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(54) DIAGNOSTIC INFORMATION GENERATION APPARATUS AND ULTRASONIC DIAGNOSTIC SYSTEM

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(57) **ABSTRACT**

An ultrasonic diagnostic system, which is intended to perform the wireless communication of ultrasonic diagnostic information within the speed range of general-purpose data communication standards, is arranged in a first and second units. The first unit includes ultrasonic wave transmit/receive means which transmits an ultrasonic wave and receives the echo of the wave, data generation means which produces digital diagnostic data based on the received echo, data compression means which compresses the digital data, and data communication means which sends out the compressed data in wireless manner. The second unit includes data communication means which receives the transmitted data, data expansion means which expands the received data, and information generation means which produces display information from the expanded data.

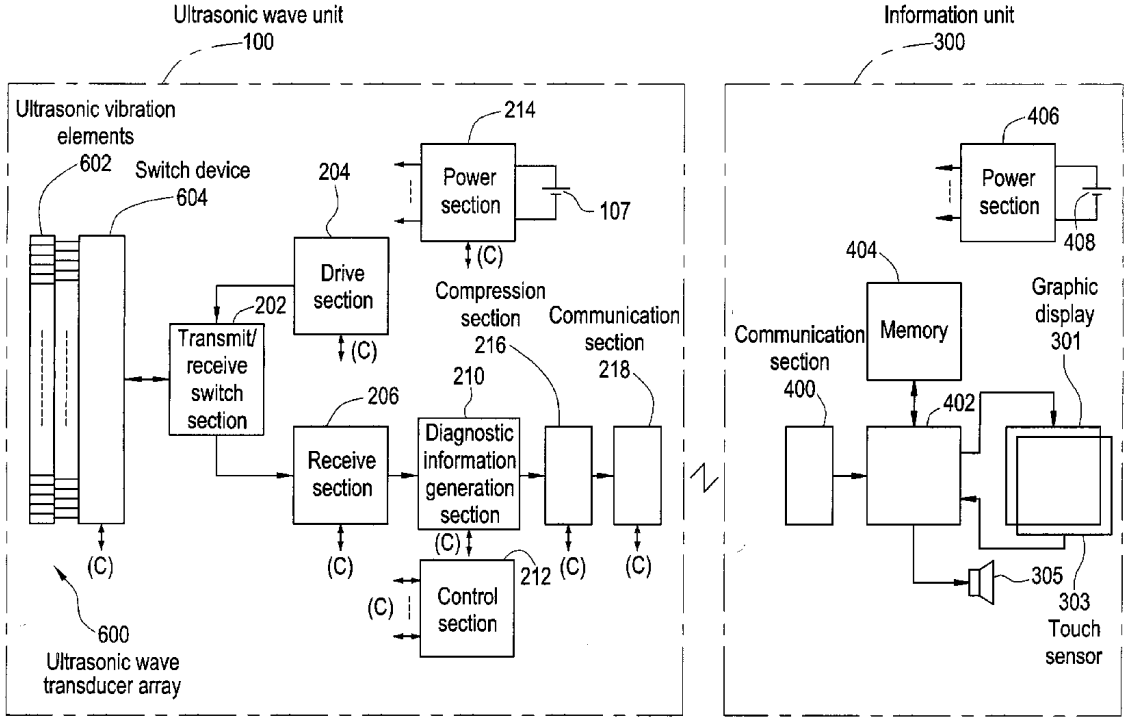


FIG. 1

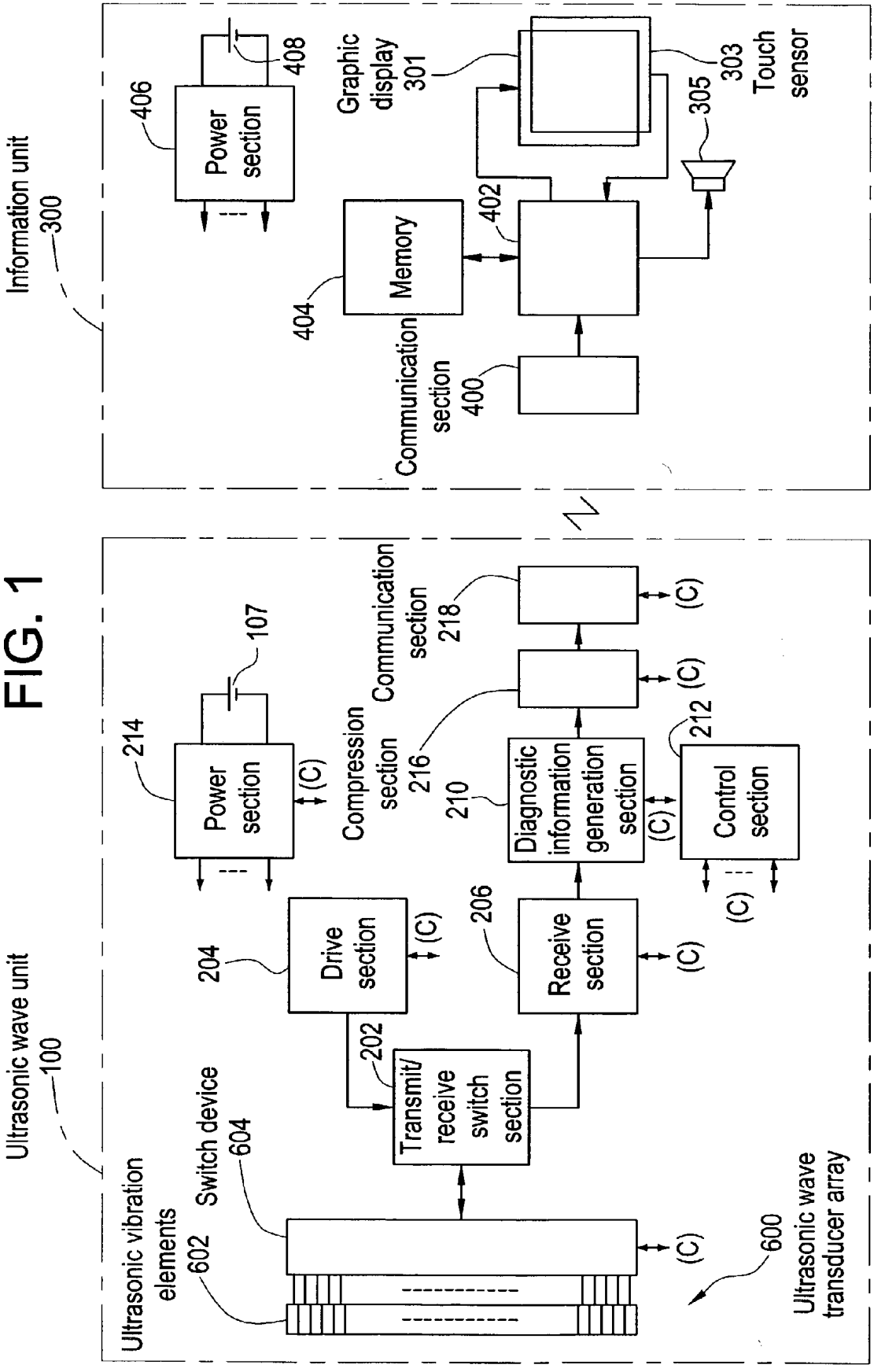

Information unit
300
Power section
406
408
Graphic display
301
303
Touch sensor
305
Memory
404
402
Communication section
400
Ultrasonic wave unit
100
Power section
214
107
(C)
Compression section
216
Communication section
218
(C)
(C)
212
Diagnostic information generation section
210
(C)
Control section
(C)
Drive section
204
(C)
206
Receive section
(C)
202
Transmit/ receive switch section
Switch device
604
Ultrasonic vibration elements
602
(C)
600
Ultrasonic wave transducer array

FIG. 2

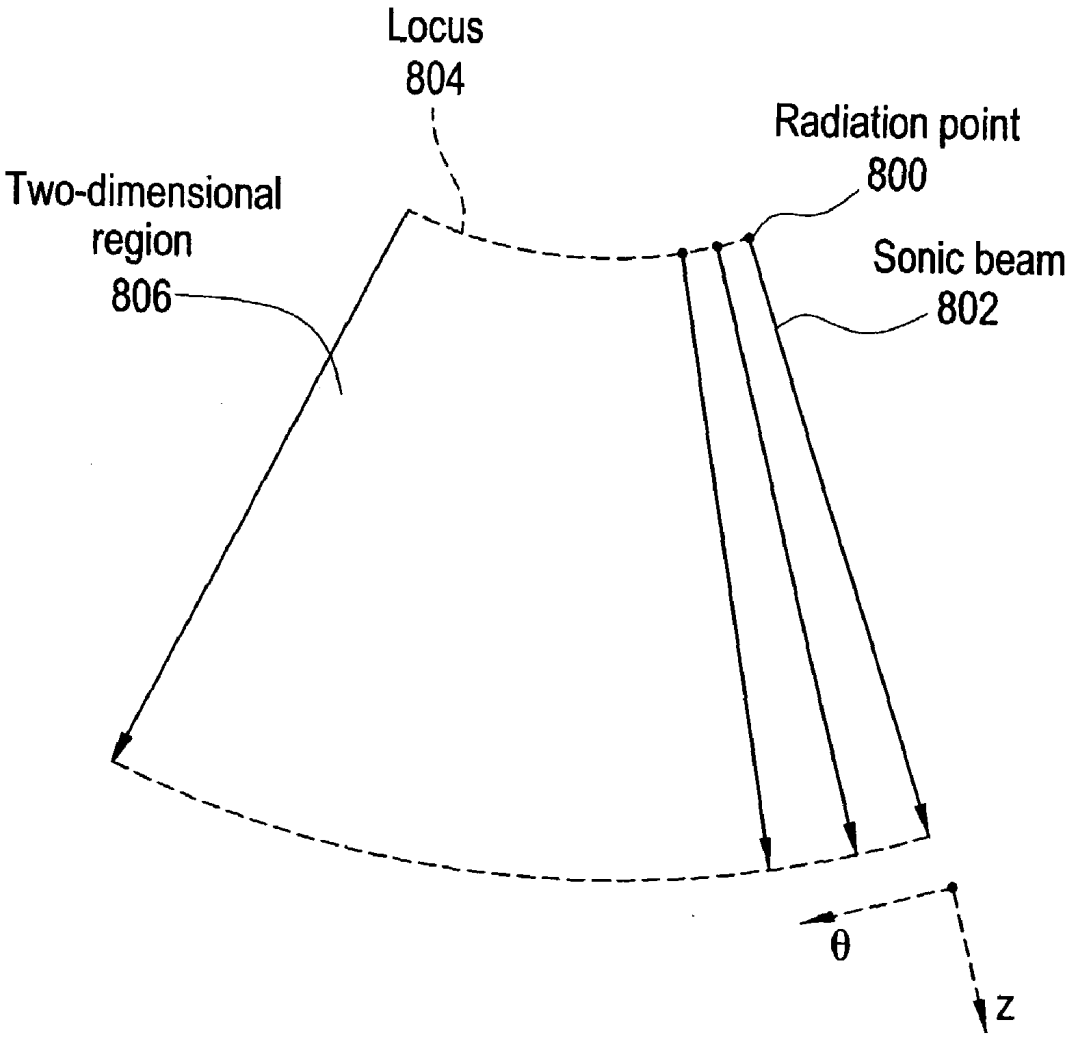

Locus
804
Radiation point
800
Two-dimensional
region
806
Sonic beam
802
θ
z

FIG. 3

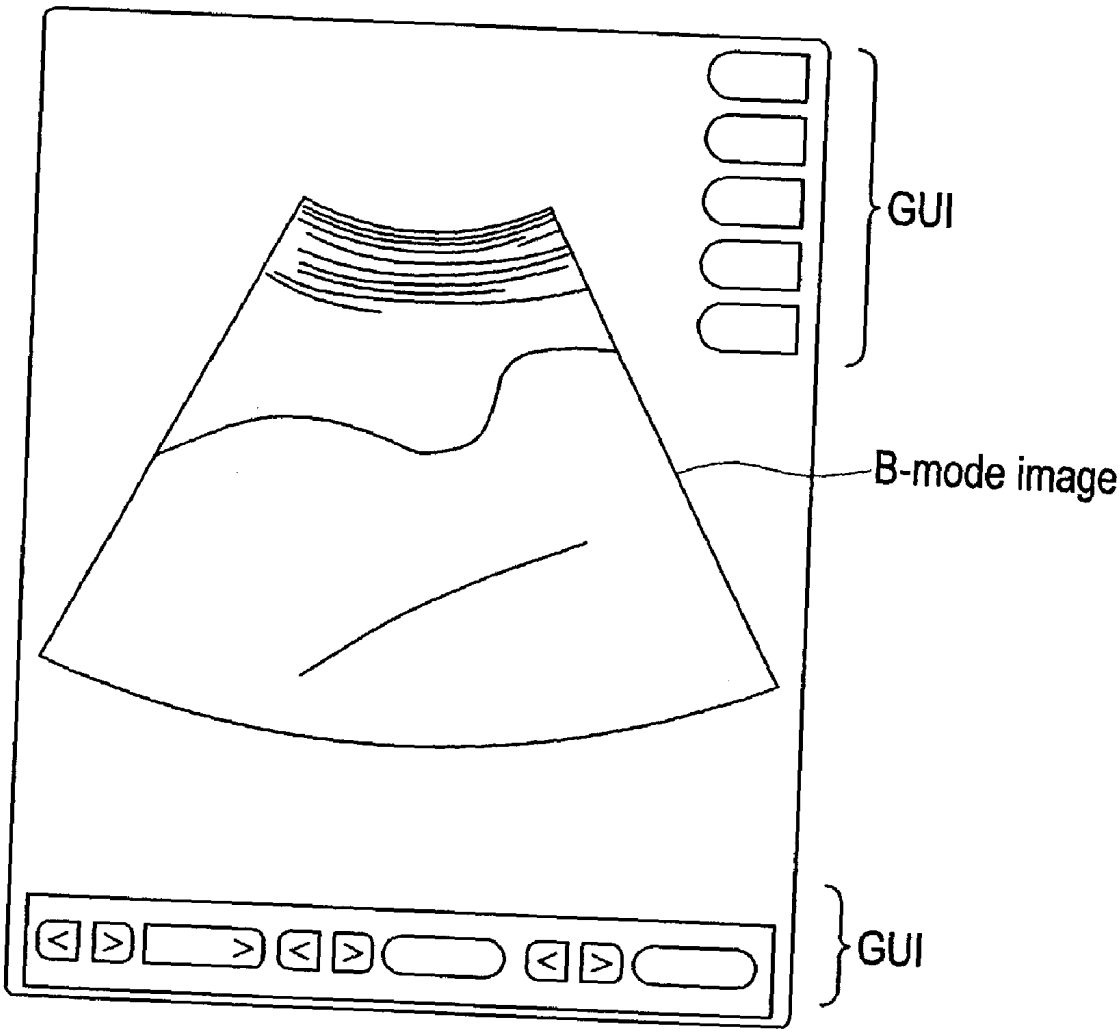
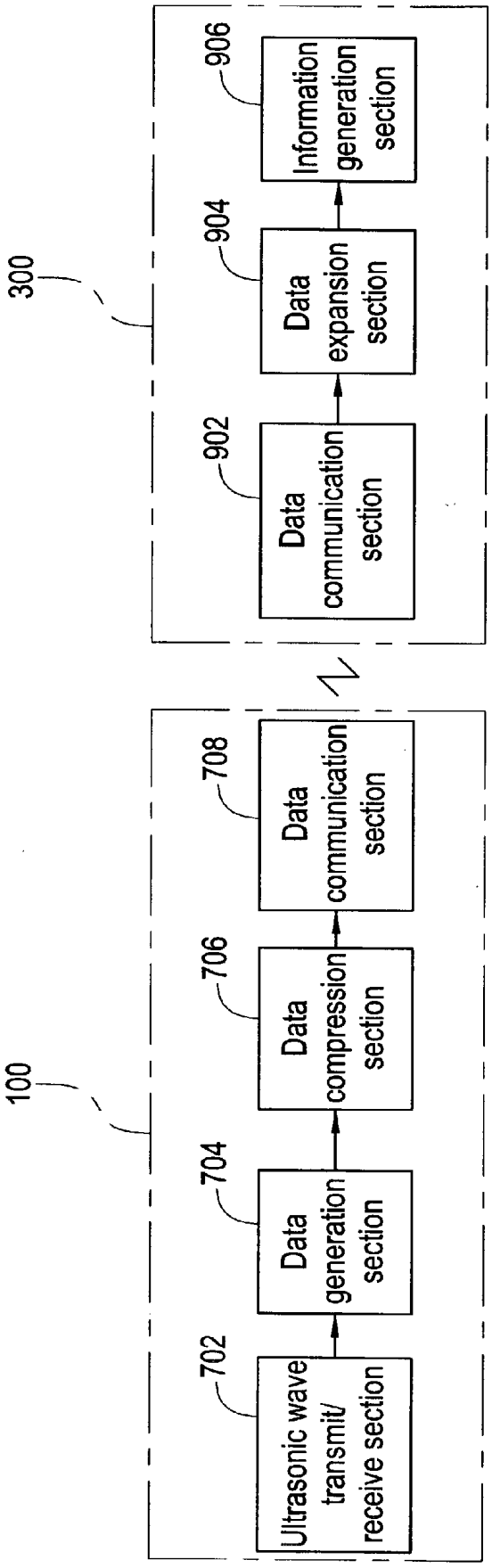


FIG. 4


100
702
Ultrasonic wave transmit/ receive section
704
Data generation section
706
Data compression section
708
Data communication section
300
902
Data communication section
904
Data expansion section
906
Information generation section

DIAGNOSTIC INFORMATION GENERATION APPARATUS AND ULTRASONIC DIAGNOSTIC SYSTEM

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a diagnostic information generation apparatus and an ultrasonic diagnostic system, and particularly to a diagnostic information generation apparatus and ultrasonic diagnostic system which utilize an ultrasonic wave.

[0002] An ultrasonic diagnostic system operates to scan the inside of a subject of diagnosis with ultrasonic beams, receive a resulting echo, produce image data based on the strength of echo, and produce a so-called B-mode image. This scheme is also called B-mode imaging.

[0003] In addition, the apparatus evaluates the Doppler shift of the echo and produces a color image indicative of the flow velocity distribution of fluid such as blood, i.e., so-called color Doppler image, based on the Doppler shift of echo. The apparatus also produces a color image indicative of the power of Doppler signal, i.e., so-called power Doppler image. The apparatus implements the frequency analysis of the Doppler signal and displays resulting spectra or releases resulting Doppler sound signals. This scheme is also called Doppler diagnosis.

[0004] Japanese Patent Unexamined Publication No.S53-108690 discloses a technique of building an ultrasonic diagnostic system in two divided sections. One of the two section is a unit which scans the inside of a subject of diagnosis with ultrasonic beams, receives a resulting echo, and produces diagnostic information from the echo. The other section is a unit which produces display information from the diagnostic information. The diagnostic information is transferred from the one unit to the other unit by wireless communication.

[0005] The above-mentioned wireless communication is required to be as fast as around several megabytes/sec in order to keep the real-time performance of diagnosis. Such a high communication speed exceeds overwhelmingly the speed of communication means which are based on general-purpose wireless communication standards such as Bluetooth for example. On this account, general-purpose communication means cannot be used, and a special communication means must be designed.

SUMMARY OF THE INVENTION

[0006] Accordingly, it is an object of the present invention to accomplish a diagnostic information generation apparatus which performs the wireless communication for ultrasonic diagnostic information within the speed range of general-purpose data communication standards, and also accomplish an ultrasonic diagnostic system which uses the diagnostic information generation apparatus. In this specification, the wireless communication implies the communication based on the use of radio wave, light, etc. which travels in the space.

[0007] (1) The present invention at one viewpoint for solving the foregoing problem resides in a diagnostic information generation apparatus which is characterized by comprising an ultrasonic wave transmit/receive means which transmits an ultrasonic wave and receives the echo of the wave, data generation means which produces digital diagnostic data based on the received echo, data compression means which compresses the digital data, and data communication means which sends out the compressed data in wireless manner.

[0008] The invention at this viewpoint is designed to transmit an ultrasonic wave and receive the echo of the wave, produce digital diagnostic data based on the received echo, compress the digital data and send out in wireless manner, whereby it is possible to perform the wireless communication for ultrasonic diagnostic information within the speed range of general-purpose data communication standards.

[0009] (2) The present invention at another viewpoint for solving the foregoing problem resides in an ultrasonic diagnostic system arranged in a first section which produces diagnostic information by utilization of ultrasonic wave and a second section which produces display information from the diagnostic information, wherein the first section includes ultrasonic wave transmit/receive means which transmits an ultrasonic wave and receives the echo of the wave, data generation means which produces digital diagnostic data based on the received echo, data compression means which compresses the digital data, and data communication means which sends out the compressed data in wireless manner, and the second section includes data communication means which receives the transmitted data, data expansion means which expands the received data, and information generation means which produces display information from the expanded data.

[0010] The invention at this viewpoint is designed to operate on the part of the first section to transmit an ultrasonic wave and receive the echo of the wave, produce digital diagnostic data based on the received echo, compress the digital data, and send out the compressed data in wireless manner, whereby it is possible to perform the wireless communication for ultrasonic diagnostic information within the speed range of general-purpose data communication standards.

[0011] It operates on the part of the second section to receive and expand the transmitted data, and produce display information from the expanded data, whereby it is possible to obtain information for real-time display. The released information can be a B-mode image, color Doppler image, power Doppler image, Doppler spectra, Doppler sound, or the like.

[0012] The data compression means preferably implements the data compression in compliance with a general-purpose data compression standard, since it is readily available. The general-purpose data compression standard can be JPEG, MPEG, or the like.

[0013] The data communication means preferably implements the communication in compliance with a general-purpose data communication standard, since it is readily available.

[0014] The data communication means preferably implements the communication based on radio wave, since it is good in terms of information propagation. The data communication standard can be Bluetooth, CDMA2000, IEEE802.11, SWAP, or the like.

[0015] The data communication means preferably implements the communication based on light, since it is small in power consumption. The data communication standard can be IrDA, or the like.

[0016] The digital data is preferably sonic beam data, so that it minimizes data processing in need before compression.

[0017] The sonic beam data is preferably derived from the detection and logarithmic conversion of the signal of received echo, since it is proper for B-mode imaging.

[0018] The sonic beam data is preferably derived from the autocorrelation process of the signal of received echo, since it is proper for color Doppler imaging.

[0019] The ultrasonic wave transmit/receive-means preferably implements the transmission and reception after the end of communication frame of the data communication means, so that the ultrasonic wave transmission/reception take place in concert with the data communication.

[0020] The information generation means preferably converts the coordinates of sonic beam space into the coordinates of real space for the sonic beam data, so that it produces image information which indicates accurately the shape of the subject of imaging.

[0021] The first section of the system is preferably a transportable unit, so that it is large in terms of latitude of the site of use.

[0022] The second section of the system is preferably a transportable general-purpose information unit, since it is readily available. The information unit can be a portable personal computer, portable information terminal, portable telephone unit, or the like.

[0023] According to the present invention, it is possible to accomplish a diagnostic information generation apparatus which performs the wireless communication of ultrasonic diagnostic information within the speed range of general-purpose data communication standards, and an ultrasonic diagnostic system which uses the diagnostic information generation apparatus.

BRIEF DESCRIPTION OF DRAWINGS

[0024] **FIG. 1** is a block diagram of an example of embodiment of the system of this invention.

[0025] **FIG. 2** is a conceptual diagram of sonic beam scanning.

[0026] **FIG. 3** is a diagram showing briefly an example of image display.

[0027] **FIG. 4** is a functional block diagram of an example of embodiment of the system of this invention.

DETAILED DESCRIPTION OF THE INVENTION

[0028] An embodiment of the present invention will be explained in detail with reference to the drawings. **FIG. 1** shows a block diagram of an ultrasonic diagnostic system. This system is an embodiment of this invention. The arrangement of this system shows an example of embodiment pertinent to the inventive system.

[0029] As shown in the figure, the system is arranged in two units, which are an ultrasonic wave unit **100** and an information unit **300**. The ultrasonic wave unit **100** and information unit **300** are an example of embodiment of the first section and second section, respectively, defined by this invention. The ultrasonic wave unit **100** is also an example of embodiment of the inventive diagnostic information generation apparatus. The arrangement of this apparatus shows an example of embodiment pertinent to the inventive diagnostic information generation apparatus.

[0030] The ultrasonic wave unit **100** includes an ultrasonic wave transducer array **600**. The ultrasonic wave transducer array **600** is a one-dimensional array, for example, which consists of ultrasonic vibration elements **602** of 64 to 128 in number. The ultrasonic vibration element **602** is formed of piezoelectric material, e.g., PZT (titanium (Ti) acid zirconium (Zr) acid lead) ceramics.

[0031] The ultrasonic wave transducer array **600** is, for example, an arcuate array which is convex toward the radiating direction of ultrasonic wave, i.e., it is a so-called convex array.

[0032] The ultrasonic vibration elements **602** of the ultrasonic wave transducer array **600** are connected individually to a switch device **604**. The switch device **604** selects a certain number of ultrasonic vibration elements **602** that contribute to ultrasonic wave transmission and reception of the ultrasonic wave transducer array **600**. The number of ultrasonic vibration elements **602** to be selected is 16 for example, and this number larger than 1 is arbitrary.

[0033] The selected ultrasonic vibration elements **602** of 16 in number, for example, form the aperture for ultrasonic wave transmission/reception. The 16 ultrasonic vibration elements of the aperture are changed in their combination sequentially. Consequently, the aperture moves in steps from one end to another end of the ultrasonic wave transducer array **600**. This switching operation takes place under control of a control section **212** which will be explained later.

[0034] The ultrasonic wave unit **100** further includes a transmit/receive switch section **202**. The transmit/receive switch section **202** is connected with the switch device **604**, a drive section **204** and a receive section **206**.

[0035] The transmit/receive switch section **202** puts drive signals, which are released by the drive section **204**, in to the switch device **604** at the time of communication. The number of drive signals corresponds to the number (e.g.,16) of ultrasonic vibration elements **602** of the aperture. Each drive signal is given a phase difference for beam forming of the output ultrasonic wave. The drive signals put in to the switch device **604** are applied to the respective ultrasonic vibration elements **602**, which then emit ultrasonic wave beams.

[0036] The echo of the ultrasonic wave is received by each corresponding ultrasonic vibration element **602** of the aperture. The transmit/receive switch section **202**, at the time of reception, puts a number (e.g.,16) of echo reception signals, which are conducted by the switch device **604**, in to the receive section **206**. The receive section **206** gives phase differences for beam forming to the echo reception signals and sums the signals, thereby producing an echo reception signal of one sonic beam. The above-mentioned transmit/receive operation is carried out while moving the aperture by the switch device **604**.

[0037] Due to the design of the ultrasonic wave transducer array **600** as a convex array, the radiation point **800** of the sonic beam **802** moves along an arcuate locus **804** to scan a two-dimensional sectoral region **806** at directions θ thereby performing the so-called convex scanning as shown in **FIG. 2**.

[0038] The ultrasonic wave transducer array **600** can be formed arbitrarily, instead of the foregoing arrangement. It may be a two-dimensional array, instead of one-dimensional array. In these cases, the switch device **604**, drive section **204** and receive section **206** are arranged to match with the ultrasonic wave transducer array **600**.

[0039] The echo reception signal produced by the receive section **206** is put in to a diagnostic information generation section **210**. The diagnostic information generation section **210** produces digital diagnostic data based on the echo reception signal. The digital diagnostic data is B-mode imaging data for example. B-mode imaging data is produced by detecting the echo reception signal and computing the logarithm of the detected signal. B-mode imaging data is produced for each sonic beam.

[0040] Digital diagnostic data may be color Doppler imaging data which is based on the Doppler shift of echo reception signal, instead of B-mode imaging data. Or, it may be Doppler diagnostic data.

[0041] Color Doppler imaging data is produced by computing the autocorrelation of the echo reception signal. Color Doppler imaging data is a set of data which express the flow velocity, variance, power, etc. Color Doppler imaging data is also produced for each sonic beam. In the following explanation, data produced for each sonic beam will be termed sonic beam data.

[0042] Doppler diagnostic data is data which expresses a spectrum of Doppler signal or data which expresses a Doppler sound. Data of Doppler signal spectrum is produced by the frequency analysis of Doppler signal. Data of Doppler sound is produced by evaluating instantaneous values of Doppler signal.

[0043] A compress section **216** implements the data compression for the output data of the diagnostic information generation section **210**. Data compression takes place in compliance with a general-purpose data compression standard. Based on the data compression in compliance with a data compression standard, circuit parts of compress section **216** are readily available in the market. The general-purpose data compression standard can be JPEG, MPEG, or the like. Or, it may be MP3 for the compression of Doppler sound data.

[0044] Data compression by the compress section **216** takes place for each sonic beam for example. This scheme minimizes the preliminary data processing before compression. Data compression may be designed for two-dimensional data which is a set of multiple sonic beam data. In consequence, efficient compression can take place.

[0045] Compressed data is sent out in wireless manner by a communication section **218**. The wireless communication uses radio wave for example. The radio wave can go through walls of buildings and the like existing on the course. Accordingly, it is desirable in terms of good information propagation. The wireless communication may use light, e.g., infrared light. Using light is desirable in terms of small power consumption.

[0046] The wireless communication takes place in compliance with a general-purpose-data communication standard. Based on the adoption of general-purpose data communication standard, circuit parts of the communication section **218** are readily available in the market. The general-purpose data communication standard can be Bluetooth, CDMA2000, IEEE802.11, SWAP, IrDA, or the like.

[0047] These communication standards have data communication speeds of, for example,16 Mbps at maximum in the case of IrDA with the physical layer specifications of version 1.4, and the communication based on data compression readily attains data rates ranging from 2M to several megabytes per second in terms of data before compression. Accordingly, it is possible to implement properly the communication of ultrasonic diagnostic data which is required to be a real-time performance.

[0048] The ultrasonic wave unit **100** further includes a control section **212**. The control section **212** issues the control signals to the switch device **604**, drive section **204**, . . . , communication section **218**, thereby controlling these sections. The controlled sections return status signals, etc. to the control section **212**. The transmit/receive switch section **202** generally consists solely of passive elements, operates automatically for transmit/receive switching and therefore does not need the supply of control signal, however, the supply of control signal is obviously necessary when it is formed of active elements.

[0049] Transmission and reception of ultrasonic wave take place under control of the control section **212** at the each end of communication of one frame by the communication section **218**. In consequence, the ultrasonic wave transmission/reception which is harmonious with communication can be performed.

[0050] The ultrasonic wave unit **100** further includes a power section **214**. The power section **214** produces the power voltages to be supplied to the sections in the unit **100** based on the conversion of electric power of a battery **107**. The power conversion is the DC/DC conversion or the like. The power section **214** is also under control of the control section **212**.

[0051] The information unit **300** includes a communication section **400**. The communication section **400** is the data communication partner of the communication section **218** of the ultrasonic wave unit **100**. Both communication sections have communication based on a general-purpose data communication standard.

[0052] The information unit **300** further includes a CPU (Central Processing Unit) **402**. The CPU **402** has input of reception data from the communication section **400**. Reception data is compressed data. The CPU **402** expands compressed data. Data expansion takes place in compliance with a general-purpose compression standard. In consequence, the digital diagnostic data produced by the diagnostic information generation section **210** is restored.

[0053] The CPU **402** is connected with a memory **404**. The restored digital diagnostic data is stored in the memory **404**. The memory **404** also stores programs, based on which

the CPU **402** operates. The stored programs include a general-purpose OS, for example, and various application programs which are run under the OS. Among these application programs are programs for ultrasonic diagnosis.

[**0054**] The application programs for ultrasonic diagnosis are designed to produce information to be released from diagnostic data. These programs produce a B-mode image from B-mode imaging data, a color Doppler image and power Doppler image from color Doppler imaging data, and a spectrum image and Doppler sound from digital diagnostic data.

[**0055**] The application programs for ultrasonic diagnosis further include a DSC (Digital Scan Conversion) program. This program converts the coordinates of sonic beam space into the coordinates of real space. Based on this coordinate conversion, a B-mode image, color Doppler image, etc. show correctly the shape of the subject of imaging.

[**0056**] The CPU **402** is further connected with a graphic display **301**. The graphic display **301** displays image information released by the CPU **402**. **FIG. 3** shows an example of display of image information. The figure shows an example of display of a B-mode image. The CPU **402** is further connected with a speaker **305**, which releases a Doppler sound.

[**0057**] The graphic display **301** has on its front face a transparent touch sensor **303**. The touch sensor **303** is connected to the CPU **402**. The touch sensor **303** has its output signal put in to the CPU **402**. The user can enter intended operational commands to the CPU **402** by bringing a stylus or the like to comes in contact with the GUI (Graphical User Interface) which is displayed on the graphic display **301**. The input section for entering operational commands and the like may be a keyboard in place of the touch sensor.

[**0058**] The information unit **300** has its own power section **406**. The power section **406** produces the power voltages to be supplied to the sections in the unit **300** based on the conversion of electric power of a battery **408**. The power section **406** is a DC/DC converter or the like.

[**0059**] The ultrasonic wave unit **100** and the information unit **300** are built as separate units. These units can be used in different places within the allowable range of wireless communication. Obviously, these units may be placed closely for use in one place, or may even be integrated. Consequently, this system has a great latitude in terms of place of use.

[**0060**] The ultrasonic wave unit **100** and the information unit **300** are built as transportable units. Consequently, the latitude of the place of use can be fully exerted. In regard to this affair, the portion including the ultrasonic wave transducer array **600** and switch device **604** may be built as an ultrasonic probe separately from the rest of unit **100**, with both portions being connected through a signal cable.

[**0061**] The information unit **300** is a general-purpose information unit. The general-purpose information unit is desirable, since it is readily available in the market. The information unit **300** is a portable PC (Personal Computer) for example. Or, it can be a portable PDA (Personal Data Assistant) or a portable telephone unit.

[**0062**] **FIG. 4** shows a block diagram of this system. As shown in the figure, the ultrasonic wave unit **100** includes an ultrasonic wave transmit/receive section **702**, data generation section **704**, data compression section **706**, and data communication section **708**.

[**0063**] The ultrasonic wave transmit/receive section **702** transmits an ultrasonic wave and receives the echo of the wave, and puts the echo reception signal in to the data generation section **704**. The ultrasonic wave transmit/receive section **702** is equivalent to the portion including the ultrasonic wave transducer array **600**, switch device **604**, transmit/receive switch section **202**, drive section **204** and receive section **206** explained previously. The ultrasonic wave transmit/receive section **702** is an example of embodiment of the ultrasonic wave transmit/receive means of this invention.

[**0064**] The data generation section **704** produces diagnostic data based on the echo reception signal and puts the data in to the data compression section **706**. The data generation section **704** is equivalent to the diagnostic information generation section **210** explained previously. The data generation section **704** is an example of embodiment of the data generation means of this invention.

[**0065**] The data compression section **706** compresses its input data and puts the resulting data in to the data communication section **708**. The data compression section **706** is equivalent to the compression section **216** explained previously. The data compression section **706** is an example of embodiment of the data compression means of this invention.

[**0066**] The data communication section **708** sends out its input data. The data communication section **708** is equivalent to the communication section **218** explained previously. The data communication section **708** is an example of embodiment of the data communication means of this invention.

[**0067**] The information unit **300** includes a data communication section **902**, data expansion section **904**, and information generation section **906**. The data communication section **902** puts the received data in to the data expansion section **904**. The data communication section **902** is equivalent to the communication section **400** explained previously. The data communication section **902** is an example of embodiment of the data communication means of this invention.

[**0068**] The data expansion section **904** expands its input data and puts the resulting data in to the information generation section **906**. The data expansion section **904** is equivalent to the data expansion function of the CPU **402** explained previously. The data expansion section **904** is an example of embodiment of the data expansion means of this invention.

[**0069**] The information generation section **906** produces display information from its input data. The information generation section **906** is equivalent to the display information generation function of the CPU **402** explained previously. The information generation section **906** is an example of embodiment of the information generation means of this invention.

[**0070**] While the present invention has been explained in connection with a preferred embodiment, various alterations

and replacements are obviously possible for those skilled in the technical field of this invention without departing from the technical scope of the invention. Therefore, the technical scope of this invention includes not only the foregoing embodiment, but all forms that belongs to the Scope of claim for a Patent.

[0071] Many widely different embodiments of the invention may be configured without departing from the spirit and the scope of the present invention. It should be understood that the present invention is not limited to the specific embodiments described in the specification, except as defined in the appended claims.

1. An ultrasonic diagnostic system comprising:

an ultrasonic wave transmit/receive device for transmitting an ultrasonic wave and receiving the echo of the wave;

a data generation device for producing digital diagnostic data based on the received echo;

a data compression device for compressing the digital data; and

a data communication device for sending out the compressed data in wireless manner.

2. The ultrasonic diagnostic system of claim 1, wherein said data compression device implements the data compression in compliance with a general-purpose data compression standard.

3. The ultrasonic diagnostic system of claim 1, wherein said data communication device implements the data communication in compliance with a general-purpose data communication standard.

4. The ultrasonic diagnostic system of claim 1, wherein said data communication device implements the data communication based on radio wave.

5. The ultrasonic diagnostic system of claim 1, wherein said data communication device implements the data communication based on light.

6. The ultrasonic diagnostic system of claim 1, wherein said digital data is sonic beam data.

7. The ultrasonic diagnostic system of claim 1, wherein said sonic beam data is derived from the detection and logarithmic conversion of the signal of received echo.

8. The ultrasonic diagnostic system of claim 1, wherein said sonic beam data is derived from the autocorrelation process of the signal of received echo.

9. The ultrasonic diagnostic system of claim 1, wherein said ultrasonic wave transmit/receive device implements the transmission and reception after the end of communication frame of said data communication device.

10. An ultrasonic diagnostic system arranged in a first section which produces diagnostic information by utilization of ultrasonic wave and a second section which produces display information from the diagnostic information,

said first section including:

an ultrasonic wave transmit/receive device for transmitting an ultrasonic wave and receives the echo of the wave;

a data generation device for producing digital diagnostic data based on the received echo;

a data compression device for compressing the digital data; and

a data communication device for sending out the compressed data in wireless manner;

said second section including:

a data communication device for receiving the transmitted data;

a data expansion device for expanding the received data; and

an information generation device for producing display information from the expanded data.

11. The ultrasonic diagnostic system of claim 10, wherein said data compression device implements the data compression in compliance with a general-purpose data compression standard.

12. The ultrasonic diagnostic system of claim 10, wherein said data communication device implements the data communication in compliance with a general-purpose data communication standard.

13. The ultrasonic diagnostic system of claim 10, wherein said data communication device implements the communication based on radio wave.

14. The ultrasonic diagnostic system of claim 10, wherein said data communication device implements the data communication based on light.

15. The ultrasonic diagnostic system of claim 10, wherein said digital data is sonic beam data.

16. The ultrasonic diagnostic system of claim 10, wherein said sonic beam data is derived from the autocorrelation process of the signal of received echo.

17. The ultrasonic diagnostic system of claim 10, wherein said ultrasonic wave transmit/receive device implements the transmission and reception after the end of communication frame of said data communication device.

18. The ultrasonic diagnostic system of claim 10, wherein said information generation device converts the coordinates of sonic beam space into the coordinates of real space for the sonic beam data.

19. The ultrasonic diagnostic system of claim 10, wherein said first section is a transportable unit.

20. The ultrasonic diagnostic system of claim 10, wherein said second section is a transportable general-purpose information unit.

* * * * *

专利名称(译)	诊断信息生成装置和超声波诊断系统		
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[标]申请(专利权)人(译)	SHINICHI雨宫 良太OHSUMI 通用电器横河医疗系统株式会社		
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当前申请(专利权)人(译)	通用电气医疗系统全球性技术公司，有限责任公司		
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其他公开文献	US6855113		
外部链接	Espacenet USPTO		

摘要(译)

用于在通用数据通信标准的速度范围内执行超声诊断信息的无线通信的超声诊断系统布置在第一和第二单元中。第一单元包括发送超声波并接收波形回波的超声波发送/接收装置，基于接收到的回波产生数字诊断数据的数据产生装置，压缩数字数据的数据压缩装置，以及数据通信装置以无线方式发送压缩数据。第二单元包括接收发送数据的数据通信装置，扩展接收数据的数据扩展装置，以及从扩展数据产生显示信息的信息发生装置。