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(54) **ULTRASONIC DIAGNOSIS DEVICE**

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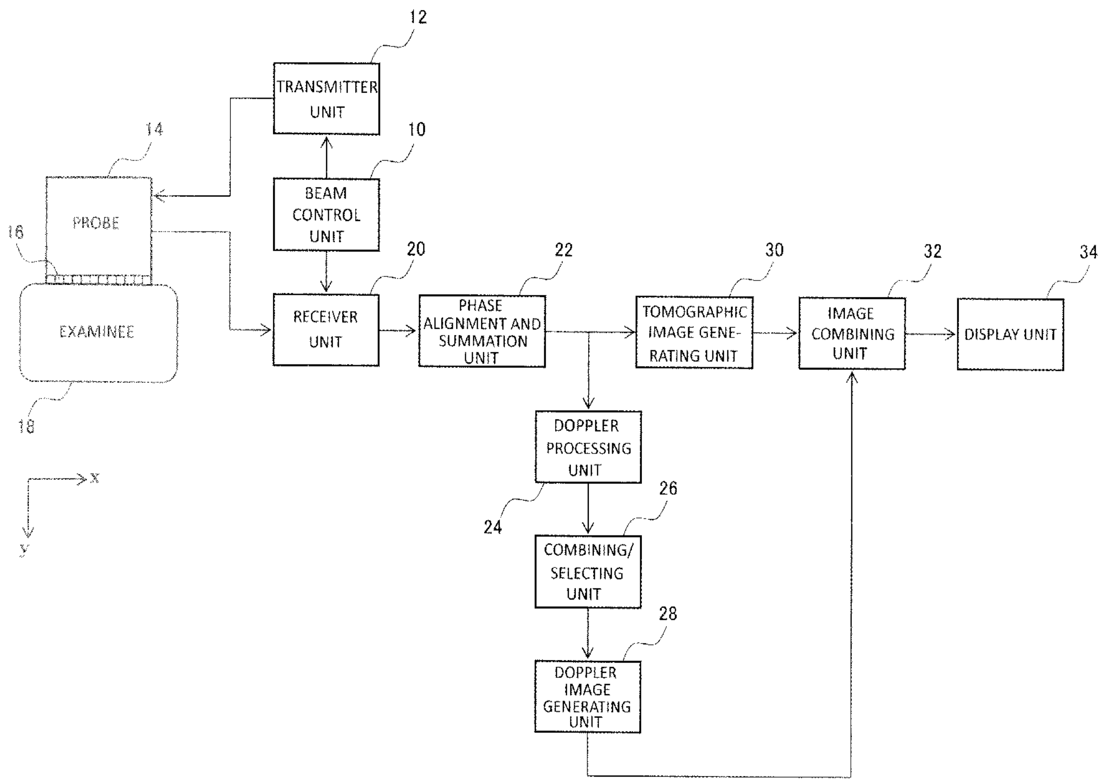
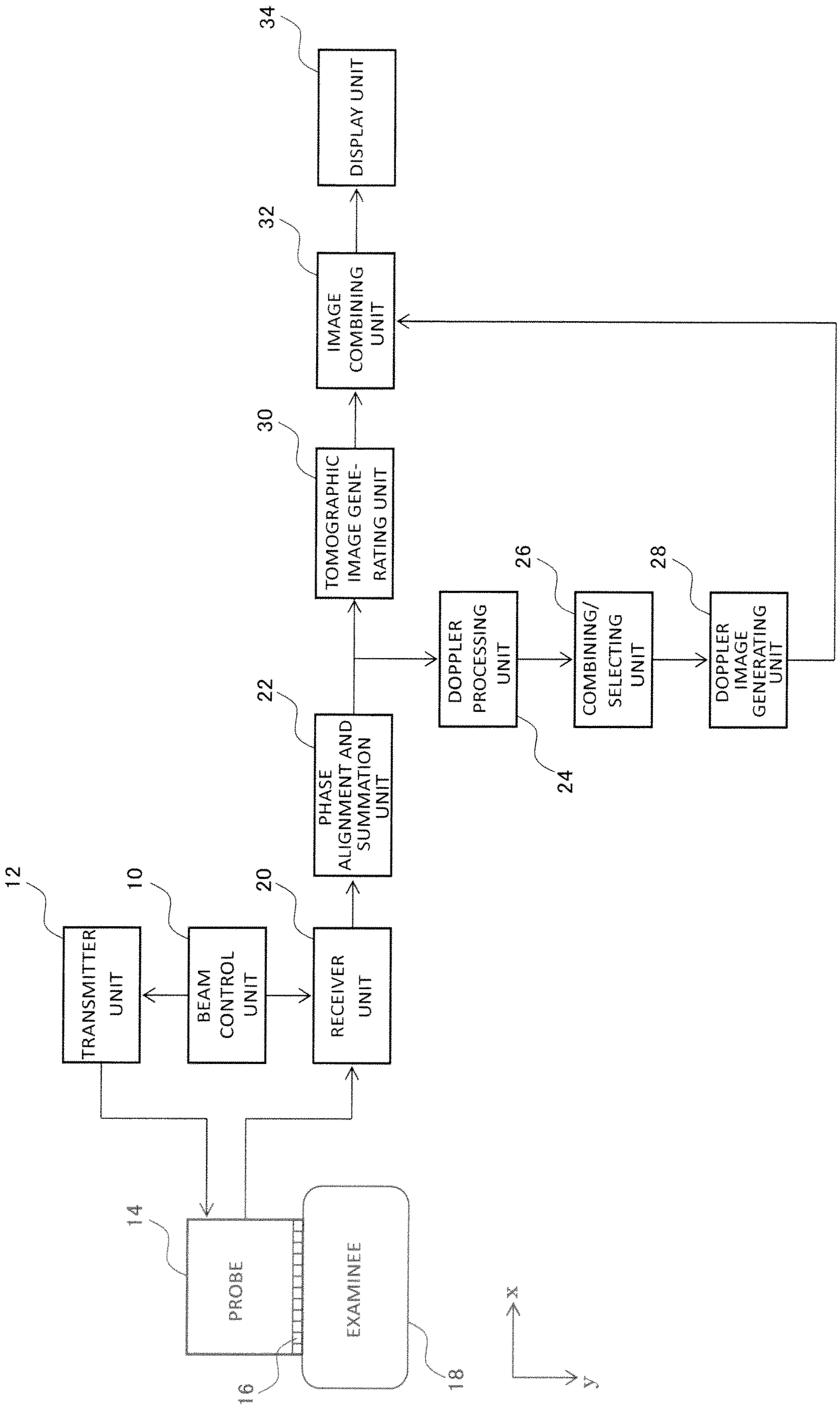
(57) **ABSTRACT**

The purpose of the present invention is to improve the accuracy of Doppler measurements. An ultrasonic diagnosis device comprises: a transmission unit **12** for transmitting, through a probe **14**, an ultrasonic wave for each of a plurality of transmit beams formed at different positions or in different directions; a reception unit **20** for receiving, through the probe **14**, an ultrasonic wave for each receive beam included in a receive beam set formed to correspond to each transmit beam; a Doppler processing unit **24** for determining a Doppler measurement for each of the receive beams; and a combining/selecting unit **26** for combining a first Doppler measurement determined for a first receive beam belonging to a receive beam set formed to correspond to a first transmit beam and a second Doppler measurement determined for a second receive beam belonging to a receive beam set formed to correspond to a second transmit beam when the first receive beam and the second receive beam are in a predetermined positional relationship.





TRANSMITTER UNIT
12
BEAM CONTROL UNIT
10
RECEIVER UNIT
20
PHASE ALIGNMENT AND SUMMATION UNIT
22
TOMOGRAPHIC IMAGE GENE-RATING UNIT
30
IMAGE COMBINING UNIT
32
DISPLAY UNIT
34
DOPPLER PROCESSING UNIT
24
COMBINING/ SELECTING UNIT
26
DOPPLER IMAGE GENERATING UNIT
28
PROBE
14
16
EXAMINEE
18
x
y

FIG. 1

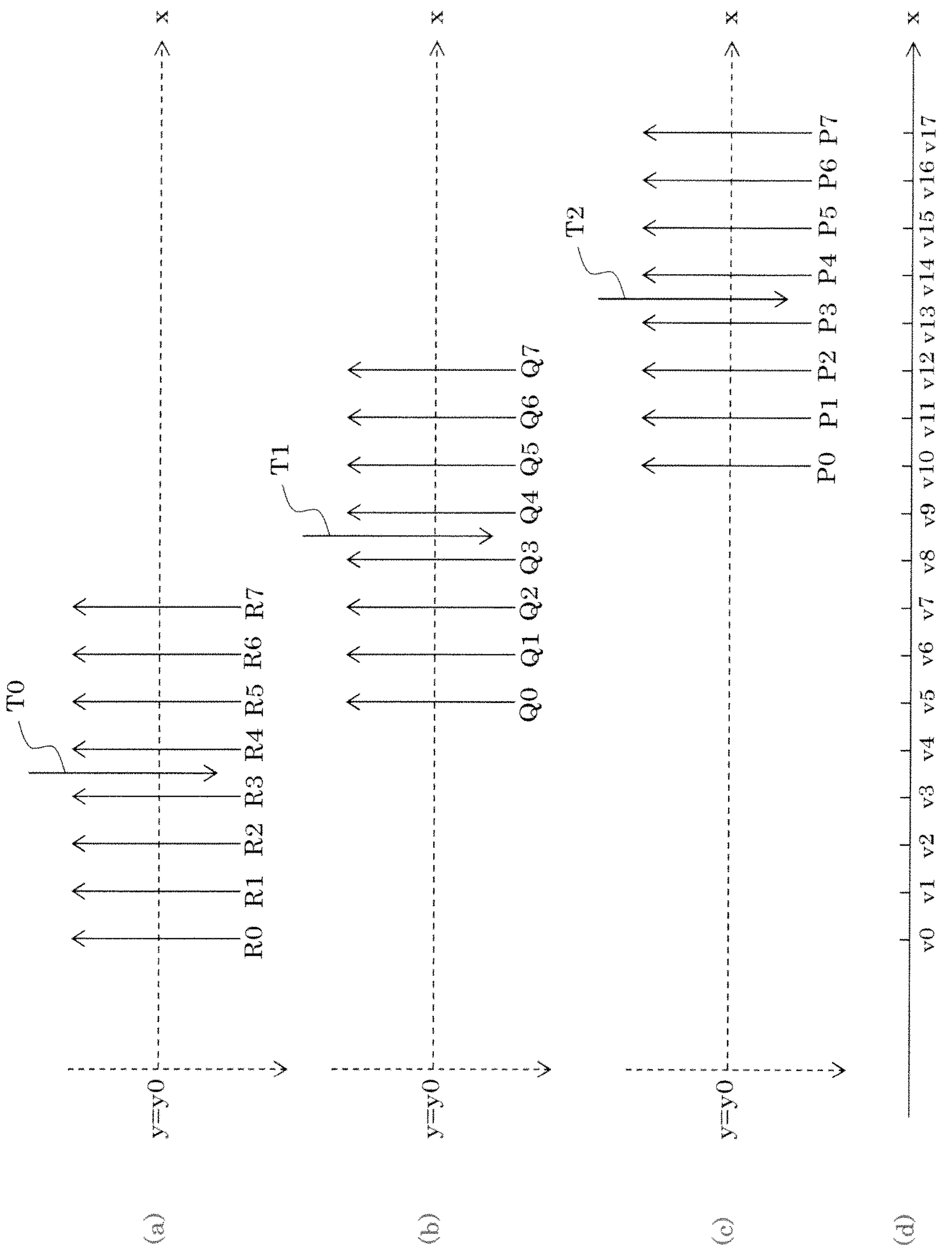

(a)
(b)
(c)
(d)
y=y0
y=y0
y=y0
x
x
x
x
T0
T1
T2
R0 R1 R2 R3 R4 R5 R6 R7
Q0 Q1 Q2 Q3 Q4 Q5 Q6 Q7
P0 P1 P2 P3 P4 P5 P6 P7
v0 v1 v2 v3 v4 v5 v6 v7 v8 v9 v10 v11 v12 v13 v14 v15 v16 v17

FIG. 2

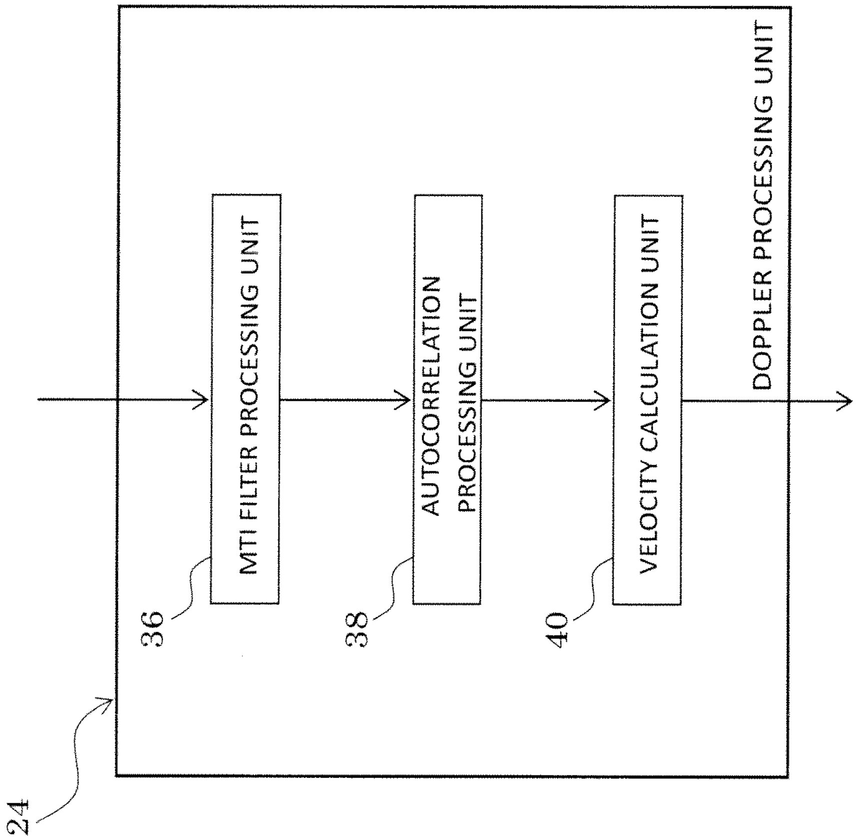

DOPPLER PROCESSING UNIT
MTI FILTER PROCESSING UNIT
AUTOCORRELATION PROCESSING UNIT
VELOCITY CALCULATION UNIT
24
36
38
40

FIG. 3

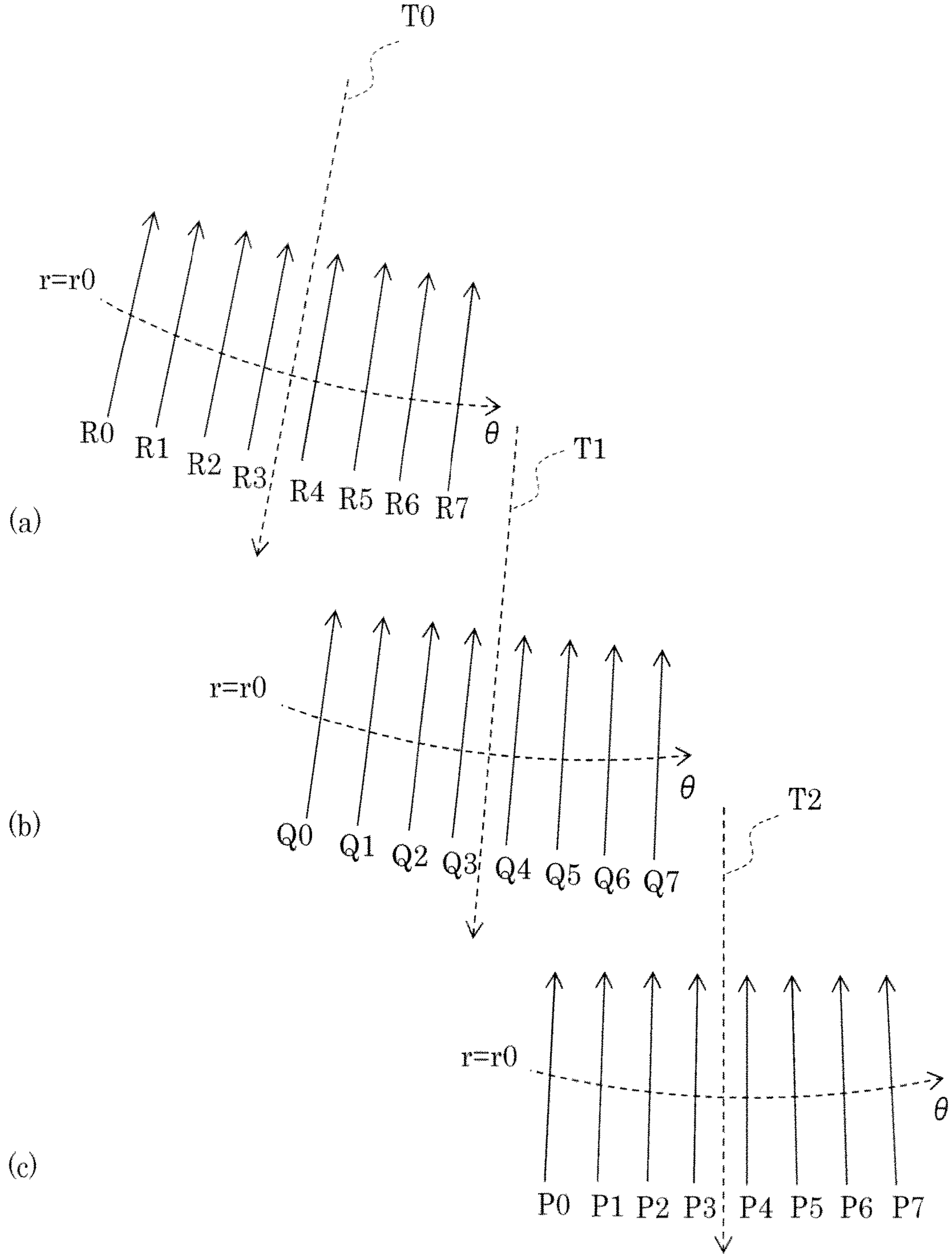

T0
r=r0
θ
R0
R1
R2
R3
R4
R5
R6
R7
(a)
T1
r=r0
θ
(b)
Q0
Q1
Q2
Q3
Q4
Q5
Q6
Q7
T2
r=r0
θ
(c)
P0
P1
P2
P3
P4
P5
P6
P7

FIG. 4

ULTRASONIC DIAGNOSIS DEVICE

TECHNICAL FIELD

[0001] The present invention relates to an ultrasonic diagnostic device, and particularly to an ultrasonic diagnostic device that forms a plurality of received beams at different positions or in different directions for a single transmitting beam.

BACKGROUND

[0002] Ultrasonic diagnostic devices designed for measuring the velocity of blood flow of an examinee using a Doppler technique are widely used. These ultrasonic diagnostic devices include a multiline ultrasonic diagnostic device that transmits ultrasound waves for one transmitting beam, and, based on ultrasound waves received from each direction of a plurality of received beams having different positions or directions, performs Doppler measurement.

[0003] The multiline ultrasonic diagnostic devices described in Patent Documents 1 and 2 transmit ultrasound waves with respect to a plurality of parallel transmitting beams. For each transmitting beam, an ensemble of a plurality of parallel received beams (a set of received beams) is formed, and ultrasound waves are received for each received beam. A received beam outside each ensemble overlaps a received beam outside the adjacent ensemble.

[0004] When received beams that belong to an ensemble formed corresponding to one transmitting beam overlap received beams that belong to an ensemble formed corresponding to another transmitting beam, the Doppler frequency or velocity is determined for one received beam direction, based on each of received data items obtained for the overlapping received beams.

CITATION LIST

Patent Literature

[0005] [Patent Document 1] JP 2010-511420 A

[0006] [Patent Document 2] U.S. Pat. No. 8,475,380 B2, description

SUMMARY

Technical Problem

[0007] In general, the accuracy of Doppler measurement depends on a positional relationship between transmitting beams and received beams. In Doppler measurement performed by forming a plurality of received beams at different positions or in different directions for one transmitting beam, the accuracy of Doppler measurement values, such as Doppler frequency and velocity, may be reduced depending on the positional relationship between the received beams and the transmitting beams.

[0008] An object of the invention is to increase the accuracy of Doppler measurement values.

Solution to Problem

[0009] In accordance with an aspect of the invention, an ultrasonic diagnostic device includes a transmitter unit configured to transmit ultrasound waves for each of a plurality of transmitting beams formed at different positions or in different directions, a receiver unit configured to receive ultrasound waves concerning each of a plurality of received beams in each set of received beams, the plurality of received beams being formed at different positions or in different directions, the each set of received beams being formed corresponding to each transmitting beam, a Doppler processing unit configured to determine a Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit, and a combining unit configured to combine, when a first received beam that belongs to a set of received beams formed corresponding to a first transmitting beam and a second received beam that belongs to a set of received beams formed corresponding to a second transmitting beam are in a predetermined positional relationship, a first Doppler measurement value determined for the first received beam and a second Doppler measurement value determined for the second received beam.

[0010] In embodiments of the present invention, when the first received beam corresponding to the first transmitting beam and the second received beam corresponding to the second transmitting beam are in a predetermined positional relationship, the first Doppler measurement value determined for the first received beam and the second Doppler measurement value determined for the second received beam are combined. This approach can determine correct measurement values based on Doppler measurement values determined for two sets of received beams. The Doppler measurement values in the embodiments of the present invention include, for example, measurement values of Doppler frequencies and measurement values of velocities.

[0011] In preferred embodiments, the combining unit is configured to weight-combine the first Doppler measurement value and the second Doppler measurement value, with weighting in accordance with a positional relationship between the first transmitting beam and the first received beam and a positional relationship between the second transmitting beam and the second received beam.

[0012] In general, the accuracy of Doppler measurement values depends on the positional relationship between transmitting beams and received beams. For example, as a distance between a transmitting beam and a received beam becomes smaller, the accuracy of Doppler measurement values which is determined becomes higher. Further, as the difference between the direction of a transmitting beam and the direction of a received beam becomes closer to 180°, for example, the accuracy of Doppler measurement values which is determined is higher. In embodiments of the present invention, the first Doppler measurement value and the second Doppler measurement value are weight-combined appropriately in accordance with the positional relationship between the transmitting beam and the received beam.

[0013] In preferred embodiments, the transmitter unit is configured to transmit ultrasound waves a plurality of times for one transmitting beam, and the Doppler processing unit is configured to determine the Doppler measurement value for each of the received beams based on ultrasound waves received by the receiver unit a plurality of times. The ultrasonic diagnostic device further includes a variation determining unit configured to determine, for each of the received beams, a variation level based on an amount that contributes to the Doppler measurement value, concerning the ultrasound waves received by the receiver unit a plurality of times for each of the received beams. The combining unit is configured to weight-combine the first Doppler measurement value and the second Doppler measurement value, with weighting in accordance with the variation level determined for each of the first Doppler measurement value and the second Doppler measurement value.

[0014] In embodiments of the present invention, the Doppler processing unit determines a Doppler measurement value for each received beam based on ultrasound waves received by the receiver unit a plurality of times. Further, the variation determining unit determines a variation level for each received beam. In general, as the variation level becomes smaller, the accuracy of Doppler measurement value which is determined becomes higher. According to embodiments of the present invention, the first Doppler measurement value and the second Doppler measurement value are appropriately weight-combined, with weighting in accordance with the variation level concerning an amount of contribution to the Doppler measurement values.

[0015] In accordance with another aspect of the invention, an ultrasonic diagnostic device includes a transmitter unit configured to transmit ultrasound waves for each of a plurality of transmitting beams formed at different positions or in different directions, a receiver unit configured to receive ultrasound waves concerning each of a plurality of received beams in each set of received beams, the plurality of received beams being formed at different positions or in different directions, the each set of received beams being formed corresponding to each transmitting beam, a Doppler processing unit configured to determine a Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit, and a selecting unit configure to select, when a first received beam that belongs to a set of received beams formed corresponding to a first transmitting beam and a second received beam that belongs to a set of received beams formed corresponding to a second transmitting beam are in a predetermined positional relationship, either a first Doppler measurement determined for the first received beam or a second Doppler measurement determined for the second received beam, based on an evaluation condition for each Doppler measurement value.

[0016] In embodiments of the present invention, when the first received beam corresponding to the first transmitting beam and the second received beam corresponding to the second transmitting beam are in a predetermined positional relationship, one of the first Doppler measurement value determined for the first received beam and the second Doppler measurement value determined for the second received beam is selected based on an evaluation condition for each Doppler measurement value. As a result, one of the Doppler measurement values determined for two received beam sets is appropriately selected.

[0017] In preferred embodiments, the selecting unit is configured to select either the first Doppler measurement value or the second Doppler measurement value based on a positional relationship between the first transmitting beam and the first received beam and a positional relationship between the second transmitting beam and the second received beam.

[0018] In general, the accuracy of Doppler measurement values depends on the positional relationship between a transmitting beam and a received beam. According to embodiments of the present invention, one of the first Doppler measurement value or the second Doppler measurement value is selected appropriately based on the positional relationship between the transmitting beam and the received beam.

[0019] In preferred embodiments, the transmitter unit is configured to transmit ultrasound waves a plurality of times for one transmitting beam, and the Doppler processing unit is configured to determine the Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit a plurality of times. The ultrasonic diagnostic device further comprises a variation determining unit configured to determine, for each of the received beams, a variation level based on an amount that contributes to the Doppler measurement value, concerning the ultrasound waves received by the receiver unit a plurality of times for each of the received beams. The selecting unit is configured to select either the first Doppler measurement value or the second Doppler measurement value based on the variation level determined for each of the first Doppler measurement value and the second Doppler measurement value.

[0020] In embodiments of the present invention, the Doppler processing unit determines a Doppler measurement value for each received beam based on ultrasound waves received by the receiver unit a plurality of times. Further, the variation determination unit determines the variation level for each received beam. The accuracy of Doppler measurement values which is determined generally becomes higher as the variation level becomes smaller. According to embodiments of the present invention, one of the first Doppler measurement value and the second Doppler measurement value is selected appropriately based on the variation level concerning the amount of contribution to the Doppler measurement value.

Advantageous Effects of Invention

[0021] According to embodiments of the present invention, the accuracy of Doppler measurement values can be increased.

BRIEF DESCRIPTION OF DRAWINGS

[0022] FIG. **1** is a diagram illustrating the structure of an ultrasonic diagnostic device according to an embodiment of the present invention.

[0023] FIG. **2** is a diagram illustrating an example positional relationship between transmitting beams and received beams when linear scanning is performed.

[0024] FIG. **3** is a diagram illustrating the structure of a Doppler processing unit.

[0025] FIG. **4** is a diagram illustrating an example positional relationship between transmitting beams and received beams when sector scanning is performed.

DESCRIPTION OF EMBODIMENTS

[0026] FIG. **1** illustrates the structure of an ultrasonic diagnostic device according to an embodiment of the present invention. The ultrasonic diagnostic device executes measurement in B-mode and measurement in Doppler mode in time division. The ultrasonic diagnostic device transmits and receives ultrasound waves to and from an examinee **18**. In B-mode, the ultrasonic diagnostic device displays a tomographic image based on ultrasound waves received from the examinee **18**. In Doppler mode, the ultrasonic diagnostic device measures and displays blood flow velocity within the examinee **18** based on Doppler frequencies of ultrasound waves received from the examinee **18**. The blood flow velocity is a vector having a direction and a magnitude and is displayed with graphics such as arrows, a combination of color and luminance, or two component values.

[0027] The structure of the ultrasonic diagnostic device, and processing to be executed by the ultrasonic diagnostic device will be described. A probe **14** is in contact with a body surface of the examinee **18**. In the following description, the direction along the surface of the examinee **18** is referred to as an x-axis direction, and the direction corresponding to the depth direction of the examinee **18** is referred to as a y-axis positive direction. The probe **14** includes a plurality of transducer elements **16**. A transmitter unit **12** outputs transmitting signals to each transducer element **16** of the probe **14** under control of a beam control unit **10**. As a result, ultrasound waves are transmitted from the probe **14**. The beam control unit **10** controls the transmitter unit **12** to form transmitting beams in the probe **14** and scan the transmitting beams with respect to the examinee **18**. More specifically, the transmitter unit **12**, under control of the beam control unit **10**, forms the transmitting beams in the probe **14** while adjusting the delay time and the level of each transmitting signal and scans the transmitting beams with respect to the examinee **18**. In this embodiment, the transmitting beams are directed to the y-axis positive direction and scanned linearly in the x-axis direction.

[0028] Receiving ultrasound waves reflected within the examinee **18**, each transducer element **16** of the probe **14** outputs electrical signals in accordance with the received ultrasound waves to a receiver unit **20**. The receiver unit **20**, under control of the beam control unit **10**, applies amplification, orthogonal detection, and other processing to the received signals output from each transducer element **16**. The receiver unit **20** thus generates received baseband signals of a plurality of channels corresponding to the plurality of transducer elements **16**, and temporarily stores each received baseband signal for phase alignment and summation. Each received baseband signal includes an in-phase component I and an orthogonal component Q. The argument of a vector (I, Q) in an IQ plane represents a phase angle of the received signal, and a variation quantity of the argument of the vector (I, Q) per unit time represents a Doppler frequency.

[0029] A phase alignment and summation unit **22** applies phase alignment and summation to the received baseband signals of a plurality of channels generated in the receiver unit **20** to generate received data. The probe **14** thus forms the received beams and generates the received data based on the ultrasound waves received along the received beams. The received data, similar to the received baseband signals, include an in-phase component and an orthogonal component. The phase alignment and summation unit **22** outputs the received data to a tomographic image generating unit **30** under operation in the B-mode, and outputs the received data to a Doppler processing unit **24** under operation in the Doppler mode.

[0030] The operation in the B-mode will be described. The phase alignment and summation unit **22** applies phase alignment and summation to the received baseband signals of a plurality of channels generated by the receiver unit **20**. The phase alignment and summation unit **22** thereby generates received data based on ultrasound waves received along the received beams in the same direction as the direction of scanned transmitting beams, and outputs the received data to the tomographic image generating unit **30**. The phase alignment and summation unit **22** thus generates each received data item based on ultrasound waves received from each direction of the received beam scanned within the examinee **18**, and outputs the received data to the tomographic image generating unit **30**. The tomographic image generating unit **30** generates tomographic image data based on the received data obtained for each received beam direction, and outputs the tomographic image data to an image combining unit **32**. One tomographic image data item based on the transmitting beam and the received beam for one scanning corresponds to image data of one frame, which, in turn, corresponds to one tomographic image. The beam control unit **10**, the transmitter unit **12**, the probe **14**, the receiver unit **20**, the phase alignment and summation unit **22**, and the tomographic image generating unit **30** sequentially generate tomographic image data in conjunction with repeated scanning of the transmitting beams and the received beams, and output each tomographic image data item to the image combining unit **32**. A plurality of tomographic image data items generated on a time series basis form motion image data.

[0031] The operation in the Doppler mode will be now described. In the Doppler mode, ultrasonic pulses are transmitted a plurality of N times at repeated time intervals T for one transmitting beam direction. The receiver unit **20** generates received baseband signals in accordance with each received ultrasonic pulse reflected within the examinee **18**.

[0032] The phase alignment and summation unit **22** executes processing for forming a plurality of received beams for one time transmission of ultrasonic pulse. More specifically, the phase alignment and summation unit **22** applies phase alignment and summation to the received baseband signals of a plurality of channels generated by the receiver unit **20**, to form a plurality of received beams having the same direction as the direction of the transmitting beam and arranged in parallel to each other. The phase alignment and summation unit **22** then generates received data based on the ultrasound waves received along each received beam. The phase alignment and summation unit **22** subsequently outputs each received data item to the Doppler processing unit **24**.

[0033] FIG. **2** illustrates an example positional relationship between the transmitting beams and the received beams. As illustrated in this drawing, the transmitting beams T**0**, T**1**, and T**2** are formed toward the depth direction (y-axis positive direction). In the example in FIG. **2**(*a*), at the position with depth y=y0, eight received beams R**0** to R7 are formed at equal intervals toward the y-axis negative direction with the transmitting beam T**0** as their center.

[0034] The phase alignment and summation unit **22** generates, concerning each of the ultrasonic pulses transmitted and received for N times, each received data item based on the ultrasound waves received along each of a plurality of received beams.

[0035] When M received beams are formed, N received data items are generated for each of the M received beams, and received data items in the number of (M·N) are output from the phase alignment and summation unit **22** to the Doppler processing unit **24**. In the example illustrated in FIG. **2**(*a*), with M=8, the received beams R**0** to R7 are formed, and received data items in the number of (8·N) are output from the phase alignment and summation unit **22** to the Doppler processing unit **24**.

[0036] As described above, the transmitting beams are scanned linearly in the x-axis direction. The phase alignment and summation unit **22** generates N received data items for each of M received beams, with respect to each position of the transmitting beams linearly scanned in the x-axis direction, and outputs the generated received data to the Doppler processing unit **24**.

[0037] In the example illustrated in FIG. **2**(*b*), the transmitting beam is scanned in the x-axis direction, and the transmitting beam T**1** is formed at a position toward the right from the transmitting beam T**0**, and eight received beams Q**0** to Q**7** are formed toward the y-axis negative direction at equal intervals, with the transmitting beam T**1** as their center, at the position with the depth y=y0. The phase alignment and summation unit **22** performs processing similar to the processing with respect to the received beam R**0** to R**7** illustrated in FIG. **2**(*a*). The phase alignment and summation unit **22** thereby generates each received data item based on ultrasound waves received along each of the received beams Q**0** to Q**7**, for each of the ultrasonic pulses transmitted and received for N times, and outputs each received data item that is generated to the Doppler processing unit **24**.

[0038] In the example illustrated in FIG. **2**(*c*), the transmitting beam is scanned in the x-axis direction, and the transmitting beam T**2** is formed at a position toward the right from the transmitting beam T**1**, and eight received beams P**0** to P**7** are formed toward the y-axis negative direction at equal intervals, with the transmitting beam T**2** as their center, at the position with the depth y=y0. The phase alignment and summation unit **22** performs processing similar to the processing with respect to the received beam R**0** to R**7** illustrated in FIG. **2**(*a*). The phase alignment and summation unit **22** thereby generates each received data item based on ultrasound waves received along each of the received beams P**0** to P**7**, for each of the ultrasonic pulses transmitted and received for N times, and outputs each received data item that is generated to the Doppler processing unit **24**.

[0039] FIG. **3** illustrates the structure of the Doppler processing unit **24**. The Doppler processing unit **24** includes an MTI filter processing unit **36**, an autocorrelation processing unit **38**, and a velocity calculation unit **40**, and executes the following Doppler operation processing with respect to the N received data items obtained for one received beam to obtain velocity measurement values. MTI is an abbreviation of Moving Target Indication.

[0040] The MTI filter processing unit **36** reduces or eliminates, from Doppler frequency components of the received data, components having a frequency which is equal to or less than a predetermined cutoff frequency. The received data item includes an in-phase component and an orthogonal component, each including a Doppler frequency component. The MTI filter processing unit **36** applies processing for reducing or eliminating a Doppler frequency component having a frequency equal to or less than the cutoff frequency, to each of the in-phase component and the orthogonal component contained in the received data.

[0041] The autocorrelation processing unit **38** auto-correlates the N received data items. The received data for the k-th (k=1 to N) ultrasonic pulse, among the N ultrasonic pulses transmitted at the repeated time intervals T, is represented by the following Formula 1:

$$z(y,k)=I(y,k)+j\cdot Q(y,k) \quad \text{[Formula 1]}$$

[0042] In Formula 1, y is a coordinate value in the depth direction, I(y, k) indicates an in-phase component and Q(y, k) indicates an orthogonal component, and j is the imaginary unit. The autocorrelation processing unit **38** determines, in accordance with the following Formula 2, an autocorrelation value S(y) for N received data items z(y, 1), z(y, 2), . . . z(y, N), and outputs the result to the velocity calculation unit **40**.

$$S(y)=\sum_{k=1}^{N-1} z(y,k)\cdot z(y,k+1)^{*} \quad \text{[Formula 2]}$$

[0043] In the above formula, the superscript "*" indicates a complex conjugate. The velocity calculation unit **40** obtains velocity measurement values v(y) according to the following Formula 3 using a real part Re[S(y)] and an imaginary part Im[S(y)] of the autocorrelation value S(y) obtained by the autocorrelation processing unit **38** and outputs the result to a combining/selecting unit **26**.

$$v(y)=\frac{c}{2f_0}\cdot\frac{1}{2\pi T}\arctan\left[\frac{Im[S(y)]}{Re[S(y)]}\right] \quad \text{[Formula 3]}$$

[0044] In Formula 3, c is a propagation velocity of an ultrasound wave propagating within the examinee **18**, and f_0 is a frequency of an ultrasound wave transmitted and received at the probe **14**. Of the right side of Formula 3, a right part with respect to $c/(2f_0)$ represents a Doppler frequency. The velocity measurement value v(y) represents a y-axis direction component of the blood flow velocity at the depth y. When the angle φ formed by the direction of the blood flow with respect to the y-axis is known, v(y)/cos φ is the blood flow velocity.

[0045] When it is not necessary to obtain absolute values of blood flow velocity (values in MKSA system of unit, for example), such as when measuring distribution of the blood flow velocity, the velocity measurement value may be obtained by multiplying the value obtained by Formula 3 by an arbitrary constant. Alternatively, in place of the velocity measurement value, a Doppler frequency measurement value corresponding to the right part of $c/(2f_0)$ in the right side of Formula 3 may be used.

[0046] The Doppler processing unit **24**, according to the processing described above, obtains a velocity measurement value for each of M received beams formed with regard to one transmitting beam, and outputs the velocity measurement value obtained for each received beam to the combining/selecting unit **26**. The Doppler processing unit **24** further obtains a velocity measurement value for each of M received beams, with respect to each position of the transmitting beam linearly scanned in the x-axis direction, and outputs the result to the combining/selecting unit **26**.

[0047] When any of M received beams formed for one of two adjacent transmitting beams and any of M received beams formed for the other transmitting beam overlap, the combining/selecting unit **26** combines the velocity measurement values obtained for each of the overlapping received beams.

[0048] Combining executed by the combining/selecting unit **26** will be described with reference to FIG. **2**. As illustrated in FIGS. **2**(*a*) and (*b*), of the received beams R**0** to R7 formed with the transmitting beam T**0** as their center, the received beam R**5** to R**7** are formed at positions respectively corresponding to the positions where the received beams Q**0** to Q**2**, among the received beams Q**0** to Q**7** formed with the transmitting beam T**1** as their center, are formed. Further, as illustrated in FIGS. **2**(*b*) and (*c*), of the received beams Q**0** to Q**7** formed with the transmitting beam T1 as their center, the received beams Q**5** to Q**7** are formed at positions respectively corresponding to the positions where the received beams P**0** to P**2**, among the received beams P**0** to P7 formed with the transmitting beam T**2** as their center, are formed.

[0049] The combining/selecting unit **26** obtains, concerning each of the positions in the x-axis direction at the depth y=y0 of the received beams R**0** to R7, the received beams Q**3** to Q7, and the received beams P3 to P7, a combined measurement value that is a combined value of the velocity measurement values. More specifically, the combining/selecting unit **26** obtains, concerning the **18** received beams to be observed, which are the received beams R0 to R7, the received beams Q3 to Q7, and the received beams P3 to P7, combined measurement values v0 to v17 sequentially from left to right. FIG. **2**(*d*) indicates a relationship between the positions in the x-axis direction and the combined measurement values v0 to v17.

[0050] The combining/selecting unit **26** first determines the combined measurement values v0 to v4 for the received beams R**0** to R4 to be the same values as the velocity measurement values output from the Doppler processing unit **24**, respectively. The combining/selecting unit **26** then obtains the combined measurement values v5 to v7 for the received beams R**5** to R**7** to be observed, according to Formula 4.

$$\begin{cases} v5 = w5 \cdot v(R5) + (1 - w5) \cdot v(Q0) \\ v6 = w6 \cdot v(R6) + (1 - w6) \cdot v(Q1) \\ v7 = w7 \cdot v(R7) + (1 - w7) \cdot v(Q2) \end{cases} \quad \text{[Formula 4]}$$

[0051] In Formula 4, v(R**5**) to v(R**7**) are velocity measurement values obtained according to Formula 3 for the received beams R**5** to R**7**, respectively, at the depth y=y0. Further, v(Q**0**) to v(Q**2**) are velocity measurement values obtained according to Formula 3 for the received beams Q**0** to Q2, respectively, at the depth y=y0, and w5 to w7 are weighting coefficients determined for the received beams R**5** to R7, respectively. The weighting coefficient w is determined in accordance with a relationship of lengths between an observing side transmitting and receiving distance between a received beam to be observed and a transmitting beam corresponding to the received beam, and a combining side transmitting and receiving distance between a received beam to be combined and a transmitting beam corresponding to the received beam. For example, when the observing side transmitting and receiving distance is greater than the combining side transmitting and receiving distance, the weighting coefficient w is determined within a range of 0<w<0.5. When the observing side transmitting and receiving distance is less than the combining side transmitting and receiving distance, the weighting coefficient w is determined within a range of 0.5<w<1. When the observing side transmitting and receiving distance is equal to the combining side transmitting and receiving distance, the weighting coefficient w is determined as w=0.5.

[0052] In the example illustrated in FIGS. **2**(*a*) and (*b*), assuming that the distance between received beams is D, the distance between the received beam R**5** and the transmitting beam T**0** is 1.5D. The distance between the received beam Q**0** and the transmitting beam T**1** is 3.5D. As the observing side transmitting and receiving distance is therefore smaller than the combining side transmitting and receiving distance, the weighting coefficient w5 is determined within a range of 0.5<w5<1. Further, as the distance between the received beam R**6** and the transmitting beam T**0** is 2.5D and the distance between the received beam Q**1** and the transmitting beam T**1** is also 2.5D, the observing side transmitting and receiving distance and the combining side transmitting and receiving distance are equal to each other, and therefore the weighting coefficient w6 is determined to be 0.5. Further, the distance of the received beam R**7** and the transmitting beam T**0** is 3.5D and the distance between the received beam Q**2** and the transmitting beam T**1** is 1.5D. As the observing side transmitting and receiving distance is therefore greater than the combining side transmitting and receiving distance, the weighting coefficient w7 is determined within a range of 0<w7<0.5.

[0053] The combining/selecting unit **26** then determines the combined measurement values v8 and v9 for the received beams Q**3** and Q**4** to be the same values as the velocity measurement values, respectively, output from the Doppler processing unit **24**. The combining/selecting **26** further obtains the combined measurement values v10 to v12 for the received beams Q**5** to Q**7** to be observed according to Formula 5.

$$\begin{cases} v10 = w10 \cdot v(Q5) + (1 - w10) \cdot v(P0) \\ v11 = w11 \cdot v(Q6) + (1 - w11) \cdot v(P1) \\ v12 = w12 \cdot v(Q7) + (1 - w12) \cdot v(P2) \end{cases} \quad \text{[Formula 5]}$$

[0054] In Formula 5, v(Q**5**) to v(Q**7**) are velocity measurement values obtained according to Formula 3 for the received beams Q**5** to Q**7**, respectively, at the depth y=y0. Further, v(P**0**) to v(P2) are velocity measurement values obtained according to Formula 3 for the received beams P**0** to P2 at the depth y=y0. Also, w10 to w12 are weighting coefficients determined for the received beams Q**5** to Q**7**, respectively. Each weighting coefficient is determined based on the length relationship between the observing side transmitting and receiving distance and the combining side transmitting and receiving distance, similar to Formula 5.

[0055] In the example illustrated in FIGS. **2**(*b*) and (*c*), assuming that the distance between received beams is D, the distance between the received beam Q5 and the transmitting beam T**1** is 1.5D. The distance between the received beam P**0** and the transmitting beam T**2** is 3.5D. As the observing side transmitting and receiving distance is therefore smaller than the combining side transmitting and receiving distance, the weighting coefficient w10 is determined within a range of 0.5<w10<1. Further, as the distance between the received beam Q**6** and the transmitting beam T**1** is 2.5D and the distance between the received beam P**1** and the transmitting beam T**2** is also 2.5D, the observing side transmitting and receiving distance and the combining side transmitting and receiving distance are equal to each other and the weighting coefficient w11 is determined to be 0.5. Further, the distance of the received beam Q7 and the transmitting beam T1 is 3.5D and the distance between the received beam P2 and the transmitting beam T2 is 1.5D. As the observing side transmitting and receiving distance is therefore greater than the combining side transmitting and receiving distance, the weighting coefficient w12 is determined within a range of $0<w12<0.5$.

[0056] Finally, the combining/selecting unit **26** determines the combined measurement values v13 to v17 for the received beams P**3** to P**7** to be as same values as the velocity measurement values output from the Doppler processing unit **24**, respectively.

[0057] When the first received beam that belongs to a set of received beams formed corresponding to a transmitting beam to be observed (the first transmitting beam) and the second received beam that belongs to a set of received beams formed corresponding to another transmitting beam (the second transmitting beam) overlap each other as described above, the combining/selecting unit **26** combines the velocity measurement value as the Doppler measurement value obtained for the first received beam and the velocity measurement value as the second Doppler measurement value obtained for the received beam, to obtain a measurement value for the transmitting beam to be observed.

[0058] The combining/selecting unit **26** generates, based on the combined measurement value obtained for each position (each depth) in the y-axis direction and each position in the x-axis direction, velocity measurement data corresponding to xy coordinate values, and outputs the velocity measurement data to a Doppler image generating unit **28**.

[0059] The Doppler image generating unit **28** generates Doppler image data by transforming the xy coordinate values to coordinates values of the display screen, concerning the velocity measurement data. The Doppler image generating unit **28** may apply to the Doppler image data space filter processing for smoothing variations of pixel values in the display screen direction. A Doppler image represented by the Doppler image data is, for example, a color Doppler image including pixels having colors determined based on the polarity of the combined measurement value. Further, in the Doppler image, the luminance of each pixel may be determined based on the magnitude of the combined measurement value. The Doppler image generating unit **28** outputs the Doppler image data to the image combining unit **32**.

[0060] The Doppler image generating unit **28** may also generate Doppler image data that represents the velocity measurement values by filling patterns, instead of colors. Alternatively, the Doppler image generating unit **28** may generate numerical value image data representing the velocity measurement values by numerical values and graphs, for example.

[0061] The beam control unit **10**, the transmitter unit **12**, the probe **14**, the receiver unit **20**, the phase alignment and summation unit **22**, the Doppler processing unit **24**, the combining/selecting unit **26**, and the Doppler image generating unit **28** repeat scanning of the transmitting beam and each received beam and sequentially generate the Doppler image data, and output each Doppler image data item to an image combining unit **32**. A plurality of Doppler image data items generated in time sequence form motion image data.

[0062] The image combining unit **32**, based on the tomographic image data output from the tomographic image generating unit **30** and the Doppler image data output from the Doppler image generating unit **28**, superposes a Doppler image on a tomographic image to generate a tomographic/Doppler image data, and outputs the tomographic/Doppler image data to a display unit **34**. The display unit **34** displays an image based on the tomographic/Doppler image data. When a plurality of tomographic image data items are output from the tomographic image generating unit **30** in time sequence and a plurality of Doppler image data items are output from the Doppler image generating unit **28** in time sequence, the image combining unit **32** generates the tomographic/Doppler image data in time sequence based on each image data item, and the display unit **34** displays the moving image based on the tomographic/Doppler image data generated in time sequence.

[0063] The display unit **34** may display numerical values or graphs, for example, that represent the velocity measurement values, based on the numerical value image data output from the Doppler image generating unit **28** and input to the image combining unit **32**.

[0064] The above processing determines the velocity measurement value for each of a plurality of received beams formed with respect to each transmitting beam. When any of a plurality of received beams formed for one of adjacent transmitting beams overlaps any of a plurality of received beams formed for the other transmitting beam, the velocity measurement values for the overlapping received beams are weight-combined, and a combined measurement value is obtained. This approach prevents an image based on the Doppler image data from being displayed on the display unit **34** in a discontinuous manner in the screen direction. In color Doppler images, for example, generation of a discontinuous region such as black dot defects at boundaries between an image region formed by one set of received beams and an image region formed by another set of received beams can be reduced. Further, when weight-combining the velocity measurement values for two received beams, the weighting coefficient for a received beam which is closer to a transmitting beam is set greater than that for a received beam which is more distant. Generally, the shorter the distance between a received beam and a transmitting beam corresponding to the received beam, the higher the accuracy of measurement values based on ultrasound waves received according to the received beam. Therefore, the weighted combining as described above enhances the accuracy of the combined measurement values.

[0065] In the above example, the combining/selecting unit **26** weight-combines the velocity measurement values for two overlapping beams. Alternatively, the combining/selecting unit **26** may select one of the two velocity measurement values obtained for two overlapping received beams, based on a predetermined evaluation condition. A value representing the evaluation condition may be, for example, a variation level for a plurality of received data items from which the velocity measurement values have been obtained. More specifically, statistics representing the degree of variation, such as dispersion or standard deviation, for N received data items obtained based on ultrasonic pulses transmitted and received N times are used.

[0066] In this case, the velocity calculation unit **40** in FIG. **3** operates as a variation determining unit that determines, for each received beam, the variation level concerning the amount that contributes to the velocity measurement value. Specifically, the velocity calculation unit **40** uses the real part and the imaginary part of $z(y, k) \cdot z(y, k+1)^*$ which is summed in the right side of Formula 2 to determine a neighboring time-Doppler frequency fa(y, k) according to Formula 6 for each of k=1 to N−1.

$$fa(y, k) = \frac{1}{2\pi T}\arctan\left[\frac{Im[z(y, k) \cdot z(y, k+1)^*]}{Re[z(y, k) \cdot z(y, k+1)^*]}\right] \qquad \text{[Formula 6]}$$

[0067] The velocity calculation unit **40** determines the variation level for N−1 neighboring time-Doppler frequencies fa(y, 1), fa(y, 2), . . . fa(y, N−1), and outputs the result to the combining/selecting unit **26**. The variation level is defined by dispersion, standard deviation, and the like, for the N−1 neighboring time-Doppler frequencies.

[0068] When the first received beam that belongs to a set of received beams formed corresponding to the first transmitting beam and the second received beam that belongs to a set of received beams formed corresponding to the second transmitting beam overlap each other, the combining/selecting unit **26** operates as a selection unit that selects one of the velocity measurement value obtained for the first received beam or the velocity measurement value obtained for the second received beam, based on the evaluation condition for each velocity measurement value.

[0069] The combining/selecting unit **26** first determines selected measurement values v0 to v4 for the received beams R**0** to R**4** to be the same values as the velocity measurement values, respectively, output from the Doppler processing unit **24**.

[0070] The combining/selecting unit **26** selects, of the velocity measurement value v(R**5**) obtained for the received beam R**5** at the depth y=y0 based on Formula 3 and the velocity measurement value v(Q**0**) obtained for the received beam Q0 at the depth y=y0 based on Formula 3, a velocity measurement value with the smaller variation level, as a selected measurement value v5. The combining/selecting unit **26** similarly selects, of the velocity value v(R**6**) obtained for the received beam R**6** and the velocity measurement value v(Q**1**) obtained for the received beam Q**1**, a velocity measurement value with the smaller variation level as a selected measurement value v6. The combining/selecting unit **26** similarly selects, of the velocity measurement value v(R7) obtained for the received beam R7 and the velocity measurement value v(Q**2**) obtained for the received beam Q**2**, a velocity measurement value with the smaller variation level as a selected measurement value v7.

[0071] This processing corresponds to the processing for determining, when the variation level obtained for the received beam to be observed (the first received beam) is smaller than the variation level obtained for the received beam to be combined (the second received beam), the weighting coefficient for the received beam to be observed to be 1 in Formula 4. This processing further corresponds to the processing for determining, when the variation level obtained for the received beam to be observed is greater than the variation level obtained for the received beam to be combined, the weighting coefficient for the received beam to be observed to be 0. For example, when the variation level for the received beam R**5** is smaller than the variation level for the received beam Q**0**, the weighting coefficient w5 is 1. When the variation level for the received beam R**5** is greater than the variation level for the received beam Q**0**, the weighting coefficient w5 is 0.

[0072] The combining/selecting unit **26** similarly selects, of the velocity measurement value v(Q**5**) obtained for the received beam Q**5** and the velocity measurement value v(P**0**) obtained for the received beam P**0**, a velocity measurement value with the smaller variation level, as a selected measurement value v10. The combining/selecting unit **26** further selects, of the velocity measurement value v(Q**6**) obtained for the received beam Q**6** and the velocity measurement value v(P**1**) obtained for the received beam P**1**, a velocity measurement value with the smaller variation level, as a selected measurement value v11. The combining/selecting unit **26** also selects, of the velocity measurement value v(Q7) obtained for the received beam Q**7** and the velocity measurement value v(P**2**) obtained for the received beam P**2**, a velocity measurement value with the smaller variation level, as a selected measurement value v12. Finally, the combining/selecting unit **26** determines selected measurement values v13 to v17 for the received beams P**3** to P**7** to be the same values as the velocity measurement values output from the Doppler processing unit **24**, respectively.

[0073] The combining/selecting unit **26**, based on the selected measurement values obtained for each position (each depth) in the y-axis direction and for each position in the x-axis direction, generates velocity measurement data correlated to xy coordinate values, and outputs the xy coordinate values to the Doppler image generating unit **28**.

[0074] The processing described above selects, of two velocity measurement values obtained for two overlapping received beams, one with a smaller variation, and determines the selected velocity measurement value as a selected measurement value for the two received beams. The variation level indicates the degree of variation of a measurement value based on ultrasonic pulses transmitted and received N times, and usually, as the variation level decreases, the accuracy of the velocity measurement values increases. It is therefore likely that, of two velocity measurement values obtained for two overlapping received beams, the one with the higher measurement accuracy is selected as a selected measurement value.

[0075] One of two velocity measurement values obtained for two overlapping received beams may be selected based on the observing side transmitting and receiving distance and the combining side transmitting and receiving distance. In this case, when the observing side transmitting and receiving distance is smaller than the combining side transmitting and receiving distance, the velocity measurement value obtained for the received beam to be observed is selected, whereas when the observing side transmitting and receiving distance is greater than the combining side transmitting and receiving distance, the velocity measurement value obtained for the received beam to be combined is selected. When the observing side transmitting and receiving distance and the combining side transmitting and receiving distance are equal to each other, either one of the two velocity measurement values is selected as desired.

[0076] In the above example, when two received beams overlap each other, the combined measurement value or the selected measurement value is obtained for the overlapping two received beams. Alternatively, when two received beams are in another predetermined positional relationship, the combined measurement value or the selected measurement value may be determined for the two received beams. For example, when two received beams are within a predetermined distance range at a certain depth, such as when the distance on the x-axis at the depth of y=y0 is equal to or less than a threshold value δ, the combined measurement value or the selected measurement value may be obtained for the two received beams.

[0077] The transmitting beams may be sector-scanned. The sector scanning refers to scanning for oscillating transmitting beams about a reference point fixed for the probe serving as a center. FIG. **4** illustrates an example positional relationship between the transmitting beams and the received beams when sector scanning is performed. In FIG. **4**, an r-axis positive direction is defined in the depth direction, and a θ-axis is defined in the direction in which the transmitting beams oscillate. FIGS. **4** (*a*) to (*c*), which are arranged in the vertical direction for the convenience of explanation, show the transmitting beams and the received beams formed at the same depth with different time points.

[0078] FIG. **4** (*a*) illustrates eight received beams R**0** to R**7** formed at positions with the depth r=r0 at equal angular intervals toward the r-axis direction with a transmitting beam T**0** being their center. FIG. **4** (*b*) illustrates scanning of the transmitting beam in the θ-axis positive direction and forming a transmitting beam T**1** in a direction different from the direction of the transmitting beam T**0**. At positions with the depth r=r0, eight received beams Q**0** to Q**7** are formed at equal angular intervals toward the r-axis direction with the transmitting beam T**1** being their center. FIG. **4** (*c*) illustrates scanning of the transmitting beam in the θ-axis positive direction and forming a transmitting beam T**2** in a direction different from the direction of the transmitting beam T**1**. At positions with the depth r=r0, eight received beams P**0** to P**7** are formed at equal angular intervals toward the r-axis direction with the transmitting beam T**2** being their center.

[0079] The phase alignment and summation unit 22 illustrated in FIG. **1** generates, for each of the ultrasonic pulses transmitted and received N times for one transmitting beam, received data based on ultrasound waves received along each received beam, and outputs each received data unit to the Doppler processing unit **24**.

[0080] The Doppler processing unit **24** obtains a velocity measurement value for each received beam and outputs the velocity measurement values to the combining/selecting unit **26**. When any of M received beams formed for one of two adjacent transmitting beams and any of M received beams formed for the other of the two adjacent transmitting beams overlap each other, the combining/selecting unit **26** combines the velocity measurement values obtained for the overlapping received beams.

[0081] As illustrated in FIGS. **4** (*a*) and (*b*), the received beams R**5** to R**7**, among the received beams R**0** to R**7** formed with the transmitting beam T**0** being as their center, are respectively formed at the same positions as those of the received beams Q**0** to Q**2**, among the received beams Q**0** to Q**7** formed with the transmitting beam T**1** being as their center. Further, as illustrated in FIGS. **4** (*b*) and (*c*), the received beams Q**5** to Q**7**, among the received beams Q**0** to Q**7** formed with the transmitting beam T**1** being as their center, are respectively formed at the same positions as those of the received beams P**0** to P**2**, among the received beams P**0** to P**7** formed with the transmitting beam T**2** being as their center.

[0082] The combining/selecting unit **26** determines, concerning each direction in the θ-axis direction at the depth r=r0 of the received beams R**0** to R**7**, the received beams Q**3** to Q**7**, and the received beams P**3** to P**7**, a combined measurement value by using the velocity measurement value according to Formula 3. Specifically, the combining/selecting unit **26** obtains combined measurement values v0 to v17 for the **18** received beams to be observed, which are the received beams R**0** to R**7**, the received beams Q**3** to Q**7**, and the received beams P**3** to P**7**, sequentially from the left.

[0083] The combining/selecting unit **26** first determines the combined measurement values v0 to v4 for the received beams R**0** to R**4** to be the same values as the velocity measurement values output from the Doppler processing unit **24**, respectively. The combining/selecting unit **26** then obtains the combined measurement values v5 to v7 for the received beams R**5** to R**7** to be observed according to Formula 4.

[0084] The combining/selecting unit **26** further determines the combined measurement values v8 and v9 for the received beams Q**3** to Q**4** to be the same values as the velocity measurement values output from the Doppler processing unit **24**, respectively. The combining/selecting unit **26** then obtains the combined measurement values v10 to v12 for the received beams Q**5** to Q**7** to be observed according to Formula 5.

[0085] The combining/selecting unit **26** further determines the combined measurement values v13 to v17 for the received beams P**3** to P**7** to be the same values as the velocity measurement values output from the Doppler processing unit **24**, respectively.

[0086] The combining/selecting unit **26**, based on the combined measurement value obtained at each position in the r-axis direction (each depth) and each position in the θ-axis direction, generates velocity measurement data corresponding to rθ coordinate values, and outputs the data to the Doppler image generating unit **28**. The Doppler image generating unit **28**, concerning the velocity measurement data, transforms the rθ coordinate values to coordinate values for the display screen to thereby generate Doppler image data.

[0087] In the case of sector scanning, similar to linear scanning, one of two velocity measurement values obtained for two overlapping received beams may be selected based on an evaluation value such as the variation level for each received data item, the observing side transmitting and receiving distance, and the combining side transmitting and receiving distance. Also, in place of combining the velocity measurement values or selecting one of the velocity measurement values when two received beams overlap each other (hereinafter referred to as combining/selecting), combining/selecting may be executed when two received beams are in other predetermined positional relationships. For example, combining/selecting may be executed when two received beams are within a predetermined distance range at a given depth. In this case, when the distance on the θ-axis at the depth r=r0 is a threshold value δ or less, combining/selecting is executed.

[0088] In either linear scanning or sector scanning, the combining of the velocity measurement values when two received beams overlap each other may include, in place of determining a weighting coefficient based on the observing side transmitting and receiving distance and the combining side transmitting and receiving distance, determining a weighting coefficient in accordance with the variation level. For example, the weighting coefficient w for a received beam to be observed is determined within a range of $0<w<0.5$ when the variation level obtained for the received beam to be observed is greater than the variation level for the received beam to be combined. When the variation level obtained for the received beam to be observed is smaller than the variation level for the received beam to be combined, the weighting coefficient w is determined within a range of $0.5<w<1$. When the variation level obtained for the received beam to be observed is equal to the variation level for the received beam to be combined, w=0.5 is determined.

[0089] In the above embodiment, an example in which combining/selecting is executed for three sets of received beams is described. More specifically, in the above example, combining/selecting is executed for received beams on the right end side of one set of received beams and received beams on the left end side of an adjacent set of received beams on the right. Four or more sets of received beams may be used. In this case, similar to the case of three sets of received beams, combining/selecting is executed sequentially from the left such that one or more received beams on the right end side of one set of received beams and one or more received beams on the left end side of one set of received beams to the right are combined or one or more received beams on one side are selected. Alternatively, combining/selecting is executed sequentially from the right such that one or more received beams on the left end side of one set of received beams and one or more received beams on the right end side of one set of received beams to the left undergo combining/selecting.

REFERENCE SIGNS LIST

[0090] **10** beam control unit, **12** transmitter unit, **14** probe, **16** transducer element, **18** examinee, **20** receiver unit, **22** phase alignment and summation unit, **24** Doppler processing unit, **26** combining/selecting unit, **28** Doppler image generating unit, **30** tomographic image generating unit, **32** image combining unit, **34** display unit, **36** MTI filter processing unit, **38** autocorrelation processing unit, **40** velocity calculation unit, T**0** to T**2** transmitting beam, R**0** to R**7**, Q**0** to Q**7**, P**0** to P**7** received beam.

1. An ultrasonic diagnostic device, comprising:

a transmitter unit configured to transmit ultrasound waves for each of a plurality of transmitting beams formed at different positions or in different directions;

a receiver unit configured to receive ultrasound waves concerning each of a plurality of received beams in each set of received beams, the plurality of received beams being formed at different positions or in different directions, the each set of received beams being formed corresponding to each transmitting beam;

a Doppler processing unit configured to determine a Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit; and

a combining unit configured to combine, when a first received beam that belongs to a set of received beams formed corresponding to a first transmitting beam and a second received beam that belongs to a set of received beams formed corresponding to a second transmitting beam are in a predetermined positional relationship, a first Doppler measurement value determined for the first received beam and a second Doppler measurement value determined for the second received beam,

wherein

the combining unit is configured to weight-combine the first Doppler measurement value and the second Doppler measurement value, with weighting in accordance with a distance between the first transmitting beam and the first received beam or a difference in directions between the first transmitting beam and the first received beam, and a distance between the second transmitting beam and the second received beam or a difference in directions between the second transmitting beam and the second received beam, and

the combining unit is configured to set, in weight-combining, greater weighting for the first Doppler measurement value or the second Doppler measurement value that is determined based on a smaller distance between the transmitting beam and the received beam or based on a greater difference in directions between the transmitting beam and the received beam.

2. (canceled)

3. An ultrasonic diagnostic device, comprising:

a transmitter unit configured to transmit ultrasound waves for each of a plurality of transmitting beams formed at different positions or in different directions, the transmitter unit configured to transmit ultrasound waves a plurality of times for one transmitting beam;

a receiver unit configured to receive ultrasound waves concerning each of a plurality of received beams in each set of received beams, the plurality of received beams being formed at different positions or in different directions, the each set of received beams being formed corresponding to each transmitting beam;

a Doppler processing unit configured to determine a Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit a plurality of times; and

a combining unit configured to combine, when a first received beam that belongs to a set of received beams formed corresponding to a first transmitting beam and a second received beam that belongs to a set of received beams formed corresponding to a second transmitting beam are in a predetermined positional relationship, a first Doppler measurement value determined for the first received beam and a second Doppler measurement value determined for the second received beam, and

a variation determining unit configured to determine, for each of the received beams, a variation level based on an amount that contributes to the Doppler measurement value, concerning the ultrasound waves received by the receiver unit a plurality of times for each of the received beams,

wherein

the combining unit is configured to weight-combine the first Doppler measurement value and the second Doppler measurement value, with weighting in accordance with the variation level determined for each of the first Doppler measurement value and the second Doppler measurement value, and

the combining unit is configured to set, in weight-combining, greater weighting for the first Doppler measurement value or the second Doppler measurement value for which the variation level is smaller value or the second Doppler measurement value having a smaller variation value.

4. An ultrasonic diagnostic device, comprising:

a transmitter unit configured to transmit ultrasound waves for each of a plurality of transmitting beams formed at different positions or in different directions;

a receiver unit configured to receive ultrasound waves concerning each of a plurality of received beams in each set of received beams, the plurality of received beams being formed at different positions or in different directions, the each set of received beams being formed corresponding to each transmitting beam;

a Doppler processing unit configured to determine a Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit; and

a selecting unit configure to select, when a first received beam that belongs to a set of received beams formed corresponding to a first transmitting beam and a second received beam that belongs to a set of received beams formed corresponding to a second transmitting beam are in a predetermined positional relationship, either a first Doppler measurement determined for the first received beam or a second Doppler measurement determined for the second received beam, based on an evaluation condition for each Doppler measurement value.

5. The ultrasonic diagnostic device according to claim **4**, wherein

the selecting unit is configured to select either the first Doppler measurement value or the second Doppler measurement value based on a positional relationship between the first transmitting beam and the first received beam and a positional relationship between the second transmitting beam and the second received beam.

6. The ultrasonic diagnostic device according to claim **4**, wherein

the transmitter unit is configured to transmit ultrasound waves a plurality of times for one transmitting beam, and

the Doppler processing unit is configured to determine the Doppler measurement value for each of the received beams based on the ultrasound waves received by the receiver unit a plurality of times,

the ultrasonic diagnostic device comprising a variation determining unit configured to determine, for each of the received beams, a variation level based on an amount that contributes to the Doppler measurement value, concerning the ultrasound waves received by the receiver unit a plurality of times for each of the received beams,

the selecting unit being configured to select either the first Doppler measurement value or the second Doppler measurement value based on the variation level determined for each of the first Doppler measurement value and the second Doppler measurement value.

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摘要(译)

本发明的目的是提高多普勒测量的准确度。一种超声波诊断装置，包括：传输单元 12 ，用于通过探头传输超声波，用于在不同位置或不同位置形成的多个发射波束中的每一个。方向;接收单元 20 ，用于通过探头 14 接收包括在形成为对应于每个发送波束的接收波束组中的每个接收波束的超声波;多普勒处理单元 24 ，用于确定每个接收波束的多普勒测量;组合/选择单元 26 ，用于组合针对属于形成为对应于第一发送波束的接收波束组的第一接收波束确定的第一多普勒测量和针对第二接收确定的第二多普勒测量当第一接收波束和第二接收波束处于预定位置关系时，属于接收波束组的波束形成为对应于第二发射波束。