagram showing a configuration of a medical image processing apparatus according to a present embodiment; and

[0018] FIG. **10** is a block diagram showing functions of the medical image processing apparatus according to the present embodiment.

DETAILED DESCRIPTION

[0019] An ultrasonic diagnostic apparatus and a medical image processing apparatus according to a present embodiment are described with reference to the accompanying drawings.

[0020] The ultrasonic diagnostic apparatus according to the present embodiment includes transceiver circuitry, image generating circuitry and processing circuitry. The transceiver circuitry is configured to transmit, to an ultrasonic probe, a transmission signal for transmitting ultrasonic waves, and to receive a received signal based on the ultrasonic waves. The image generating circuitry is configured to generate an ultrasonic image where temporal variation over a given time period is imaged, based on the received signal, and to display the ultrasonic image to a display. The processing circuitry is configured to: (A) set a measurement range on the ultrasonic image; (B) generate a marker for dividing the measurement range, at substantially equal intervals, the number of the marker according to the numerically number of beats; and (C) superimpose the marker on the displayed ultrasonic image.

[0021] 1. Ultrasonic Diagnostic Apparatus

[0022] FIG. **1** is a schematic diagram showing a configuration of an ultrasonic diagnostic apparatus according to a present embodiment.

[0023] FIG. **1** shows the ultrasonic diagnostic apparatus **10** according to the present embodiment. The ultrasonic diagnostic apparatus **10** includes an ultrasonic probe **11** and an apparatus main body **12**. The apparatus main body **12** is sometimes referred to as an ultrasonic diagnostic apparatus. In this case, the aforementioned ultrasonic diagnostic apparatus is connected to an ultrasonic probe provided outside of the ultrasonic diagnostic apparatus.

[0024] The ultrasonic probe **11** transmits and receives ultrasonic waves to and from an object (e.g., a patient). The ultrasonic probe **11** transmits and receives ultrasonic waves with its front surface being in contact with the surface of the object, and includes one- or two-dimensionally arranged minute transducers (piezoelectric elements), the number of which is M, at its distal end. The transducer is an electroacoustic transducer, and has functions of converting electric pulses into ultrasonic pulses (transmission ultrasonic waves) during transmission and converting ultrasonic reflected waves (reception ultrasonic waves) into an electric signal (received signal) during reception.

[0025] The ultrasonic probe **11** has a small and light-weight configuration, and is connected to the apparatus main body **12** through a cable. The ultrasonic probe **11** supports sector scanning, linear scanning, and convex scanning, any of which is freely selected in conformity with the diagnostic site.

[0026] The apparatus main body **12** includes a processor (e.g., processing circuitry) **31**, a storage (e.g., memory circuitry) **32**, an input device (e.g., input circuitry) **33**, a display device (e.g., a display) **34**, a reference signal generator (e.g., reference signal generating circuitry) **35**, a transceiver (e.g., transceiver circuitry) **36**, an echo data processor (e.g., echo data processing circuitry) **37**, and an image generator (e.g., image generating circuitry) **38**. A part of or the entire function of a digital circuit that constitutes the reference signal generator **35**, the transceiver **36**, the echo data processor **37** and the image generator **38** may be achieved through software that causes a processor to execute a program stored in a predetermined memory, in some cases. The description is herein made assuming that the functions of the reference signal generator **35**, the transceiver **36**, the echo data processor **37** and the image generator **38** are achieved through digital circuits.

[0027] The processing circuitry **31** reads various control programs stored in the memory circuitry **32** and performs various calculation, and integrally controls the processing operations in the elements **32** to **38**.

[0028] The processing circuitry **31** means any one of dedicated or general central processing unit (CPU) and a micro processor unit (MPU), an application specific integrated circuit (ASIC), and a programmable logic device. The programmable logic device may be, for example, any one of a simple programmable logic device (SPLD), a complex programmable logic device (CPLD), a field programmable gate array (FPGA) and the like. The processing circuitry **31** reads programs stored in the memory circuitry **32** or directly implemented in the processing circuitry **31** and executes these programs to achieve functions **311-314** shown in FIG. **2**.

[0029] The processing circuitry **31** may be a single processing circuit or a combination of multiple processing circuits. In the latter case, the memory circuitry **32** includes multiple memory circuits each storing an element of a program, each of the multiple memory circuits is provided for each of the multiple circuits. Alternatively, the memory circuitry **32** includes a single memory circuit storing the program, the single memory circuit is provided for the multiple processing circuits.

[0030] The memory circuitry **32** includes semiconductor memory elements, such as RAM (random access memory) and flash memory, a hard disk, and an optical disk. The memory circuitry **32** may include portable media, such as USB (universal serial bus) memory and DVD (digital video disk). The memory circuitry **32** stores various processing programs used in the processing circuitry **31** (including not only application programs but also an OS (operating system)), data required to execute the programs, and ultrasonic images. The OS may include GUI (graphical user interface). The GUI uses many graphical items for displaying information for an operator on the display **34** and allows the operator to perform basic operations through the input circuitry **33**.

[0031] The input circuitry **33** is a circuit that receives signals from input devices, such as a pointing device (such as mouse) and a keyboard, and is operable by the operator. It is herein assumed that the input device itself is included in the input circuitry **33**. When the input device is operated by the operator, the input circuitry **33** generates an input signal according to the operation and outputs the signal to the processing circuitry **31**. The apparatus main body **12** may include a touch panel where the input device is integrally configured with the display **34**.

[0032] When the operator operates an end button or a freeze button of the input circuitry **33**, transmission and reception of ultrasonic waves are finished and the ultrasonic diagnostic apparatus **10** is brought into a temporary stop state. The input circuitry **33** outputs a transmission condition set by the operator to the processing circuitry **31**. The transmission condition is, for example, the central frequency of ultrasonic waves to be transmitted through the ultrasonic probe **11** to the object. The central frequency varies according to the scanning mode such as linear, convex or sector, the diagnostic target site of the object, the ultrasonic-diagnostic mode such as B mode, Doppler mode or color Doppler mode, the distance from the surface of the object to the diagnostic target site and the like.

[0033] The display **34**, which includes a general display output device, such as a liquid crystal display or an OLED (organic light emitting diode) display, displays ultrasonic image data generated by the image generating circuitry **38** according to control by the processing circuitry **31**.

[0034] The reference signal generating circuitry **35** generates, for example, continuous waves or square waves having a frequency substantially identical to the central frequency of the ultrasonic pulses, for the transceiver circuitry **36**, according to a control signal from the processing circuitry **31**.

[0035] The transceiver circuitry **36** causes the ultrasonic probe **11** to perform transmission and reception according to the control signal from the processing circuitry **31**. The transceiver circuitry **36** includes: a transmitting circuitry **361** that generates a drive signal for causing the ultrasonic probe **11** to emit transmission ultrasonic waves from the ultrasonic probe **11**; and a receiving circuitry **362** that applies phasing and addition to signals received from the ultrasonic probe **11**.

[0036] The transmitting circuitry **361** includes a rate pulse generator, a transmission delay circuit, and a pulser, which are not shown. The rate pulse generator generates rate pulses that determine the repetitive period of transmission ultrasonic waves by frequency-dividing continuous waves or square waves supplied from the reference signal generating circuitry **35**, and supplies the rate pulses to the transmission delay circuit. The transmission delay circuit, which includes independent delay circuits as many as the transducers used for transmission (M channels), provides the rate pulses with a delay time for converging the transmission ultrasonic waves to a predetermined depth to obtain a narrow beam width for transmission and a delay time for emitting the transmission ultrasonic waves in a predetermined direction, and supplies the rate pulses to the pulser. The pulser, which includes M-channel independent drive circuits, generates drive pulses for driving the transducers embedded in the ultrasonic probe **11**, on the basis of the rate pulses.

[0037] The receiving circuitry **362** of the transceiver circuitry **36** includes a pre-amplifier, an A/D (analog to digital) conversion circuit, a reception delay circuit, and an adder circuit, which are not shown. The pre-amplifier, which has an M-channel configuration, amplifies weak signals converted as electric received signals by the transducers, and secures a sufficient S/N. The M-channel received signals amplified to have predetermined intensities by the pre-amplifier are converted into digital signals by the A/D conversion circuit, and transmitted to the reception delay circuit. The reception delay circuit provides each of the M-channel received signals output from the A/D conversion circuit with the delay time for convergence to converge the ultrasonic reflected waves from the predetermined depth and the delay time for deflection to set a receiving directionality with respect to a predetermined direction. The adder circuit applies phasing and addition to signals received from the reception delay circuit (adds up the phases of signals received in the predetermined direction).

[0038] The echo data processing circuitry **37** applies a process for generating an ultrasonic image to the echo data input from the receiving circuitry **362** according to the control signal from the processing circuitry **31**. For example, the echo data processing circuitry **37** performs a process such as a B-mode process or a Doppler process, the B-mode process including a logarithmic compression process and an envelope detection process, the Doppler process including an orthogonal detection process and a filtering process.

[0039] The image generating circuitry **38** causes a scan converter to scan and convert the data received from the echo data processing circuitry **37** to generate ultrasonic image data, according to the control signal from the processing circuitry **31**. The image generating circuitry **38** then causes the display **34** to display an ultrasonic image based on the ultrasonic image data. The ultrasonic images include, for example a B-mode image which is sectional information at a given time (frame), and an M-mode image and a Doppler spectrum image, in which temporal variation over a given time period is imaged.

[0040] Subsequently, the functions of the ultrasonic diagnostic apparatus **10** according to the present embodiment are described.

[0041] FIG. **2** is a block diagram showing functions of the ultrasonic diagnostic apparatus **10** according to the present embodiment.

[0042] Execution of programs by the processing circuitry **31** allows the ultrasonic diagnostic apparatus **10** to function as an ultrasonic image generating function **311**, a measurement range setting function **312**, a measurement range dividing function **313**, and a measuring function **314**. The description is made exemplifying a case where the functions **311** to **314** operate as software. Alternatively, some or all of the functions **311** to **314** may be provided as hardware for the ultrasonic diagnostic apparatus **10**.

[0043] The ultrasonic image generating function **311** is a function of controlling the operation of the ultrasonic probe **11** through the reference signal generating circuitry **35** to perform scanning, and causing the image generating circuitry **38** to generate an ultrasonic image. The ultrasonic image generating function **311** generates, as the ultrasonic image, at least an ultrasonic image (such as the M-mode image or the Doppler spectrum image) where temporal variation over the given time period is imaged. The ultrasonic image generating function **311** causes the display **34** to display the ultrasonic image.

[0044] The B-mode image is an amplitude distribution image of luminance values converted from the reflective strengths (amplitudes) obtained by transmitting and receiving ultrasonic beams along rasters (scanning lines) in the array direction (azimuth direction). Furthermore, B-mode images are generated over a given time period.

[0045] The Doppler spectrum image is an image representing flow velocities (flow velocity transition) obtained over a given time period. For example, the Doppler spectrum image represents the flow velocity transition at a position of the sample volume (SV) set on the B-mode image.

[0046] The M-mode image is an image representing amplitudes (amplitude transition) obtained by transmitting and receiving the ultrasonic beam to and from one raster in the array direction over a given time period. For example, the M-mode image represents the amplitude transition at the position of a raster that is set on the B-mode image.

[0047] A case is hereinafter described where the ultrasonic image generating function **311** generates the Doppler spectrum image as the ultrasonic image where temporal variation over the given time period is imaged.

[0048] The measurement range setting function **312** is a function of setting a measurement range (measurement time period) for a measurement target, such as a heart rate, on the basis of the Doppler spectrum image generated by the ultrasonic image generating function **311**. The measurement range setting function **312** sets two telediastolic times in the cardiac sequence to thereby set the measurement range between the set two times. The end-diastole is determined on the basis of R waves in an ECG signal (electrocardiographic signal).

[0049] The measurement range dividing function **313** is a function of generating markers (or a marker) for dividing the measurement range set by the measurement range setting function **312**, at substantially regular intervals, the number of markers according to the numerically set number of beats, and superimposing the markers on the displayed ultrasonic image. Preferably, the number of markers according to the numerically set number of beats is "n−1" in a case where the numerically set number of beats is "n" (n: an integer at least two). However, the number is not limited to this case.

[0050] Each of FIGS. **3** to **7** is a diagram to illustrate an example of dividing the measurement range.

[0051] Each of FIGS. **3** to **5** and **7** schematically shows a Doppler spectrum image that represents Doppler waveforms. First, in the Doppler mode, a Doppler spectrum image in a time period including heartbeats is generated and the state is brought into the freeze state. When a measurement mode for the heart rate is activated, measurement range markers MS and ME that represent two times (a start time and an end time) based on R waves are displayed on the Doppler spectrum image by the operator, and the measurement range markers MS and ME are manually, laterally slid as necessary to thereby designate two times. FIG. **6** schematically shows the M-mode image. First, in the M mode, an M-mode image in a time period including heartbeats is generated and the state is brought into the freeze state. When the measurement mode for the heart rate is activated, measurement range markers MS and ME that represent two times based on R waves are displayed on the M-mode image by the operator, and the measurement range markers MS and ME are manually, laterally slid as necessary to thereby designate two times.

[0052] Here, the numerical value of the number of beats is set irrespective of the measurement range indicated by the measurement range markers MS and ME. The numerical value of the number of beats is set as a default or set by changing the default value. In the case where the numerically set number of beats is "n", "n−1" dividing times (or a dividing time) for equally dividing the measurement range between the set two times into "n" are calculated, and the "n−1" dividing markers (or a dividing marker) that represent dividing times are aligned and displayed on the Doppler spectrum image (or M-mode image).

[0053] More specifically, FIG. **3** shows a Doppler spectrum image and measurement range markers MS and ME in the case where the numerically set number of beats is three (n=3). As shown in FIG. **3**, in the case where the numerically set number of beats is three, two dividing times for equally dividing the measurement range between the set two times into three are calculated, and the two dividing markers M**1** and M**2** that represent dividing times are aligned and displayed on the Doppler spectrum image. In FIG. **3**, the markers MS, ME, M**1** and M**2** are displayed as lines (solid lines and broken lines) representing the times, on the Doppler spectrum image. Some or all of the markers MS, ME, M**1** and M**2** may be displayed as pointers that represent times on the Doppler spectrum image. According to such display, it is possible for the operator to intuitively, visually identify the number of beats numerically set irrespective of the measurement range, on the Doppler spectrum image.

[0054] In the example shown in FIG. **3**, the numerically set number of beats "3" coincides with the number of beats in the measurement range between the set two times "3". Consequently, if the heartbeat is not disordered, the dividing markers M**1** and M**2** substantially coincide with two end-diastoles between the measurement range markers MS and ME.

[0055] FIG. **4** shows a Doppler spectrum image and measurement range markers MS and ME in the case where the numerically set number of beats is two (n=2). As shown in FIG. **4**, in the case where the numerically set number of beats is two, one dividing time for equally dividing the measurement range between the set two times into two are calculated, and the one dividing marker Ml that represents a dividing time is aligned and displayed on the Doppler spectrum image. According to such display, it is possible for the operator to intuitively, visually identify the number of beats numerically set irrespective of the measurement range, on the Doppler spectrum image.

[0056] In the example shown in FIG. **4**, the numerically set number of beats "2" does not coincide with the number of beats in the measurement range between the set two times "3". Consequently, the dividing marker M**1** does not coincide with two end-diastoles between the measurement range markers MS and ME.

[0057] Therefore, in comparison between FIGS. **3** and **4**, it is possible for the operator to intuitively, visually identify the inconsistency between the number of beats numerically set irrespective of the measurement range and the number of beats in the measurement range between the two times set on the Doppler spectrum image.

[0058] FIG. **5** shows a Doppler spectrum image and measurement range markers MS and ME in the case where the numerically set number of beats is three (n=3). As shown in FIG. **5**, in the case where the numerically set number of beats is three, two dividing times for equally dividing the measurement range between the set two times into three are calculated, and the two dividing markers M**1** and M**2** that represent dividing times are aligned and displayed on the Doppler spectrum image. According to such display, it is possible for the operator to intuitively, visually identify the number of beats numerically set irrespective of the measurement range, on the Doppler spectrum image.

[0059] In the example shown in FIG. **5**, the numerically set number of beats "3" coincides with the number of beats in the measurement range between the set two times "3". There is however a disorder (abnormal cardiac rhythm) as indicated by G. Consequently, the dividing markers M**1** and M**2** do not coincide with two end-diastoles between the measurement range markers MS and ME.

[0060] Therefore, in comparison between FIGS. **3** and **5**, it is possible for the operator to intuitively, visually identify the disorder (abnormal cardiac rhythm) between the measurement range markers MS and ME.

[0061] In case an abnormal cardiac rhythm is automatically recognized in the measurement range, the recognition may be notified to the operator. This is because a waveform including an abnormal cardiac rhythm during measurement using the measurement range is intended to be excluded from the measurement target. For example, in case the flow velocities at positions where a trace line tracing a Doppler waveform crosses the dividing markers M**1** and M**2** exceed a threshold, presence of an abnormal cardiac rhythm is identified. When the presence of an abnormal cardiac rhythm is identified, heartbeats where the abnormal cardiac rhythm occurs are automatically loop-reproduced.

[0062] FIG. **6** shows an M-mode image and measurement range markers MS and ME in the case where the numerically set number of beats is three (n=3). As shown in FIG. **3**, in the case where the numerically set number of beats is three, two dividing times for equally dividing the measurement range between the set two times into three are calculated, and the two dividing markers M**1** and M**2** that represent dividing times are aligned and displayed on the M-mode image. According to such display, it is possible for the operator to intuitively, visually identify the number of beats numerically set irrespective of the measurement range on the M-mode image.

[0063] In the example shown in FIG. **6**, the numerically set number of beats "3" coincides with the number of beats in the measurement range between the set two times "3". Consequently, if the heartbeat is not disordered, the dividing markers M**1** and M**2** substantially coincide with two end-diastoles between the measurement range markers MS and ME.

[0064] Therefore, according to FIG. **6**, it is possible for the operator to intuitively, visually identify the inconsistency between the number of beats numerically set irrespective of the measurement range and the number of beats in the measurement range between the set two times set on the M-mode image.

[0065] FIG. **7** shows a variation example of the display of FIG. **3**. As shown in FIG. **7**, pixels around which pixels representing a Doppler waveform exist among the pixels indicating the measurement range markers MS and ME and the dividing markers M**1** and M**2** are set to have a luminance value representing the Doppler waveform. That is, when a part of the markers MS, ME, M1 and M2 is disposed around a Doppler spectrum, this part is set to be hidden (or translucent).

[0066] Consequently, it is possible for the operator to preferentially, visually identify the Doppler spectrum image without interference by the display of the measurement range markers MS and ME and the dividing markers M1 and M2. Returning to the description on FIG. 2, the measuring function 314 is a function of performing measurement in the measurement range set by the measurement range setting function 312. The measuring function 314 measures a heart rate (BPM: beats per minute) [bpm] based on the number of beats in the measurement range set by the measurement range setting function 312. The measured numerical value is displayed on the display 34.

[0067] The measuring function 314 may measure the maximum flow velocity in the Doppler spectrum image by tracing the maximum flow velocity in the measurement range set by the measurement range setting function 312. Alternatively, the flow velocity range of the Doppler spectrum image may be measured on the basis of the variation in flow velocity in the measurement range set by the measurement range setting function 312.

[0068] Subsequently, referring to FIGS. 1 and 8, the operation of the ultrasonic diagnostic apparatus 10 according to the present embodiment is described.

[0069] FIG. 8 is a flowchart showing operations of the ultrasonic diagnostic apparatus 10 according to the present embodiment.

[0070] The processing circuitry 31 controls the reference signal generating circuitry 35 and the like to execute scanning, generates a Doppler spectrum image in a mode for generating an ultrasonic image where temporal variation over a given time period is imaged, for example, the Doppler mode, and displays the Doppler spectrum image on the display 34 (step ST1). The ultrasonic image generated in step ST1 may be an M-mode image generated in the M mode.

[0071] After transition to the mode for measuring the heart rate and the like, the processing circuitry 31 brings the Doppler mode into the freeze state (step ST2), and accepts designation of the measurement range (measurement time period) for the measurement target, such as the heart rate, from the operator (step ST3).

[0072] The processing circuitry 31 determines whether the numerically set number of beats is higher than one (n>1) or not (step ST4). In step ST4, the processing circuitry 31 uses, as the numerically set number of beats, a number set as the default or a number set by changing the default value according to NO in step ST10.

[0073] In the case of YES in the determination in step ST4, that is, in the case where the numerically set number of beats is determined to be higher than one, the processing circuitry 31 calculates "n−1" dividing times for equally dividing the measurement range designated in step ST3 into "n", and calculates the positions (times) of the "n−1" dividing markers representing the dividing times (step ST5).

[0074] The processing circuitry 31 determines whether at least one pixel representing a Doppler waveform exists (e.g., within 10 pixels) or not around a target pixel of pixels representing the dividing markers and the measurement range markers (step ST6). In the case of YES in the determination in step ST6, that is, in the case where at least one pixel representing the Doppler waveform exists around the target pixel of the pixels representing the dividing markers and the measurement range markers, the processing circuitry 31 displays the target pixel with the luminance value of the Doppler waveform (step ST7).

[0075] On the contrary, in the case of NO in the determination in step ST6, that is, in the case where no pixel representing the Doppler waveform exists around the target pixel of the pixels representing the dividing markers and the measurement range markers, the processing circuitry 31 displays the target pixel with the luminance value for the dividing markers and the measurement range markers (step ST8).

[0076] The processing circuitry 31 determines whether or not the processing circuitry 31 has performed the determination in step ST6 for all the pixels representing the dividing markers and the measurement range markers (step ST9). In the case of YES in the determination in step ST9, that is, in the case where it is determined that the determination in step ST6 has been performed for all the pixels representing the dividing markers and the measurement range markers, the processing circuitry 31 determines whether or not to finally determine the numerically set number of beats and the measurement range designated in step ST3 (step ST10).

[0077] In the case of YES in the determination in step ST10, that is, in the case where it is determined to finally determine the numerically set heart rate and the measurement range designated in step ST3, the processing circuitry 31 measures the heart rate on the basis of the number of beats and the measurement range finally determined in step ST10 (step ST11).

[0078] On the contrary, in the case of NO in the determination in step ST10, that is, in the case where it is determined not to finally determine the numerically set heart rate and the measurement range designated in step ST3 and to change the heart rate or the measurement range instead, the processing circuitry 31 performs the determination in step ST4 for the changed heart rate and measurement range.

[0079] For example, in the case of NO in the determination in step ST10, that is, in the case where the measurement range marker ME (shown in FIG. 3) is slid to the left through an operation by the operator, the dividing markers M1 and M2 (shown in FIG. 3) are slid to the left while the intervals for the equally divided three are maintained in the measurement range (step ST5).

[0080] In the case of NO in the determination in step ST4, that is, in the case where it is determined that the numerically set number of beats is one or lower, the processing circuitry 31 determines whether or not to finally determine the numerically set heart rate and the measurement range designated in ST3 (step ST10).

[0081] In the case of NO in the determination in step ST9, that is, in the case where it is determined that the determination in step ST6 has been performed for not all the pixels representing the dividing marker and the measurement range marker, the processing circuitry 31 returns the processing to the determination in step ST6 for the next one of the pixels representing the dividing markers and the measurement range markers.

[0082] The markers MS, ME, M1 and M2 are thus displayed in the mode shown in FIG. 7 where all the pixels representing the dividing markers and the measurement range markers are displayed with the luminance value of the Doppler waveform or the marker. In FIG. 8, when all the pixels representing the dividing markers and the measurement range markers are displayed with the luminance value of the marker, the markers MS, ME, M1 and M2 are displayed in the mode shown in FIGS. **3** and **4**.

[0083] The ultrasonic diagnostic apparatus **10** thus displays the marker(s) corresponding to the numerically set number of beats on the ultrasonic image. Consequently, it is possible for the operator to intuitively, visually identify an erroneous setting of the number of beats and the measurement range.

[0084] 2. Medical Image Processing Apparatus

[0085] FIG. **9** is a schematic diagram showing a configuration of a medical image processing apparatus according to a present embodiment.

[0086] FIG. **9** shows the medical image processing apparatus **50** according to the present embodiment. The medical image processing apparatus **50** is any of a medical image management apparatus (image server), a workstation, a reading terminal and the like, which are not shown, and is provided in a medical imaging system to which this apparatus is connected via a network. Alternatively, the medical image processing apparatus **50** may be an offline apparatus.

[0087] The medical image processing apparatus **50** includes a processing unit (e.g., processing circuitry) **51**, a storage (e.g., memory circuitry) **52**, an input device (e.g., input circuitry) **53**, a display device (e.g., a display) **54**, and a communication unit (e.g., IF (interface)) **55**.

[0088] The processing circuitry **51** has a configuration equivalent to that of the processing circuitry **31** shown in FIG. **1**. The processing circuitry **51** reads various control programs stored in the memory circuitry **52** and performs various calculation, and integrally controls the processing operation in the elements **52** to **55**.

[0089] The memory circuitry **52** has a configuration equivalent to that of the memory circuitry **32** shown in FIG. **1**. The memory circuitry **52** stores various processing programs used in the processing circuitry **51**, data required to execute the programs, and medical images, such as ultrasonic images, obtained via the IF **55**. The OS may include GUI. The GUI uses many graphical items for displaying information for an operator on the display **54** and allows the operator to perform basic operations through the input circuitry **53**.

[0090] The input circuitry **53** has a configuration equivalent to that of the input circuitry **33** shown in FIG. **1**. When the input device is operated by the operator, the input circuitry **53** generates an input signal according to the operation and outputs the signal to the processing circuitry **51**. The medical image processing apparatus **50** may include a touch panel where the input device is integrally configured with the display **54**.

[0091] The display **54** has a configuration equivalent to that of the display **34** shown in FIG. **1**. The display **54** displays image data generated according to the control by the processing circuitry **51**.

[0092] The IF **55** includes a connector in conformity with parallel connection specifications and serial connection specifications. The IF **55** performs communication control according to the corresponding specifications, and has a function of connection to a network via a telephone line. This function connects the medical image processing apparatus **50** to the network.

[0093] Subsequently, the functions of the medical image processing apparatus **50** according to the present embodiment are described.

[0094] FIG. **10** is a block diagram showing functions of the medical image processing apparatus **50** according to the present embodiment.

[0095] Execution of programs by the processing circuitry **51** allows the medical image processing apparatus **50** to function as an ultrasonic image obtaining function **511**, a measurement range setting function **512**, a measurement range dividing function **513**, and a measuring function **514**. The description is made exemplifying a case where the functions **511** to **514** operate as software. Alternatively, some or all of the functions **511** to **514** may be provided as hardware for the medical image processing apparatus **50**.

[0096] The ultrasonic image obtaining function **511** is a function of obtaining (reading), as the ultrasonic image, at least an ultrasonic image where temporal variation over a given time period is imaged (e.g., an M-mode image or a Doppler spectrum image), from the memory circuitry **52**. The ultrasonic image obtaining function **511** causes the display **54** to display the ultrasonic image.

[0097] The measurement range setting function **512**, the measurement range dividing function **513** and the measuring function **514** function in manners analogous to those of the measurement range setting function **312**, the measurement range dividing function **313** and the measuring function **314** shown in FIG. **2**.

[0098] The operations of the medical image processing apparatus **50** are analogous to the operations in steps ST**3** to ST**11** in the ultrasonic diagnostic apparatus **10** shown in FIG. **8**. Consequently, description of the operations is omitted.

[0099] The medical image processing apparatus **50** displays the marker(s) corresponding to the numerically set number of beats on the ultrasonic image. Consequently, it is possible for the operator to intuitively, visually identify an erroneous setting of the number of beats and the measurement range.

[0100] According to at least one of the ultrasonic diagnostic apparatus and the medical image processing apparatus of the embodiments described above, it is possible for the operator to intuitively, visually identify an erroneous setting on the number of beats and the measurement range and to reduce the test time.

[0101] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel methods and systems described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the methods and systems described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

What is claimed is:

1. An ultrasonic diagnostic apparatus, comprising:

transceiver circuitry configured to transmit, to an ultrasonic probe, a transmission signal for transmitting ultrasonic waves, and to receive a received signal based on the ultrasonic waves;

image generating circuitry configured to generate an ultrasonic image where temporal variation over a given time period is imaged, based on the received signal, and to display the ultrasonic image to a display; and

processing circuitry configured to
(A) set a measurement range on the ultrasonic image,
(B) generate a marker for dividing the measurement range, at substantially equal intervals, the number of the marker according to the numerically number of beats, and
(C) superimpose the marker on the displayed ultrasonic image.

2. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to display the marker on the ultrasonic image as a line representing a time.

3. The ultrasonic diagnostic apparatus according to claim **2**,
wherein the processing circuitry is configured to set, when a part of the line is disposed around a waveform of a Doppler spectrum image, the part to be hidden or translucent.

4. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to set, in a case where the number of beats is "n" (n: an integer at least two), the number of the marker according to the number of beats to "n−1".

5. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the image generating circuitry is configured to generate a Doppler spectrum image as the ultrasonic image.

6. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the image generating circuitry is configured to generate an M-mode image as the ultrasonic image.

7. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to further measure a heart rate based on the number of beats and the measurement range.

8. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to further measure a maximum flow velocity by tracing a maximum flow velocity in the measurement range on the Doppler spectrum image as the ultrasonic image, based on the measurement range.

9. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to further measure a flow velocity range by variation in flow velocity in the measurement range on the Doppler spectrum image as the ultrasonic image, based on the measurement range.

10. The ultrasonic diagnostic apparatus according to claim **1**,
wherein the processing circuitry is configured to issue, when a flow velocity at a position where a Doppler waveform of the Doppler spectrum image as the ultrasonic image crosses the marker exceeds a threshold, a notification of the exceeding.

11. A medical image processing apparatus, comprising a processing circuitry configured to:
obtain an ultrasonic image where temporal variation over a given time period is imaged, and display the ultrasonic image to a display;
set a measurement range on the ultrasonic image;
generate a marker for dividing the measurement range, at substantially equal intervals, the number of the marker according to the numerically number of beats; and
superimpose the marker on the displayed ultrasonic image.

* * * * *

专利名称(译)	超声波诊断装置和医学图像处理装置		
公开(公告)号	US20170105704A1	公开(公告)日	2017-04-20
申请号	US15/196176	申请日	2016-06-29
[标]申请(专利权)人(译)	东芝医疗系统株式会社		
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[标]发明人	AKIYAMA MITSUO		
发明人	AKIYAMA, MITSUO		
IPC分类号	A61B8/08 A61B8/02 A61B8/00		
CPC分类号	A61B8/5207 A61B8/461 A61B8/5223 A61B8/4483 A61B8/486 A61B8/02 A61B8/488 G16H50/30		
优先权	2015203757 2015-10-15 JP		
外部链接	Espacenet USPTO		

摘要(译)

根据本实施例的超声诊断设备包括收发器电路，图像生成电路和处理电路。收发器电路被配置为向超声探头发送用于发送超声波的发送信号，并且基于超声波接收接收信号。图像生成电路被配置为生成超声图像，其中基于接收的信号对给定时间段内的时间变化进行成像，并将超声图像显示到显示器。处理电路被配置为：（A）在超声图像上设置测量范围；（B）根据数量的节拍数，以基本相等的间隔产生用于划分测量范围的标记；（C）将标记叠加在显示的超声波图像上。