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(54) ULTRASONIC MEASUREMENT INSTRUMENT

ULTRASCHALLMESSINSTRUMENT

INSTRUMENT DE MESURE ULTRASONORE

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(56) References cited:
JP-A- 3 162 837 **JP-A- 5 281 342**
US-A- 5 339 084

- **YOSHIZAWA M ET AL: "HIGH SIGNAL-TO-NOISE RATIO ULTRASONIC POINT DETECTION METHOD USING A FUSED QUARTZ ROD AS A PULSE COMPRESSION FILTER AND A SENSOR" JAPANESE JOURNAL OF APPLIED PHYSICS, JAPAN SOCIETY OF APPLIED PHYSICS, TOKYO, JP, vol. 36, no. 5B, PART 1, May 1997 (1997-05), pages 3157-3159, XP002934389 ISSN: 0021-4922**
- **PIERO TORTOLI ET AL.: 'Velocity profile reconstruction using ultrafast spectral analysis of doppler ultrasound' IEEE TRANSACTIONS ON SONICS AND ULTRASONICS vol. SU-32, no. 4, July 1985, pages 555 - 561, XP001055073**

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Description

TECHNICAL FIELD

[0001] The present invention relates to a measurement apparatus utilizing ultrasound. In particular, it is related to a measurement apparatus using chirp signals.

BACKGROUND ART

[0002] Conventionally, measurement has been performed and images obtained utilizing reflected ultrasound waves and the like. For example, with an ultrasound diagnosis apparatus, a tomogram of an organism is obtained by transmitting an impulse wave from an ultrasound transducer, receiving back the reflected echo, and then subjecting it to image processing. For such an ultrasound diagnosis apparatus, the deepest invasion depth and highest resolution possible is required.

[0003] There is a pulse compression technique that satisfies this requirement. With this, an originally long pulse is compressed and therefore shortened by subjecting a to-be-transmitted ultrasound signal to FM modulation (hereinafter, the resulting signal is referred to as a chirp signal) and upon reception, passing it through a filter corresponding to the chirp signal. An attempt is then made to increase resolution due to the compression, and at the same time improve the signal-to-noise ratio, and improve the invasion depth.

[0004] Pulse compression is widely used with the objective of attempting to increase transmission energy under the limitation of transmission peak-power in the field of radar and sonar in order to increase survey distance and/or gain higher resolution. Much research on introducing the pulse compression technique with similar objectives is also being carried out in the field of medical ultrasound. Notwithstanding benefits such as being able to improve resolution in a predetermined region in order to allow manipulation of the transmission signal spectrum in the time domain, this pulse compression technique has yet to reach realization in the field of medical ultrasound. Diverse research on utilizing the pulse compression technique that is utilized in such field of radar is being carried out in the field of medical ultrasound.

[0005] JP 3162837 discloses an image processing circuit performing an addition arithmetic operation and a subtraction arithmetic operation of two signals in the up-chirp and down-chirp of a transmission signal from the same echo source of an inputted A mode image signal, and the sum and differential signals can be obtained. As the sum signal, a signal with the same beat frequency is outputted to a fixed target, and a signal with beat of 1/2 of the difference at the mean frequency position of beat frequency of reception signals for two times is outputted to a mobile target. The image processing circuit further integrates the signal, and a signal with an amplitude in proportion to Doppler shift can be obtained. An obtained sum signal from the fixed target is displayed as a B mode image shown in black-and-white display, and the differential signal as Doppler mode image in color display on a display device.

[0006] US 3,165,741 discloses a radar system in which a pulse is split into a plurality of channels, each of the split pulses is delayed and converted in frequency, and the resultant pulses are combined in a time-division multiplex to a resulting pulse.

DISCLOSURE OF THE INVENTION

[0007] The inventors of the present invention have previously published regarding Doppler measurement using complementary chirp signals (signals including both those where the modulating frequency increases (up chirp signal) and those where the modulating frequency decreases (down chirp signal) (refer to Moriya, "Study of a Method for Doppler Measurement Using Complementary Chirp Signals", J. Med. Ultrasonics, Vol. 27, No. 4, 73-P178, 2000, XP 9 057 398, and Japanese Patent Application Laid-open Hei 11-271454, for example). This study is related to measurement covering quick movement detection. Conclusively from this study, chirp signal width must be effectively longer in order to detect slow movement. However, since the detectable frequency displacement corresponds to the time-average of the chirp signal width, chirp signal width cannot be significantly long when detecting slow movement.

[0008] As a result, the object of the present invention is to perform measurement without increasing chirp signal pulse width during measurement utilizing chirp signal ultrasound.

[0009] The object is attained by an ultrasound measurement apparatus according to claim 1. Further developments of the invention are specified in the dependent claims, respectively.

[0010] According to the above configuration, the measurement apparatus of the present invention is capable of performing measurement without increasing pulse width by dividing and then multiplexing the chirp signal spectrum

BRIEF DESCRIPTION OF DRAWINGS

[0011]

FIG. 1a and FIG. 1b are diagrams illustrating up chirp signals.

FIG. 2a and FIG. 2b are diagrams illustrating compressed signals of the up chirp signals.

FIG. 3a and FIG. 3b are diagrams illustrating down chirp signals.

FIG. 4a and FIG. 4b are diagrams illustrating compressed signals of the down chirp signals.

FIG. 5 is a diagram illustrating a structural example of Doppler measurement.

FIG. 6a is a diagram illustrating a multiplexed up chirp signal during Doppler measurement, and FIG.

6b is a diagram illustrating a received chirp signal for a single up chirp signal during Doppler measurement.

FIG. 7a and FIG. 7b are diagrams illustrating waveforms of a single complementary chirp signal after cross-correlation and envelope detection are performed.

FIG. 8a and FIG. 8b are diagrams illustrating waveforms of a multiplexed complementary chirp signal after cross-correlation and envelope detection are performed.

FIG. 9 is a diagram illustrating a structural example of ultrasound tomographic measurement.

BEST MODE FOR CARRYING OUT THE INVENTION

[0012] The embodiments of the present invention are described in detail while referencing the drawings.

[0013] The present invention is one to perform measurement through dividing and then multiplexing the chirp signal spectrum, rather than increasing pulse width.

[DOPPLER MEASUREMENT APPARATUS]

[0014] An embodiment where velocity is measured through utilizing the Doppler effect using up chirp and down chirp signals is described.

[0015] The up chirp and down chirp signals used in Doppler measurement and the Doppler effect for these signals are described using FIG. 1 through FIG. 4.

[0016] To begin with, the case with the up chirp signal is considered. A case where there is no Doppler effect is first dτescribed. FIG. 1(a) is a diagram schematically illustrating a linear FM chirp signal, which is a chirp signal with pulse width T and the frequency of which shows a linear increase from f_1 to $f_2 = f_1 + \Delta f$. When the chirp signal is compressed it becomes a waveform as illustrated in FIG. 2(a). At this point, time delay from an arbitrary base time is assumed to be T_0. Next, a case where there is the Doppler effect is considered. It is to be assumed that the chirp signal illustrated in FIG. 1(a) is frequency-shifted (Doppler shift) in conformity with the Doppler effect illustrated in FIG. 1(b) to become a chirp signal that has changed from $f_1 + f_d$ to $f_2 + f_d$. Here fd denotes the Doppler frequency representing the frequency shift of the Doppler effect, and is assumed to be positive. The compressed waveform of the chirp signal that is frequency-shifted takes on a waveform such as illustrated in FIG. 2 (b), and the delay from the base time is $T_0 - \tau_4$.

[0017] Next, the case with the down chirp signal is considered. In a case without the Doppler effect, FIG. 3(a) schematically illustrates a chirp signal with frequency linearly decreasing from f_2 to $f_1 = f_2 - \Delta f$. A compressed waveform as illustrated in FIG. 4(a) may be obtained by processing this signal. At this point, time delay from the base time is set as T_0.

[0018] In a case with the Doppler effect, it is to be assumed that the chirp signal illustrated in FIG. 3(a) is frequency-shifted in conformity with the Doppler effect to change into a chirp signal with frequency being changed from $f_2 + f_d$ to $f_1 + f_d = f_2 + f_d - \Delta f$ as illustrated in FIG. 3 (b). Since the entire frequency of this signal increases, delay of the compressed waveform from the base time becomes To + τd as illustrated in FIG. 4(b).

[0019] As illustrated in FIG. 2(b) and FIG. 4(b), since the post-compression signals of the up chirp signal and the down chirp signal respectively shift in opposite directions due to the Doppler effect, detection of this shift makes it possible to detect the Doppler-shifted signal itself.

[0020] FIG. 5 is a block diagram illustrating the structure of a measurement apparatus 100 of the present invention. In FIG. 5, an ultrasound wave is transmitted from a probe 120 to a reflector 130, which is moving in the direction of the arrow, and the ultrasound wave reflected from the reflector 130 is then received back by the same probe 120.

[0021] With n divided wave bands of the to-be-used spectrum, the ultrasound wave to be transmitted from the probe 120 is made up of up chirp signals and down chirp signals in the respective bands from n number of down chirp signal generators 112 and 113 and n number of up chirp signal generators 116 and 117. These n number of down chirp signals and n number of up chirp signals are combined through synthesizers 114 and 118, respectively, to create a synthesized up chirp and down chirp signal. Here, this is called a multiplexed complementary chirp signal. Ultrasound signals corresponding to this multiplexed complementary chirp signal are output from the probe 120.

[0022] This transmitted chirp signal is Doppler-shifted when being reflected from the reflector 130, and once again received back by the probe 120. After reception by the probe 120, compressed signals are generated by taking the cross-correlation with the respective band down chirp signals, respectively, which are given from the n number of down chirp signal generators 142 and 143, for each respective band by correlators 152 and 153. Similarly, compressed signals are generated by taking the cross-correlation with the up chirp signals, respectively, which are given from the up chirp signal generators 146 and 147, by correlators 156 and 157. The respective compressed signals are combined through synthesizers 144 and 148 so as to obtain synthesized, compressed signals of the down chirp and the up chirp signals, respectively. Doppler measurement is performed by finding the correlation distance through taking the cross-correlation between these compressed signals by a cross-correlator 160 and performing envelope detection by an envelope detector 170.

[0023] Simulation results of the apparatus configuration of the present invention indicated in FIG. 5 are given in FIG. 6 through FIG. 8.

[0024] The examples illustrated in FIG. 6 through FIG. 8 configure paired multiplexed complementary chirp signals, which are made up of combined up chirp signals of the two bands of 0.5 to 1.0 and 1.0 to 1.5 MHz and combined down chirp signals of the two bands of 1.5 to 1.0 and 1.0 to 0.5 MHz, where pulse width of the to-be-used ultrasound waves is 1000 μs. It should be noted that for comparison a single up chirp signal and a single down chirp signal in the same band are given. Assuming the same rate of frequency change over time, chirp signal width may be shortened by performing frequency division and combining chirp signals.

[0025] FIG. 6 shows the resulting signal from this signal being Doppler-shifted and then received. FIG. 6(a) illustrates the aforementioned multiplexed up chirp signal spectrum where the frequency has shifted 1 kHz, and FIG. 6(b) illustrates a single up chirp signal spectrum for comparison.

[0026] The signal given in FIG. 6(a) is a received chirp signal when combining and transmitting in the time domain the chirp signal of 0.5 to 1 MHz and the chirp signal of 1 to 1.5 MHz. By contrast, the single up chirp signal spectrum illustrated in FIG. 6(b) is a spectrum that is obtained by sweeping from 0.5 to 1.5 MHz in the same time span, rather than by combining. The difference between the signals given in FIG. 6(a) and FIG. 6(b) is that discontinuity occurs in the spectrum.

[0027] It should be noted that an example of two combined chirp signals is given, however, for example, combining chirp signals of 1.5 to 2.0 MHz, namely three or more chirp signals is also possible.

[0028] FIG. 7 shows each normalized waveform that is obtained by taking the cross-correlation between the compressed waveforms of the respective single up chirp signal and single down chirp signal, performing envelope detection, and normalizing it with the maximum value. Similarly, FIG. 8 shows each normalized waveform that is obtained by taking the cross-correlation between the compressed waveforms of the respective multiplexed up chirp signal and multiplexed down chirp signal, performing envelope detection, and normalizing it with the maximum value. In either diagram, (a) illustrates the case where there is no Doppler shift, and (b) illustrates the case where a Doppler shift of 0.5 kHz happens. As illustrated in FIG. 7 and FIG. 8, in the case where the Doppler shift happens, there is peak temporal shift from peak position in the case where there is no Doppler shift. This shift is the correlation distance in cross-correlation and corresponds to the amount of the above Doppler shift, namely amount of frequency shift, as well as velocity. In other words, large shifts lead to high measurement sensitivity. In FIG. 7 and FIG. 8, the peak is shown to be at 2000 in the case where there is no Doppler shift. When a Doppler shift occurs, shift away from the time of 2000 occurs, and the time span thereof corresponds to the Doppler shift.

[0029] The cross-correlated waveform of the multiplexed complementary signal given in FIG. 8 has a shift of approximately twice as in comparison to the cross-correlated waveform of the single complementary signal given in FIG. 7. This is because two chirp signals are combined; whereby the shift triples if three chirp signals are combined, and quadruples if four chirp signals are combined. However, peak-power triples and quadruples (namely, amplitude of the to-be-transmitted chirp signals triples, quadruples) when combined.

[0030] As indicated above, by dividing and combining chirp signal wave bands, only half the pulse width is necessary to cause the same shift to happen. As such, performing Doppler measurement without increasing pulse width is effective.

[RELATIONSHIP BETWEEN MULTIPLEXED UP CHIRP SIGNAL AND MULTIPLEXED DOWN CHIRP SIGNAL]

A. A case where both the up chirp and the down chirp signal are in the same wave band

[0031] The above is an example described in detail, where the up chirp and the down chirp signal are multiplexed with frequencies in the same wave band. For example, assume that transmission/ reception is possible with a probe that covers frequencies of 1 to 4 MHz, and three up chirp signals and three down chirp signals, a total of six-fold, are multiplexed. At this time, all of the up chirp signals in each wave band of 1 to 2, 2 to 3, and 3 to 4 MHz, and the down chirp signals in each wave band of 4 to 3, 3 to 2, and 2 to 1 MHz are combined and transmitted/ received.

[0032] In this case, an up chirp signal compressed waveform is made by combining together the three waveforms resulting from taking cross-correlations between the reception signal and the 1 to 2 MHz up chirp signal, the reception signal and 2 to 3 MHz up chirp signal, and the reception signal and 3 to 4 MHz up chirp signal and then compressing each of them. For a down chirp signal, three compressed waveforms are also similarly combined together.

[0033] This holds the following advantages.

1. The entire spectrum can be utilized.
2. Acoustic feature effects of the organism specimen frequency dependence do not differ between the up chirp and the down chirp signal

[0034] However, the following disadvantage exists.

1. Since the multiplexed chirp signal is a periodic function along the frequency axis, the compressed signal has discrete values and finding of peak position is difficult (This resembles a discrete spectrum resulting from subjecting the periodic function to Fourier expansion).

B. A case where the up chirp and the down chirp signal are respectively in separate wave bands

[0035] The up chirp and the down chirp signal are multiplexed in separate wave bands. For example, assume that a probe covering frequencies of 1 to 4 MHz can perform transmission/ reception, and three up chirp signals and three down chirp signals, a total of six-fold, are multiplexed. At this time, all of the up chirp signals of 1 to 1.5, 1.5 to 2, and 2 to 2.5 MHz, and the down chirp signals of 4 to 3.5, 3.5 to 3, and 3 to 2.5 MHz are combined together and transmitted/ received.

[0036] In this case, returning to the pre-multiplexing chirp signals by filtering the multiplexed complementary chirp signals, they are then linked together along the time axis, cross-correlation with the originally provided chirp signal is taken and then compressed. For example, up chirp signals of 1 to 1.5, 1.5 to 2, and 2 to 2.5 MHz are separated from one another through a filter, which are then linked together; producing a 1 to 2.5 MHz up chirp signal. Cross-correlation with the pre-prepared 1 to 2.5 MHz up chirp signal is taken and then compressed. The down chirp signal is similarly processed. Dividing the spectrum is necessary in order to allow for separation of the up chirp and the down chirp signal through a filter (namely, separate into six chirps).

[0037] This holds the following advantage.

1. Since they do not make a periodic function along the frequency axis regardless of being multiplexed, the compressed signal is successive and the peak position is easily found.

[0038] However, the following disadvantages also exist.

1. The spectrum that the respective up chirp and down chirp signals can utilize becomes half.
2. Since acoustic feature effects of the organism specimen frequency dependence differ between up chirp signals and down chirp signals, Doppler shift measurement may be effected.

[ULTRASOUND TOMOGRAPHIC APPARATUS]

[0039] Combining two or more spectra together and then transmitting/ receiving chirp signals may also be utilized in ultrasound tomographic apparatus, which are used for diagnosis of the abdomen and the like, apart from the above Doppler shift measurement. When using a single probe (single used with many ultrasound tomographic apparatus), since the time span of the chirp signal is longer than that of an impulse signal, which is a general pulse echo method transmission wave, receiving reception signals during transmission is not possible. Thus, by providing a delay transmission path in accordance with the chirp signal time span, the reflected reception waves are kept from reaching the probe until all transmission chirp signals have been transmitted. Due to delay resulting from inserting this transmission path, repetition time becomes longer, becoming a restriction against raising the frame rate.

[0040] Configuration of an ultrasound tomographic apparatus 200 that uses a multiplexed chirp signal is illustrated in FIG. 9. In FIG. 9, a multiplexed chirp signal generator 210, which generates multiplexed chirp signals for transmission, generates a multiplexed chirp signal by combining, for example, a plurality of chirp signals; specifically, that multiplexed chirp signal is generated by a synthesizer 214 synthesizing a plurality of down chirp signals that come from down chirp generators 212 and 213, which are divided for each frequency spectrum to generate down chirp signals. Here, down chirp signals are used as the multiplexed chirp signal, however up chirp signals may also be multiplexed.

[0041] An ultrasound wave is generated by a probe 220 with the multiplexed chirp signal from this multiplexed chirp signal generator 210. This ultrasound wave is transmitted to a measurement subject 230 via a transmission path 223 such as a quartz rod, for example. While the multiplexed chirp signal is being transmitted, the connection to the reception side is disconnected with a switch 225. When transmission of the multiplexed chirp signal is completed, the switch 225 is changed over, the connection with the transmission side is disconnected, and the probe 220 is connected to the reception side. The reflected wave from the measurement subject is received by the probe 220 via the transmission path 223. The probe 220 and transmission 223 move as a single unit in order to scan the measurement subject, allowing a general controller (not shown in the drawing) to detect that movement.

[0042] The signal received by the probe 220 is then compressed by a compressed signal generator 240 into a compressed signal. In the compressed signal generator 240, down chirp generators 242 and 243 generate the same down chirp signals as those from the multiplexed chirp signal generator 210; and compressed signals corresponding to the respective down chirp signals are generated by taking correlation between these down chirp signals and the respective received signals and then synthesized by a synthesizer 244.

[0043] A tomogram is produced using this signal. To this end, for example, a two-dimensional location of the signal is determined utilizing the scanning movement of the transmission path 223 and probe 220 and the tomographic distance calculated based on the reception time of the reception signal. The signal is analog to digital converted to a gray scale pixel value for that determined signal location, providing a two-dimensional digital image. The obtained image may be displayed through a display device 270. Printing out this image from a printer is also possible.

[0044] With such ultrasound tomographic apparatus, since the time span is less than half even in the same chirp signal wave band by using a multiplexed chirp signal, there are advantages allowing reduction of transmission path distance to less than half as well as easily raising the frame rate.

Industrial Applicability

[0045]

(1) By taking the cross-correlation between the compressed signals of the received up chirp signals and the compressed signals of the down chirp signals using complementary chirp signals, the Doppler shift may be determined from the cross-correlation distance.
(2) Having a Doppler shift sensitivity, twice if double-fold and triple if triple-fold, with the same spectrum and same pulse width is possible.
(3) When implementing the multiplexed chirp/ pulse compression method to the ultrasound tomographic apparatus, the transmission path may be shortened and the frame rate may be heightened.

Claims

1. An ultrasound measurement apparatus (100; 200), comprising:

    a chirp signal generator (110; 210), which generates a chirp signal through synthesizing chirp signals and
    a probe (120; 220), which transmits an ultrasound wave of the chirp signal and receives a reflected wave from a measurement subject (130; 230);

    characterized in that
    the chirp signal generator generates a frequency-division multiplexed chirp signal through synthesizing chirp signals that are divided into a plurality of frequency wave bands and
    the apparatus further comprises a compressed signal generator (140; 240), which provides a compressed signal of the received signals from the probe by generating a plurality of compressed signals by taking correlation between the received signals and the chirp signals that are divided into a plurality of frequency wave bands and then synthesizing the plurality of compressed signals.

2. The ultrasound measurement apparatus (100) according to claim 1, wherein
    the chirp signal generator (110) generates a frequency-division multiplexed chirp signal comprising both up chirp signals where the modulation frequency increases and down chirp signals where the modulation frequency decreases through synthesizing down chirp signals and up chirp signals that are divided into a plurality of frequency wave bands; and the compressed signal generator (140) provides compressed signals of a plurality of down chirp signals and up chirp signals by taking the correlation between the received signal from the probe and the down chirp and the up chirp signals that are divided into a plurality of frequency wave bands so as to obtain compressed signals of the down chirp and the up chirp signals through respectively synthesizing the compressed signals of the down chirp signals and the compressed signals of the up chirp signals, the apparatus further comprising:

    a cross-correlator (160), which takes cross-correlation using the compressed signals of the down chirp and the up chirp signals from the compressed signal generator;

    wherein Doppler measurement is performed based on the correlation distance of the cross-correlation.

3. The ultrasound measurement apparatus (200) according to claim 1, wherein
    the chirp signal generator (210) generates a frequency-division multiplexed chirp signal by synthesizing down chirp signals or up chirp signals that are divided into a plurality of frequency wave bands; and
    the compressed signal generator (240) generates a compressed signal by taking the correlation between the received signal from the probe (220) and down chirp signals or up chirp signals that are divided into a plurality of frequency wave bands so as to obtain a plurality of compressed signals and then synthesizing the plurality of compressed signals;
    the apparatus further comprising:

    a delay transmission path (223) provided in accordance with the chirp signal time span between the probe and the measurement subject;
    a scanning unit, which scans the measurement subject using the transmission path and the probe;
    an image processing unit (260), which provides a tomogram by processing the compressed signals; and
    a display device (270), which displays the tomogram.

Patentansprüche

1. Ultraschallmesseinrichtung (100; 200) mit:

    einem Chirpsignalgenerator (110; 210), der ein Chirpsignal durch das Synthetisieren von Chirpsignalen erzeugt, und
    einem Tastkopf (120; 220), der eine Ultraschallwelle des Chirpsignals aussendet und eine von einem Messobjekt (130; 230) reflektierte Welle empfängt;

    dadurch gekennzeichnet, dass

der Chirpsignalgenerator ein Frequenzmultiplexchirpsignal erzeugt durch Synthetisieren von Chirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind, und
die Einrichtung weiter einen Komprimiersignalgenerator (140; 240) enthält, der ein komprimiertes Signal des von dem Tastkopf empfangenen Signals liefert durch Erzeugen einer Mehrzahl von komprimierten Signalen durch Hernehmen einer Korrelation zwischen den Empfangssignalen und den Chirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind, und anschließendes Synthetisieren der Mehrzahl von komprimierten Signalen.

2. Ultraschallmesseinrichtung (100) nach Anspruch 1, bei der
der Chirpsignalgenerator (110) ein Frequenzmultiplexchirpsignal erzeugt, das sowohl Aufwärtschirpsignale enthält, bei denen die Modulationsfrequenz ansteigt, als auch Abwärtschirpsignale, bei denen die Modulationsfrequenz abfällt, durch Synthetisieren von Abwärtschirpsignalen und Aufwärtschirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind; und
der Komprimiersignalgenerator (140) komprimierte Signale aus einer Mehrzahl von Abwärtschirpsignalen und Aufwärtschirpsignalen erzeugt durch Hernehmen einer Korrelation zwischen dem von dem Tastkopf empfangenen Signal und den Abwärtschirpsignalen und Aufwärtschirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind, zum Gewinnen komprimierter Signale der Abwärtschirpsignale und der Aufwärtschirpsignale durch jeweiliges Synthetisieren der komprimierten Signale der Abwärtschirpsignale und der komprimierten Signale der Aufwärtschirpsignale,
wobei die Einrichtung weiter enthält:

einen Kreuzkorrelator (160), der die Kreuzkorrelation inter Verwendung der komprimierten Signale der Abwärtschirpsignale und der Aufwärtschirpsignale von dem Komprimiersignalgenerator hernimmt;

wobei eine Dopplermessung durchgeführt wird auf der Grundlage des Korrelationsabstands der Kreuzkorrelation.

3. Ultraschallmesseinrichtung (200) nach Anspruch 1, bei der
der Chirpsignalgenerator (210) ein Frequenzmultiplexchirpsignal erzeugt durch Synthetisieren von Abwärtschirpsignalen oder Aufwärtschirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind; und
der Komprimiersignalgenerator (240) ein komprimiertes Signal erzeugt durch Verwenden einer Korrelation zwischen dem von dem Tastkopf (220) empfangenen Signal und den Abwärtschirpsignalen oder Aufwärtschirpsignalen, die in eine Mehrzahl von Frequenzwellenbändern aufgeteilt sind, zum Gewinnen einer Mehrzahl von komprimierten Signalen, und anschließendes Synthetisieren der Mehrzahl von komprimierten Signalen;
wobei die Einrichtung weiter enthält:

einen Verzögerungsübertragungspfad (223), der entsprechend der Zeitspanne des Chirpsignals zwischen dem Tastkopf und dem Messobjekt angeordnet ist;
eine Abtasteinheit, die das Messobjekt unter Verwendung des Übertragungspfads und des Tastkopfs abtastet;
eine Bildverarbeitungseinheit (260), die durch Verarbeiten der komprimierten Signale ein Tomogramm liefert; and
eine Anzeigevorrichtung (270), die das Tomogramm anzeigt.

Revendications

1. Appareil de mesure par ultrasons (100 ; 200), comprenant :

un générateur de signaux de fluctuation (110 ; 210), qui génère un signal de fluctuation en synthétisant des signaux de fluctuation et
une sonde (120 ; 220), qui transmet une onde ultrasonore du signal de fluctuation et reçoit une onde réfléchie d'un sujet mesuré (130 ; 230) ;

caractérisé en ce que
le générateur de signaux de fluctuation génère un signal de fluctuation multiplexé par répartition en fréquence en synthétisant les signaux de fluctuation qui sont divisés en une pluralité de bandes d'ondes de fréquence et
l'appareil comprend en outre un générateur de signaux compressés (140 ; 240), qui délivre un signal compressé des signaux reçus de la sonde en générant une pluralité de signaux compressés en prenant la corrélation entre les signaux reçus et les signaux de fluctuation qui sont divisés en une pluralité de bandes d'ondes de fréquence et ensuite en synthétisant la pluralité de signaux compressés.

2. Appareil de mesure par ultrasons (100) selon la revendication 1, dans lequel
le générateur des signaux de fluctuation (110) génère un signal de fluctuation multiplexé par répartition en fréquence comprenant à la fois les signaux de fluctuation à la hausse où la fréquence de modulation augmente et les signaux de fluctuation à la baisse où la fréquence de modulation diminue en synthétisant les signaux de fluctuation à la baisse et

les signaux de fluctuation à la hausse qui sont divisés en une pluralité de bandes d'ondes de fréquence ; et le générateur de signaux compressés (140) délivre des signaux compressés d'une pluralité de signaux de fluctuation à la baisse et de signaux de fluctuation à la hausse en prenant la corrélation entre le signal reçu de la sonde et les signaux de fluctuation à la baisse et de fluctuation à la hausse qui sont divisés en une pluralité de bandes d'ondes de fréquence de manière à obtenir des signaux compressés des signaux de fluctuation à la baisse et de fluctuation à la hausse en synthétisant respectivement les signaux compressés des signaux de fluctuation à la baisse et les signaux compressés des signaux de fluctuation à la hausse,
l'appareil comprenant en outre :

un corrélateur croisé (160) qui prend la corrélation croisée en utilisant les signaux compressés des signaux de fluctuation à la baisse et de fluctuation à la hausse en provenance du générateur de signaux compressés ;

dans lequel la mesure Doppler est effectuée sur la base de la distance de corrélation de la corrélation croisée.

3. Appareil de mesure par ultrasons (200) selon la revendication 1, dans lequel
le générateur de signaux de fluctuation (210) génère un signal de fluctuation multiplexé par répartition en fréquence en synthétisant les signaux de fluctuation à la baisse ou les signaux de fluctuation à la hausse qui sont divisés en une pluralité de bandes d'ondes de fréquence ; et
le générateur de signaux compressés (240) génère un signal compressé en prenant la corrélation entre le signal reçu de la sonde (220) et les signaux de fluctuation à la baisse ou les signaux de fluctuation à la hausse qui sont divisés en une pluralité de bandes d'ondes de fréquence de manière à obtenir une pluralité de signaux compressés et ensuite en synthétisant la pluralité de signaux compressés ;
l'appareil comprenant en outre :

une voie de transmission avec retard (223) prévue conformément à l'intervalle de temps des signaux de fluctuation entre la sonde et le sujet mesuré ;
une unité de balayage, qui balaye le sujet mesuré en utilisant la voie de transmission et la sonde,
une unité de traitement d'images (260), qui délivre une tomographie en traitant les signaux compressés ; et
un dispositif d'affichage (270), qui affiche la tomographie.

FIG. 1

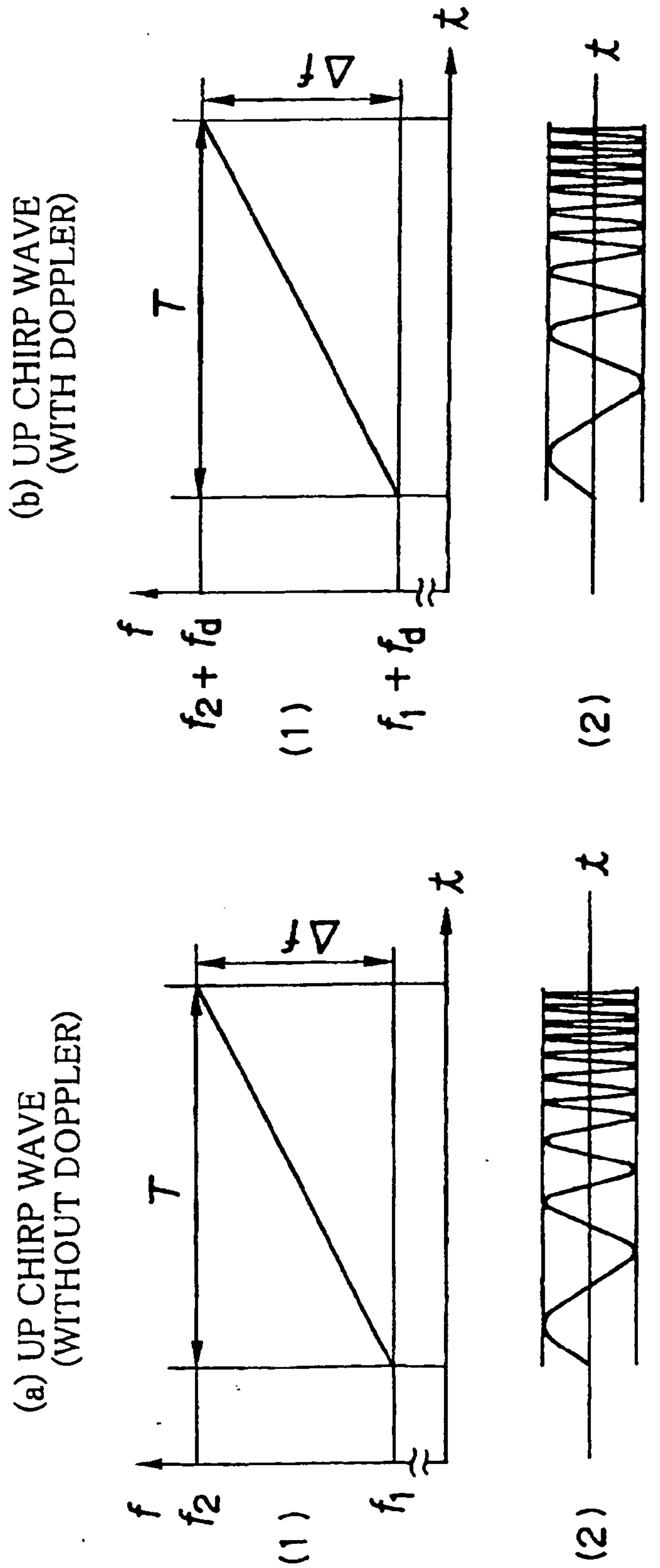

(a) UP CHIRP WAVE
(WITHOUT DOPPLER)
f
f_2
f_1
T
Δf
t
(1)
(2)
(b) UP CHIRP WAVE
(WITH DOPPLER)
$f_2 + f_d$
$f_1 + f_d$

FIG. 2

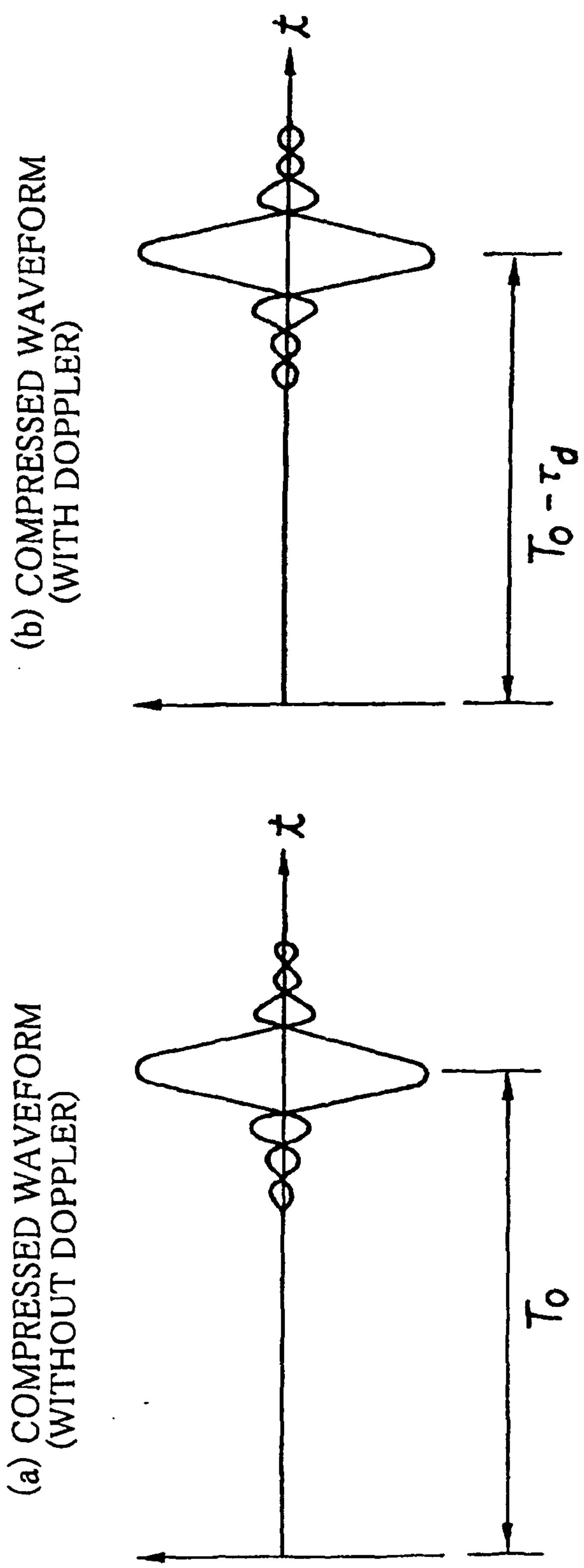

(a) COMPRESSED WAVEFORM
(WITHOUT DOPPLER)
(b) COMPRESSED WAVEFORM
(WITH DOPPLER)
t
T_0
$T_0 - \tau_d$

FIG. 3

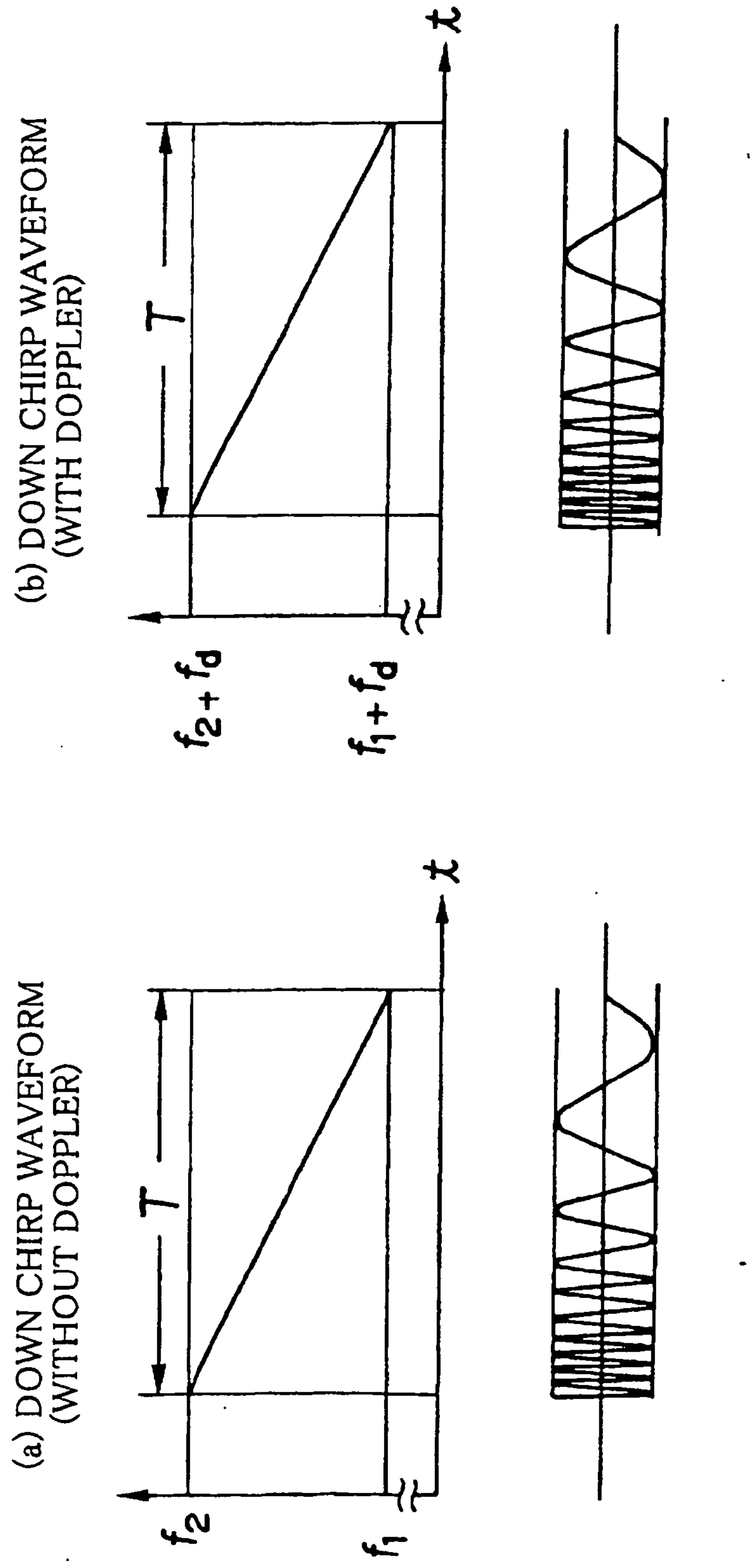

(a) DOWN CHIRP WAVEFORM
(WITHOUT DOPPLER)
f_2
f_1
T
t
(b) DOWN CHIRP WAVEFORM
(WITH DOPPLER)
f_2+f_d
f_1+f_d
T
t

FIG. 4

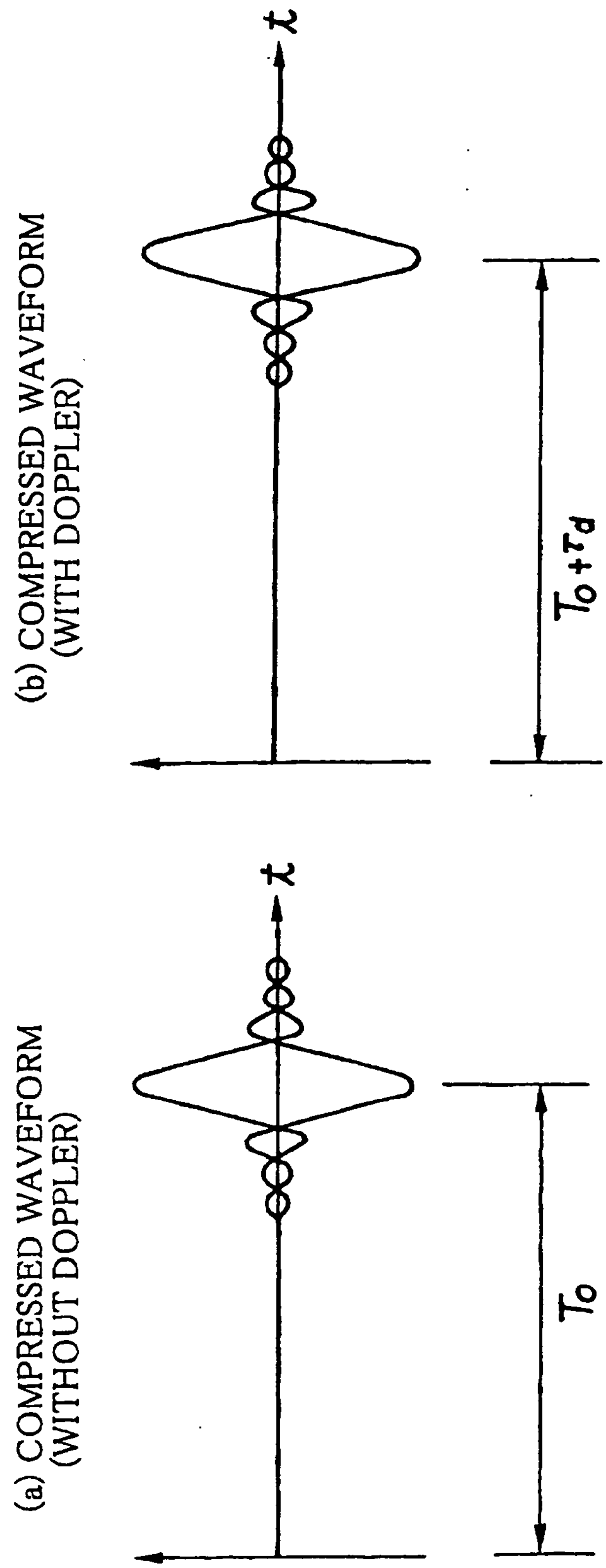

(a) COMPRESSED WAVEFORM
(WITHOUT DOPPLER)
τ
T_0
(b) COMPRESSED WAVEFORM
(WITH DOPPLER)
τ
$T_0+\tau_d$

FIG. 5

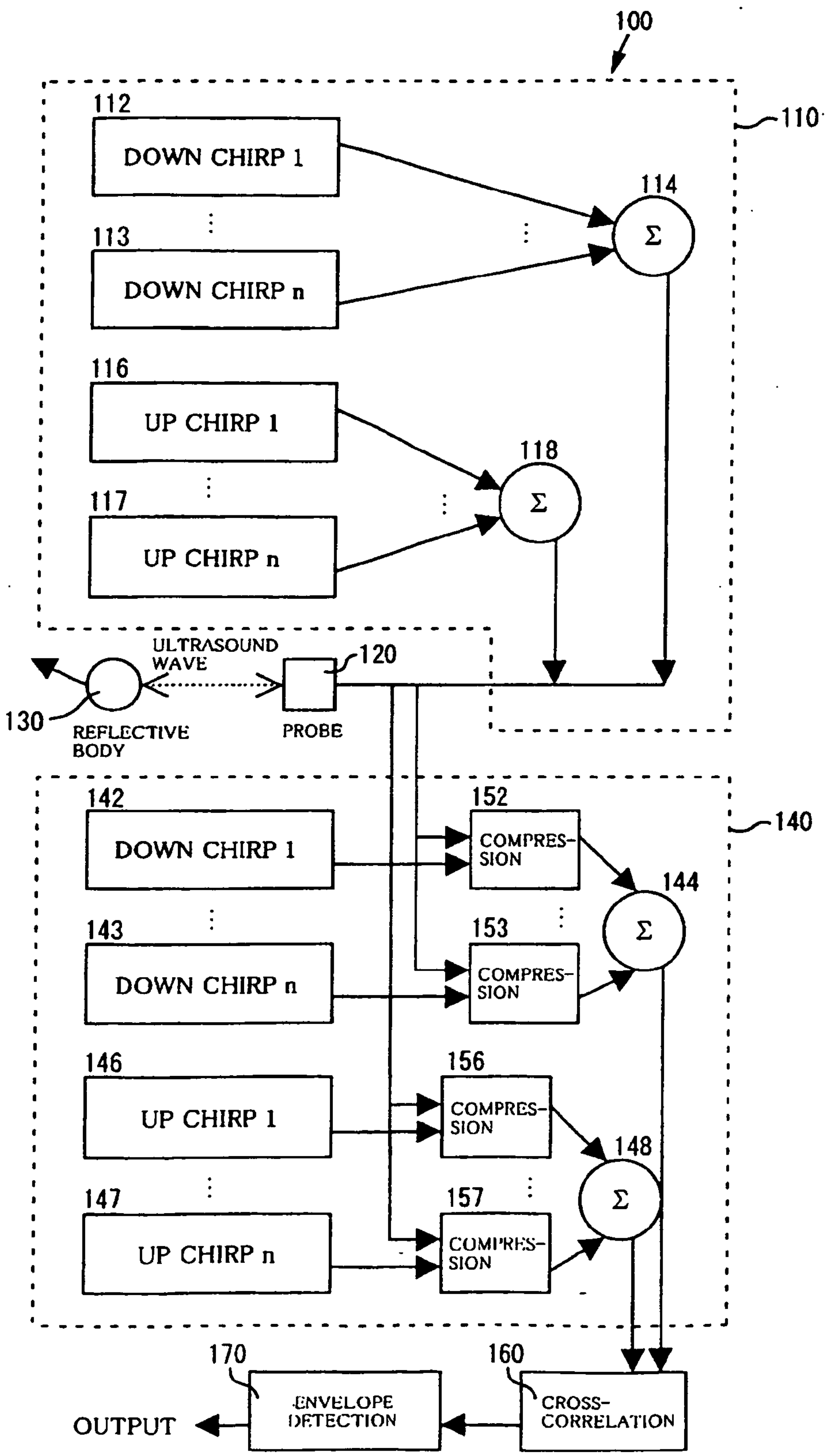
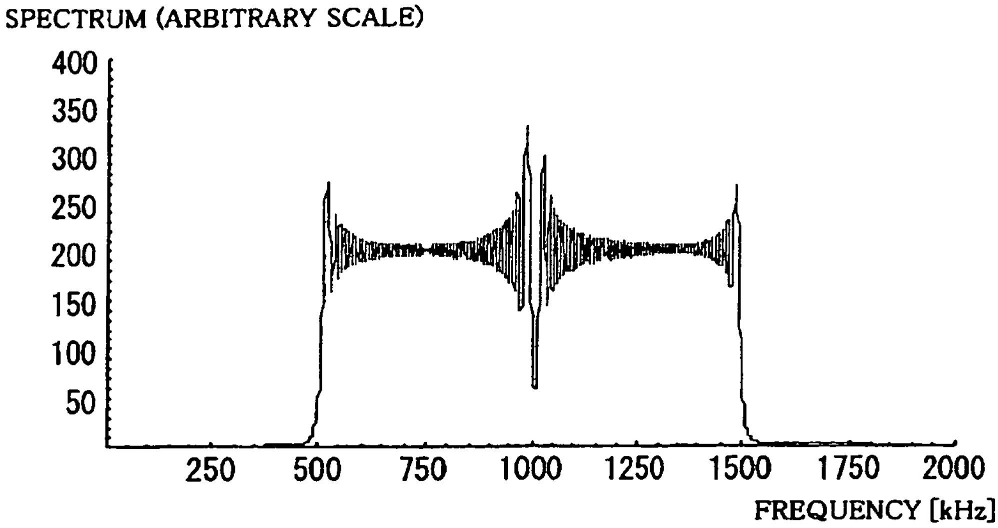
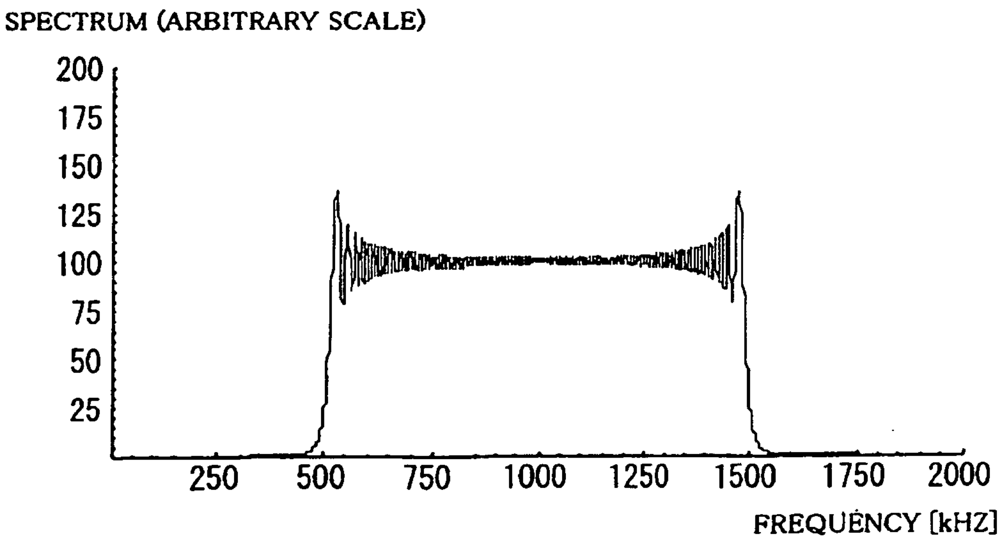

100
110
112
DOWN CHIRP 1
113
DOWN CHIRP n
114
Σ
116
UP CHIRP 1
117
UP CHIRP n
118
Σ
ULTRASOUND WAVE
120
130
REFLECTIVE BODY
PROBE
140
142
DOWN CHIRP 1
143
DOWN CHIRP n
146
UP CHIRP 1
147
UP CHIRP n
152
COMPRES-SION
153
COMPRES-SION
156
COMPRES-SION
157
COMPRES-SION
144
Σ
148
Σ
170
ENVELOPE DETECTION
160
CROSS-CORRELATION
OUTPUT

FIG. 6



(a) MULTIPLEXED UP CHIRP SIGNAL SPECTRUM



(b) SINGLE UP CHIRP SIGNAL SPECTRUM

FIG. 7

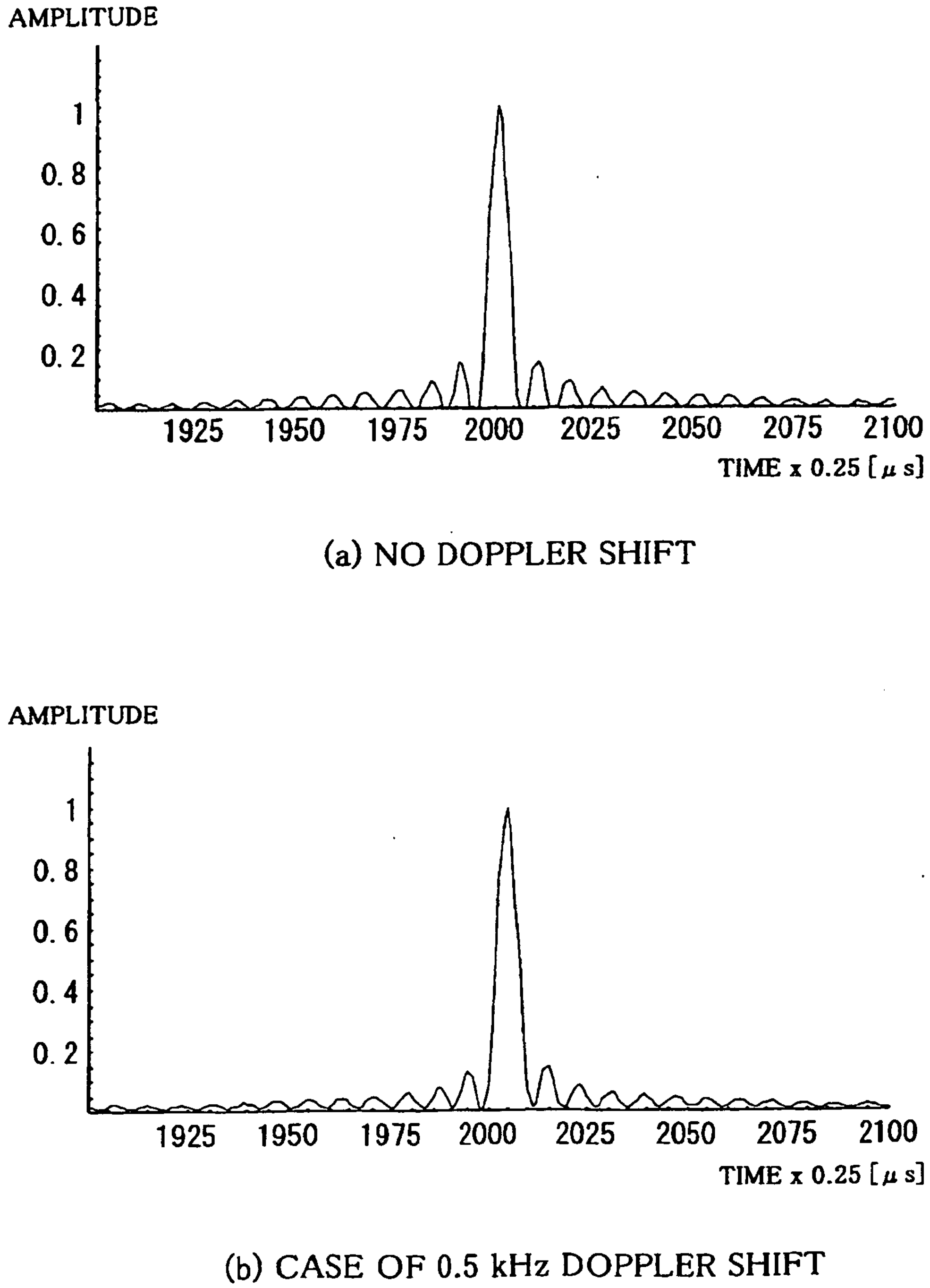
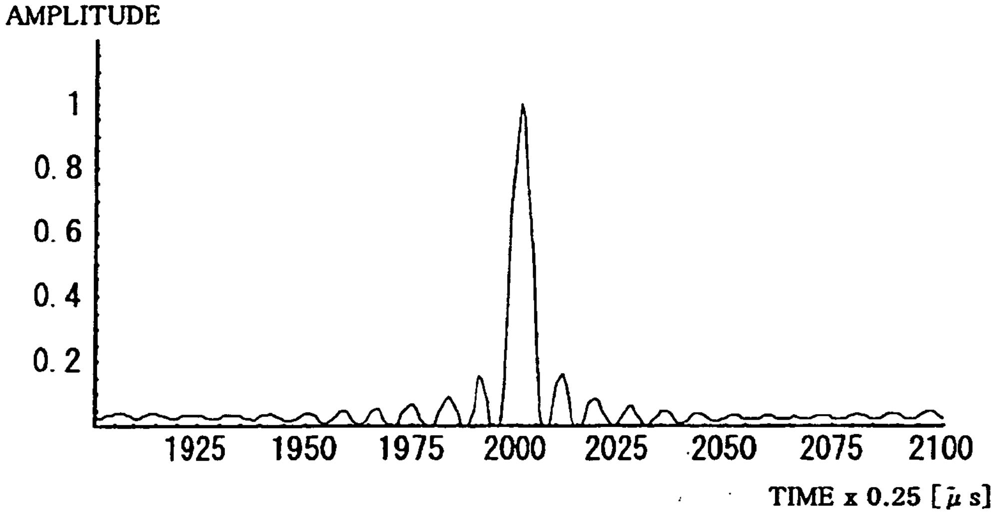
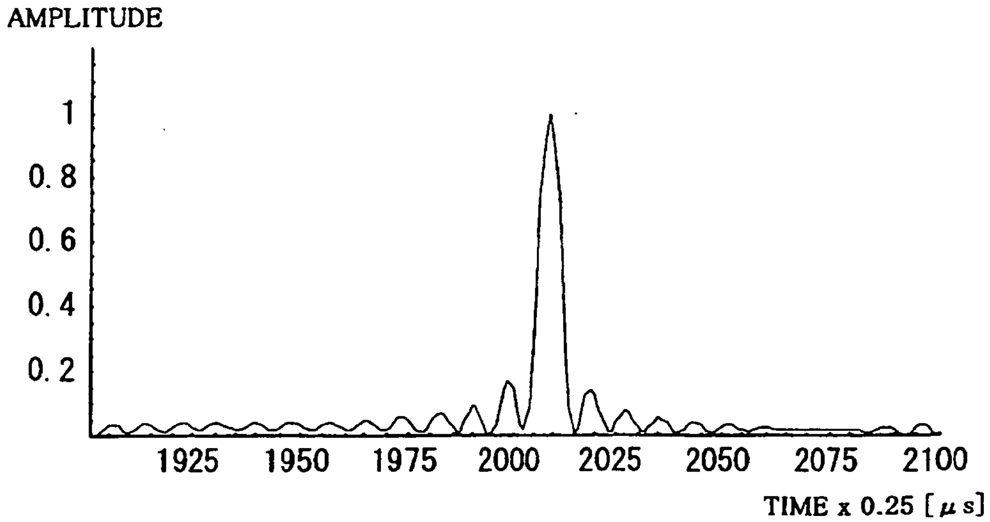

AMPLITUDE
1
0.8
0.6
0.4
0.2
1925 1950 1975 2000 2025 2050 2075 2100
TIME x 0.25 [μ s]
(a) NO DOPPLER SHIFT
AMPLITUDE
1
0.8
0.6
0.4
0.2
1925 1950 1975 2000 2025 2050 2075 2100
TIME x 0.25 [μ s]
(b) CASE OF 0.5 kHz DOPPLER SHIFT

FIG. 8

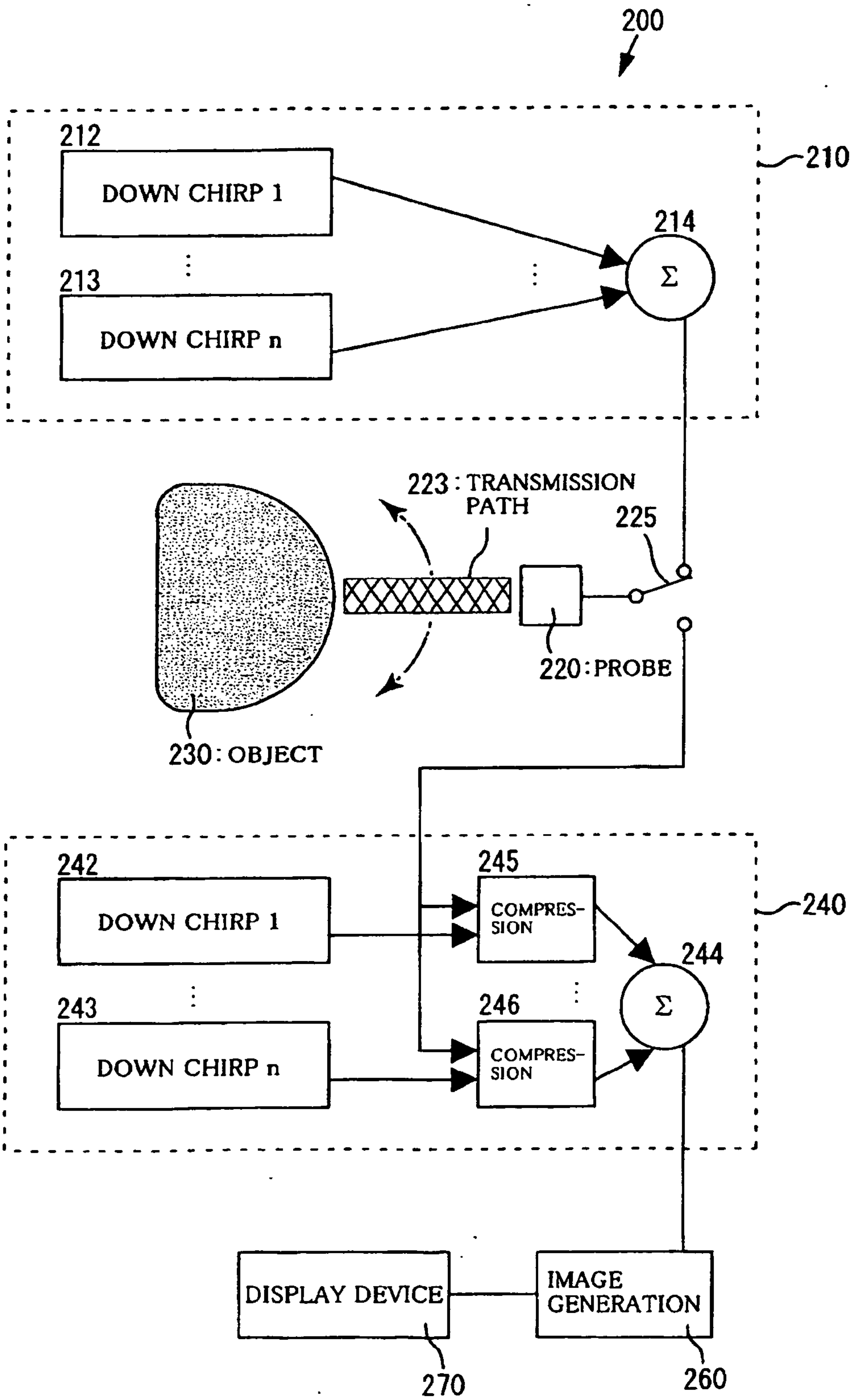


(a) NO DOPPLER SHIFT



(b) CASE OF 0.5 kHz DOPPLER SHIFT

FIG. 9


200
210
212
DOWN CHIRP 1
213
DOWN CHIRP n
214
Σ
223 : TRANSMISSION PATH
225
220 : PROBE
230 : OBJECT
240
242
DOWN CHIRP 1
243
DOWN CHIRP n
245
COMPRES-SION
246
COMPRES-SION
244
Σ
DISPLAY DEVICE
IMAGE GENERATION
270
260

专利名称(译)	超声波测量仪器		
公开(公告)号	EP1346691B1	公开(公告)日	2007-01-24
申请号	EP2001980951	申请日	2001-11-01
[标]申请(专利权)人(译)	独立行政法人科学技术振兴机构		
申请(专利权)人(译)	日本科学技术振兴事业团		
当前申请(专利权)人(译)	日本科学技术振兴事业团		
[标]发明人	MORIYA TADASHI TANAHASHI YOSHIKATSU YOSHIZAWA MASASUMI		
发明人	MORIYA, TADASHI TANAHASHI, YOSHIKATSU YOSHIZAWA, MASASUMI		
IPC分类号	A61B8/06 G01S15/89 G01B17/00 A61B8/08 A61B8/14 G01S15/10 G01S15/34		
CPC分类号	G01S15/8954 G01S15/34 G01S15/8961 G01S15/8979		
优先权	2000336460 2000-11-02 JP		
其他公开文献	EP1346691A1 EP1346691A4		
外部链接	Espacenet		

摘要(译)

超声波从探头（120）传输到移动反射器（130），并且反射的超声波由同一探头（120）接收。对于待使用频谱的n分频波段，要传输的超声波由来自n个向下线性调频信号发生器（112,113）和向上线性调频信号发生器的向上线性调频信号和向下线性调频信号组成。（116,117），通过合成器（114,118）产生互补的多路复用啁啾信号。在探头（120）处接收的接收信号与上啁啾和下啁啾信号之间的相关器分别进行互相关，以便提供压缩的上下信号，然后通过合成器组合所获得的压缩信号（144,148）。通过交叉相关器（160）通过这些压缩信号之间的互相关来确定相关距离并通过包络检测器（170）执行包络检测来执行多普勒测量。