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(54) **Ultrasound diagnosis apparatus and method of processing ultrasound data**

Diagnostisches Ultraschallgerät und Verfahren zur Verarbeitung von Ultraschalldaten

Appareil de diagnostic à ultrasons et procédé de traitement de données échographiques

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Description

BACKGROUND

Technical Field

[0001] The present invention relates to an ultrasound diagnosis apparatus, and more particularly to ultrasonic diagnosis technology for a fetal heart.

Related Art

[0002] Ultrasonic diagnosis of a fetus in it's mother womb has become commonplace in medical practice. One of the purposes of such diagnoses is to diagnose or treat congenital heart diseases at an early stage. If a serious heart disease can be diagnosed prior to delivery, it is often possible to successfully treat the disease using medicine, surgery, or the like immediately after childbirth. In ultrasonic diagnosis of a fetal heart, the shape or size of the heart is displayed on a tomographic image, or the state of blood flow in the heart is displayed on a two-dimensional color Doppler image (or a color flow mapping image). Also, according to the pulse Doppler method, Doppler information obtained from a sample gate (or a sample volume) which is set within the heart is subjected to frequency analysis, so that Doppler waves formed by the frequency analysis are displayed. Alternatively, it is also possible to use three-dimensional ultrasonic diagnosis technology to perform three-dimensional image forming or three-dimensional measurement with regard to the fetal heart.

[0003] JP 3045642 B describes processing of a two-dimensional ultrasonic image, and particularly describes processing for extracting the outline of the left ventricle in the heart to form an image such as a multi-ring. JP 2004-159997 A describes processing of a three-dimensional ultrasonic image, and particularly describes processing for extracting a heart chamber portion within the heart. JP 2000-197633 A discloses measurement and analysis of a cardiac valve signal of a fetus. Although this publication, JP 2000-197633 A, describes a method which uses an ultrasonic Doppler method, the publication does not describe technology of processing an image which represents a change in the shape of the heart such as a tomographic image and a three-dimensional image to thereby obtain information indicative of the motion of the heart. JP 11-221210 A describes technology of displaying a temporal change of the areas of a plurality of regions defined in the left ventricle in a plurality of graphs. JP 8-103442 A describes image processing technology for extracting the left ventricle as a closed region. US 2005-0049503 Al describes a method and an apparatus for acquiring and processing a volumetric scan of a periodically moving object. A volumetric scan is performed of the periodically moving object which repeats a cycle of movement over time. A time interval of the periodical movement of the object is identified within the volumetric scan, and the volumetric scan is rearranged based on the time interval. US 2006-074315 Al discloses methods, computer readable media and systems for automatic characterizing motion, such as cardiac motion, from ultrasound information. Ultrasound information associated with particular time periods relative to the motion cycle are extracted, such as identifying and extracting ultrasound information associated with systole in cardiac imaging using the ultrasound information. By tracking an area of the heart or other organ, such as an area within the endocardiocontur, the cycle time periods are identified. US 5,322,067 discloses a method and an apparatus for determining the volume of a fluid filled cavity in a patient's body in real time from an ultrasound image. An ultrasound display of the cavity and the surrounding tissue is obtained. The ultrasound display includes a sequence of ultrasound images. The user traces a fixed region of interest around the image of the cavity at the largest volume for which the volume determination is to be made. The region of interest is subdivided into a predetermined number of segments. None of the above-noted publications describes the technology of obtaining information which is an alternative to electrocardiographic information from the temporal change in the shape of the heart.

[0004] Generally, in ultrasonic diagnosis of the heart, an electrocardiograph is used to measure an electrocardiograhic signal in real time, and the electrocardiographic signal is then used as information representing the period of motion of the heart or as a synchronization signal for measurement. However, it is not possible to bring a plurality of electrodes into direct contact with a fetus for obtaining an electrocardiographic signal. In this regard, ultrasonic diagnosis of a fetus in the womb suffers from a specific problem which would not arise in the normal ultrasonic diagnosis of the heart. As such, with regard to fetuses, it is difficult to obtain information concerning heartbeats (cardiac information) in the ultrasonic diagnosis of the heart, which makes it difficult to recognize the state of the heart or measure the heart functions.

[0005] Here, as the cardiac cycle of the fetal heart is much shorter than that of the adult heart, it is necessary to increase the frame rate (or the volume rate) when displaying the fetal heart in an ultrasonic image. However, if data transmission and reception based on the ultrasonic Doppler method described in JP 2000-197633 A indicated above is performed in addition to data transmission and reception for measuring or displaying the fetal heart as an ultrasonic image, the frame rate (or the volume rate) is inevitably reduced.

SUMMARY

[0006] In accordance with one aspect, the present invention advantageously provides an ultrasound diagnosis apparatus suitable for diagnosis or measurement of the fetal heart.

[0007] In accordance with another aspect, the present invention advantageously provides an ultrasound diagnosis apparatus which can obtain information concerning heartbeats (cardiac information) in real time while performing ultrasonic diagnosis of the fetal heart.

[0008] In accordance with still another aspect, the present invention advantageously provides an ultrasound diagnosis apparatus which can obtain information representing the periodical motion of the heart based on echo data which is used for representing fetal heart in an image.

[0009] The present invention relates to an ultrasound diagnosis apparatus which includes a transmitter/receiver section for transmitting and receiving ultrasound with respect to a fetal heart; a motion information measurement section for measuring motion information representing a temporal change in a shape of the heart caused by a periodical motion of the fetal heart, based on data obtained by transmission and reception of the ultrasound; and a time measurement section for measuring a specific time in the periodical motion of the fetal heart based on the motion information.

[0010] With the above structure, ultrasound is transmitted to and received from a fetus in the mother womb. Consequently, echo data for representing the fetal heart in a two-dimensional image or a three-dimensional image is captured. In general, based on the echo data thus captured, an image is formed in predetermined time units (in units of frames or volumes). Processing with respect to the echo data is performed at a stage prior to or after the image formation, so that motion information representing a temporal change in the shape of the heart is obtained. In this case, for each frame data (or each tomographic image), an area of a portion of interest in the heart is calculated, to thereby measure the motion information indicating the changes of the area. It is also possible to process three-dimensional data to measure the temporal change in the volume as the motion information. Because the motion information is information indicating the change of the shape along the time axis, the periodical change in the motion information substantially corresponds to the periodical change of an electrical signal supplied to the heart (i.e. an electrocardiographic signal). As such, by analyzing the motion information, information equivalent to the information represented by an electrocardiographic signal can be obtained. According to the present invention, a specific time is determined from the motion information. Here, the specific time refers to a specific phase or a specific period in a cardiac cycle, such as end-diastole, end-systole, and so on. A synchronization signal indicative of the period of an R wave contained in an electrocardiographic signal can also be generated from the motion information.

[0011] As described above, according to the present invention, even in a situation where a fetal electrocardiographic signal cannot be observed directly, information equivalent to an electrocardiographic signal can be obtained by performing analysis of the ultrasonic data, especially analysis of the tissue motion, so that the information thus obtained can be displayed or the information can be used to compute further information. Conventionally, various measurements using an electrocardiographic signal from a fetus cannot be performed because an electrocardiographic signal cannot be obtained from a fetus. The above structure of the present invention makes it possible to perform such measurements even with regard to the fetal heart. In conjunction with the above structure, the time information may be obtained in real time while an ultrasonic image is being displayed, or the time information may be obtained by using echo data stored in a memory.

[0012] According to the invention, the motion information is information representing a change in an area; alternatively, the motion information may also be information representing a change in a volume concerning a portion of interest in the fetal heart. While the portion of interest is desirably a heart chamber in the fetal heart, it may be a cardiac muscle portion. The heart chamber may be a left ventricle, for example, and the temporal change in the area (area value) or the volume (volume value) concerning an entire heart chamber or a portion of the heart chamber may be observed.

[0013] According to the invention, the motion information measurement section includes an extraction section for extracting, for each frame, a region corresponding to a portion of interest in the fetal heart based on echo data which is used for forming a tomographic image, the echo data having been obtained by transmission and reception of the ultrasound; an area calculation section for calculating an area concerning the region corresponding to the portion of interest for each frame; and a graph generation section for generating, as the motion information, a graph representing a temporal change in the area which is calculated for each frame.

[0014] Preferably, the time measurement section performs waveform analysis of the graph generated as the motion information to specify at least one of a maximum value and a minimum value as a peak for each heartbeat.

[0015] According to the invention, the time measurement section includes a smoothing section for performing smoothing processing with respect to the graph serving as the motion information; and a peak specification section for specifying the peak for each heartbeat in a graph to which the smoothing processing has been performed. With this structure, because the peak can be specified after smoothing the waveform by the smoothing processing the likelihood of the time measurement being effected by noise can be reduced, so that the accuracy of measurement can be increased. While the timing at which the maximum value occurs generally corresponds to the actual enddiastole (or end-systole), they may not correspond, depending on the portion measured. In such a case, correction with regard to time can be performed so as to establish a correspondence between the maximum value and the diastolic or systolic peak. However, when the cardiac cycle is simply being observed, such inconsistency of timing creates not disadvantage or problem.

[0016] According to the invention, the peak specification section is an end-diastole specification section, and when a plurality of local maximum values are present on the graph, the end-diastole specification section specifies the maximum value among the plurality of local maximum values by using a determination window which is smaller than a standard cardiac period concerning a fetal heart. In order to increase the accuracy of time measurement, it is necessary to prevent misidentification of the maximal value and the minimum value. In this regard, it is according to the invention that the reference for detecting the maximum and minimum values is determined based on the standard cardiac cycle concerning the fetal heart. The determination window on the time axis is set as a time period which is shorter than the standard cardiac period, and this determination window is used to determine the range within which the maximum value in each heartbeat is searched. In this case, a plurality of time conditions may be used, or a determination condition of the maximum value or the like may be provided in the direction of the amplitude axis.

[0017] Preferably, the ultrasound diagnosis apparatus further includes a cardiac information calculation section for calculating cardiac information concerning the fetal heart based on the specific time which is measured. The cardiac information may include, for example, the heart rate per minute, the cardiac cycle (a time period of a single heartbeat), a degree of variation in these values (distribution), and so on. According to the invention, the ultrasound diagnosis apparatus further includes an evaluation value calculation section for calculating an evaluation value for evaluating a function concerning the fetal heart based on the specific time which is measured. In general, the evaluation value may be a value obtained as a result of heart function measurement using an electrocardiographic signal or a cardiac synchronization signal. According to the invention, the evaluation value is defined by a size of the left ventricle or a portion of the left ventricle at end-diastole and end-systole; and is an ejection fraction (EF).

[0018] Preferably, the ultrasound diagnosis apparatus further includes a display processing unit for displaying a graph which directly or indirectly represents the motion information and a mark indicative of the specific time on the graph. With this structure, correctness of the measurement concerning the specific time can be confirmed on the screen.

[0019] A method according to the present invention includes the steps of the method according to appended claim 3.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] A preferred embodiment of the present invention will be described in detail based on the following figures, wherein:

Fig. 1 is a block diagram showing an ultrasound diagnosis apparatus according to one embodiment of the present invention;

Fig. 2 is a view showing a region of interest which is set on a tomographic image;

Fig. 3 is a graph showing a state prior to averaging processing;

Fig. 4 is a graph showing a state after averaging processing;

Fig. 5 is a view for explaining a method of specifying the maximal value among a plurality of local maximal values;

Fig. 6 is a view, which is similar to Fig. 5, for explaining a method of specifying the maximal value among a plurality of local maximal values;

Fig. 7 is a view showing an example method for specifying the maximal value and the minimum value for each heartbeat;

Fig. 8 is a flowchart showing an example operation of a time and heart function measurement section which is shown in Fig. 1;

Fig. 9 is a conceptual view for explaining information obtained by the time and heart function measurement section;

Fig. 10 is a view showing an example image displayed on the display section;

Fig. 11 is a view showing another example image displayed on the display section;

Fig. 12 is a view showing another example waveform image;

Fig. 13 is a view for explaining a region of interest which is segmented into a plurality of partial regions; and

Fig. 14 is a view for explaining a time difference between two graphs.

DETAILED DESCRIPTION

[0021] A preferred embodiment of the present invention will be described in detail with reference to the accompanying drawings.

[0022] Fig. 1 shows an ultrasound diagnosis apparatus according to one embodiment of the present invention. Specifically, Fig. 1 is a block diagram showing an overall structure of an ultrasound diagnosis apparatus. The ultrasound diagnosis apparatus according to the present embodiment performs ultrasonic diagnosis concerning the heart in a living body, particularly concerning the heart of a fetus (a fetal heart), although the apparatus of the present embodiment can obviously also be used for ultrasonic diagnosis of a heart in a living body other than a fetus.

[0023] A probe 10 is a transmitter/receiver which transmits ultrasound pulse and receives reflected ultrasound to thereby form an ultrasound beam B. The probe 10 includes an array transducer formed of a plurality of transducer elements. The ultrasound beam B which is formed by the array transducer is electronically scanned. As electronic scanning methods, electronic sector scanning, electronic linear scanning, and so on are known. While in this embodiment, a 1D (one-dimensional) array transducer is provided in the probe 10, a 2D array transducer may be provided.

[0024] When the ultrasound beam B is electronically scanned, a scan plane S is formed as shown in Fig. 1. In Fig. 1, the electronic scanning direction is indicated as the θ direction. The scan plane S is a two-dimensional data acquisition region, and a tomographic image concerning the fetal heart is formed based on echo data on the scan plane, as will be described below. The scan plane S is formed repeatedly, so that a tomographic image is displayed on the display screen as a motion image. Under such conditions it is possible, according to the present embodiment, to obtain a synchronization signal (a pseudo electrocardiographic signal) equivalent to an electrocardiographic signal. In addition, such a synchronization signal can be obtained in real time, as will be described in detail below.

[0025] Here, the probe 10 is brought into contact with the abdomen of the fetus' mother. Alternatively, the probe 10 may be inserted into the mother's vagina. Other types of probe may also be used.

[0026] A transmitter/receiver section 12 functions as a transmitting beam former and a receiving beam former. The transmitter/receiver section 12 supplies a plurality of transmission signals to the array transducer where a transmitting beam is formed. Reflection waves from within the living body are received by the array transducer, which then transmits a plurality of reception signals to the transmitter/receiver section 12. The transmitter/receiver section 12 applies phase-alignment and summation processing to the plurality of reception signals, thereby electronically forming a receiving beam. The reception signal having been subjected to the phase-alignment and summation processing is output to a conversion section 14 via a signal processing section which is not shown.

[0027] In the present embodiment, the conversion section 14 is provided with a coordinate converting function, an interpolation processing function, and so on, and is formed by a digital scan converter (DSC). Through the processing of the conversion section 14, a tomographic image is formed based on the echo data on the scan plane S. The image data of the tomographic image is to be stored in a data memory 15. In the present embodiment, area calculation, time measurement, and so on is performed with respect to the image data having been subjected to coordinate conversion, as will be described below. However, area calculation, time measurement, and so on can also be applied to the image data prior to coordinate conversion. More specifically, the frame data which are subjects of calculation and measurement may be a group of beam data prior to coordinate conversion or image data after coordinate conversion, both of which corresponds to frame data. It is also possible to apply volume calculation or the like to volume data, rather than the frame data. The image data of each frame which is output from the data memory 15 is supplied to a synthesizing section 18 and is also supplied to an area change measurement section 16.

[0028] The synthesizing section 18 has a function of synthesizing, in frame units, the tomographic image and an image of a heart chamber which is formed by the area change measurement section 16 and generating a synthesized image. This synthesizing section 18 is provided, as required.

[0029] A display processing section 20 forms display screen data including the synthesized image described above, a graph image, and numeral information as a result of calculation, and outputs the data to a display section 24. The content of the display screen can be appropriately determined in accordance with a user request. A control section 26 performs operation control of each structure shown in Fig. 1, and an operation panel 28 is connected to the control section 26. The control panel 28 includes a keyboard, a trackball, and the like, and can be used by a user for setting a region of interest (ROI), inputting measurement conditions and operation mode, and so on.

[0030] The area change measurement section 16 will be described. The image data output from the conversion section 14 has been sent to a binarization processing section 30. The binarization processing section 30 is a module which executes, on the frame basis, binarization processing or two-point discrimination with respect to the image data. For example, the binarization processing section 30 executes processing for allocating a pixel value "1" to the heart chamber portion in the heart and allocating a pixel value "0" to other portions. In such a case, the threshold value required for the binarization processing can be variably set by a user through control of the control section 26.
Further, it is possible to designate, as a region of interest, a subject of the binarization processing or a region to which extraction processing is to be applied, which will be described below, so that the binarization processing or the extraction processing is applied only within the region of interest. In this case, more than one region of interest can be designated. It is also possible to apply area calculation processing to a plurality of partial regions in parallel.

[0031] A noise removing section 32 executes noise removing processing with respect to the binary image formed by the binarization processing section 30. An extraction section 34 then executes processing for extracting the heart chamber in the binary image which has been subjected to noise removal. For example, the extraction section 34 can extract, as a closed region, the left ventricle included in the region of interest by repeatedly executing image processing including image expansion and image contraction. Here, it should be obvious that any heart chamber other than the left ventricle, i.e., the right ventricle, the right atrium, and the left atrium can also be extracted. With this extraction processing, the left ventricle, for example, is extracted as a specific portion of interest, and an image of the heart chamber representing the portion of interest is generated. The image data of the heart chamber image is supplied to the synthesizing section 18 and is also supplied to an area calculation section 36.

[0032] The area calculation section 36 calculates an area (an area value) concerning the heart chamber thus extracted. This area calculation is performed on a frame basis. Specifically, in a state where a series of heart chamber images are input in time sequence, the area of the heart chamber image in each frame is calculated. Consequently, a series of area data (area values) is generated in time sequence.

[0033] A graph generation section 38 generates a graph (an area graph or an area change graph) representing the series of area data obtained as described above on the time axis. This graph corresponds to image data which represents a temporal change in the area as a waveform. This image data is supplied to the display processing section 20 and is also output to a time and heart function measurement section 22. The above-described graph represents a temporal change of the shape of a specific region in the fetal heart. The graph can be considered to represent cardiac information of the fetus because the fetal heart periodically moves in accordance with an electrocardiograph signal. As such, while directly measuring an electrocardiographic signal from fetal heart is normally impossible or problematic, with the present invention a graph, that is motion information, can be obtained, so that temporal information concerning the fetal heart can be obtained by analyzing the waveform of the motion information, and, more particularly, a specific time can be determined. For this reason, the time and heart function measurement section 22 which will be described below is provided.

[0034] In the time and heart function measurement section 22, the image data which represents the above-descried graph is input to a smoothing section 40. The smoothing section 40 performs smoothing processing, that is, averaging processing, with regard to the image data. With this processing, noises that are present on the graph can be reduced, so that detection of the maximum value and detection of the minimum value which will be described below can be performed with high precision.

[0035] A detection section 42 applies a method which will be described in detail below to the graph which has been subjected to averaging, to thereby specify, as peaks, the maximum value and the minimum value of the waveform for each heartbeat. Here, when the heart chamber being subjected to area calculation is the left ventricle, it is determined that the maximum value corresponds to the time of the end-diastole and the minimum value corresponds to the time of end-systole. As such, the detection of the maximum value and the minimum value as described above enables detection of information indicative of a specific time, such as R wave which is obtained from an electrocardiographic signal. Here, while the period of the waveform of an actual electrocardiographic signal should be identical with the period of the waveform represented by the above-described graph, if times do not correspond to each other between these graphs, such a time difference may be eliminated by correction, or measurement and calculation may be performed in consideration of the time difference.

[0036] A calculation section 44 specifies the end-diastole and the end-systole from the times indicated by the maximum value and minimum value that are detected, and outputs the timing information indicative of the specified information to the display processing section 20. Further, the calculation section 44 specifies the time of the end-diastole for each heartbeat to thereby calculate the heart rate per minute, and outputs the heart rate to the display processing section 20. The calculation section 44 uses the similar method to further calculate the cardiac cycle and outputs the information to the display processing section 20. Here, it is also possible to sequentially observe the time of the end-systole to thereby calculate the cardiac information rather than sequentially observing the time of the end-diastole to calculate the cardiac information. Alternatively, two calculation results obtained by these two types of information can be compared and adjusted to thereby obtain the cardiac information with higher precision.

[0037] In the present embodiment, the calculation section 44 has a function of calculating the ejection fraction (EF) as an evaluation value for the heart functions. Conventionally, calculation of the ejection fraction through ultrasonic diagnosis of a fetal heart has been problematic because an electrocardiographic signal cannot be obtained. According to the present embodiment, however, the ejection fraction can be calculated in a simple manner by using the specified time phases and the results of area calculation described above. Here, the ejection fraction (EF) can be obtained from the operation "(area at the end-diastole (end-diastolic area) - area at the end-systole (end-systolic area)) / area at the end-diastole (end-diastolic area)", for example. The volume can be used in place of the area. Further, as will be described below, it is also possible, when a plurality of partial regions are set within the heart chamber, to calculate the ejection fraction or the equivalent information for each partial region. The numeral value information indicative of the ejection fraction obtained by the calculation section 44 is output to the display processing section 20.

[0038] Fig. 2 illustrates tomographic image data 100. More specifically, the illustrated tomographic image data 100 is binary data obtained after binarization processing. The region of interest (ROI) is set, by a user or automatically, so as to enclose the left ventricle 104 of a fetal heart, and the region indicated by the ROI is to be subjected to the extraction processing. As a valve is present within the heart and the valve moves periodically, there are cases where a closed region cannot be extracted. In order to deal with such cases, the ROI is set and the extraction operation is executed within the range of ROI, so that a problem that the extraction operation is dispersed can be prevented. Accordingly, when the closed region can reliably be extracted, it is not necessary to set the ROI. In Fig. 2, numeral 102 indicates endocardium, and the portion located internally with respect to the endocardium serving as a boundary is the fetal left ventricle 104 and the portion located externally with respect to the endocardium is cardiac muscle or other sites. In the drawing, other heart chamber such as the left atrium are not shown because these heart chambers are removed from the extraction subjects by setting the ROI.

[0039] As shown in Fig. 2, a center point O of the fetal left ventricle 104 is set, and a plurality of lines 106 extending radially from the center point 104 are also set, as required. Consequently, a plurality of regions (partial regions) r1 to r6 segmented by the plurality of lines 106 are defined, and area calculation can be performed for each partial region r1 to r6. For example, it is possible to generate the above-described graph concerning a region with a greater change in the area, or to form a plurality of graphs and then specify the time phase in heartbeat while comprehensively considering the graphical information.

[0040] With reference to Figs. 3 and 4, the operation of the smoothing section 40 shown in Fig. 1 will be described. Fig. 3 shows a graph 110 which is generated by the graph generation section 38 shown in Fig. 1. In the graph 110, the horizontal axis is a time axis and the vertical axis indicates an area (an area value). In some cases, the graph 110 contains noise or ripple components as illustrated, and there is therefore a possibility that specification of times (time phases) cannot be performed precisely if the maximum and minimum values are detected with this state. Accordingly, the smoothing section 40 performs the averaging processing as shown in Fig. 4 prior to detection of the maximum and minimum values. More specifically, numeral 112 represents a graph after the averaging processing. When the waveform is observed after this averaging processing, three periods clearly appear along the time axis. Here, numeral 114 indicates the upper peak, that is, the maximum value, and numeral 116 indicates the lower peak, that is, the minimum value. The maximum value and the minimum value are specified for each heartbeat.

[0041] Here, there is a possibility, even with the averaging processing described above, of a plurality of local maximum values and a plurality of local minimum values appearing within each heartbeat. Therefore, according to the present embodiment, a time window for searching the local maximum and the local minimum on the time axis, that is, a time condition, is adopted. Such a time condition is determined using the heart rate of a standard fetus. Here, the heart rate of an average fetus is 110 per minute to 160 per minute. In general, a heart rate over 180 beats per minute is diagnosed as tachycardia, and a heart rate under 100 beats per minute is diagnosed as bradycardia. With conversion of the heart rate into the cardiac cycle, a standard cycle of a single heartbeat of a fetus is determined to be 400 to 500 msec. Therefore, a cycle under 330 msec is determined to be tachycardia and a cycle over 600 msec is determined to be bradycardia. As such, a normal cardiac cycle of a fetus can be considered to be 330 msec or more, for example. Specifically, by using, as a determination criteria, the time range shorter than this cycle which serves as one reference, the maximum value and the minimum value for each heartbeat can be precisely determined. While, in the method of the present embodiment which will be described below, the cycle of 300 msec is adopted as an example, it is desirable that the numeral be variably set depending on the situation. Further, when a plurality of time conditions are simultaneously applied, the determination of the maximum and minimum values can be accomplished with an even higher precision.

[0042] Figs. 5 and 6 illustrate a basic principle of the maximum value specification method, only as one example. When a plurality of local maximum values are present within a single heartbeat as shown in Figs. 5 and 6, it is necessary to specify the maximum value among these local maximum values. Accordingly, in the present embodiment, a time condition α is defined, and a time period t between the local maximum detected immediately before the present time and the local maximum currently detected is compared with α. If the condition $t \leq \alpha$ is satisfied, processing in which the temporary maximum value specified heretofore (a candidate maximum value) is updated is executed, while otherwise no such update processing is executed. When searching the maximum value, α can be set to 100 msec or 200 msec. For example, as shown in Fig. 5, when two local maximum values P1 and P2 are present on the graph 120 and P1 is first detected and then P2 is detected within a time range which satisfies the time condition $t \leq \alpha$, the values of P1 and P2 are compared. If P2 is greater than P1, P2 is determined to be the maximum value (candidate). In this case, if another local maximum is present after P2, it is possible to set a new time condition using P2 as a reference, and, in a state where the time condition is satisfied, to perform comparison once again. At this time, the time condition using P1 as a reference may be maintained. In the example shown in Fig. 6 in which two local maximum values P3 and P4 are present on the graph 122, while P4 satisfies a time condition which is defined using P3 as a reference, P4 is smaller than P3. Accordingly, P3 is maintained as the maximum value (candidate).

[0043] Fig. 7 shows an example processing performed by the detection section 42 shown in Fig. 1. A local maximum value P1 is first detected on a graph 124, and a determination width α is first set using P1 as a reference. Then, as a local maximum value P2 which is detected the next is within the range α, the values of P1 and P2 are compared. In this example, because P2 is greater than P1, P2 is designated as a candidate of the maximum value. Then, the time width α is set once again, with P2 being used as a time reference (see A in Fig. 7). Here, the local maximum P1 which is detected first may be set as a fixed time reference.

[0044] After the maximum value candidate P2 is detected, a local maximum is searched for along the time axis direction along the graph 124. In the present embodiment, the search for a minimum value is executed in parallel with the search for the maximum value, and the smallest value of the values which have been referred at any point are always stored. In the example shown in Fig. 7, when no new candidate for the maximum value appears within the range of α with reference to the timing of P2, the local maximum P2 which was previously detected is confirmed to be the maximum value at the termination of the period α (see B in Fig. 7). At the same time, the local minimum value having the smallest value among the values detected until then is determined to be the minimum value. In the example shown in Fig. 7, the local minimum indicated as P3 constitutes the minimum value, and its value is specified as the minimum value (see C in Fig. 7). Here, for measurement of the heart rate and the cardiac cycle with regard to the fetal heart, it is sufficient to specify at least one of the minimum value and the maximum value, while, in the operation example which will be described below, only the time at which the maximum value appears is sequentially specified. More specifically, in that example, monitoring of the time at which the minimum value indicated by P3 appears is not performed.

Nevertheless, if the time phase concerning the minimum value is additionally specified, more precise measurement can be achieved.

[0045] In the present embodiment, at a time point where the time period α elapses from a start point which is the local maximum P2 serving as the maximum value, the heart rate, the cardiac cycle, and the ejection fraction (EF) are calculated. Simultaneously, the maximum value, the minimum value, and the maximum value time (i.e. the end-diastole time) which have been detected until that time are temporarily cleared, and further search is resumed. More specifically, in the next heartbeat, a local maximum P4 which is the maximum value is specified. When a local maximum P5 is detected thereafter, the local maximum P5, whose value is smaller than P4, is disregarded.

[0046] It should be noted that the determination method shown in Fig. 7 is only an example, and various modifications can be considered. For example, as described above, it is possible to fixt the local maximum P1 which is detected first as a start timing for setting the time period α. Further, the time condition which is used for searching the maximum value and the time condition which is used for searching the minimum value may be set individually. It is also possible to define a comparatively short time range $\alpha 1$ using the timing of P2 as a reference, and, when the time period $\alpha 1$ terminates, to determine the maximum value P2 in the current heartbeat and also specify the minimum value in the previous heartbeat that appears prior to the maximum value P2 (see D in Fig. 7). When this is done, however, for calculation of the ejection fraction (EF), in each heartbeat, the maximum value and the minimum value appearing after the maximum value are used. Alternatively, with the timing of the maximum value in the previous heartbeat being used as a reference, the range for searching the maximum value in the following heartbeat may be determined. In such a case, the ranges $\alpha 2$ and $\alpha 3$ are determined, and the search for the maximum value may be performed within the time width W3 which is defined between these values. In addition, while in the above description the determination condition for the time information is illustrated, it may be desirable to additionally set the determination condition concerning the area, for example. For example, the width W1 can be set for determining whether or not the value detected as the maximum value is appropriate. Similarly, the width W2 can be set for determining whether or not the value detected as the minimum value is appropriate. In this regard, a condition may also be set for determining whether or not the ejection fraction which is finally calculated falls within an appropriate range.

[0047] Regardless of the configuration employed, it is always desirable that waveform analysis be performed in such a manner that the maximum value and the minimum value in each heartbeat can be precisely specified on the graph. It is further desirable that the maximum value and the minimum value for each heartbeat which are thus specified are used to calculate the evaluation value for heart function. Here, it is advantageous that erroneous determination in specifying the maximum value and the minimum value can be prevented by defining the determination conditions for the maximum value and the minimum value based on average or standard cardiac cycle and peak values for a fetal heart.

[0048] The flowchart in Fig. 8 illustrates an example operation of the time and heart function measurement section 22 shown in Fig. 1. The flowchart shown in Fig. 8 illustrates an example method for executing the waveform processing shown in Fig. 7. In step S101, initialization with respect to buffers is performed. In the present embodiment, three buffers, that is, a maximum value buffer, a minimum value buffer, and a maximum value time buffer, are provided. With initialization of the maximum value buffer and the maximum value time buffer, 0 is written as a content of the respective buffers. With initialization of the minimum value buffer, a maximum buffer value is provided. It is a matter of course that various methods may be used for the initialization.

[0049] In step S102, when reading the waveform data of the graph generated by the area change measurement section 16 shown in Fig. 1, it is determined whether or not a next set of data is present and, if next data does not exist, this processing is terminated. If the next data is present, on the other hand, the process in step S103 is executed. In step S103, an amount of the waveform data corresponding to one point is read. Then, in step S104, the averaging processing with respect to the waveform data thus read is performed. This averaging processing is moving average processing, for example, in which filtering is performed along the time axis direction so that smoothing with respect to the waveform can be achieved. This processing corresponds to the function of the smoothing section 40 shown in Fig. 1.

[0050] The processes in step S105 and the subsequent steps indicate an example operation of the detection section 42 and the calculation section 44. In step S105, processing for updating the minimum value is executed. More specifically, the value which is currently being referred to and the value stored in the minimum value buffer are compared with each other, and, if the former is smaller, processing for writing this value in the minimum buffer is performed. With this processing, the smallest value is always stored in the minimum value buffer after initialization.

[0051] In step S106, whether or not a time condition is satisfied is determined. More specifically, whether or not the current time is within a period α from the time of appearance of the local maximum which is first detected. When the previous local maximum is not detected, this condition is always determined to be satisfied. In step S107, whether or not the value which is currently being referred to is a local maximum. For example, it is possible to detect a local maximum by obtaining a differential value of the waveform. It the value is not a local maximum value, the above-described processes in step S102 and the following steps are repeated.

[0052] When, on the other hand, it is determined in step S107 that the value which is currently being referred to is a local maximum, the local maximum value which was previously detected and the local maximum value which is currently detected are compared. If the former is greater than the latter, the process proceeds to step S102, whereas if the latter is greater than the former, the process proceeds to step S109.

[0053] In step S109, it is assumed that the local maximum value as a candidate of the maximum value is detected, the content of the maximum value buffer is updated. Specifically, the value of the local maximum newly detected is stored in the maximum value buffer. Further, the content of the minimum value buffer is initialized. Specifically, a largest buffer value is stored in the minimum value buffer, thereby clearing the value which is previously stored. In addition, the content of the maximum value time buffer is updated. Here, the maximum value time buffer, which is a buffer storing the time information in the present embodiment, may be configured to function as a timer. In such a case, in step S109, the maximum value time buffer is initialized, and more specifically, the count value is cleared. Thereafter, the processes in step S102 and the subsequent steps are executed.

[0054] On the other hand, when it is determined, in step S106, that the time condition is not satisfied, that is, when it is determined that the current time point is beyond the range of α from the time of appearance of the local maximum previously detected, in step S110, the values stored in the maximum value buffer and the minimum value buffer at that time point are confirmed, and then the contents are verified. More specifically, whether or not the two values respectively stored in the two buffers are within an optimal range is determined, and if they are within the optimal range, these values are to be used in the calculation in the following step S111. If any error is found in these values, error processing is performed. Here, it is also possible to additionally determine whether or not the heart rate, the cardiac cycle, and the ejection fraction are within an optimal range, so that generation of an error can be automatically recognized.

[0055] In step S111, the heart rate and the cardiac cycle are calculated as cardiac information from the time intervals of a plurality of maximum values which have been detected until the present time. In this case, it is also possible to calculate such information from the time intervals of a plurality of minimum values which have been detected until the present time. Further, the end-diastolic area serving as the maximum value and the end-systolic area serving as the minimum value are used to calculate the ejection fraction. In step S112, the content of all buffers is initialized, and the above-described processing is repeated in a similar manner with regard to the next heartbeat. The flowchart shown in Fig. 8 is only an example, and a variety of algorithms can be adopted as long as the maximum value and the minimum value can be appropriately determined for each heartbeat.

[0056] Fig. 9 conceptually shows the content of processing performed by the time and heart function measurement section 22 shown in Fig. 1. As described above, the cardiac cycle 130 and the heart rate 132 are specified as cardiac information from the graph 112 which represents a change of area, and such information is displayed. Furthermore, on the basis of the graph 112, the end-diastole time 134 and the end-systole time 136 are specified, and displayed as required. Simultaneously, based on the end-diastolic area (the maximum value) 138 and the end-systolic area (the minimum value) 140 specified at the respective times, the ejection fraction serving as an evaluation value is calculated as indicated by numeral 142, and the calculation result is displayed. Here, each of the cardiac cycle 130, the heart rate 132, the end-diastole time 134, and the end-systole time 136 can be considered as a pseudo-electrocardiographic signal 144, that is, as an alternative to an electrocardiographic signal.

[0057] Fig. 10 shows an example display content which is displayed on the display section. Within a display screen 150, a tomographic image 152 is displayed. The tomographic image 152 represents a cross section of the left ventricle 154, and a region of interest 156 is set so as to enclose the left ventricle 154. A change in the area related to the left ventricle is represented by a waveform image 158. Specifically, the waveform image 158 includes a graph 159 in which a marker 160 indicative of the maximum value and a marker 162 indicative of the minimum value are displayed for each heartbeat. The markers are displayed using different shapes or different colors to enable the user to identify marker information and easily recognize the end-diastole time and the end-systole time for each heartbeat. Further, by monitoring such information, it is possible to confirm whether automatic calculation is being performed in an optimal manner.

[0058] The calculation result is displayed on the display screen 150 as numeral information 164. In the present embodiment, the area which continually changes is displayed using numerical values, and the ejection fraction (EF) which is calculated for each heartbeat is also displayed by numerical values. Naturally, a graph indicating a change of the ejection fraction can also be displayed in addition to the graph 159 indicating the change in the area.

[0059] Fig. 11 shows another display example, in which a tomographic image 152A, a waveform image 158, and numeral display 164A are displayed on the display screen 150. In the tomographic image 152A, regions of interest 156A and 156B are set concerning the left ventricle 154A and the right ventricle 154B, respectively, and the area change is observed for each heart chamber. Accordingly, two graphs 159A and 159B are shown in the waveform image 158, representing the area change of the left ventricle and the area change of the right ventricle, respectively. On the respective graphs 159A and 159B, markers 160A and 160B indicative of the maximum values and markers 162A and 162B indicative of the minimum values are shown. In the example shown in Fig. 11, the times on the graph 159B representing the area change of the right ventricle are specified with reference to the graph 159A representing the area change of the left ventricle, so that the times indicated by the markers correspond to each other between the two graphs.

[0060] Naturally, in place of the above structure, a structure may be adopted in which the maximum value and the minimum value are detected independently on each graph 159C, 159D in the waveform image 158, and the corresponding markers are displayed, as shown in Fig. 12.

[0061] Fig. 13 shows another example of setting of a region of interest. Specifically, in the tomographic image 152, an ROI is set so as to enclose the left ventricle, and the internal portion of the ROI is segmented into a plurality of regions r1 to r6. An area change in each region may be represented in a graph. Further, as shown in Fig. 14, the time difference between the graph 159C representing an area change of the left ventricle and the graph 159D representing an area change of the right ventricle, for example, may be displayed. In such a case, the time difference $\Delta t1$ between the maximum values specified in the respective graphs and the time difference $\Delta t2$ between the minimum values specified in the respective graphs may be measured independently. It is well known that in the heart various sites moves at different timings, and a difference in the timings may be indicative of a degree of damage or illness. Accordingly, with quantification of the difference in timings as described above, it is possible to provide a user with information which is useful for diagnosis of disorders or diseases.

[0062] As described above, with the ultrasound diagnosis apparatus in accordance with the present embodiment, it is possible to generate information equivalent to an electrocardiographic signal, which cannot be conventionally observed, on the basis of a tomographic image for each frame, and further to evaluate the heart functions while obtaining such information in real time. Thus, various measurements concerning the fetal heart which cannot be performed in the conventional ultrasonic diagnosis can now be achieved. As such, the present invention advantageously provides an ultrasound diagnosis apparatus which is useful for confirming healthfulness and diagnosing a disease concerning the heart of a fetus.

[0063] While the preferred embodiment of the present invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the scope of the appended claims.

Claims

1. An ultrasound diagnosis apparatus, comprising:

- a transmitter/receiver section (12) for transmitting and receiving ultrasound with respect to a fetal heart;
- a motion information measurement section for measuring motion information representing a temporal change of a shape of the heart caused by periodical motion of the fetal heart, based on data obtained by transmission and reception of the ultrasound; and
- a time measurement section (22) for measuring a specific time in the periodical motion of the fetal heart based on the motion information;
- wherein the motion information measurement section includes:
    - an extraction section for extracting, for each frame, a region corresponding to a portion of interest in the fetal heart based on echo data which is used for forming a tomographic image (152), the echo data having been obtained by transmission and reception of the ultrasound;
    - an area calculation section (36) for calculating an area concerning the region corresponding to the portion of interest for each frame; and
    - a graph generation section (38) for generating, as the motion information, a graph (110, 122, 124) representing a temporal change in the area which is calculated for each frame; wherein

    the time measurement section includes
    a smoothing section (40) for performing smoothing processing with respect to the

graph (110, 122, 124) serving as the motion information and an enddiastole specification section; and
wherein the time measurement section is configured to measure end-diastole and end-systole in the periodical motion of the fetal heart for each heartbeat to thereby identify an end-diastolic area and an end-systolic area for each heartbeat; and
wherein the ultrasound diagnosis apparatus further comprises an evaluation value calculation section for calculating an ejection fraction for evaluating the fetal cardiac function for each heartbeat based on the end-diastolic area and the end-systolic area for each heartbeat
characterized in that
when a plurality of local maximum values (114) is present on the graph (110, 122, 124), the end-diastole specification section is configured to specify the maximum value among the plurality of local maximum values (114) by using a determination window (α) which is smaller than a standard cardiac period concerning the fetal heart
wherein, a time period (t) between a local maximum value detected immediately before a present time and a local maximum value currently detected is compared with the determination window (α) and if the time period (t) is smaller or equal to the determination window (α) a processing in which the temporary maximum value specified heretofore is updated, is executed, while otherwise no such update processing is executed.

2. The ultrasound diagnosis apparatus according to claim 1, further comprising:

   a display processing unit (20, 150) for displaying a graph (110, 122, 124) which is configured to directly or indirectly represent the motion information and a mark indicative of the specific time on the graph (110, 122, 124).

3. A method of processing echo data in an ultrasound diagnosis apparatus, comprising:

   extracting a region corresponding to the left ventricle (104, 154A) or a portion of the left ventricle (104, 154A) in the fetal heart based on echo data which is used for forming a tomographic image (152), the echo data having been obtained by transmission and reception of ultrasound;
   calculating the area of the left ventricle (104, 154A) or a portion of the left ventricle (104, 154A) in units of predetermined time based on echo data obtained by transmitting and receiving ultrasound with respect to a fetal heart and generating a graph (110, 122, 124) representing a temporal change concerning the area of the left ventricle (104, 154A) or a portion of the left ventricle (104, 154A);
   performing smoothing processing with respect to the graph (110, 122, 124) serving as the motion information;
   measuring end-diastole and end-systole in the periodical motion of the fetal heart for each heartbeat to thereby identify an end-diastolic area and the end-systolic area for each heartbeat; and
   calculating an ejection fraction for evaluating the fetal cardiac function for each heartbeat based on the end-diastolic area and the end-systolic area for each heartbeat,
   characterized by
   when a plurality of local maximum values (114) is present on the graph (110, 122, 124), specifying the maximum value among the plurality of local maximum values (114) by using a determination window (α) which is smaller than a standard cardiac period concerning the fetal heart,
   wherein, a time period (t) between a local maximum value detected immediately before a present time and a local maximum value currently detected is compared with the determination window (α) and if the time period (t) is smaller or equal to the determination window (α) a processing in which the temporary maximum value specified heretofore is updated, is executed, while otherwise no such update processing is executed.

Patentansprüche

1. Ein Ultraschall-Diagnosegerät mit:

   - einem Sender-/Empfängerabschnitt (12) zum Senden und Empfangen von Ultraschall bezüglich eines fetalen Herzens;
   - einem Bewegungsinformations-Messabschnitt zum Messen von Bewegungsinformation, die eine zeitliche Änderung der Form des Herzens darstellt, verursacht durch periodische Bewegung des fetalen Herzens, basierend auf Daten, welche durch Senden und Empfangen des Ultraschalls erhalten werden; und
   - einem Zeiterfassungsabschnitt (22) zum Messen einer spezifischen Zeit in der periodischen Bewegung des fetalen Herzens basierend auf der Bewegungsinformation;

   wobei der Bewegungsinformations-Messabschnitt aufweist:

- einen Extraktionsabschnitt zum Extrahieren, für jeden Frame, einer Region entsprechend eines Interessensbereichs in dem fetalen Herzen basierend auf Schalldaten, welche zum Bilden eines tomographischen Bildes (152) verwendet werden, wobei die Schalldaten durch Senden und Empfangen des Ultraschalls erhalten werden;
- einen Zonenberechnungsabschnitt (36) zum Berechnen einer Zone in Bezug auf die Region, entsprechend des Interessenbereiches für jeden Frame; und
- einen Graphenerzeugungsabschnitt (38) zum Erzeugen, als Bewegungsinformation, einen Graphen (110, 122, 124), der eine zeitliche Änderung in der Zone darstellt, welche für jeden Frame berechnet wird; wobei
- der Zeitmessungsabschnitt einen Glättungsabschnitt (40) zum Ausführen eines Glättungsprozesses in Bezug auf den Graphen (110, 122, 124), der als Bewegungsinformation dient und einen enddiastolen Spezifizierungsabschnitt aufweist; und

wobei der Zeitmessungsabschnitt konfiguriert ist, Enddiastole und Endsystole in der periodischen Bewegung des fetalen Herzens für jeden Herzschlag zu messen, um **dadurch** eine enddiastolische Zone und eine endsystolische Zone für jeden Herzschlag zu identifizieren; und
wobei das Ultraschall-Diagnosegerät weiterhin einen Bewertungswert-Berechnungsabschnitt zum Berechnen eines Ausstoßanteils zum Bewerten der fetalen Herzfunktion für jeden Ausstoßschlag, basierend auf der enddiastolischen Zone und der endsystolischen Zone für jeden Herzschlag
dadurch gekennzeichnet, dass
wenn eine Vielzahl der lokalen Maximawerte (114) auf dem Graphen (110, 122, 124) vorhanden sind, der Enddiastolen-Spezifizierungsabschnitt konfiguriert ist, um den Maximumwert unter einer Vielzahl von lokalen Maximawerten (114) unter Verwendung eines Bestimmungsfensters (α) festzulegen, welches kleiner ist als eine Standardherzperiode bezüglich des fetalen Herzens,
wobei eine Zeitperiode (t) zwischen einem lokalen Maximumwert, welcher unmittelbar vor einem gegenwärtigen Zeitpunkt detektiert wurde, und einem lokalen Maximumwert, welcher gegenwärtig detektiert wurde, mit dem Bestimmungsfenster (α) verglichen wird und wenn die Zeitperiode (t) kleiner oder gleich dem Bestimmungsfenster (α) ist, ein Prozess ausgeführt wird, in welchem der temporäre Maximumwert der bis dahin spezifiziert wurde, aktualisiert wird, während andererseits kein solcher Aktualisierungsprozess ausgeführt wird.

2. Ultraschall-Diagnosegerät nach Anspruch 1 mit:

einem Anzeigeprozesseinheit (20, 150) zum Anzeigen eines Graphen (110, 122, 124), der konfiguriert ist, um direkt oder indirekt die Bewegungsinformation und einem Marker zum Kennzeichnen der spezifischen Zeit auf dem Graphen (110, 122, 124) darzustellen.

3. Eine Methode zum Verarbeiten von Schalldaten in einem Ultraschall-Diagnosegerät mit:

- Extrahieren einer Region welche dem linken Ventrikel (104, 154A) oder einem Bereich des linken Ventrikels (104, 154A) in dem fetalen Herzen entspricht basierend auf Schalldaten, welche zum Bilden eines tomographischen Bildes (152) verwendet werden, wobei die Schalldaten durch Senden und Empfangen des Ultraschalls erhalten wurden;
- Berechnen der Zone des linken Ventrikels (104, 154A) oder eines Bereichs des linken Ventrikels (104, 154A) in Einheiten einer vorbestimmten Zeit basierend auf den Schalldaten, welche durch Senden und durch Empfangen von Ultraschall in Bezug auf ein fetales Herz und Erzeugen eines Graphens (110, 122, 124), welcher eine zeitliche Änderung bezüglich der Zone des linken Ventrikels (104, 154A) oder einen Bereich des linken Ventrikels (104, 154A) darstellt;
- Durchführung eines Glättungsprozesses in Bezug auf den Graphen (110, 122, 124), welcher als Bewegungsinformation dient;
- Messen der Enddiastole und der Endsystole in einer periodischen Bewegung des fetalen Herzens für jeden Herzschlag, um **dadurch** eine enddiastolische Zone und die endsystolische Zone für jeden Herzschlag zu identifizieren; und
- Berechnen eines Ausstoßanteils zur Auswertung der fetalen Herzfunktion für jeden Herzschlag, basierend auf der enddiastolischen Zone und der endsystolischen Zone für jeden Herzschlag,

dadurch gekennzeichnet, dass
wenn eine Vielzahl von lokalen Maximawerten (114) auf dem Graphen (110, 122, 124) vorhanden sind, Festlegen des Maximumwertes unter der Vielzahl von lokalen Maximawerten (114) durch Verwendung eines Bestimmungsfensters (α), welches kleiner ist als eine Standardherzperiode bezüglich des fetalen Herzens, wobei eine Zeitperiode (t) zwischen einem lokalen Maximumwert, der unmittelbar vor einem gegenwärtigen Zeitpunkt detektiert wurde, und einem lokalen Maximumwert, welcher gegenwärtig detektiert wurde, mit dem Bestimmungsfenster (α) verglichen wird und wenn die Zeitperiode (t) kleiner oder gleich dem Bestimmungsfenster (α) ist,

ein Prozess ausgeführt wird, in welchem der temporäre Maximumwert der bis dahin spezifiziert wurde, aktualisiert wird, während anderenfalls kein solcher Aktualisierungsprozess ausgeführt wird.

Revendications

1. Appareil de diagnostic à ultrasons comprenant :

- une section émettrice/réceptrice (12), destinée à émettre et recevoir des ultrasons en relation avec le coeur d'un foetus;
- une section de mesure d'informations de mouvement, destinée à mesurer des informations de mouvement représentant un changement temporel d'une forme du coeur provoqué par le mouvement périodique du coeur du foetus, sur la base de données obtenues par transmission et réception des ultrasons ; et
- une section (22) de mesure du temps, destinée à mesurer un temps spécifique dans le mouvement périodique du coeur du foetus, sur la base des informations de mouvement ;
- dans lequel la section de mesure d'informations de mouvement comprend :

  - une section d'extraction pour extraire, pour chaque acquisition, une zone correspondant à une portion d'intérêt du coeur du foetus sur la base des données d'écho qui est utilisée pour former une image tomographique (152), les données d'écho ayant été obtenues par transmission et réception des ultrasons ;
  - une section (36) de calcul d'aire destinée à calculer une aire concernant la région correspondant à la portion d'intérêt pour chaque acquisition ; et
  - une section (38) de génération de graphiques, destiné à générer, en tant qu'information de mouvement, un graphique (110, 122, 124) représentant un changement temporel dans l'aire qui est calculée pour chaque acquisition ; dans lequel

  la section de mesure du temps comprend :

    une section de lissage (40) destinée à la réalisation d'un traitement de lissage vis-à-vis du graphique (110, 122, 124) servant d'information de mouvement et une section de spécification de télédiastole ; et

    dans lequel la section de mesure du temps est configurée pour mesurer la télédiastole et la télésystole dans le mouvement périodique du coeur du foetus pour chaque battement du coeur afin d'identifier ainsi une aire télédiastolique et une aire télésystolique pour chaque battement du coeur ; et

    dans lequel l'appareil de diagnostic à ultrasons comprend de plus une section de calcul d'une valeur d'évaluation destinée à calculer une fraction d'éjection afin d'évaluer la fonction cardiaque du foetus pour chaque battement du coeur sur la base de l'aire télédiastolique et de l'aire télésystolique pour chaque battement du coeur

    caractérisé en ce que

    lorsqu'une pluralité de valeurs maximales locales (114) sont présentes sur le graphique (110, 122, 124), la section de spécification de télédiastole est configurée pour spécifier la valeur maximale parmi la pluralité de valeurs maximales locales (114) en utilisant une fenêtre de détermination (α) qui est plus petite qu'une période cardiaque standard concernant le coeur du foetus,

    dans lequel une période de temps (t) entre une valeur maximale locale détectée immédiatement avant un temps présent et une valeur maximale locale actuellement détectée est comparée avec la fenêtre de détermination (α) et, si la période de temps (t) est plus petite que, ou égale à, la fenêtre de détermination (α), un traitement dans lequel la valeur temporaire maximale spécifiée auparavant est mise à jour, est réalisé, alors que dans le cas contraire, aucun tel traitement de mise à jour n'est réalisé.

2. Appareil de diagnostic à ultrasons selon la revendication 1, comprenant de plus :

  une unité (20, 150) de traitement de la visualisation destinée à afficher un graphique (110, 122, 124) qui est configuré pour représenter, directement ou indirectement, les informations de mouvement et un repère indicatif du temps spécifique sur le graphique (110, 122, 124).

3. Procédé de traitement des données d'écho dans un appareil de diagnostic à ultrasons, comprenant :

  l'extraction d'une zone correspondant au ventricule gauche (104, 154A) ou à une portion du ventricule gauche (104, 154A) dans le coeur d'un foetus sur la base des données d'écho, qui est utilisée pour former une image tomographique (152), les données d'écho ayant été obte-

nues par transmission et réception des ultrasons ;
le calcul de l'aire du ventricule gauche (104, 154A) ou d'une portion du ventricule gauche (104, 154A) dans des unités de temps prédéterminé sur la base des données d'écho obtenues par transmission et réception d'ultrasons en rapport avec le coeur d'un foetus, et la génération d'un graphique (110, 122, 124) représentant un changement temporel concernant l'aire du ventricule gauche (104, 154A) ou d'une portion du ventricule gauche (104, 154A) ;
la réalisation d'un traitement de lissage en relation avec le graphique (110, 122, 124) servant d'information de mouvement ;
la mesure de la télédiastole et de la télésystole dans le mouvement périodique du coeur du foetus pour chaque battement du coeur afin d'identifier ainsi une aire télédiastolique et l'aire télésystolique pour chaque battement du coeur ; et
le calcul d'une fraction d'éjection afin d'évaluer la fonction cardiaque du foetus pour chaque battement du coeur sur la base de l'aire télédiastolique et de l'aire télésystolique pour chaque battement du coeur,
caractérisé par
lorsqu'une pluralité de valeurs maximales locales (114) sont présentes sur le graphique (110, 122, 124), la spécification de la valeur maximale parmi la pluralité de valeurs maximales locales (114) en utilisant une fenêtre de détermination (α) qui est plus petite qu'une période cardiaque standard concernant le coeur du foetus,
dans lequel une période de temps (t) entre une valeur maximale locale détectée immédiatement avant un temps présent et une valeur maximale locale actuellement détectée est comparée avec la fenêtre de détermination (α) et, si la période de temps (t) est plus petite que, ou égale à, la fenêtre de détermination (α), un traitement dans lequel la valeur temporaire maximale spécifiée auparavant est mise à jour, est réalisé, alors que dans le cas contraire, aucun tel traitement de mise à jour n'est réalisé.

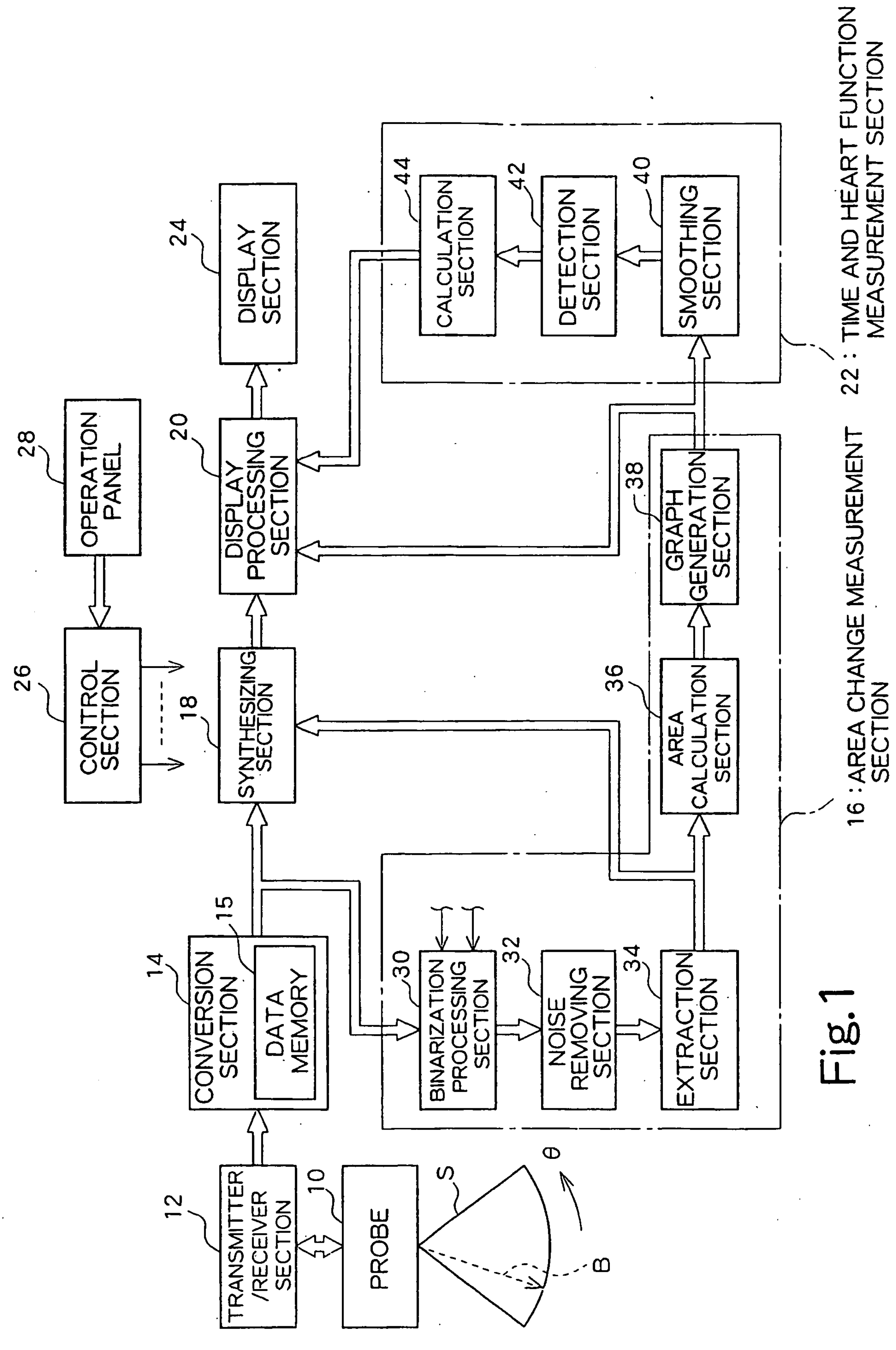
TRANSMITTER /RECEIVER SECTION
12
PROBE
10
S
θ
B
CONVERSION SECTION
14
DATA MEMORY
15
CONTROL SECTION
26
OPERATION PANEL
28
SYNTHESIZING SECTION
18
DISPLAY PROCESSING SECTION
20
DISPLAY SECTION
24
BINARIZATION PROCESSING SECTION
30
NOISE REMOVING SECTION
32
EXTRACTION SECTION
34
AREA CALCULATION SECTION
36
GRAPH GENERATION SECTION
38
SMOOTHING SECTION
40
DETECTION SECTION
42
CALCULATION SECTION
44
16 : AREA CHANGE MEASUREMENT SECTION
22 : TIME AND HEART FUNCTION MEASUREMENT SECTION

Fig.1

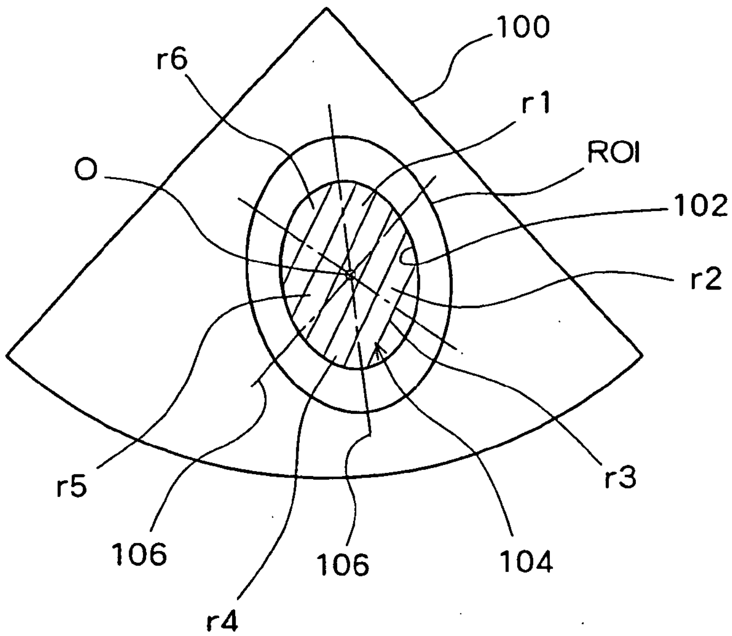

Fig.2

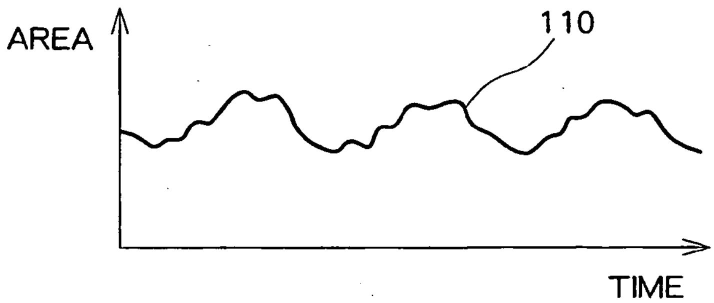

Fig.3

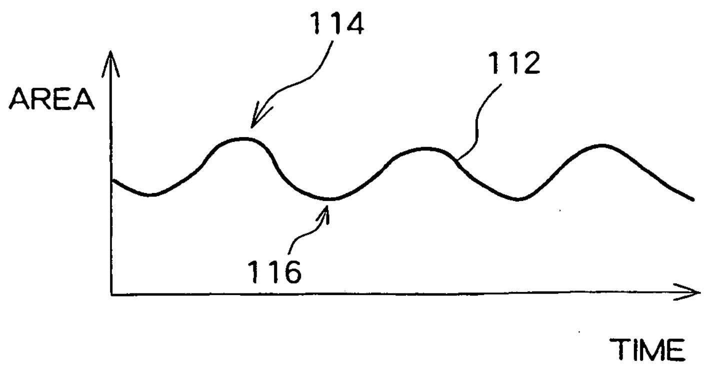

Fig.4

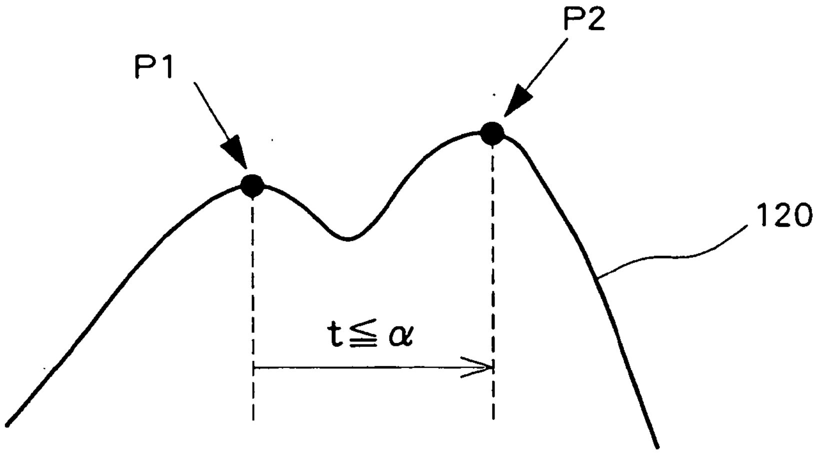

Fig.5

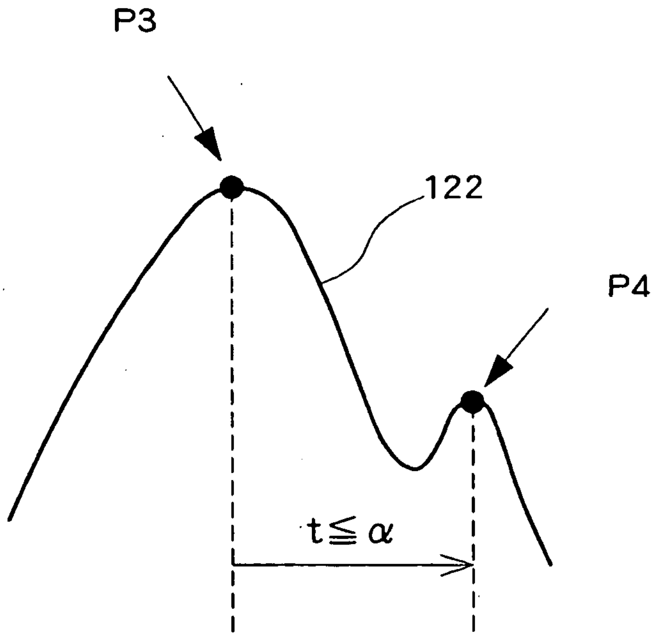

Fig.6

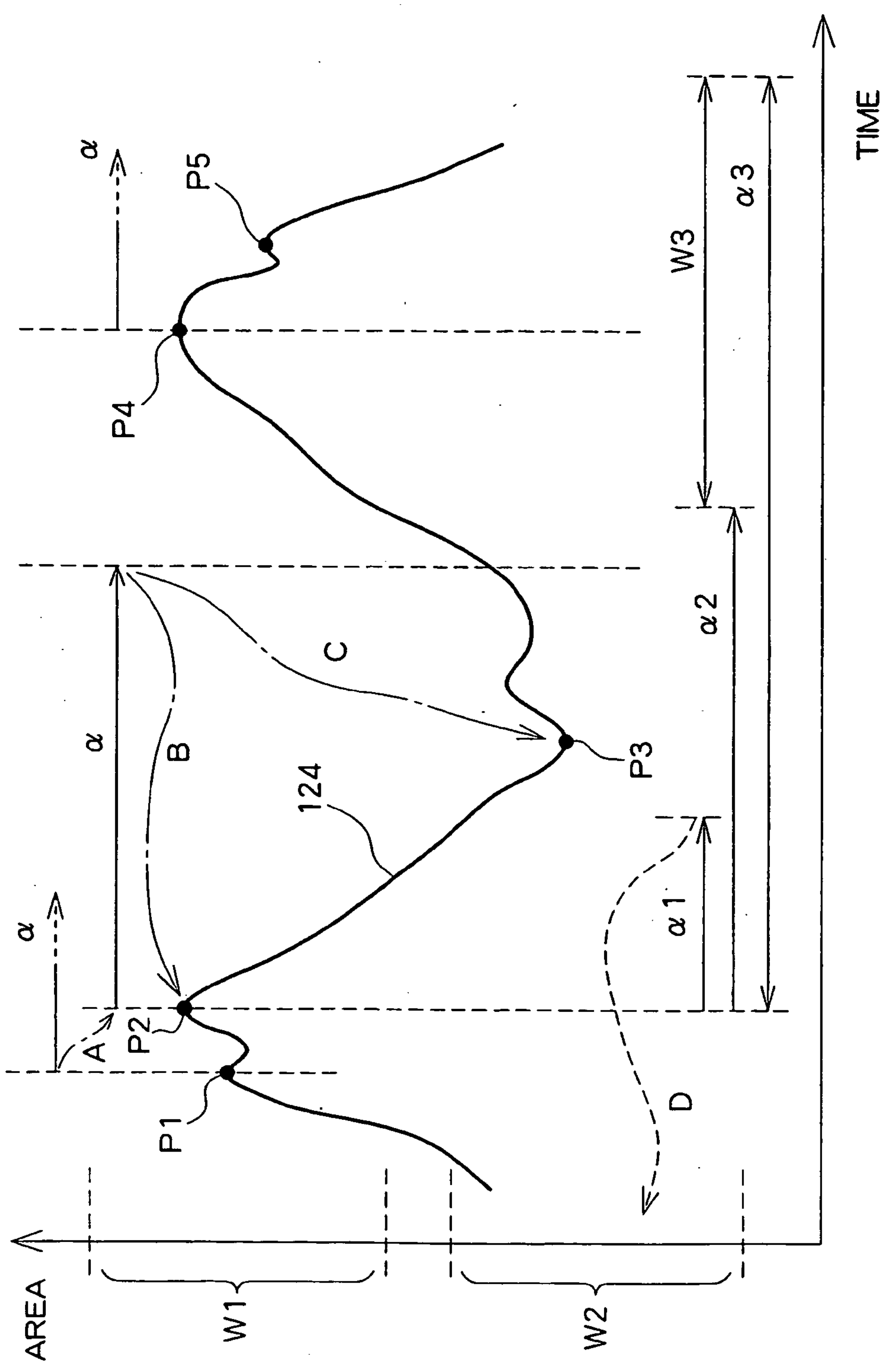

Fig.7

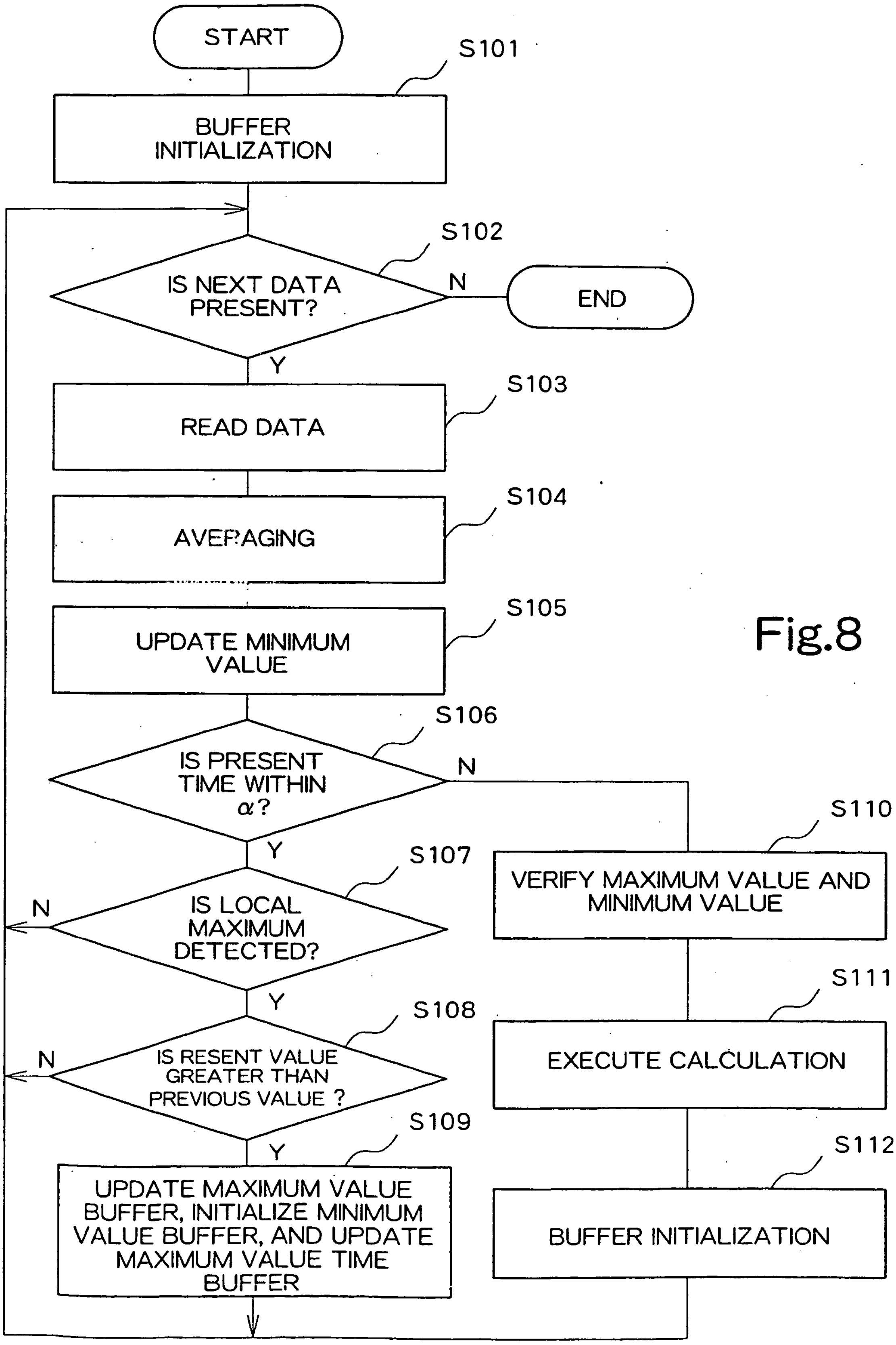
START
S101
BUFFER INITIALIZATION
S102
IS NEXT DATA PRESENT?
N
END
Y
S103
READ DATA
S104
AVERAGING
S105
UPDATE MINIMUM VALUE
S106
IS PRESENT TIME WITHIN α?
N
Y
S107
IS LOCAL MAXIMUM DETECTED?
N
Y
S108
IS RESENT VALUE GREATER THAN PREVIOUS VALUE ?
N
Y
S109
UPDATE MAXIMUM VALUE BUFFER, INITIALIZE MINIMUM VALUE BUFFER, AND UPDATE MAXIMUM VALUE TIME BUFFER
S110
VERIFY MAXIMUM VALUE AND MINIMUM VALUE
S111
EXECUTE CALCULATION
S112
BUFFER INITIALIZATION

Fig.8

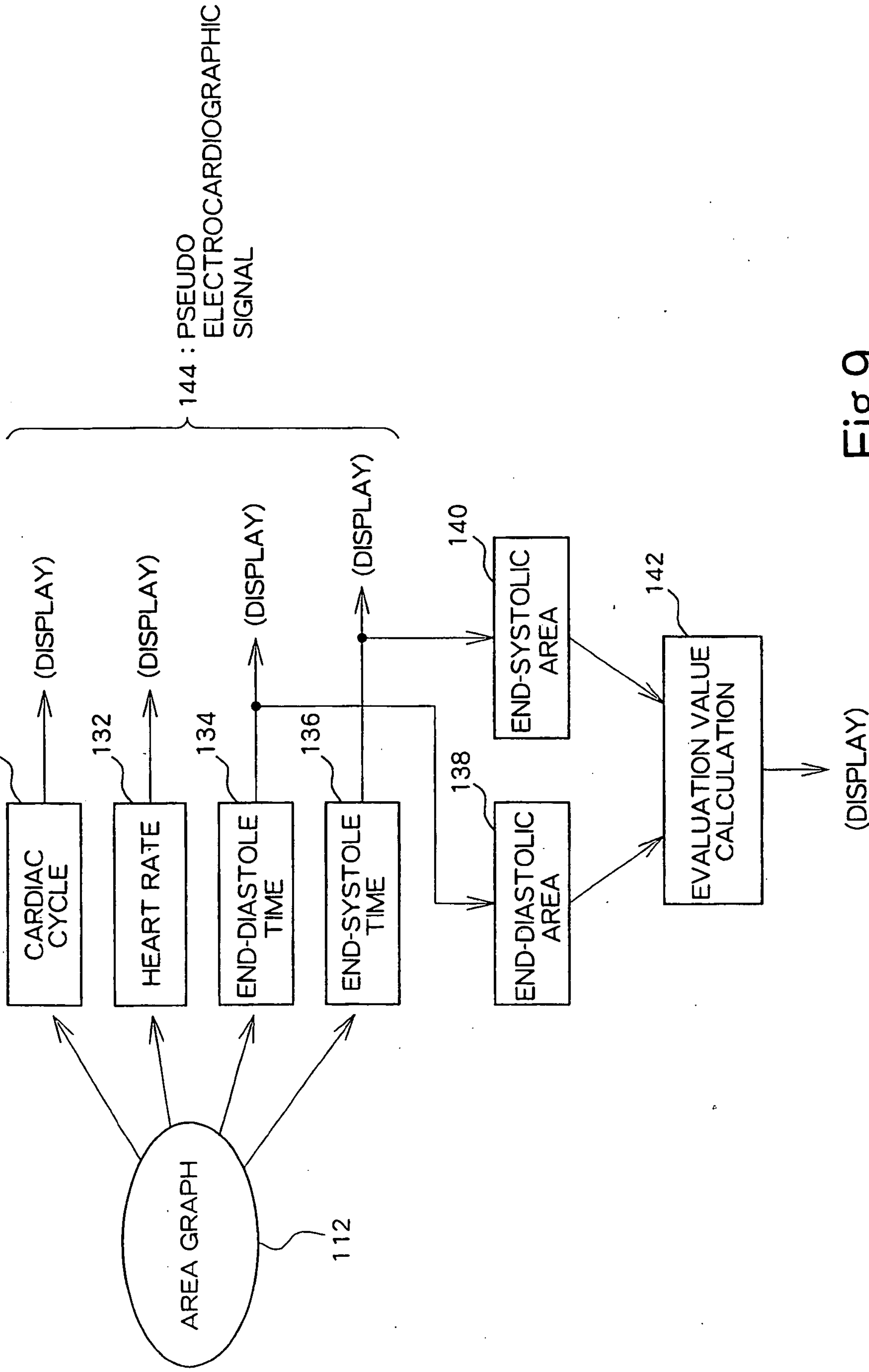
AREA GRAPH
112
CARDIAC CYCLE
130
HEART RATE
132
END-DIASTOLE TIME
134
END-SYSTOLE TIME
136
(DISPLAY)
(DISPLAY)
(DISPLAY)
(DISPLAY)
144 : PSEUDO ELECTROCARDIOGRAPHIC SIGNAL
END-DIASTOLIC AREA
138
END-SYSTOLIC AREA
140
EVALUATION VALUE CALCULATION
142
(DISPLAY)

Fig.9

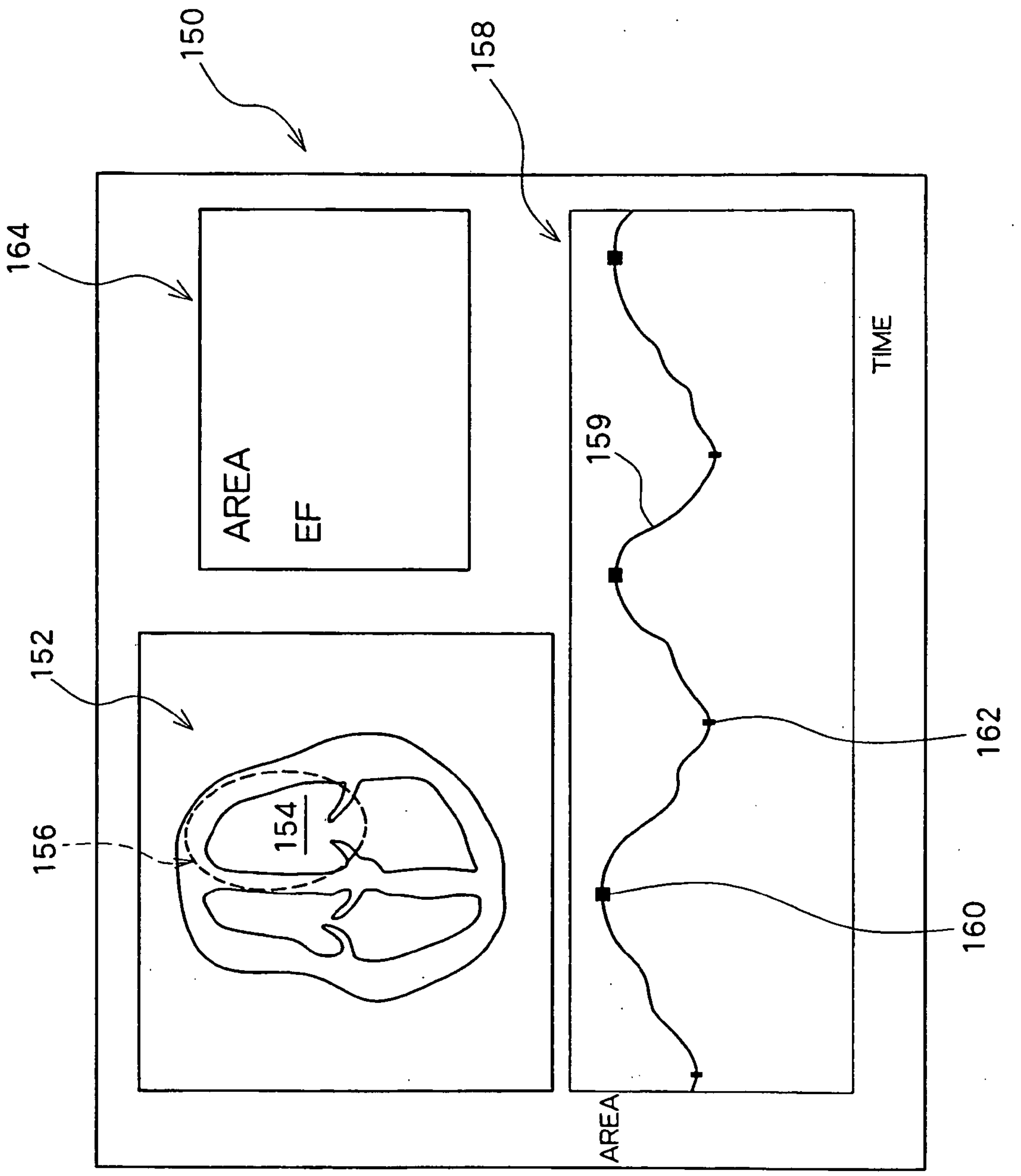

Fig.10

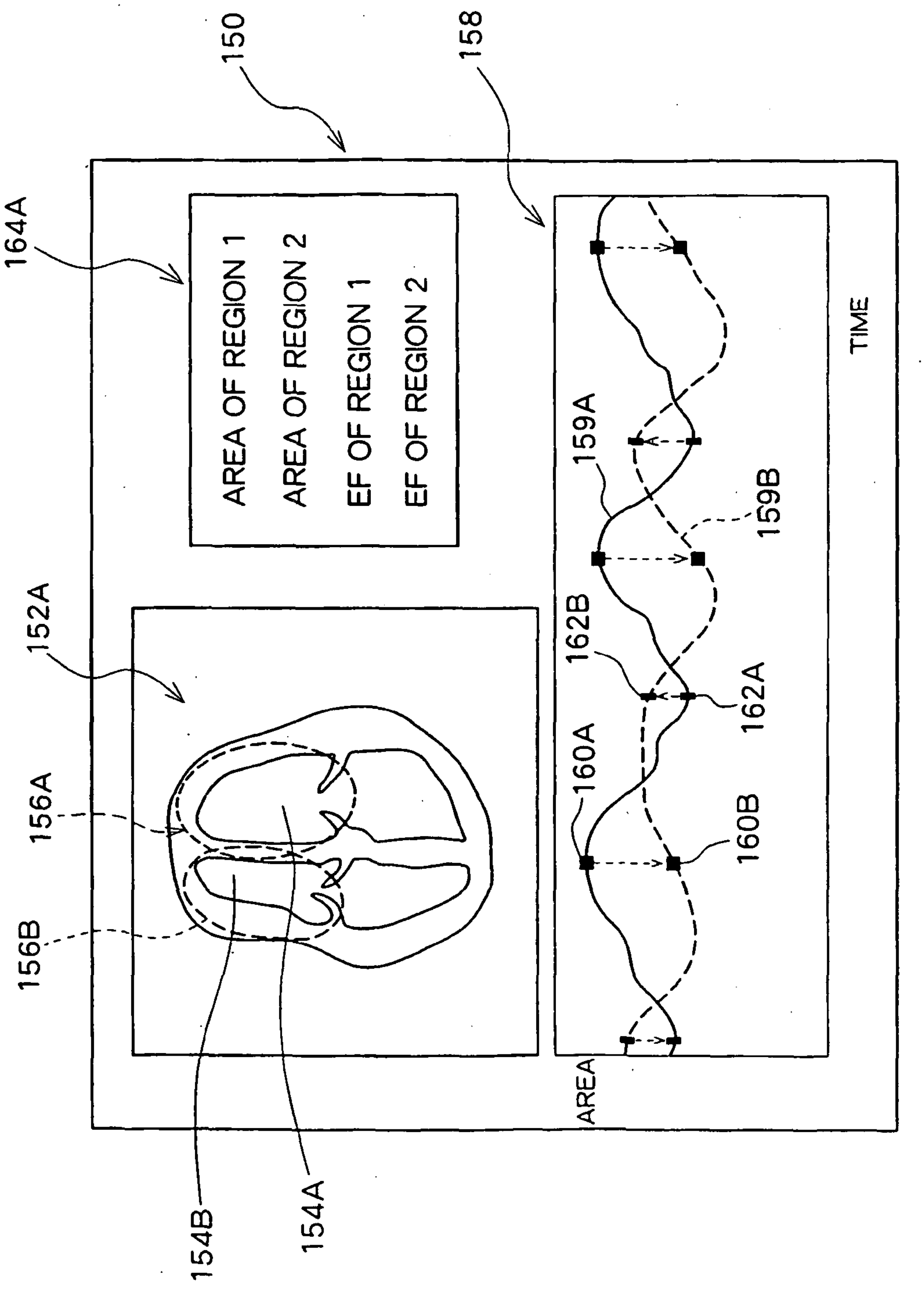
150
158
164A
152A
156A
156B
154B
154A
AREA OF REGION 1
AREA OF REGION 2
EF OF REGION 1
EF OF REGION 2
159A
159B
162B
162A
160A
160B
AREA
TIME

Fig.11

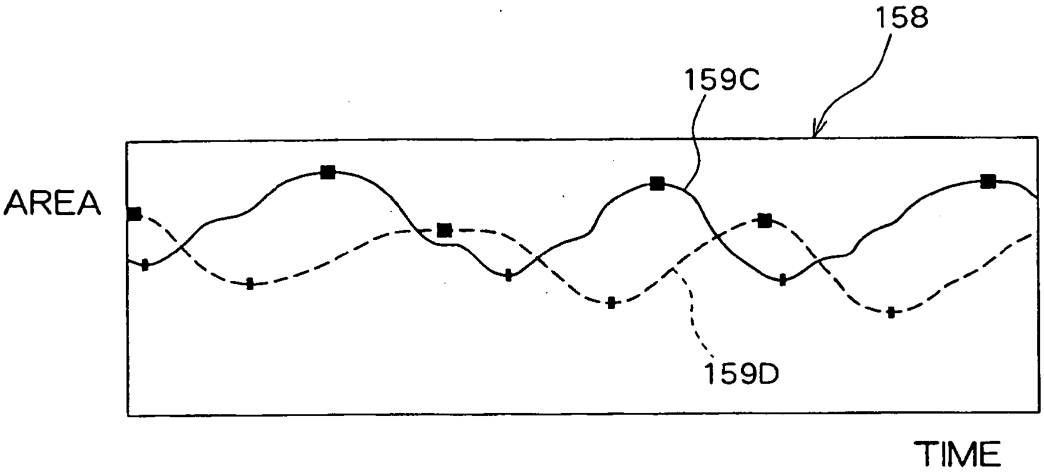

Fig. 12

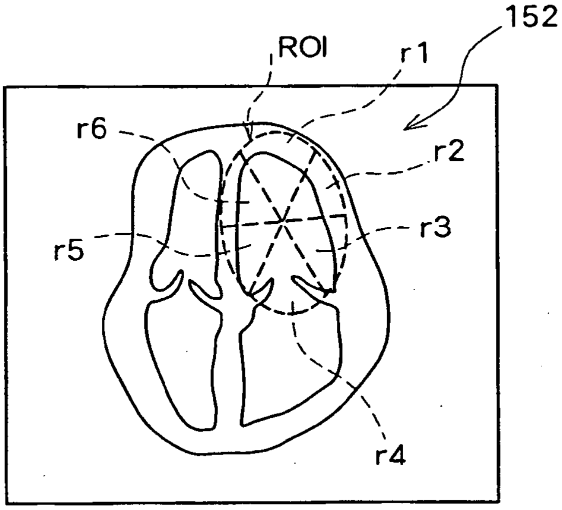

Fig. 13

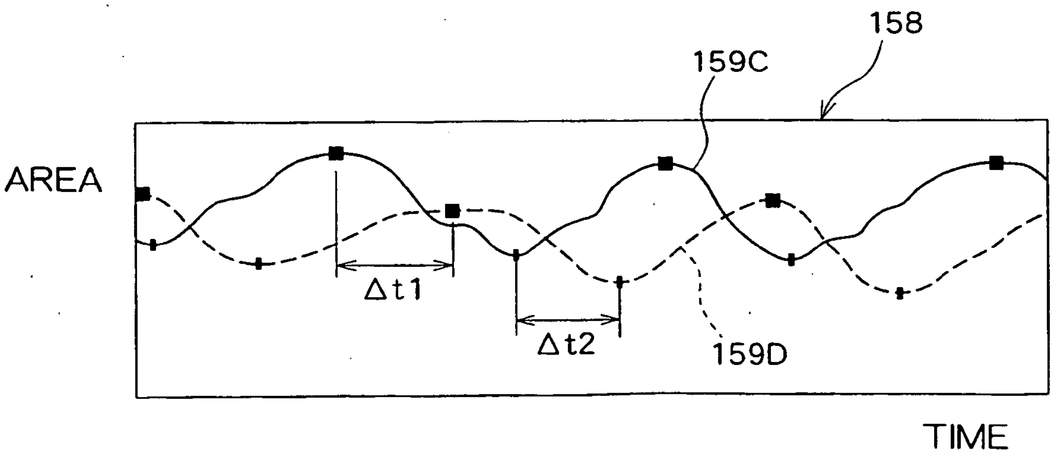

Fig. 14

REFERENCES CITED IN THE DESCRIPTION

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申请(专利权)人(译)	ALOKA CO.，LTD.		
当前申请(专利权)人(译)	日立ALOKA MEDICAL.，LTD.		
[标]发明人	MURASHITA MASARU		
发明人	MURASHITA, MASARU		
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其他公开文献	EP1875867A1		
外部链接	Espacenet		

摘要(译)

一种超声波诊断装置，其对胎儿心脏进行超声波诊断。区域变化测量部分以帧为单位计算胎儿心脏中的特定心室（左心室）的面积。此外，区域变化测量部分生成表示以帧为单位计算的区域的图表。在图中指定最大值和最小值，从而指定舒张末期和收缩末期。基于该信息，计算关于胎儿心脏的心率和心动周期。此外，还从舒张末期区域和收缩末期区域计算射血分数。