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(54) **Medical digital ultrasonic imaging apparatus capable of storing and reusing radio-frequency (RF) ultrasound pulse echoes**

Digitales medizinisches Ultraschall- Bilderzeugungsgerät mit Speicherung und Wiedergebrauch von RF Ultraschalimpulsechos

Appareil médical numérique pour l'imagerie ultrasonique avec stockage er ré-utilisation d'échos ultrasoniques à radio-fréquences

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Description

1. Field of the Invention

[0001] The present invention relates to a medical digital ultrasonic imaging apparatus capable of storing and reusing the RF ultrasound pulse echoes, in which each RF ultrasound pulse echo received from a plurality of transducer elements is stored in order to implement an ultrasonic image of at least one frame, and the stored data are signal-analyzed, to thereby control the system according to the analysis result so that an optimal ultrasonic image can be implemented.

2. Description of the Related Art

[0002] Fig. 1 is a block diagram showing a configuration of a general medical digital ultrasonic imaging apparatus.

[0003] In Fig. 1, a main central processing unit (CPU) 100 controls the entire ultrasonic imaging apparatus according to user's instruction via a control panel 110. A transmitter 101 applies a transmission pulse to N elements of an array transducer. A receiver 102 receives a RF ultrasound pulse echo (referred to a RF signal) reflected and returned from an object to each transducer element. The receiver 102 consists of a pre-amplifiers, a time gain compensation (TGC) amplifier, and a filter for each array element. A beamforming unit 103 performs a dynamic focusing of the receiver 102 outputs with respect to all image points thereof in order to improve a resolution of an ultrasonic image. An ultrasonic echo processor 104 receives the focused signal and performs a series of a signal processing operations in order to obtain various modalities of ultrasonic images. A color flow (CF) processor 105 and a scan converter 106 receive the signal output from the ultrasonic echo processor 104 and implement a two-dimensional CF image and a B-mode image, respectively. A Doppler processor 108 receives the signal output from the ultrasonic echo processor 104 and a continuous wave/ElectroCadioGram (CW/ECG) unit 107 and implements a spectral Doppler waveform. An video/audio signal processor 109 processes the video/audio signal outputs from the CF processor 105, the scan converter 106 and the Doppler processor 108 and the results are output to a screen/speaker 111 or a recorder 112 for recording. Also, the video signal and the audio signal which have been recorded on the recorder 112 are output to the screen/speaker 111 as needed by a user.

[0004] Fig. 2 is a detailed block diagram showing the configuration of the beamforming unit 103 of Fig. 1.

[0005] The beamforming unit 103 of Fig. 2 includes an analog-to-digital (A/D) converter 11 which samples the received RF signals for N tranducer elements and a beamformer 12 for focusing the A/D converter 11 outputs and outputting the focused result.

[0006] The A/D converter 11 is comprised of a plurality of A/D converters 13. Here, n*th* A/D converter 13(n) receives the RF signal received at n*th* transducer element among the N transducer elements from a receiver which is not shown in Fig. 2 and samples the received RF signal.

[0007] The beamformer 12 includes a plurality of time/phase delay unit 14, a plurality of buffers 15 and an a summer 16. Here, the nth time/phase delay unit 14(n) receives the data output from the nth A/D converter 13(n) and stores the received data temporarily in the nth buffer 15(n) of small capacity. A first-in-first-out (FIFO) memory or a two-port memory is used as a buffer. The data output from each A/D converter is sequentially stored in each corresponding buffer. Thus, each buffer is capable of storing data necessary for time delay or phase delay.

[0008] When all data for focusing the RF signal at a desired image point are input to the nth buffer 15(n), the nth time/phase delay unit 14(n) impose the focusing delays on the data stored in the corresponding nth buffer 15(n). The time and/or phase-delayed data are summed by an adder 16 to finish the focusing process.

[0009] The data output from each A/D converter 13, which are stored in each buffer 15 are continuously changed since the focusing delay for each element changes with a depth. Generally, the data output from each A/D converter 13 and stored in each buffer 15 disappears if a focusing process is completed, and thus cannot be re-used. Also, an accurate focusing of the RF signals received from a plurality of the transducer elements is not accomplished due to the waveform distortion that occurs due to various physical phenomena as the ultrasound travels in an object. Thus, in most cases, it is not possible to actually obtain an ultrasonic image with the best resolution that can be achieved theoretically.

[0010] US 5,544,657 discloses an ultrasonic blood flow monitor in which "raw" ultrasound information accumulated by a transducer is recorded and periodically sampled.

[0011] EP 0 916 966 A1 discloses an ultrasonic signal focusing method for an apparatus comprising an array transducer, in which the focusing of a scan line is performed using data from adjacent scan lines. EP 0 916 966 A1 was published after the priority date of the present application.

SUMMARY OF THE INVENTION

[0012] To solve the above problems, it is an object of the present invention to provide a method for storing each RF ultrasound pulse echo received from a plurality of transducer elements in order to implement an ultrasonic image of at least one frame.

[0013] It is another object of the present invention to provide a medical digital ultrasonic imaging apparatus that can analyze and reuse the stored RF ultrasound pulse echoes to further enhance the ultrasonic image.

[0014] To accomplish the above object of the present invention, there is provided a medical digital ultrasonic imaging apparatus for focusing each RF signal received from a plurality of transducer elements to form an ultrasonic image, the medical digital ultrasonic imaging apparatus comprising a receiver (102) for converting each of the RF ultrasound pulse echoes into an electrical signal and outputting the converted result; a beamforming unit (200) for sampling the RF ultrasound pulse echoes output from the receiver, storing the sampled data for forming an ultrasonic image of at least one frame respectively, focusing the sampled data or the stored sampled data and outputting the focused result; a signal processor (104) for receiving the focused signal from the beamforming unit (200) and performing a signal processing for forming the ultrasonic image; and a controller (300) for controlling the apparatus; said beamforming unit (200) being arranged to store said sampled data for forming an ultrasonic image of the at least one frame by a respective scan line, wherein said beamforming unit (200) is arranged to perform a focusing in order to form a zoomed image with respect to a part of the ultrasonic image, using the stored sampled data.

[0015] There is also provided a medical digital ultrasonic imaging method for focusing each RF signal received from a plurality of transducer elements to form an ultrasonic image, the medical digital ultrasonic imaging method comprising converting each of the RF ultrasound pulse echoes into an electrical signal and outputting the converted result; sampling the RF ultrasound pulse echoes output from the receiver, storing the sampled data for forming an ultrasonic image of at least one frame respectively, focusing the sampled data or the stored sampled data and outputting the focused result; receiving the focused signal from the beamforming unit (200) and performing a signal processing for forming the ultrasonic image; storing said sampled data for forming an ultrasonic image of the at least one frame by a respective scan line, and performing a focusing in order to form a zoomed image with respect to a part of the ultrasonic image, using the stored sampled data.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The above objects and other advantages of the present invention will become more apparent by describing the preferred embodiments thereof in more detail with reference to the accompanying drawings in which:

Fig. 1 is a block diagram showing a configuration of a general medical digital ultrasonic imaging apparatus;
Fig. 2 shows the configuration of the beamforming unit of Fig. 1;
Fig. 3 is a block diagram showing a configuration of a medical digital ultrasonic imaging apparatus according to the present invention;
Fig. 4 is a block diagram showing a connection between the beam forming unit of Fig. 3 and a host processor located outside the beamforming unit;
Fig. 5 shows a configuration of a memory controller of Fig. 4;
Fig. 6 shows an example of the structure of a memory of Fig. 4;
Fig. 7 is a block diagram showing a connection between the beam forming unit according to an alternative embodiment of Fig. 3 and a host processor located outside the beamforming unit; and
Fig. 8 is a block diagram showing a connection between the beam forming unit according to another different embodiment of Fig. 3 and a host processor located outside the beamforming unit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0017] A preferred embodiment of the present invention will be described with reference to the accompanying drawings.

[0018] Fig. 3 is a block diagram showing a configuration of a medical digital ultrasonic imaging apparatus according to an embodiment of the present invention.

[0019] An ultrasonic imaging apparatus of Fig. 3 is assigned with the same reference numbers as those of Fig. 1 with respect to the components which perform the same functions as those of Fig. 1. Accordingly, the detailed description thereof will be omitted.

[0020] In the ultrasonic imaging apparatus of Fig. 3, a beamforming unit 200 samples the data (that is, the RF ultrasound pulse echo, referred to the RF signal) fed from a receiver 102 under the control of a host processor 300 and stores and focuses the sampled data. The beamforming unit 200 and the host processor 300 transmit data to each other. The host processor 300 analyzes the stored sampled data received from the beamforming unit 200 and controls each component of the ultrasonic imaging apparatus through an external interface bus denoted as a dotted line according to the result of the signal analysis, together with a main central processing unit (CPU) 100.

[0021] The configuration and operation of the beamforming unit 200 will be described in more detail with reference to Figs. 4 through 8.

[0022] Fig. 4 is a block diagram showing a connection between the beam forming unit 200 and a host processor 300 located outside the beamforming unit 200.

[0023] The beamforming unit 200 of Fig. 4 includes A/D converters 21(1) through 21 (N) which sample the RF signals received at N transducer elements and output the sampled data. Memory controllers 22(1) through 22(N) for transmitting data from the A/D converters 21(1) through 21 (N) to various units are connected to respective output ends of the A/D converters 21(1) through 21(N). The memories 23(1) through 23(N) for receiving data from the memory controllers 22 (1) through 22(N), storing data for implementing an ultrasonic image of at least one frame, and transmitting the stored data to the respective memory controller 22(1) through 22(N) are connected to the respective output ends of the memory controllers 22(1) through 22(N). A beamformer 24 for receiving data from the memory controllers 22(1) through 22(N), focusing the received data and outputting the focused result is connected to the output end of the memory controllers 22(1) through 22(N). A local processor 25 connected to the output end of the memory controllers 22 through 22(N) controls the memory controllers 22 through 22(N) and the beamformer 24, can receive or send data from or to the memory controller 22(1) through 22(N) and the beamformer 24, carries out signal analysis of the data stored in the memories 23(1) through 23(N), and controls the beamformer 24 according to the analysis result. As described above, the beamforming unit 200 includes the A/D converters 21(1) through 21(N), the memory controllers 22(1) through 22 (N), the memories 23(1) through 23(N), the beamformer 24 and the local processor 25.

[0024] A host processor 300 is connected externally to the beamforming unit 200. Data can be transmitted between the host processor 300 and the local processor 25 in the beamforming unit 200. The memory controllers 22(1) through 22(N) and the beamformer 24 can also be controlled by the host processor 300 through the local processor 25.

[0025] The local processor 25 in the beamforming unit 200 can be connected to each memory controller 22(1) through 22(N) one by one as many as N local processors can be used in the beamforming unit 200, that is, one for

[0026] each memory controller 22, according to the specification of the medical digital ultrasonic imaging apparatus to be designed. The host processor 300 is a single or parallel processor system which can perform a signal and image processing at a very high speed and can be replaced by a main CPU 100 according to the design specification.

[0027] The operations of the beamforming unit 200 and the host processor 300 having the above configuration will be described.

[0028] The A/D converters 21(1) through 21(N) in the beamforming unit 200 receive the RF signals received at N transducer elements through a receiver (not shown in Fig. 4) of Fig. 3 and perform a sampling of the received RF signals. The A/D converters 21(1) through 21(N) output the sampled data to each of the corresponding memory controllers 22 (1) through 22(N). The memory controllers 22(1) through 22(N) transmit the sampled data applied from the A/D converters 21(1) through 21(N) to each of the corresponding memories 23(1) through 23(N) and the beamformer 24, which is controlled by the local processor 25. Each of the memories 23(1) through 23(N) stores the sampled data for each scan line in a separate location. The beamformer 24 focuses the sampled data for each scan line and outputs the result. By doing so, the data applied to the beamforming unit 200 is sampled and stored in the memories 23(1) through 23(N) and focused in the beamformer 24. The specific configuration of the memory controllers 22(1) through 22(N) and the memories 23(1) through 23(N) will be described later with reference to Figs. 5 and 6.

[0029] The memory controllers 22(1) through 22(N) read the data stored in each of the corresponding memories 23 (1) through 23(N) under the control of the local processor 25. The memory controllers 22(1) through 22(N) transmit the read data to the beamformer 24 and the local processor 25. The local processor 25 performs a signal analysis of the data and estimates an ultrasonic velocity profile, variation of the frequency spectrum of the ultrasonic pulse echo with depth and noise characteristics, etc. which are required for focusing and forming the ultrasonic image. The local processor 25 controls the beamformer 24 according to the analysis result so that an optimal ultrasonic image can be obtained. The beamformer 24 focuses the applied data under the control of the local processor 25, and thus an ultrasonic image having an improved resolution, signal-to-noise ratio, etc. is obtained.

[0030] The local processor 25 can transmit the data sent from the memory controllers 22(1) through 22(N) to the host processor 300. The host processor 300 can also perform the signal analysis of the data from the local processor 25 and can control the ultrasonic imaging apparatus according to the analysis result.

[0031] The data analysis and system control can be properly distributed between the local processor 25 and the host processor 300.

[0032] Fig. 5 shows a configuration of a memory controller 22(n) of Fig. 4.

[0033] In Fig. 5, an external connection/control circuit 31 in the memory controller 22(n) controls the entire components of the memory controller 22(n) under the control of the local processor 25. A memory control circuit 32 generates memory control signals for reading and writing data from and to memory 23(n), and generates a memory address through a multiplexer 33.

[0034] The memory controller 22(n) transmits the data from the A/D converter 21(n) to the beamformer 24 via a mutliplexer 34, or to the memory 23(n) via a multiplexer 35. Also, the memory controller 22(n) reads the data stored in the memory 23(n) and transmits the read data to the local processor 25 via a buffer 36 or to the beamformer 24 via a mutliplexer 34. The memory controller 22(n) transmits the data from the local processor 25 to the beamformer 24 via the buffer 36 and the multiplexer 34, or to the memory 23(n) via the buffer 36 and the multiplexer 35.

[0035] Fig. 6 shows an example of the structure of a memory 23(n) of Fig. 4, which is the same for all n.

[0036] A semiconductor memory device or a hard disc storage device can be used as the memory 23(n). The memory 23(n) stores the sampled data necessary for implementing an ultrasonic image of at least one frame among the output data of the corresponding A/D converter 21(n). Also, the memory 23(n) receives the data from the local processor 25 via the corresponding memory controller 22 and stores the received data.

[0037] As shown in Fig. 6, if N scan lines are needed to implement an ultrasonic image of one frame, the memory 23 (n) stores in turn data with respect to each scan line in S1, S2, ..., SN, respectively. Also, the memory 23(n) stores all the data capable of implementing an ultrasonic image of M frames.

[0038] As described above, in the case that each transducer element corresponds to each one of the A/D converters 21(1) through 21(N), each of the A/D converters 21(1) through 21(N) performs a uniform sampling at the same instance of time, and the beamformer 24 focuses input data according to the delay-and-sum method, each capacity of the memories 23(1) through 23(N) is expressed as the following equation.

$$\text{Memory capacity} = N_{fr} \times N_{sl} \times (F_s \times 2 \times z_{max}/c)$$

[0039] Here, N_{fr} is the number of frames to be stored in memory, N_{sl} is the number of scan lines to be stored every frame, F_s is an A/D conversion rate or a sampling frequency, z_{max} is a maximum image depth, and c is an ultrasonic velocity in an object.

[0040] Since the beamforming unit 200 stores and focuses the data sampled by the A/D converters 21(1) through 21 (N), the ultrasonic imaging apparatus can re-use the data stored in the beamforming unit 200 subsequently.

[0041] For example, in the case that one desires to obtain a zoomed image of a selected region of an ultrasonic image during real-time imaging or after temporarily freezing the imaging, a conventional ultrasonic imaging apparatus displays simply an enlarged image.

[0042] However, since the ultrasonic imaging apparatus stores all the RF signals to form a complete image frame or more, the zoomed image of the selected region with increased scan lines and imaging points by the factor of the zooming ratio can be formed by using the stored RF samples. That is, the ultrasonic imaging apparatus obtains an image having an enhanced quality compared to the conventional art, because it can utilize the stored data in order to reconstruct an ultrasonic image.

[0043] Also, the ultrasonic imaging apparatus can perform a synthetic focusing, a two-way dynamic focusing, and a multiple beam focusing, using the data stored in the beamforming unit.

[0044] Fig. 7 is a block diagram showing a connection between the beamforming unit 500 according to an alternative embodiment of the present invention and a host processor 300 located outside the beamforming unit.

[0045] The beamforming unit 500 of Fig. 7 includes a beamforming processor 51 in the form of a combination of the beamformer 24 and the local processor 25 in the beamforming unit 200 of Fig. 4, or in the form of a high-speed micro-processor. Thus, since the beam forming processor 51 performs the same functions as those of the beamformer 24 and the local processor 25, the detailed description thereof will be omitted. Since the other functional blocks in the beamforming unit 500 have the same functions and connections as those in the beamforming unit 200 of Fig. 4, they are assigned the same reference numbers as those of Fig. 4 and the detailed description thereof will be omitted.

[0046] The host processor 300 shown in Fig. 7 is connected to the beam forming processor 51 and performs the same function as that of the host processor 300 shown in Fig. 4. The detailed description of the host processor 300 will be omitted.

[0047] Fig. 8 is a block diagram showing a connection between a beamforming unit 600 according to a different embodiment of the beamforming unit 200 shown in Fig. 3 and a host processor 300 located outside the beamforming unit.

[0048] Quadrature demodulators 61(1) through 61(N) in the beamforming unit 600 of Fig. 8 receive the RF signals received at N transducer elements respectively, from the receiver of Fig. 3 which is not shown in Fig. 8 and produce the inphase and quadrature components and output the results. A/D converters 62(1) through 62(N) receive the inphase components from the quadrature demodulators 61(1) through 61(N) and sample the received signals and output the inphase samples to memory controllers 65(1) through 65(N). A/D converters 63(1) through 63(N) receive the quadrature components from the quadrature demodulators 61(1) through 61(N) and sample the received signals and output the quadrature samples to memory controllers 65(1) through 65(N). The memory controllers 65(1) through 65(N) output the data received from the respective A/D converters 62(1) through 62(N) and 63(1) through 63(N) to each of the corresponding memories 64(1) through 64(N) and the beamforming processor 66. The memories 64(1) through 64(N) have the same functions and structures as those of memories 23(1) through 23(N) of Figs. 4 and 7.

[0049] The beamforming processor 66 controls data transmission paths of the memory controller 65(1) through 65 (N). The beam forming processor 66 can perform mutual data transmission with the memory controllers 65(1) through 65(N), and analyzes the data, and focuses the data from the memory controllers 65(1) through 65(N), and then output the focused result. In this manner, since the beam forming processor 66 analyzes the data applied from the memory controllers 65(1) through 65(N) and focuses the data based on the analysis result, an enhanced ultrasonic image can be obtained. That is, the beamforming processor 66 performs both the functions of the beamformer 24 and the local processor 25 in the beamforming unit 200 of Fig. 4. Thus, the beamforming processor 66 can be replaced by a functional block having a function of the beamformer 24 and a functional block having a function of the local processor 25.

[0050] Further, the beamforming processor 66 is under the control of the host processor 300 which is connected to the beamforming unit 600 externally.

[0051] The host processor 300 shown in Fig. 8 performs the same function as those of the host processors 300 shown in Figs. 4 and 7. Thus, the detailed description of the host processor 300 will be omitted.

[0052] As described above, the method for storing the RF signals and the medical digital ultrasonic imaging apparatus can store the RF signals to form an ultrasonic image of at least one frame. It is also possible to re-use the stored data during a real-time imaging or after freezing the image. Also, the medical digital ultrasonic imaging apparatus performs various types of focusing methods using the stored data, or signal analysis of the stored data to control the entire system according to the analysis result so that an optimal ultrasonic image can be implemented. As a result, an ultrasonic image having a remarkably enhanced resolution, signal-to-noise ratio, etc. can be obtained.

Claims

1. A medical digital ultrasonic imaging apparatus for focusing each RF signal received from a plurality of transducer elements to form an ultrasonic image, the medical digital ultrasonic imaging apparatus comprising:

a receiver (102) for converting each of the RF ultrasound pulse echoes into an electrical signal and outputting the converted result;
a beamforming unit (200) for sampling the RF ultrasound pulse echoes output from the receiver, storing the sampled data for forming an ultrasonic image of at least one frame, focusing the sampled data or the stored sampled data and outputting the focused result;
a signal processor (104) for receiving the focused signal from the beamforming unit (200) and performing a signal processing for forming the ultrasonic image; and
a controller (300) for controlling the apparatus,
said beamforming unit (200) being arranged to store said sampled data for forming an ultrasonic image of the at least one frame, **characterised in that** said beamforming unit (200) is arranged to perform a focusing in order to form a zoomed image with respect to a part of the ultrasonic image, using the stored sampled data.

2. The medical digital ultrasonic imaging apparatus of claim 1, wherein said beamforming unit (200) is arranged to perform one of a dynamic focusing, a synthetic focusing and a multiple beam focusing, using the stored sampled data.

3. The medical digital ultrasonic imaging apparatus of claim 1 or 2, wherein said beamforming unit (200) is arranged to analyze the stored sampled data and estimates signal characteristics required for focusing and forming the ultrasonic image, and then focus the sampled data or the stored sampled data according to the result of said analysis.

4. The medical digital ultrasonic imaging apparatus of any of claims 1-3, wherein said beamforming unit (200) comprises:

a plurality of A/D converters (21(1)-21(N)) for sampling the RF ultrasound pulse echoes and outputting the sampled result;
a plurality of memories (23(1)-23(N)) corresponding to each of said plurality of A/D converters (21(1)-21(N)), and storing the sampled data for forming an ultrasonic image of at least one frame;
a beamformer (24) for focusing and outputting the applied data;
a plurality of memory controllers (22(1)-22(N)) corresponding to each said plurality of A/D converters (21(1)-21(N)) and each said plurality of memories (23(1)-23(N)), and transmitting the sampled data received from each of the plurality of A/D converters (21(1)-21(N)) to each of the corresponding memories (23(1)-23(N)) and the beamformer (24), and controlling an input/output of the sampled data stored each of the plurality of memories (23(1)-23(N)); and
a local processor (25) for controlling the plurality of memory controllers (22(1)-22(N)) and the beamformer (200), receiving the sampled data stored in each of the plurality of memories (23(1)-23(N)), analyzing the received sampled data, estimating signal characteristics required for focusing and forming the ultrasonic image and controling the beamformer (24) according to the result of the analysis.

5. The medical digital ultrasonic imaging apparatus of claim 4, arranged so that, in the case that each transducer element corresponds to a respective one of the A/D converters (21(1)-21(N)), each of the A/D converters (21(1)-21 (N)) performs a uniform sampling at the same instance of time, the beamformer (24) focuses sampled data according to the delay-sum method, a capacity of the memory is expressed as the following equation.

$$\text{Memory capacity} = N_{fr} \times N_{sl} \times (F_s \times 2 \times z_{max}/c)$$

in which N_{fr} is the number of frames to be stored in memory, N_{s1} is the number of scan lines to be stored for each frame, F_s is an A/D conversion rate or a sampling frequency, z_{max} is a maximum image depth, and c is an ultrasonic velocity in an object.

6. The medical digital ultrasonic imaging apparatus of claim 4 or 5, wherein said controller (300) can perform a mutual data transmission with the local processor (25).

7. The medical digital ultrasonic imaging apparatus of claim 6, wherein said controller (300) is arranged to receive the result of the analysis from the local processor (25) and to control the other components according to the result of the analysis.

8. The medical digital ultrasonic imaging apparatus of claim 6, wherein said controller (300) is arranged to receive the stored sampled data from the local processor (25), analyze signal characteristics of the received sampled data and control the other components according to the result of the analysis.

9. The medical digital ultrasonic imaging apparatus of claim 8, wherein said controller (300) is arranged to analyze of the signal characteristics to estimate an ultrasonic velocity profile and variation of the frequency spectrum of the ultrasonic pulse echo with depth and noise characteristics which are required for focusing and forming the ultrasonic image with respect to the received stored sampled data.

10. The medical digital ultrasonic imaging apparatus of claim 9, wherein said controller (300) is arranged to transmit the result of the analysis to the local processor (25).

11. The medical digital ultrasonic imaging apparatus of claim 10, wherein said local processor (25) is arranged to control said beamformer (200) according to the received result.

12. The medical digital ultrasonic imaging apparatus of claim 4, wherein said plurality of memory controllers (22(1)-22 (N)) is arranged to receive the data from the local processor (25) and to transmit the received data to said plurality of corresponding memories (23(1)-23(N)) or said beamformer (24).

13. The medical digital ultrasonic imaging apparatus of claim 12, wherein said local processor (25) is arranged to transmit self-generated data or the data received from said controller (300) to said plurality of memory controllers (22(1)-22(N)).

14. The medical digital ultrasonic imaging apparatus of claim 4, wherein said plurality of memory controllers (22(1)-22 (N)) is arranged to read the sampled data stored in the corresponding memory (23(1)-23(N)) and transmit the read data to the local processor (25).

15. The medical digital ultrasonic imaging apparatus of claim 4, wherein said local processor (25) can be connected to each of said plurality of memory controllers (22(1)-22(N)) one by one.

16. The medical digital ultrasonic imaging apparatus of claim 4, wherein said beamformer (24) and said local processor (25) are provided in the form of a single processor which performs both the functions of the beamformer (24) and the local processor (25).

17. The medical digital ultrasonic imaging apparatus of claim 4, wherein said beamforming unit (200) further comprises:

a plurality of quadrature demodulators (61(1)-61(N)) for separating each RF ultrasound pulse echo received from a plurality of transducer elements into an inphase component and a quadrature component and outputting the separated result; and a plurality of A/D converters (62(1)-62(N), 63(1)-63(N)) corresponding to each of said quadrature demodulators, including a set of first A/D converters (62(1)-62(N)) for sampling an in-phase component from each of the quadrature demodulators and second A/D converters (63(1)-63(N)) for sampling a quadrature component therefrom, for outputting the sampled data to each of said corresponding memory controllers (65(1)-65(N)).

18. A medical digital ultrasonic imaging method for focusing each RF signal received from a plurality of transducer elements to form an ultrasonic image, the medical digital ultrasonic imaging method comprising:

converting each of the RF ultrasound pulse echoes into an electrical signal and outputting the converted result;
sampling the RF ultrasound pulse echoes output from the receiver, storing the sampled data for forming an ultrasonic image of at least one frame,
focusing the sampled data or the stored sampled data and outputting the focused result;
receiving the focused signal at a signal processor and performing a signal processing for forming the ultrasonic image; the method being **characterised by**
performing a focusing by a beam forming unit in order to form a zoomed image with respect to a part of the ultrasonic image, using the stored sampled data.

Patentansprüche

1. Medizinische digitale Ultraschallabbildungsvorrichtung zum Fokussieren jedes HF-Signals, die von mehreren Signalwandlerelementen empfangen werden, um ein Ultraschallbild zu erzeugen, wobei die medizinische digitale Ultraschallabbildungsvorrichtung umfasst:

einen Empfänger (102) zum Umwandeln jedes der HF-Ultraschall-Impulsechos in ein elektrisches Signal und Ausgeben des umgewandelten Ergebnisses;
eine Strahlformungseinheit (200) zum Abtasten der HF-Ultraschall-Impulsechoausgaben von dem Empfänger, Speichern der abgetasteten Daten zum Erzeugen eines Ultraschallbildes mit mindestens einem Rahmen, Fokussieren der abgetasteten Daten oder der gespeicherten abgetasteten Daten und Ausgeben des fokussierten Ergebnisses;
einen Signalprozessor (104) zum Empfangen des fokussierten Signals von der Strahlformungseinheit (200) und Ausführen einer Signalverarbeitung zum Erzeugen des Ultraschallbildes; und
eine Steuereinheit (300) zum Steuern der Vorrichtung,
wobei die Strahlformungseinheit (200) ausgelegt ist, um die abgetasteten Daten zum Erzeugen eines Ultraschallbildes aus dem mindestens einen Rahmen zu speichern, **dadurch gekennzeichnet, dass** die Strahlformungseinheit (200) ausgelegt ist, um ein Fokussieren auszuführen, um ein in Bezug auf einen Teil des Ultraschallbildes vergrößertes Bild unter Verwendung der gespeicherten abgetasteten Daten zu erzeugen.

2. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 1, wobei die Strahlformungseinheit (200) ausgelegt ist, ein dynamisches Fokussieren, ein synthetisches Fokussieren oder ein Mehrstrahlfokussieren unter Verwendung der gespeicherten abgetasteten Daten auszuführen.

3. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 1 oder 2, wobei die Strahlformungseinheit (200) ausgelegt ist, die gespeicherten abgetasteten Daten zu analysieren und die für das Fokussieren und Erzeugen des Ultraschall bildes benötigten Signaleigenschaften zu schätzen und dann entsprechend dem Ergebnis der Analyse die abgetasteten Daten oder die gespeicherten abgetasteten Daten zu fokussieren.

4. Medizinische digitale Ultraschallabbildungsvorrichtung nach einem der Ansprüche 1-3, wobei die Strahlformungseinheit (200) umfasst:

mehrere A/D-Umsetzer (21(1)-21(N)) zum Abtasten der HF-Ultraschall-Impulsechos und Ausgeben des abgetasteten Ergebnisses;
mehrere Speicher (23(1)-23(N)), die jedem der mehreren A/D-Umsetzer (21(1)-21(N)) entsprechen und die abgetasteten Daten zum Erzeugen eines Ultraschallbildes aus mindestens einem Rahmen abspeichern;
einen Strahlformer (24) zum Fokussieren und Ausgeben der angewendeten Daten;
mehrere Speichersteuereinheiten (22(1)-22(N)), die jedem der mehreren A/D-Umsetzer (21(1)-21(N)) und jedem der mehreren Speicher (23(1)-23(N)) entsprechen und die von jedem der mehreren A/D-Umsetzer (21(1)-21(N)) empfangenen abgetasteten Daten an jeden der mehreren entsprechenden Speicher (23(1)-23(N)) und

den Strahlformer (24) übermitteln, und eine Eingabe/Ausgabe der in jedem der mehreren Speicher (23(1)-23(N)) gespeicherten abgetasteten Daten steuern; und

einen lokalen Prozessor (25) zum Steuern der mehreren Speichersteuereinheiten (22(1)-22(N)) und des Strahlformers (200), Empfangen der in jedem der mehreren Speicher (23(1)-23(N)) gespeicherten abgetasteten Daten, Analysieren der empfangenen abgetasteten Daten, Schätzen der für das Fokussieren und Erzeugen des Ultraschallbildes benötigten Signaleigenschaften und Steuern des Bilderzeugers (24) entsprechend dem Ergebnis der Analyse.

5. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, die so beschaffen ist, dass in dem Fall, in dem jedes Signalwandlerelement einem jeweiligen A/D-Umsetzer (21(1)-21 (N)) entspricht, jeder der A/D-Umsetzer (21(1)-21 (N)) ein gleichmäßiges Abtasten zu demselben Zeitpunkt ausführt, der Strahlformer (24) die abgetasteten Daten entsprechend dem Verzögerungs-Additions-Verfahren fokussiert, eine Kapazität des Speichers als die folgende Gleichung gegeben ist:

$$\text{Speicherkapazität} = N_{fr} \times N_{s1} \times (F_s \times 2 \times z_{max}/c)$$

wobei N_{fr} die Anzahl der in dem Speicher zu speichernden Rahmen bezeichnet, N_{S1} die Anzahl der für jeden Rahmen zu speichernden Abtastzeilen bezeichnet, F_S eine A/D-Umsetzungsrate oder eine Abtastfrequenz bezeichnet, z_{max} eine maximale Bildtiefe bezeichnet und c eine Ultraschallgeschwindigkeit in einem Objekt bezeichnet.

6. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4 oder 5, wobei die Steuereinheit (300) eine gegenseitige Datenübertragung mit dem lokalen Prozessor (25) ausführen kann.

7. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 6, wobei die Steuereinheit (300) ausgelegt ist, um das Ergebnis der Analyse von dem lokalen Prozessor (25) zu empfangen und die anderen Komponenten entsprechend dem Ergebnis der Analyse zu steuern.

8. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 6, wobei die Steuereinheit (300) ausgelegt ist, um die gespeicherten abgetasteten Daten von dem lokalen Prozessor (25) zu empfangen, die Signaleigenschaften der empfangenen abgetasteten Daten zu analysieren und die anderen Komponenten entsprechend dem Ergebnis der Analyse zu steuern.

9. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 8, wobei die Steuereinheit (300) ausgelegt ist, um die Signaleigenschaften zu analysieren und ein Ultraschallgeschwindigkeitsprofil und eine Änderung des Frequenzspektrums des Ultraschall-Impulsechos mit der Tiefe und Rauscheigenschaften, die zum Fokussieren und Erzeugen des Ultraschallbildes benötigt werden, in Bezug auf die empfangenen gespeicherten abgetasteten Daten zu schätzen.

10. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 9, wobei die Steuereinheit (300) ausgelegt ist, um das Ergebnis der Analyse an den lokalen Prozessor (25) zu übermitteln.

11. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 10, wobei der lokale Prozessor (25) ausgelegt ist, den Strahlformer (20) entsprechend dem empfangenen Ergebnis zu steuern.

12. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, wobei die mehreren Speichersteuereinheiten (22(1)-22(N)) ausgelegt sind, um Daten von dem lokalen Prozessor (25) zu empfangen und die empfangenen Daten an die mehreren entsprechenden Speicher (23(1)-23(N)) oder den Strahlformer (24) zu übermitteln.

13. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 12, wobei der lokale Prozessor (25) ausgelegt ist, selbsterzeugte Daten oder die von der Steuereinheit (300) empfangenen Daten an die mehreren Speichersteuereinheiten (22(1)-22(N)) zu übermitteln.

14. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, wobei die mehreren Speichersteuereinheiten (22(1)-22(N)) ausgelegt sind, die in den entsprechenden Speichern (23(1)-23(N)) gespeicherten abgetasteten Daten zu lesen und die gelesenen Daten an den lokalen Prozessor (25) zu übermitteln.

15. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, wobei der lokale Prozessor (25) mit jeder der mehreren Speichersteuereinheiten (22(1)-22(N)) nacheinander verbunden werden kann.

16. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, wobei der Strahlformer (24) und der lokale Prozessor (25) in der Form eines einzelnen Prozessors vorgesehen sind, der die beiden Funktionen des Strahlformers (24) und des lokalen Prozessors (25) ausführt.

17. Medizinische digitale Ultraschallabbildungsvorrichtung nach Anspruch 4, wobei die Strahlformungseinheit (200) ferner umfasst:

mehrere Quadratur-Demodulatoren (61(1)-61(N)) zum Trennen jedes HF-Ultraschall-Impulsechos, die von den mehreren Signalwandlerelementen empfangen werden, in eine Inphase-Komponente und eine Quadraturkomponente und Ausgeben des aufgeteilten Ergebnisses; und
mehrere A/D-Umsetzer (62(1)-62(N), 63(1)-63(N)) zum Ausgeben der abgetasteten Daten an jede der entsprechenden Speichersteuereinheiten (65(1)-65(N)), die jedem der Quadratur-Demodulatoren entsprechen, und die einen Satz von ersten A/D-Umsetzern (62(1)-62(N)) zum Abtasten einer Inphase-Komponente von jedem der Quadratur-Demodulatoren und zweite A/D-Umsetzer (63(1)-63(N)) zum Abtasten einer Quadraturkomponente davon enthalten.

18. Medizinische digitale Ultraschallabbildungsvorrichtung zum Fokussieren jedes HF-Signals, die von mehreren Signalwandlerelementen empfangen werden, um ein Ultraschallbild zu erzeugen, wobei das medizinische digitale Ultraschallabbildungsverfahren umfasst:

Umwandeln jedes HF-Ultraschall-Impulsechos in ein elektrisches Signal und Ausgeben des umgewandelten Ergebnisses;
Abtasten der HF-Ultraschall-Impulsechoausgabe von dem Empfänger, Speichern der abgetasteten Daten zum Erzeugen eines Ultraschallbildes aus mindestens einem Rahmen,
Fokussieren der abgetasteten Daten oder der gespeicherten abgetasteten Daten und Ausgeben des fokussierten Ergebnisses;
Empfangen des fokussierten Signals bei einem Signalprozessor und Ausführen einer Signalverarbeitung zum Erzeugen des Ultraschallbildes; wobei das Verfahren **gekennzeichnet ist durch**
Ausführen einer Fokussierung **durch** die Strahlformungseinheit, um ein in Bezug auf einen Teil des Ultraschallbildes vergrößertes Bild unter Verwendung der gespeicherten abgetasteten Daten zu erzeugen.

Revendications

1. Appareil numérique d'échographie médicale destiné à mettre au point chaque signal RF reçu d'une pluralité d'éléments transducteurs pour former une échographie, l'appareil numérique d'échographie médicale comprenant :

un récepteur (102) destiné à convertir chacun des échos d'impulsion ultrasonore RF en un signal électrique et à sortir le résultat converti ;
une unité (200) de formation de faisceau destinée à échantillonner les échos d'impulsion ultrasonore RF sortis du récepteur, à mémoriser les données échantillonnées pour former une échographie d'au moins une vue, à mettre au point les données échantillonnées ou les données échantillonnées mémorisées et à sortir le résultat mis au point ;
un processeur (104) de signal destiné à recevoir le signal mis au point provenant de l'unité (200) de formation de faisceau et à effectuer un traitement de signal pour former l'échographie ; et
un régisseur (300) destiné à commander l'appareil,
ladite unité (200) de formation de faisceau étant conçue pour mémoriser lesdites données échantillonnées pour former une échographie d'au moins une vue,
caractérisé en ce que ladite unité (200) de formation de faisceau est conçue pour effectuer une mise au point afin de former une image zoomée en ce qui concerne une partie de l'échographie, en utilisant les données échantillonnées mémorisées.

2. Appareil numérique d'échographie médicale selon la revendication 1, dans lequel ladite unité (200) de formation de faisceau est conçue pour effectuer l'une d'une mise au point dynamique, d'une mise au point synthétique et d'une mise au point à faisceaux multiples, en utilisant les données échantillonnées mémorisées.

3. Appareil numérique d'échographie médicale selon la revendication 1 ou 2, dans lequel ladite unité (200) de formation de faisceau est conçue pour analyser les données échantillonnées mémorisées et pour estimer des caractéristiques de signal nécessaires pour la mise au point et la formation de l'échographie, et pour mettre au point ensuite les données échantillonnées ou les données échantillonnées mémorisées en fonction du résultat de ladite analyse.

4. Appareil numérique d'échographie médicale selon l'une quelconque des revendications 1 à 3, dans lequel ladite unité (200) de formation de faisceau comprend :

une pluralité de convertisseurs (21(1) à 21(N)) d'analogique en numérique (A/D) destinés à échantillonner les échos d'impulsion ultrasonore RF et à sortir le résultat échantillonné ;
une pluralité de mémoires (23(1) à 23(N)) correspondant à chacun de ladite pluralité de convertisseurs A/D (21 (1) à 21(N)), et mémorisant les données échantillonnées pour former une échographie d'au moins une vue ;
un formateur de faisceau (24) destiné à mettre au point et à sortir les données appliquées ;
une pluralité de régisseurs (22(1) à 22(N)) de mémoire correspondant à chacun de ladite pluralité de convertisseurs A/D (21(1) à 21(N)) et à chacune de ladite pluralité de mémoires (23(1) à 23(N)), et transmettant les données échantillonnées reçues de chacun de la pluralité de convertisseurs A/D (21(1) à 21(N)) à chacune des mémoires (23(1) à 23(N)) correspondantes et au formateur de faisceau (24), et commandant une entrée/sortie des données échantillonnées mémorisées dans chacune de la pluralité de mémoires (23(1) à 23(N)) ; et
un processeur local (25) destiné à commander la pluralité de régisseurs (22(1) à 22(N)) de mémoire et le formateur de faisceau (200), à recevoir les données échantillonnées mémorisées dans chacune de la pluralité de mémoires (23(1) à 23(N)), à analyser les données échantillonnées reçues, à estimer des caractéristiques de signal nécessaires pour mettre au point et pour former l'échographie, et à commander le formateur de faisceau (24) en fonction du résultat de l'analyse.

5. Appareil numérique d'échographie médicale selon la revendication 4, conçu de façon que, dans le cas où chaque élément transducteur correspond à l'un, respectif, des convertisseurs A/D (21(1) à 21(N)), chacun des convertisseurs A/D (21(1) à 21(N)) effectue un échantillonnage uniforme au même instant, le formateur de faisceau (24) met au point les données échantillonnées selon la méthode de la somme des retards, la capacité de la mémoire est exprimée par l'équation suivante :

$$\text{Capacité de mémoire} = N_{fr} \times N_{sl} \times (F_s \times 2 \times z_{max}/c)$$

dans laquelle N_{fr} est le nombre de vues à mémoriser dans la mémoire, N_{sl} est le nombre de lignes de balayage à mémoriser pour chaque vue, F_s est la vitesse de conversion A/D ou la fréquence d'échantillonnage, z_{max} est la profondeur maximale d'image, et c est la vitesse des ultrasons dans un objet.

6. Appareil numérique d'échographie médicale selon la revendication 4 ou 5, dans lequel le régisseur (300) peut effectuer une transmission mutuelle de données avec le processeur local (25).

7. Appareil numérique d'échographie médicale selon la revendication 6, dans lequel ledit régisseur (300) est conçu pour recevoir le résultat de l'analyse en provenance du processeur local (25) et pour commander les autres composants en fonction du résultat de l'analyse.

8. Appareil numérique d'échographie médicale selon la revendication 6, dans lequel ledit régisseur (300) est conçu pour recevoir les données échantillonnées mémorisées en provenance du processeur local (25), pour analyser les caractéristiques de signal des données échantillonnées reçues et pour commander les autres composants en fonction du résultat de l'analyse.

9. Appareil numérique d'échographie médicale selon la revendication 8, dans lequel ledit régisseur (300) est conçu pour analyser les caractéristiques de signal pour estimer un profil de vitesse des ultrasons et une variation du spectre de fréquences de l'écho d'impulsion ultrasonore avec des caractéristiques de profondeur et de bruit qui sont nécessaires pour mettre au point et former l'échographie en ce qui concerne les données échantillonnées mémorisées reçues.

10. Appareil numérique d'échographie médicale selon la revendication 9, dans lequel ledit régisseur (300) est conçu pour transmettre le résultat de l'analyse au processeur local (25).

11. Appareil numérique d'échographie médicale selon la revendication 10, dans lequel ledit processeur local (25) est conçu pour commander ledit formateur de faisceau (200) en fonction du résultat reçu.

12. Appareil numérique d'échographie médicale selon la revendication 4, dans lequel ladite pluralité de régisseurs (21 (1) à 21(N)) de mémoire est conçue pour recevoir les données provenant du processeur local (25) et pour transmettre les données reçues à ladite pluralité de mémoires (23(1) à 23(N)) correspondantes ou audit formateur de faisceau (24).

13. Appareil numérique d'échographie médicale selon la revendication 12, dans lequel ledit processeur local (25) est conçu pour transmettre des données auto-générées ou les données reçues dudit régisseur (300) à ladite pluralité de régisseurs (22(1) à 22(N)) de mémoire.

14. Appareil numérique d'échographie médicale selon la revendication 4, dans lequel ladite pluralité de régisseurs (22 (1) à 22(N)) de mémoire est conçue pour lire les données échantillonnées mémorisées dans la mémoire (23(1) à 23(N)) correspondante et pour transmettre les données lues au processeur local (25).

15. Appareil numérique d'échographie médicale selon la revendication 4, dans lequel ledit processeur local (25) peut être connecté à chacun de ladite pluralité de régisseurs (22(1) à 22(N)) de mémoire un par un.

16. Appareil numérique d'échographie médicale selon la revendication 4, dans lequel ledit formateur de faisceau (24) et ledit processeur local (25) sont prévus sous la forme d'un unique processeur qui remplit les deux fonctions du formateur de faisceau (24) et du processeur local (25).

17. Appareil numérique d'échographie médicale selon la revendication 4, dans lequel ladite unité (200) de formation de faisceau comprend en outre :

une pluralité de démodulateurs en quadrature (61(1) à 61(N)) destinée à séparer chacun des échos d'impulsion ultrasonore RF reçus d'une pluralité d'éléments transducteurs en une composante en phase et une composante en quadrature, et à sortir le résultat séparé ; et
une pluralité de convertisseurs A/D (62(1) à 62(N), 63(1) à 63(N)) correspondant à chacun desdits démodulateurs en quadrature, incluant un ensemble de premiers convertisseurs A/D (62 (1) à 62 (N)) destinés à échantillonner une composante en phase provenant de chacun des démodulateurs en quadrature et de seconds convertisseurs A/D (63(1) à 63(N)) destinés à en échantillonner une composante en quadrature, pour sortir les données échantillonnées vers chacun desdits régisseurs (65(1) à 65(N)) de mémoire correspondants.

18. Procédé d'échographie médicale numérique consistant à mettre au point chaque signal RF reçu d'une pluralité d'éléments transducteurs pour former une échographie, le procédé d'échographie médicale numérique comprenant :

la conversion de chacun des échos d'impulsion ultrasonore RF en un signal électrique et la sortie du résultat converti ;
l'échantillonnage des échos d'impulsion ultrasonore RF sortis du récepteur, la mémorisation des données échantillonnées pour former une échographie d'au moins une vue ;
la mise au point des données échantillonnées ou des données échantillonnées mémorisées et la sortie du résultat mis au point ;
la réception du signal mis au point au niveau d'un processeur de signal et l'exécution d'un traitement de signal pour former l'échographie ;
le procédé étant **caractérisé par** l'exécution d'une mise au point, à l'aide d'une unité de formation de faisceau, afin de former une image zoomée en ce qui concerne une partie de l'échographie, en utilisant les données échantillonnées mémorisées.

FIG. 1 (PRIOR ART)

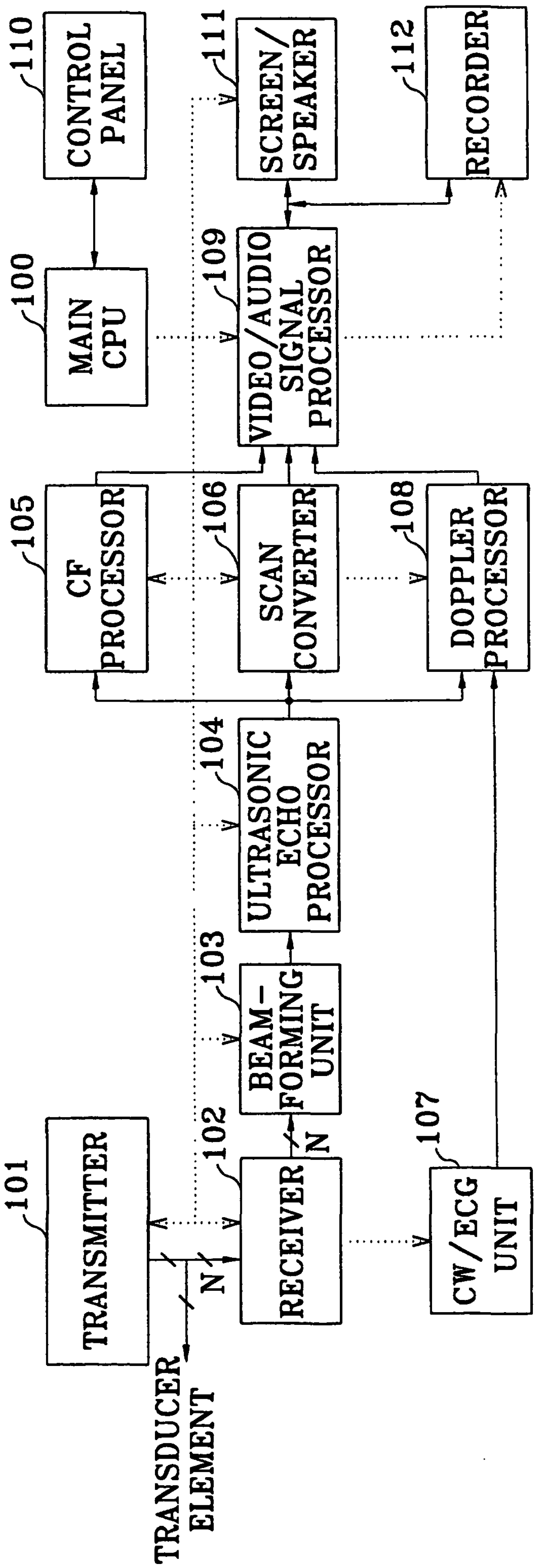


FIG. 2 (PRIOR ART)

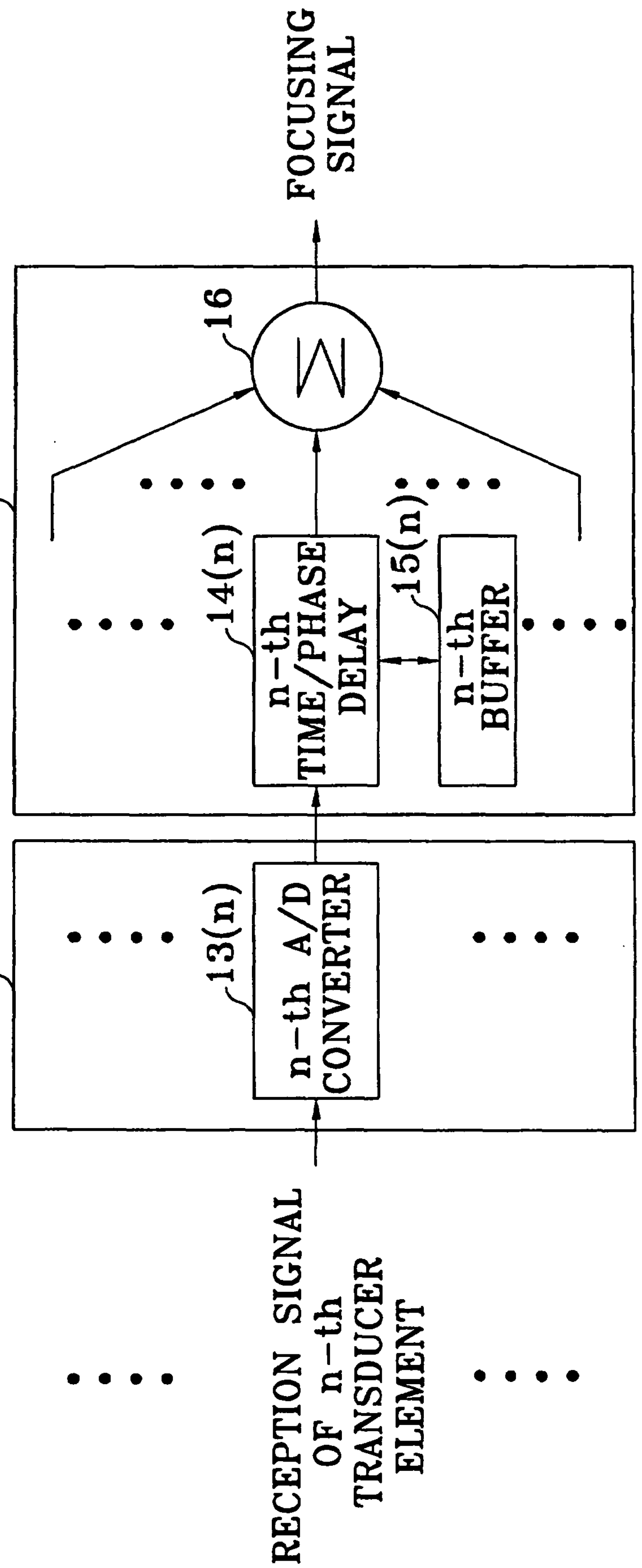


FIG. 3

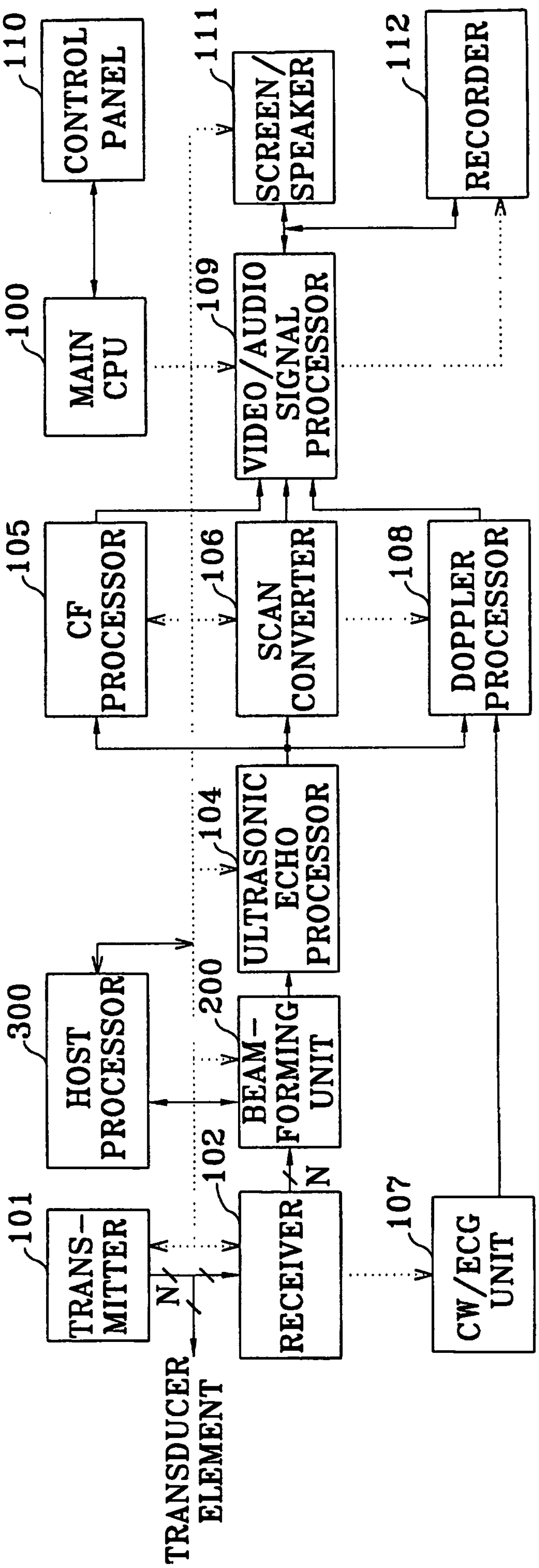

110
CONTROL PANEL
111
SCREEN/ SPEAKER
112
RECORDER
100
MAIN CPU
109
VIDEO/AUDIO SIGNAL PROCESSOR
105
CF PROCESSOR
106
SCAN CONVERTER
108
DOPPLER PROCESSOR
104
ULTRASONIC ECHO PROCESSOR
300
HOST PROCESSOR
200
BEAM-FORMING UNIT
101
TRANS-MITTER
102
RECEIVER
107
CW/ECG UNIT
N
N
TRANSDUCER ELEMENT

FIG. 4

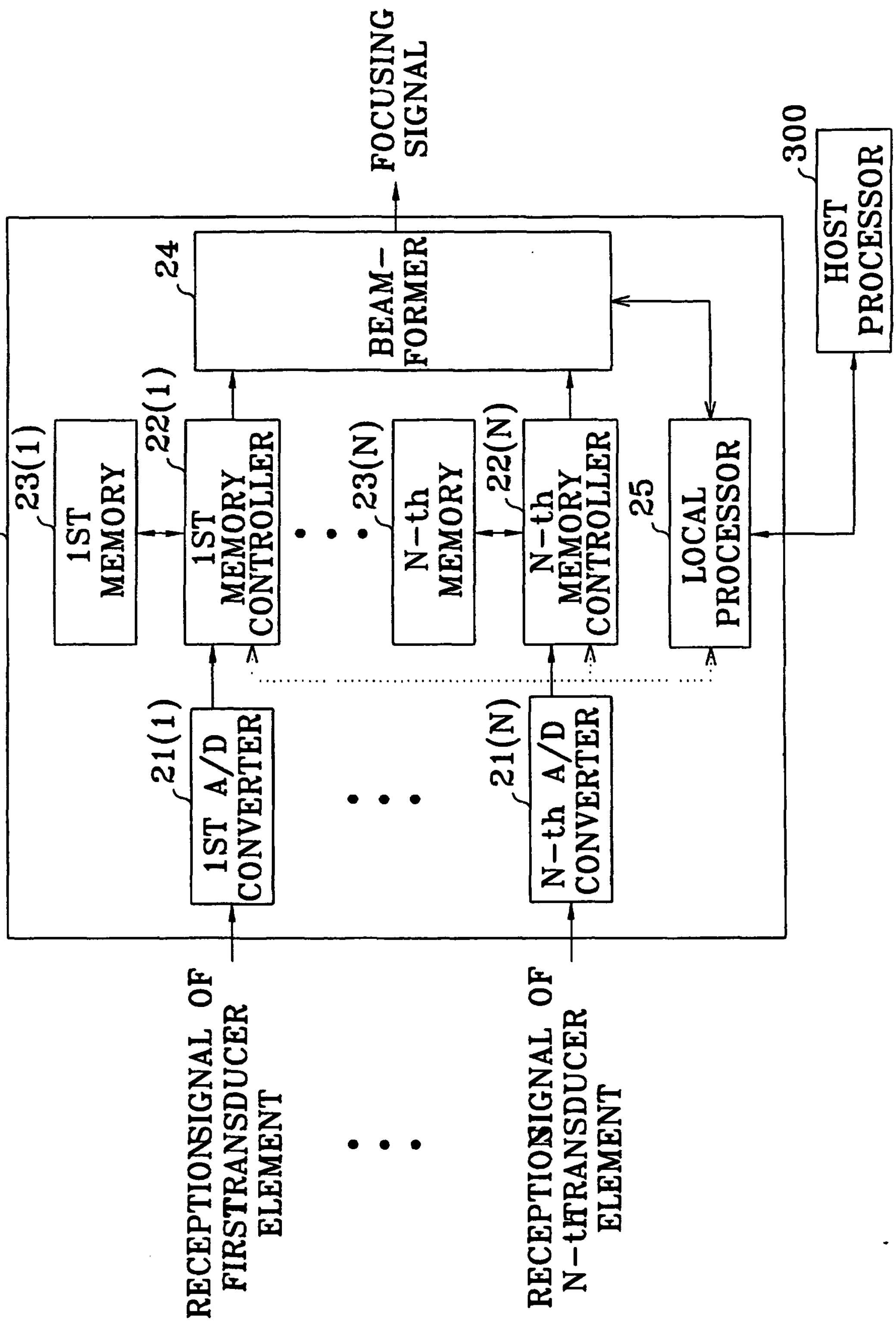

FOCUSING SIGNAL
24
BEAM-FORMER
300
HOST PROCESSOR
200
23(1)
1ST MEMORY
22(1)
1ST MEMORY CONTROLLER
23(N)
N-th MEMORY
22(N)
N-th MEMORY CONTROLLER
25
LOCAL PROCESSOR
21(1)
1ST A/D CONVERTER
21(N)
N-th A/D CONVERTER
RECEPTION SIGNAL OF FIRST TRANSDUCER ELEMENT
RECEPTION SIGNAL OF N-th TRANSDUCER ELEMENT

FIG. 5

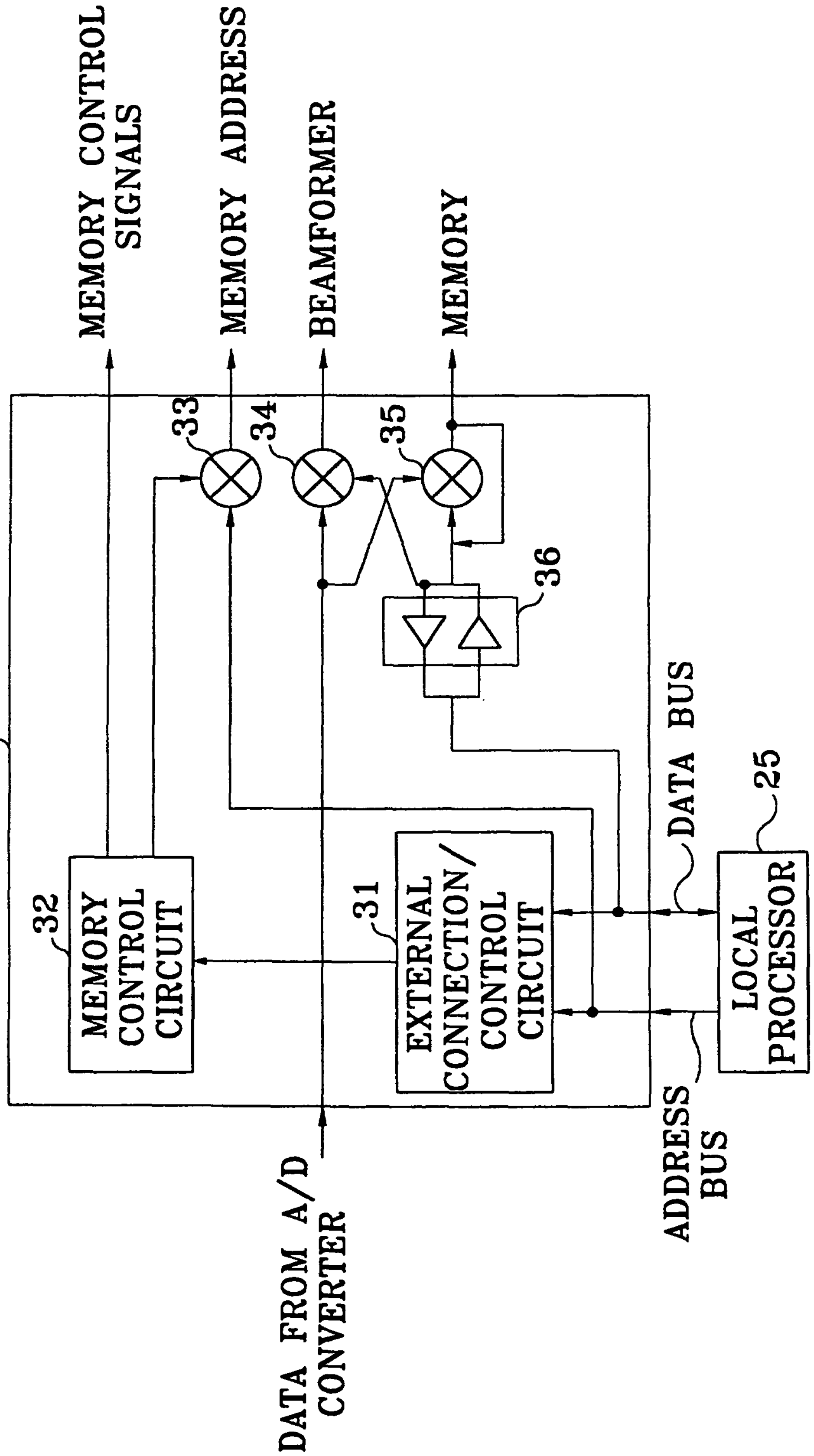

MEMORY CONTROL SIGNALS
MEMORY ADDRESS
BEAMFORMER
MEMORY
33
34
35
36
22(n)
32
MEMORY CONTROL CIRCUIT
31
EXTERNAL CONNECTION/ CONTROL CIRCUIT
DATA BUS
25
LOCAL PROCESSOR
ADDRESS BUS
DATA FROM A/D CONVERTER

FIG. 6

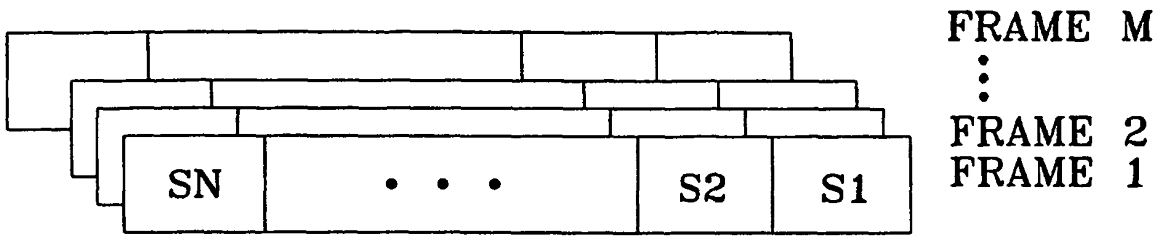


FIG. 7

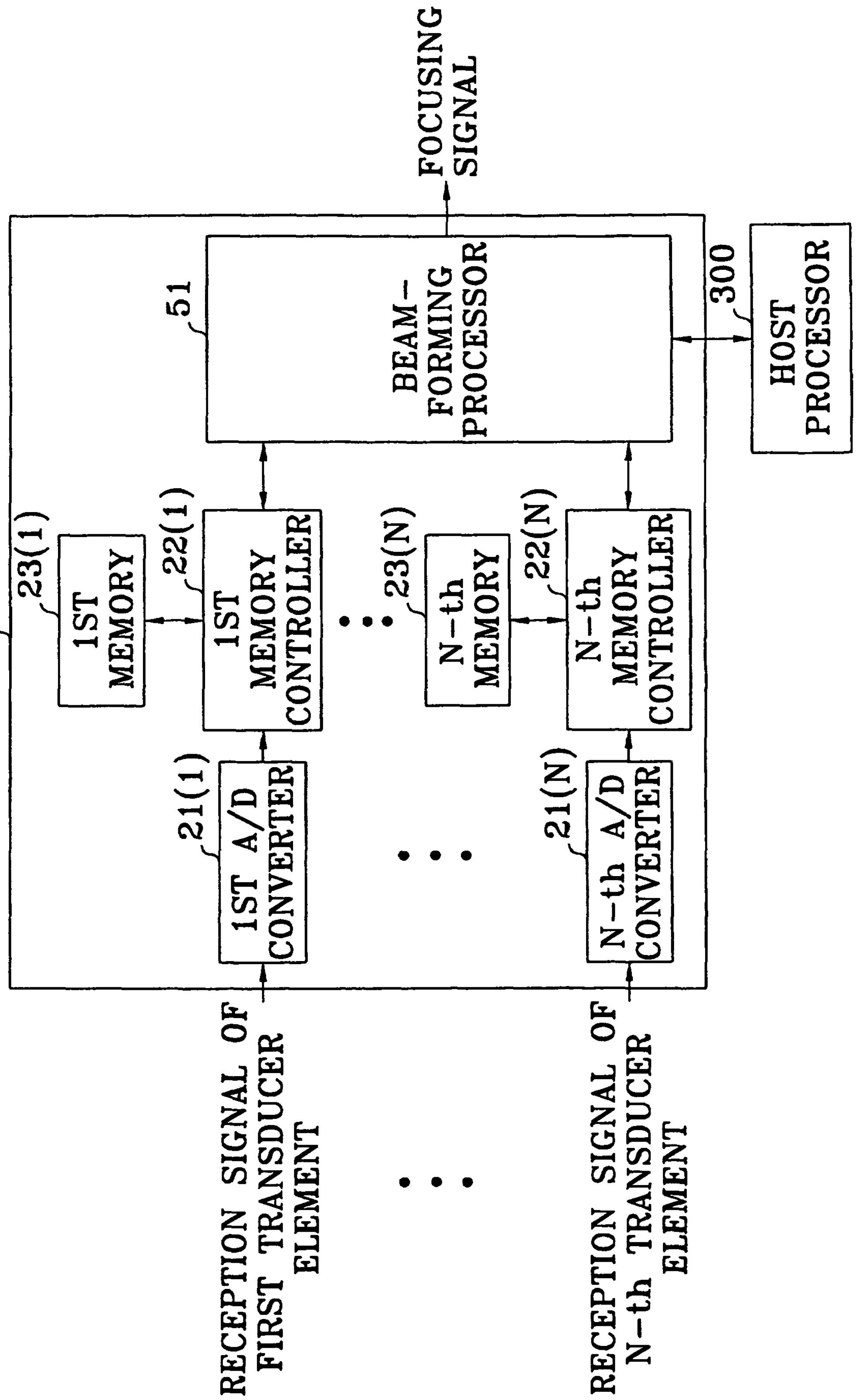
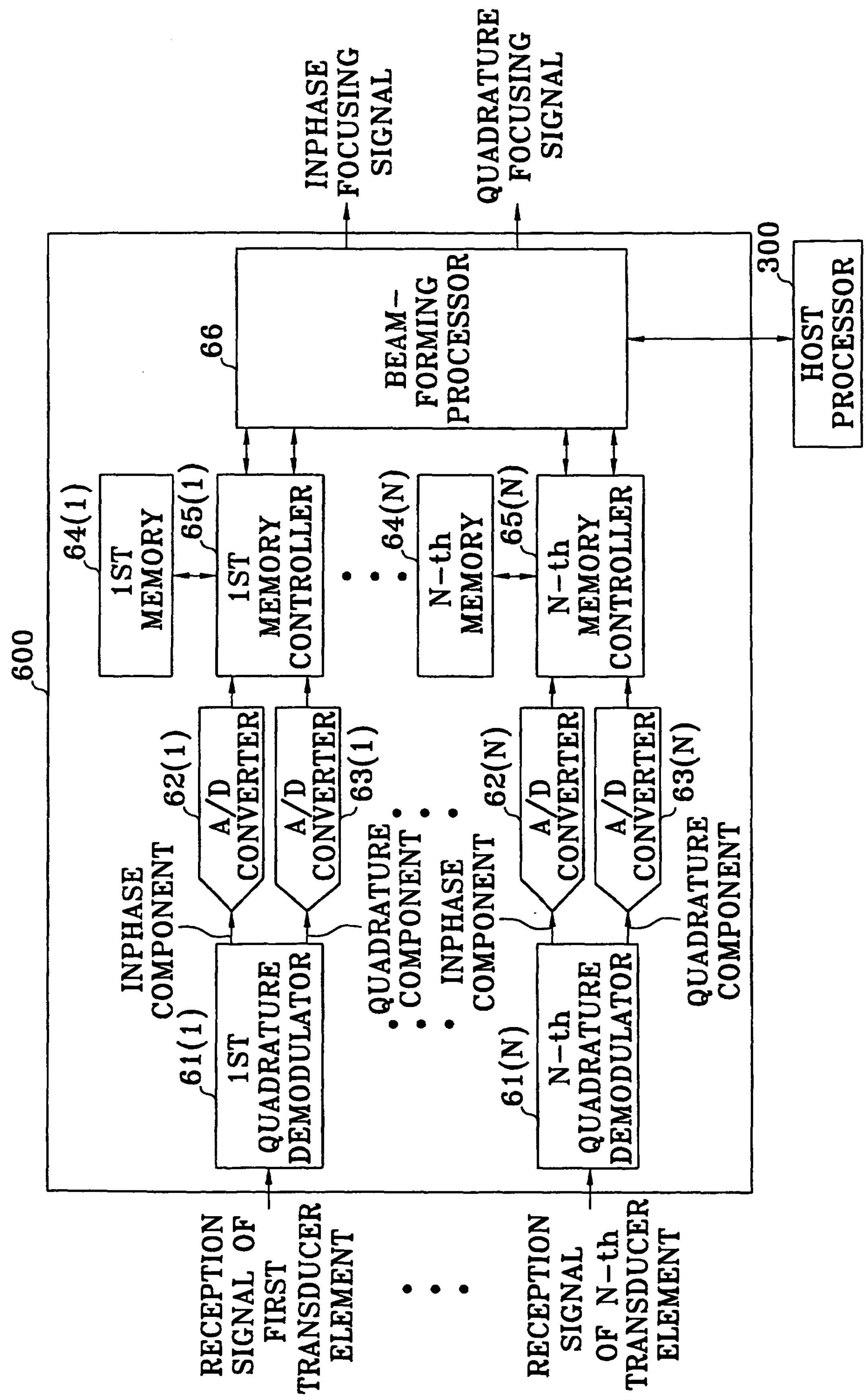

FOCUSING SIGNAL
500
23(1)
1ST MEMORY
22(1)
1ST MEMORY CONTROLLER
21(1)
1ST A/D CONVERTER
23(N)
N-th MEMORY
22(N)
N-th MEMORY CONTROLLER
21(N)
N-th A/D CONVERTER
51
BEAM-FORMING PROCESSOR
300
HOST PROCESSOR
RECEPTION SIGNAL OF FIRST TRANSDUCER ELEMENT
RECEPTION SIGNAL OF N-th TRANSDUCER ELEMENT

FIG. 8


INPHASE FOCUSING SIGNAL
QUADRATURE FOCUSING SIGNAL
600
66
BEAM-FORMING PROCESSOR
300
HOST PROCESSOR
64(1)
1ST MEMORY
65(1)
1ST MEMORY CONTROLLER
64(N)
N-th MEMORY
65(N)
N-th MEMORY CONTROLLER
62(1)
A/D CONVERTER
63(1)
A/D CONVERTER
62(N)
A/D CONVERTER
63(N)
A/D CONVERTER
INPHASE COMPONENT
QUADRATURE COMPONENT
INPHASE COMPONENT
QUADRATURE COMPONENT
61(1)
1ST QUADRATURE DEMODULATOR
61(N)
N-th QUADRATURE DEMODULATOR
RECEPTION SIGNAL OF FIRST TRANSDUCER ELEMENT
RECEPTION SIGNAL OF N-th TRANSDUCER ELEMENT

REFERENCES CITED IN THE DESCRIPTION

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- US 5544657 A **[0010]**
- EP 0916966 A1 **[0011]**

专利名称(译)	能够存储和重复使用射频（RF）超声脉冲回波的医疗数字超声成像设备		
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外部链接	Espacenet		

摘要(译)

RF超声脉冲回波的存储方法和能够重新使用所存储的RF超声脉冲回波的医用数字超声成像设备存储并聚焦从多个换能器元件接收的每个RF超声脉冲回波，以便实现超声图像。至少一帧。然后，分析所存储的RF超声脉冲回波，从而根据分析结果控制系统，这导致实现最佳超声图像。

$$\text{Memory capacity} = N_{tr} \times N_{sl} \times (F_s \times 2 \times z_{max}/c)$$