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(54) ULTRASOUND SYSTEM INCLUDING A HANDHELD PROBE

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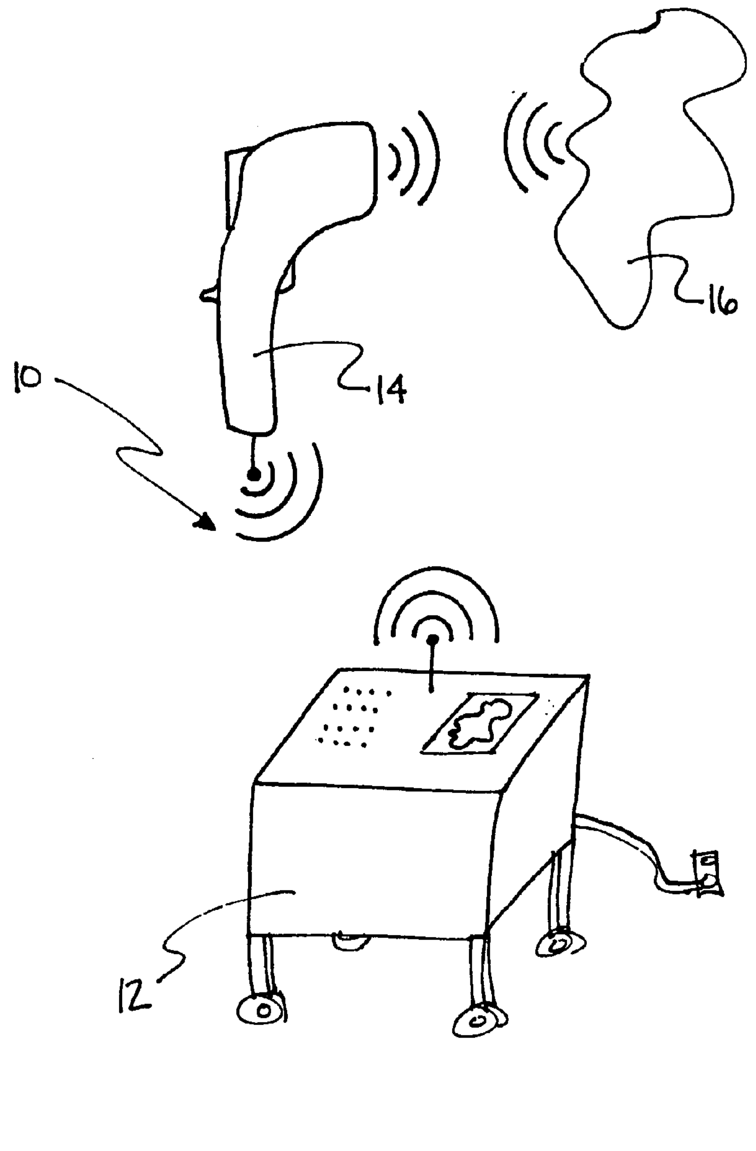
(57) **ABSTRACT**

The preferred embodiment of the invention include an ultrasound system, a handheld probe of the ultrasound device, and an integrated circuit for the handheld probe of the ultrasound system. The ultrasound system of the preferred embodiment includes a central console and a handheld probe. The handheld probe is adapted to receive a wireless beam signal from the central console, generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, combine the ultrasonic echoes into a single multiplexed echo signal, and transmit a multiplexed echo signal to the central console. The ultrasound system, including the handheld probe and the integrated circuit, provides an improved ultrasound system that collects enough echo data for 3D imaging and that transmits the echo data by a wireless link to overcome the limitations and drawbacks of typical ultrasound systems.



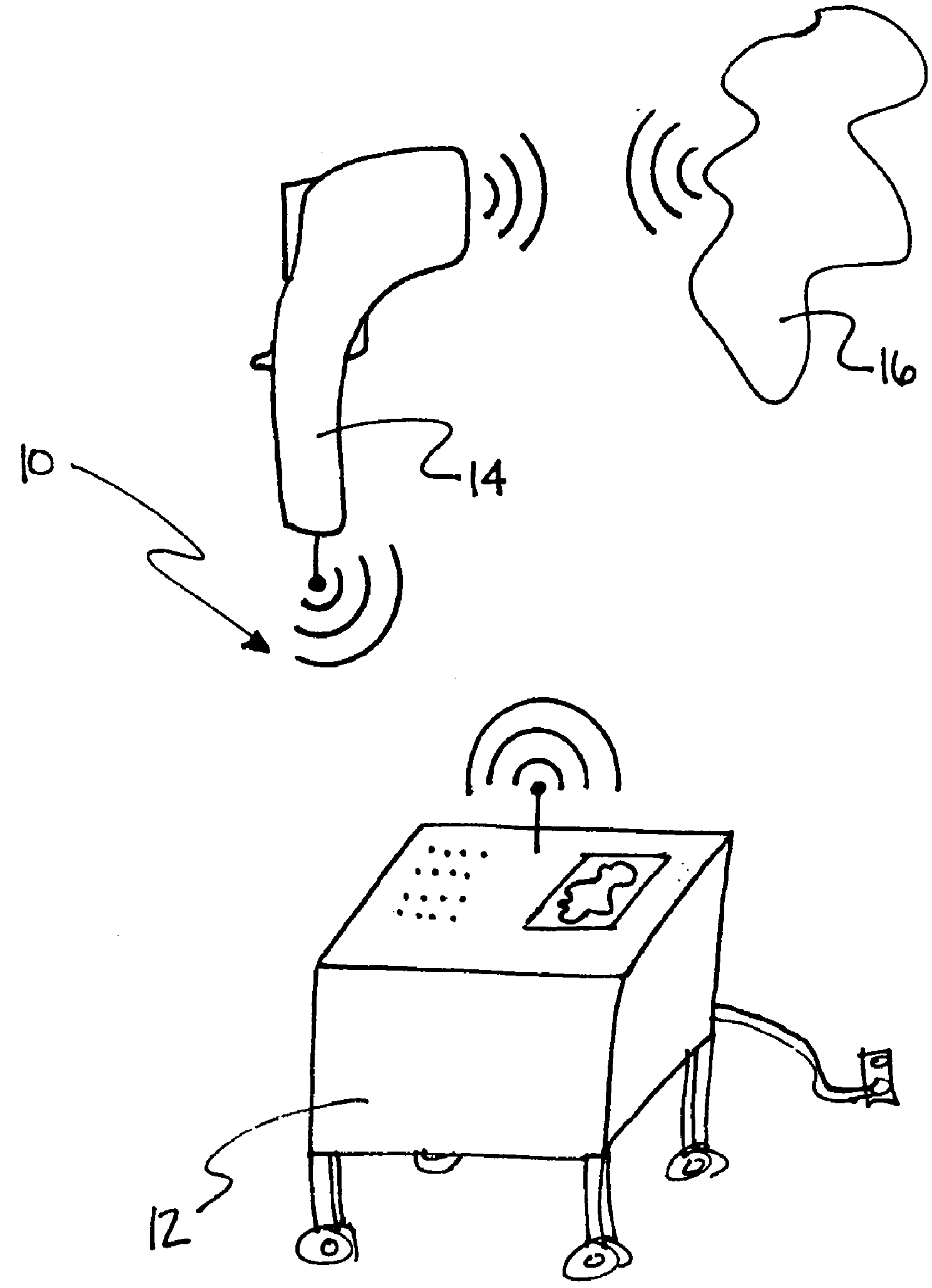


FIGURE 1

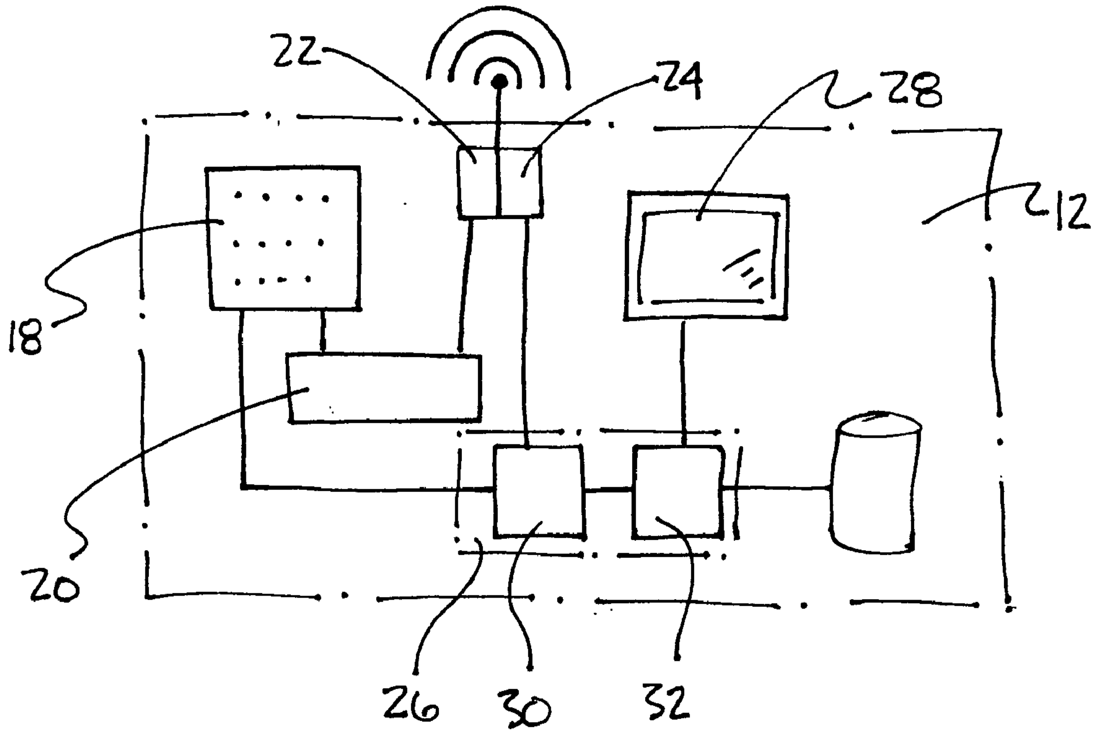


FIGURE 2

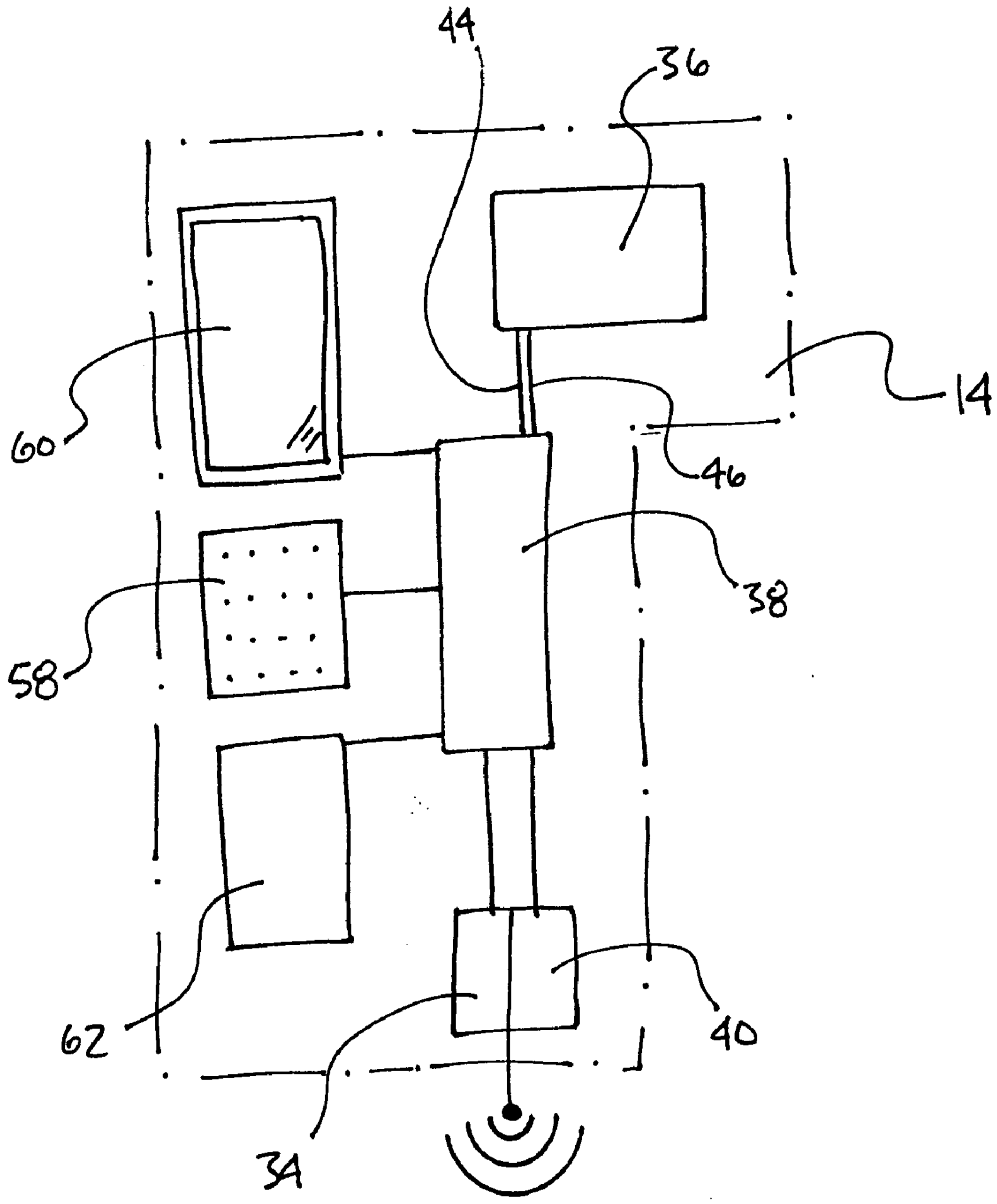


FIGURE 3

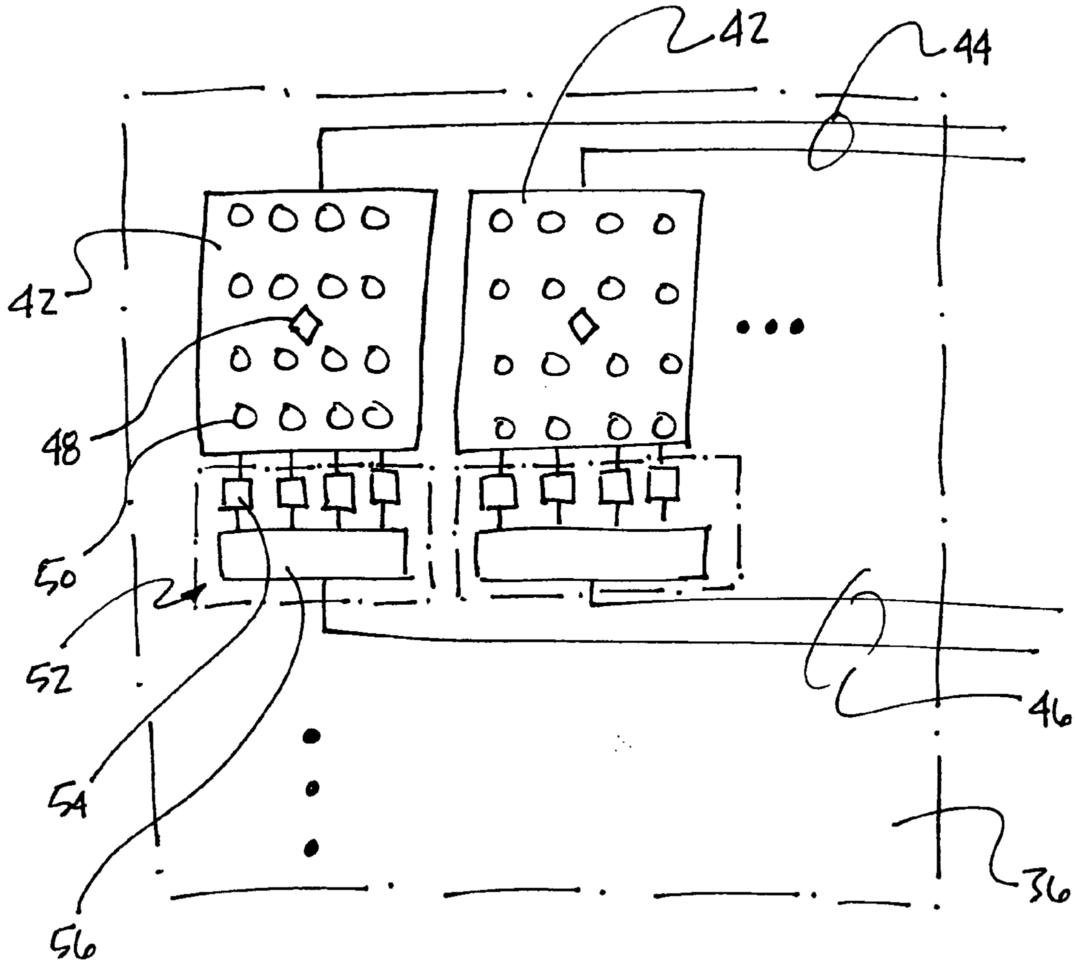


FIGURE 4

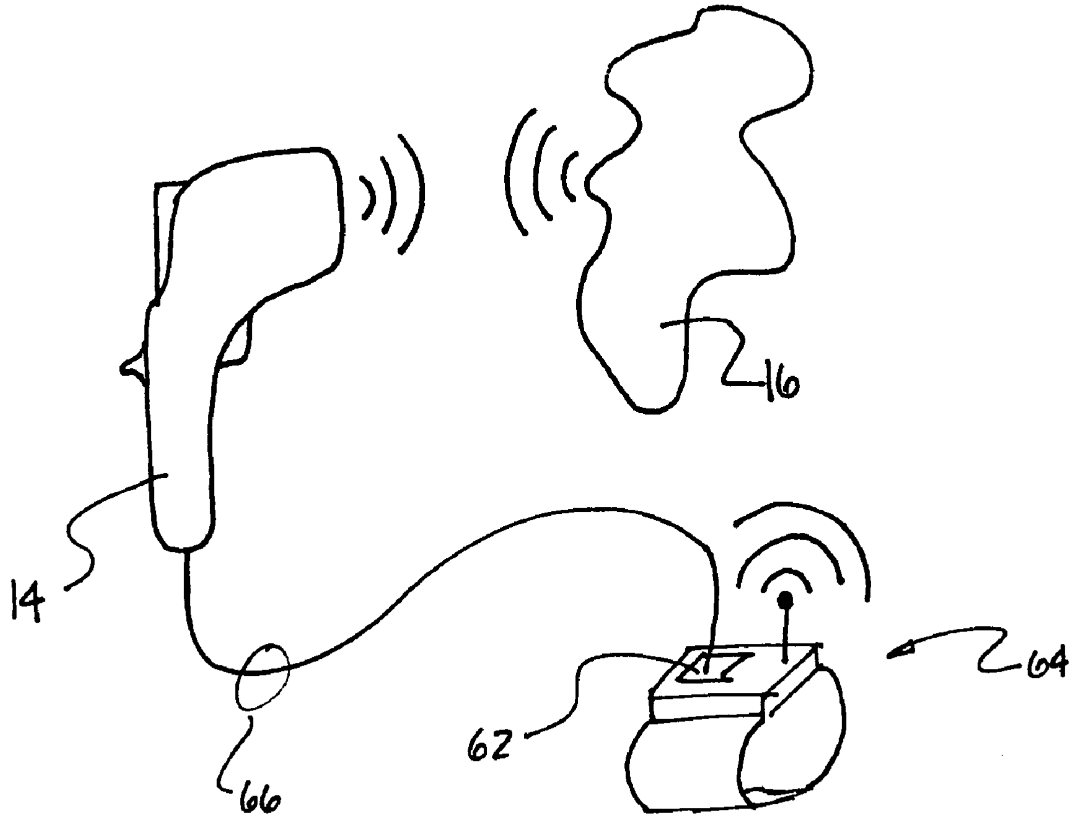


FIGURE 5

ULTRASOUND SYSTEM INCLUDING A HANDHELD PROBE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present invention claims priority to U.S. Provisional Patent Application No. 60/468,021 filed 06 May 2003 and titled "Wireless Transducer Head for Medical Ultrasound Systems", U.S. Provisional Patent Application No. 60/468,022 filed 06 May **2003** and titled "Two-Dimensional Array Design for Three-Dimensional Ultrasonic Imaging", U.S. Provisional Patent Application No. 60/468,023 filed 06 May 2003 and titled "Medical Ultrasound System Control Integral to the Transducer Head", and U.S. Provisional Patent Application No. 60/468,024 filed 06 May 2003 and titled "Three-Dimensional Ultrasonic Imaging System."

TECHNICAL FIELD

[0002] This invention relates generally to the medical field, and more specifically to an improved ultrasound system including a handheld probe.

BACKGROUND

[0003] Current medical ultrasound systems typically consist of a transducer head tethered by a communication cable to a central console, which includes the process controls for the ultrasound system. The transducer head generates acoustic waves and detects the reflected echo from the subject being insonified. The central console provides data processing and storage, image display, and/or other such functions typically required during an ultrasound examination.

[0004] The communication cable connecting the transducer head and the central console, although a necessity for existing ultrasound systems, can become a significant nuisance to the operator. The cable adds additional weight to the transducer head, which can tire the arm and wrist of the operator after long use. The cable often twists upon itself, which requires the operator—typically a highly paid sonographer or radiologist—to spend time untwisting the cable. Finally, the cable can become entangled with an injured patient or protruding pieces of delicate equipment.

[0005] There are, however, several obstacles that prevent the simple substitution of a wireless link for the communication cable of typical medical ultrasound systems. One is related to the physical distance between the transducer head and the central console; the other is related to the hardware of the transducer head.

[0006] The length of the communication cable between the transducer head and the central console of typical medical ultrasound systems is relatively short. In this manner, if the operator is holding the transducer head, the operator can reach and operate the process controls (e.g., imaging mode and frame or cine capture) on the central console. If the transducer head were wirelessly linked to the central console, however, the operators would not necessarily be within reach of the central console simply because they are holding the transducer head. Therefore, there exists a need to allow operation of an ultrasound system during a patient examination without requiring physical proximity to the central console.

[0007] Since the 1950s, ultrasound imaging has progressed from simple, analog A-mode imaging to far more sophisticated digital B-mode and color Doppler systems. Although these advancements have resulted in high-quality, 2D real-time imagers, an extension of this technology to produce 3D real-time images of comparable or vastly improved quality has not yet been realized. 3D ultrasound would allow medical specialists to view anatomy and pathologic conditions as a volume, thereby enhancing comprehension of the subject patient.

[0008] A 2D transducer array is universally acknowledged as the ideal approach for 3D ultrasound image acquisition. A single 3D frame volume from a 2D array, however, may contain gigabytes of raw data from a modest subject (e.g., an 8,000 cm^3 frame volume at 0.1 mm resolution) and frame rates for real-time imaging could exceed tens of frames per second. Such large amounts of data cannot be processed in real time by the hardware and software architecture typically used for typical ultrasound systems (e.g., 2D imaging with a 1D array). Collecting, pre-processing, and wirelessly transmitting this amount of data from a handheld probe is not currently possible with a transducer head of typical ultrasound systems.

[0009] Thus, there is a need in the medical field to create an improved ultrasound system with a handheld probe that collects enough echo data for 3D imaging and that transmits the echo data by a wireless link.

BRIEF DESCRIPTION OF THE FIGURES

[0010] **FIG. 1** is a representation of an ultrasound system of the preferred embodiment;

[0011] **FIG. 2** is a schematic representation of the central console of the ultrasound system;

[0012] **FIG. 3** is a schematic representation of a handheld probe for the ultrasound system;

[0013] **FIG. 4** is a schematic representation of an integrated circuit for the handheld probe; and

[0014] **FIG. 5** is a representation of an alternative handheld probe for the ultrasound system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0015] The following description of the preferred embodiment of the invention is not intended to limit the invention to this preferred embodiment, but rather to enable any person skilled in the art of medical devices to make and use this invention.

[0016] The preferred embodiment of the invention include an ultrasound system, a handheld probe of the ultrasound device, and an integrated circuit for the handheld probe of the ultrasound system. The ultrasound system **10** of the preferred embodiment, as shown in **FIG. 1**, includes a central console **12** and a handheld probe **14**. The handheld probe **14** is adapted to receive a wireless beam signal from the central console **12**, generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, combine the ultrasonic echoes into a single multiplexed echo signal, and transmit a multiplexed echo signal to the central console **12**. The ultrasound system lo, including the handheld probe and the integrated circuit, provides an improved ultrasound system that collects enough echo data for 3D imaging and that transmits the echo data by a wireless link to overcome the limitations and drawbacks of typical ultrasound systems.

[0017] The ultrasound system **10** has been specifically designed to allow medical specialists to view the anatomy and pathologic conditions of a patient. The ultrasound system **10** may, however, be used to view any subject **16** that at least partially reflects ultrasound beams. Such non-medical uses may include ultrasonic microscopy, non-destructive testing, and other situations that would benefit from a volumetric imaging of the subject **16**.

[0018] The central console **12** of the preferred embodiment functions to: provide interaction with the operator of the ultrasound system **10**; wirelessly communicate with the handheld probe **14**; control the ultrasonic beams of the handheld probe **14**; process the 3D images from the multiplexed echo signals of the handheld probe **14**; and display a 3D image. The central console **12** may further provide other functions, such as providing data storage, data compression, image printouts, format conversions, communication links to a network, or any other appropriate function. To accomplish the five main functions, the central console **12** is conceptually separated into console controls **18**, a beam controller **20**, a console transmitter **22** and console receiver **24**, an image processor **26**, and a console display **28**, as shown in **FIG. 2**. The central console **12** is preferably designed as a mobile unit (such as a wheeled cart or a laptop computer), but may alternatively be designed as a fixed unit (such as a cabinet structure).

[0019] The console controls **18** of the central console **12** provide interaction with the operator of the ultrasound system **10**. The console controls **18** preferably allow the operator to configure the ultrasound system **10**, to switch between imaging modes, and to capture frame/cine. The console controls **18** may alternatively provide other appropriate functions. Input from the operator is collected, parsed, and sent to the image processor **26** and/or the beam controller **20** as appropriate. The console controls **18** may include knobs, dials, switches, buttons, touch pads, fingertip sensors, sliders, joysticks, keys, or any other appropriate device to provide interaction with the operator.

[0020] The beam controller **20** of the central console **12** controls the ultrasonic beams of the handheld probe **14**. The operator of the ultrasound system **10**, through the console controls **18** described above, may select a particular imaging mode (e.g., 3D, 2D slice, or local image zoom) for a subject **16**. To comply with this selection, the beam controller **20** preferably creates a beam signal that adjusts or modulates the frequency, sampling rate, filtering, phasing scheme, amplifier gains, transducer bias voltages, and/or multiplexer switching of the handheld probe **14**. Alternatively, the beam controller **20** may create two or more signals that adjust or modulate these parameters. Further, the beam controller **20** may create a beam signal that adjusts or modulates other appropriate parameters of the handheld probe **14**.

[0021] The console transmitter **22** and the console receiver **24** of the central console **12** function to provide a wireless communication link with the handheld probe **14**. Specifically, the console transmitter **22** functions to transmit beam signals to the handheld probe **14**, while the console receiver **24** functions to receive echo signals from the handheld probe **14**. In the preferred embodiment, the console transmitter **22** and the console receiver **24** use radiofrequency (RF) communication and an appropriate protocol with a high data throughput. In an alternative embodiment, however, the console transmitter **22** and the console receiver **24** may use infrared or other high-speed optical communication instead of, or in addition to, RF communication. The console transmitter **22** and the console receiver **24** may incorporate frequency hopping, spread-spectrum, dual-band, encryption, and/or other specialized transmission techniques known in the art to ensure data security and/or integrity in noisy environments. In the preferred embodiment, the console transmitter **22** and the console receiver **24** are located within different housings and are operated at different frequencies. In an alternative embodiment, the console transmitter **22** and the console receiver **24** may be combined (as a console transceiver) and/or may operate within the same channel or frequency.

[0022] The image processor **26** of the central console **12**, which functions to construct 3D images from the multiplexed echo signals of the handheld probe **14**, is preferably composed of a frame compiler **30** and an image engine **32**. The frame compiler **30** of the image processor **26** functions to assemble a single 3D image (or 3D frame) from the multiplexed echo signals of the handheld probe **14**. The echo signals, which are a series of pulses with specific time, amplitude, and phasing information, are correlated, summed, and transformed into voxels for the 3D image. Noise reduction, phase deaberration, contrast enhancement, orthogonal compounding, and other operations are also performed at this stage. In the preferred embodiment, as much as possible, these operations are performed in parallel fashion with dedicated algorithms, thus allowing the frame compiler **30** to be optimized for maximum speed. The frame compiler **30** preferably consists of a massively parallel set of lower-cost, medium-performance DSP cores, but may alternatively include other appropriate devices.

[0023] The image engine **32** of the image processor **26** receives complete frames from the frame compiler **30** and provides all higher-level processing (such as image segmentation) of the 3D frames. In the preferred embodiment, the image engine **32** also serves as a collection point for all echo data in the ultrasound system **10**. The image engine **32** preferably consists of a high-performance, highly programmable DSP core, but may alternatively include other appropriate devices. In an alternative embodiment, the image processor **26** may include other appropriate devices to construct 3D images from the multiplexed echo signals of the handheld probe **14**.

[0024] The console display **28** functions to present an image of the subject **16** to the operator in a form that facilitates easy and intuitive manipulation, navigation, measurement, and quantification. Examples of display modes include 3D, semi-transparent rendering, and 2D slices through the 3D structure. The console display **28** preferably includes a conventional LCD screen, but may alternatively include any appropriate device (such as a holographic or stereoscopic device) to present the scanned images.

[0025] The handheld probe **14** of the preferred embodiment functions to: wirelessly receive beam signals from the central console **12**; generate an ultrasonic beam and detect an ultrasonic echo at multiple locations; combine the ultrasonic echoes into a single multiplexed echo signal; and wirelessly transmit the echo signals to the central console **12**. The handheld probe **14** may further provide other functions, such as providing data storage, data compression, or any other appropriate function. To accomplish the four main functions, the central console **12** is conceptually separated into a probe receiver **34**, a first integrated circuit **36**, a second integrated circuit **38**, and a probe transmitter **40**, as shown in **FIG. 3**.

[0026] The probe receiver **34** and the probe transmitter **40** of the handheld probe **14** function to provide a wireless communication link with the central console **12**. Specifically, the probe receiver **34** functions to receive beam signals from the central console **12**, while the probe transmitter **40** functions to transmit a multiplexed echo signal to the central console **12**. The probe receiver **34** and the probe transmitter **40** use the same communication method and protocol as the console transmitter **22** and the console receiver **24**. In the preferred embodiment, the probe receiver **34** and the probe transmitter **4o** are located within different housings. In an alternative embodiment, the probe receiver **34** and the probe transmitter **40** may be combined (as a probe transceiver).

[0027] The first integrated circuit **36** of the handheld probe **14** functions to generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, and to combine the ultrasonic echoes into multiplexed echo signals. The first integrated circuit **36** preferably accomplishes these functions with the use of a 2D array of transducer cells **42**, a series of beam signal leads **44** that are adapted to carry the beam signals to the transducer cells **42**, and a series of echo signal leads **46** that are adapted to carry the multiplexed echo signals from the transducer cells **42**, as shown in **FIG. 4**. The first integrated circuit **36** may alternatively accomplish these functions with other suitable devices.

[0028] Each transducer cell **42** of the first integrated circuit **36**, which functions as a 2D phased subarray to scan one sector of the entire viewing field, preferably includes at least one ultrasonic beam generator **48**, at least sixteen ultrasonic echo detectors **50**, and at least one first multiplexer **52**. The ultrasonic beam generator **48** and the ultrasonic echo detectors **50** of the transducer cell **42** function to generate an ultrasonic beam and to detect an ultrasonic echo at multiple locations. Preferably, the ultrasonic beam generator **48** and the ultrasonic echo detectors **50** are separate elements, which may simplify the front-end electronics for the first integrated circuit **36**. Alternatively, the ultrasonic beam generator **48** and the ultrasonic echo detectors **50** may be formed as the same component (i.e., dual-function transducers).

[0029] The first multiplexer **52** of the transducer cell **42** functions to combine the ultrasonic echoes from the ultrasonic echo detectors **50** into a multiplexed echo signal. To collect enough echo data for 3D imaging, the first integrated circuit **36** preferably includes at least 4,096 ultrasonic echo detectors **50**, and more preferably includes at least 16,384 ultrasonic echo detectors **50**. From a manufacturing standpoint, the number of echo signal leads **46** between the first integrated circuit **36** and the second integrated circuit **38** is preferably equal to or less than **1024** connections, and more preferably equal to or less than 512 connections. Thus, the first multiplexer **52** preferably combines the echo signals at least in a 4:1 ratio. The first multiplexer **52** may use time division multiplexing (TDM), quadrature multiplexing, frequency division multiplexing (FDM), or any other suitable multiplexing scheme. Further, the first multiplexer **52** may actually be two multiplexers (indicated in **FIG. 4** as a first portion **54** and a second portion **56**) combined that either use the same or different multiplexing schemes.

[0030] The ultrasonic beam generator **48**, the ultrasonic echo detectors **50**, and the first multiplexer **52** are preferably microfabricated on the first integrated circuit **36** as a capacitor micro-machined ultrasonic transducer (cMUT) with known methods, such as the method taught by U.S. Pat. No. 6,246,158 issued on 12 Jun. 2001 and titled "Microfabricated Transducers formed over other Circuit Components on an Integrated Circuit Chip and Methods for Making the Same," which is hereby incorporated in its entirety by this reference. The ultrasonic beam generator **48**, the ultrasonic echo detectors **50**, and the first multiplexer **52**, however, may be fabricated with any suitable method.

[0031] In one example of the preferred embodiment, the first integrated circuit **36** is arranged as follows: sixteen ultrasound echo detectors **50** (plus one ultrasound beam generator **48** and one first multiplexer **52**) in a transducer cell, and 1,024 transducer cells **42** in the first integrated circuit **36**. This arrangement provides a manageable level of echo signal leads **46** to the second integrated circuit **38** (1,024 echo signal leads), while providing enough echo data (16,384 ultrasonic echo detectors **50**) for 3D image rendering. The first multiplexer **52**, in this arrangement, combines sixteen echo signals into one multiplexed echo signal using a 16:1 TDM device.

[0032] In another example of the preferred embodiment, the first integrated circuit **36** is arranged in a similar manner, except that the first multiplexer **52** combines only four echo signals into one multiplexed echo signal using a 4:1 TDM device. Since there are four multiplexed echo signals and only one echo signal lead, the first integrated circuit of this example performs four passes, each pass with a new beam signal and each pass with only $\frac{1}{4}^{th}$ of the ultrasonic echo detectors **50** contributing to the echo signal. In this manner, the first multiplexer **52** is only combining a portion of the echo signals into a multiplexed signal.

[0033] The second integrated circuit **38**, as shown in **FIG. 3**, of the handheld probe **14** functions to receive and transmit the beam signals from the probe receiver **34** to the beam signal leads **44** of the first integrated circuit **36**, and to receive and transmit the multiplexed echo signals from the echo signal leads **46** to the probe transmitter **40**. Preferably, the second integrated circuit **38** further conditions the multiplexed echo signals to facilitate wireless communication to the central console **12**. The conditioning may include converting the analog echo signals to adequately sampled (e.g. above Nyquist) digital signals, amplifying the analog echo signals, compressing the digital echo signals, and performing an error-correction process on the echo signals. The conditioning may further include additional multiplexing of the multiplexed echo signals into one channel (or simply less channels). Any number of multiplexing schemes may be used, including time-division multiplexing, code division multiplexing, frequency division multiplexing, packet-based transmission, or any other suitable multiplexing scheme. The second integrated circuit **38** preferably uses conventional devices and manufacturing methods, but may alternatively use any suitable device and any suitable manufacturing method.

[0034] In the preferred embodiment, the handheld probe **14** further provides time gain compensation of the echo signals, which corrects for attenuation and allows objects at a greater depth to be clearly depicted with objects of lesser depth. This function may be integrated onto the first integrated circuit **36**, the second integrated circuit **38**, or any other suitable located within the handheld probe **14**. In alternative embodiments, the problem of attenuation may be solved with other suitable devices, either within the handheld probe **14**, the central console **12**, or any other suitable location.

[0035] In the preferred embodiment, the central console **12** transmits multiple beam signals as a signal multiplexed beam signal. For this reason, the central console **12** preferably includes a multiplexer (not shown) and the handheld probe **14** includes a de-multiplexer (not shown). In alternative embodiments, the beam signals are sent using multiple channels or using another suitable scheme.

[0036] In the preferred embodiment, the handheld probe **14** further includes probe controls **58**, which function to provide additional interaction with the operator of the ultrasound system **10**. Like the console controls **18**, the probe controls **58** preferably allow the operator to configure the ultrasound system **10**, to switch between imaging modes, and to capture frame/cine. Because of the proximity to the subject **16**, however, the probe controls **58** may further include additional features, such as flag image, add caption or notation, add voice notation, and take measurement from image. The probe controls **58** may alternatively provide other appropriate functions. Input from the operator is collected, wirelessly transmitted to the central console **12**, and routed to the image processor **26** and/or the beam controller **20** as appropriate. The probe controls **58** may include knobs, dials, switches, buttons, touch pads, fingertip sensors, sliders, joysticks, keys, or any other appropriate device to provide interaction with the operator. The handheld probe **14** with the probe controls **58** of the preferred embodiment satisfies the need to allow operation of an ultrasound system **10** during a patient examination without requiring physical proximity to the central console **12**.

[0037] In the preferred embodiment, the handheld probe **14** further includes a probe display **60**. In a first variation of the preferred embodiment, the console transmitter **22** and the probe receiver **34** are further adapted to communicate information about the system configuration (such as imaging modes). With this variation, the probe display **60** is preferably adapted to display the system configuration. In a second variation of the preferred embodiment, the console transmitter **22** and the probe receiver **34** are further adapted to communicate a processed image of the subject **16** (e.g., 3D, semi-transparent rendering, and 2D slices through the 3D structure). With this variation, the probe display **60** is preferably adapted to display the processed image. In a third variation, the console transmitter **22** and the probe receiver **34** are adapted to communicate both the information about the system configuration and the processed images. With this variation, the handheld probe **14** may include an additional probe display **60**, or may include switch between the two sources. The probe display **60** preferably includes a conventional LCD screen, but may alternatively include any appropriate device such as individual lights, digital displays, alphanumeric displays, or other suitable indicators. With the probe controls **58** and the probe display **60**, the handheld probe **14** of the preferred embodiment further exceeds the need to allow operation of an ultrasound system **10** during a patient examination without requiring physical proximity to the central console **12**.

[0038] In the preferred embodiment, the handheld probe **14** further includes a power source **62**, which functions to power the components of the handheld probe **14**. The power source **62** is preferably a conventional rechargeable battery, but may alternatively be a capacitor, a fuel cell, or any other suitable power source **62**. Considering the state of battery technology, however, it is possible that the addition of a power source **62** would make the handheld probe **14** unacceptably heavy or bulky. Thus, in a variation of the preferred embodiment shown in **FIG. 5**, the power source **62** is located in a remote portion **64** of the handheld probe **14**, which is connected to the handheld probe **14** with a lightweight cord **66**. The remote portion **64** may be designed to be strapped to the operator's body (e.g., wrist, arm, or shoulder) or clipped to the operator's belt, with the cable routed such that it is kept conveniently out of the way (e.g., along the arm). Although this variation still requires a cable connected to the handheld probe **14**, the cable moves with the operator and thus provides a degree of freedom that is still greater than a transducer head tethered to the central console. Further, in the variation of the preferred embodiment, other elements of the handheld probe **14** may be located in the remote portion **64**. For example, the probe receiver, the probe transmitter, the probe controls, and/or the probe display may be located in the remote portion **64** of the handheld probe **14**.

[0039] As a person skilled in the art of ultrasound systems will recognize from the previous detailed description and from the figures and claims, modifications and changes can be made to the preferred embodiment of the invention without departing from the scope of this invention defined in the following claims.

1. A single integrated circuit for a handheld probe of an ultrasound system, comprising:

a two-dimensional array of transducer cells, each transducer cell adapted to receive a beam signal, generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, and combine the ultrasonic echoes into a single multiplexed echo signal;

a series of beam signal leads adapted to carry the beam signals to the transducer cells; and

a series of echo signal leads adapted to carry the multiplexed echo signals from the transducer cells.

2. The integrated circuit of claim 1 comprising at least **256** transducer cells.

3. The integrated circuit of claim 2, wherein each transducer cell includes at least **1** ultrasonic beam generator and at least 16 ultrasonic echo detectors.

4. The integrated circuit of claim 2, wherein each transducer cell includes a multiplexer adapted to combine at least a portion of the ultrasonic echoes into a single multiplexed echo signal.

5. A handheld probe for an ultrasound system, comprising:

a probe receiver adapted to wirelessly receive beam signals;

a first integrated circuit including a two-dimensional array of transducer cells, each transducer cell adapted to receive a beam signal, generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, and combine the ultrasonic echoes into a single multiplexed echo signal, a series of beam signal leads connected to the wireless receiver and adapted to carry the beam signals to the transducer cells, and a series of echo signal leads adapted to carry the multiplexed echo signals from the transducer cells;

a second integrated circuit including a multiplexer connected to the series of echo signal leads and adapted to combine the multiplexed echo signals; and

a probe transmitter connected to the multiplexer and adapted to wirelessly transmit a multiplexed echo signal.

6. The handheld probe of claim 5 further comprising a display.

7. The handheld probe of claim 6 wherein the probe receiver is further adapted to wirelessly receive a system configuration signal, and wherein the display is adapted to display the system configuration.

8. The handheld probe of claim 6 wherein the probe receiver is further adapted to wirelessly receive an image signal, and wherein the display is adapted to display the image signal.

9. The handheld probe of claim 5 further comprising a probe controls adapted to provide operator interaction, wherein the probe transmitter is further connected to the probe controls and is further adapted to wirelessly transmit an operator command.

10. The handheld probe of claim 5 comprising at least 256 transducer cells.

11. The handheld probe of claim 10, wherein each transducer cell includes at least **1** ultrasonic beam generator and at least 16 ultrasonic echo detectors.

12. The handheld probe of claim 10, wherein each transducer cell includes a multiplexer adapted to combine at least a portion of the ultrasonic echoes into a single multiplexed echo signal.

13. An ultrasound system, comprising:

a central console including a controller adapted to create beam signals; a console transmitter connected to the controller and adapted to wirelessly transmit the beam signals; and

a handheld probe including a probe receiver adapted to wirelessly receive the beam signals; a first integrated circuit including a two-dimensional array of transducer cells, each transducer cell adapted to receive a beam signal, generate an ultrasonic beam, detect an ultrasonic echo at multiple locations, and combine the ultrasonic echoes into a single multiplexed echo signal, a series of beam signal leads connected to the wireless receiver and adapted to carry the beam signals to the transducer cells, and a series of echo signal leads adapted to carry the multiplexed echo signals from the transducer cells; a second integrated circuit including a multiplexer connected to the series of echo signal leads and adapted to combine the multiplexed echo signals; and a probe transmitter connected to the multiplexer and adapted to wirelessly transmit a multiplexed echo signal;

wherein the central console further includes a console receiver adapted to wirelessly receive a multiplexed echo signal; and an image processor adapted to construct an image from the echo signals.

14. The ultrasound system of claim 13 further comprising a display.

15. The ultrasound system of claim 14 wherein the probe receiver is further adapted to wirelessly receive a system configuration signal, and wherein the display is adapted to display the system configuration.

16. The ultrasound system of claim 14 wherein the probe receiver is further adapted to wirelessly receive an image signal, and wherein the display is adapted to display the image signal.

17. The ultrasound system of claim 13 further comprising a probe controls adapted to provide operator interaction, wherein the probe transmitter is further connected to the probe controls and is further adapted to wirelessly transmit an operator command.

18. The ultrasound system of claim 13 comprising at least 256 transducer cells.

19. The ultrasound system of claim 18, wherein each transducer cell includes at least 1 ultrasonic beam generator and at least **16** ultrasonic echo detectors.

20. The ultrasound system of claim 18, wherein each transducer cell includes a multiplexer adapted to combine at least a portion of the ultrasonic echoes into a single multiplexed echo signal.

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专利名称(译)	超声系统包括手持式探头		
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外部链接	Espacenet USPTO		

摘要(译)

本发明的优选实施例包括超声系统，超声设备的手持式探头，以及用于超声系统的手持式探头的集成电路。优选实施例的超声系统包括中央控制台和手持式探头。手持式探头适于从中央控制台接收无线波束信号，生成超声波束，在多个位置检测超声波回波，将超声波回波组合成单个多路复用回波信号，并将多路回波信号发送到中央控制台。超声系统，包括手持式探头和集成电路，提供了改进的超声系统，其收集足够的用于3D成像的回波数据并且通过无线链路发送回波数据以克服典型超声系统的限制和缺点。