US 20050154310A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0154310 A1**

Bruestle (43) **Pub. Date: Jul. 14, 2005**

(54) APPARATUS AND METHOD FOR CONTROLLING AN ULTRASOUND PROBE

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(21) Appl. No.: **10/756,231**

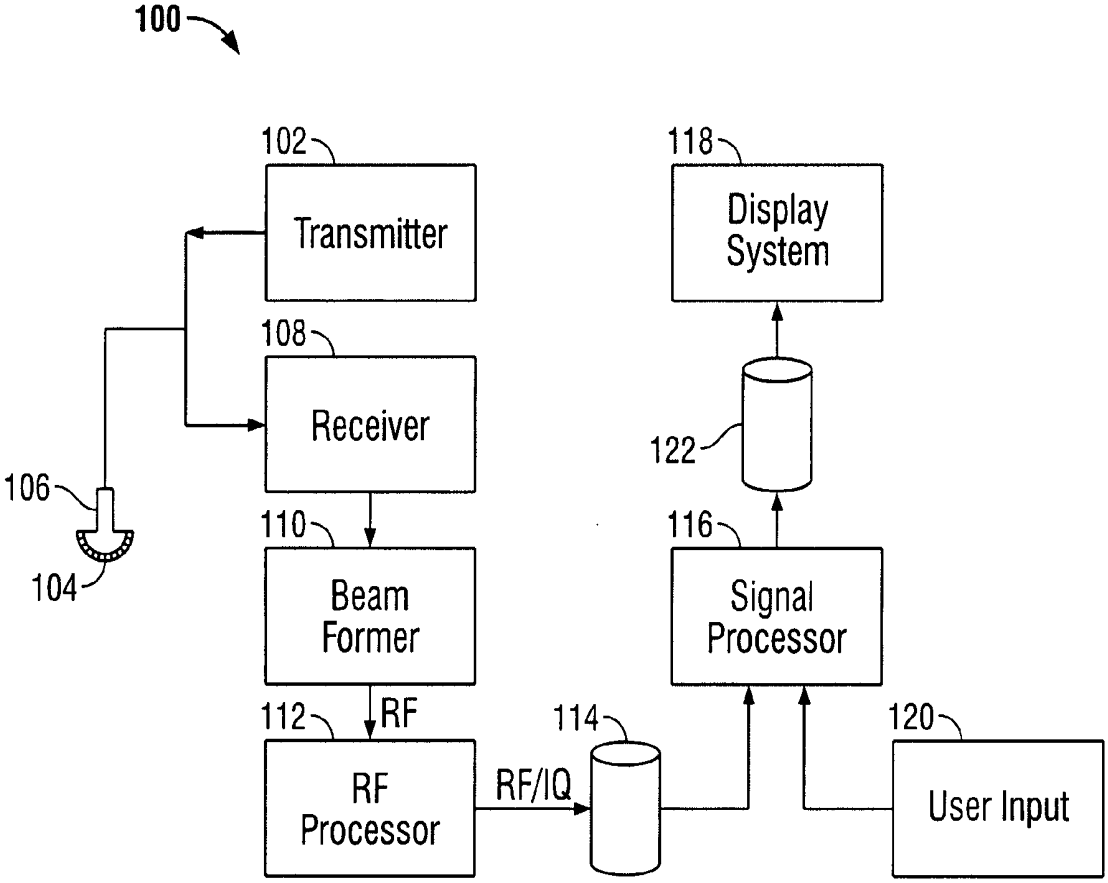
(22) Filed: **Jan. 13, 2004**

Publication Classification

(51) **Int. Cl.**^{7} **A61B 8/14**
(52) **U.S. Cl.** **600/459**

(57) ABSTRACT

An apparatus and method for controlling an ultrasound probe are provided. The ultrasound probe having the apparatus includes a scan head configured for moveable operation within a housing and a signal control circuit within the scan head for controlling a transducer array. The signal control circuit is configured to provide multiplexing operation for controlling a plurality of transducer elements forming the transducer array.



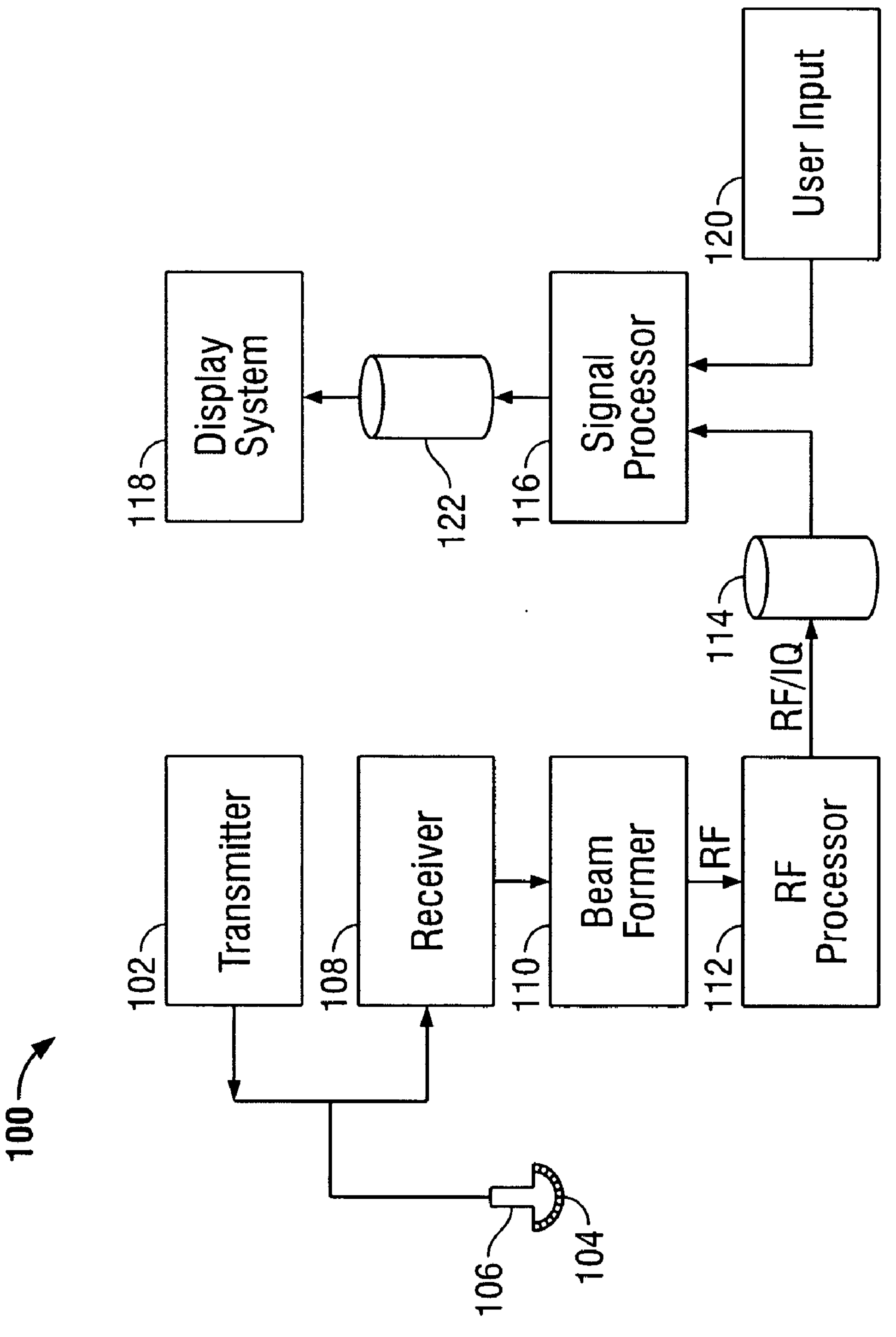

100
102
Transmitter
108
Receiver
110
Beam Former
RF
112
RF Processor
RF/IQ
114
116
Signal Processor
122
118
Display System
120
User Input
106
104

FIG. 1

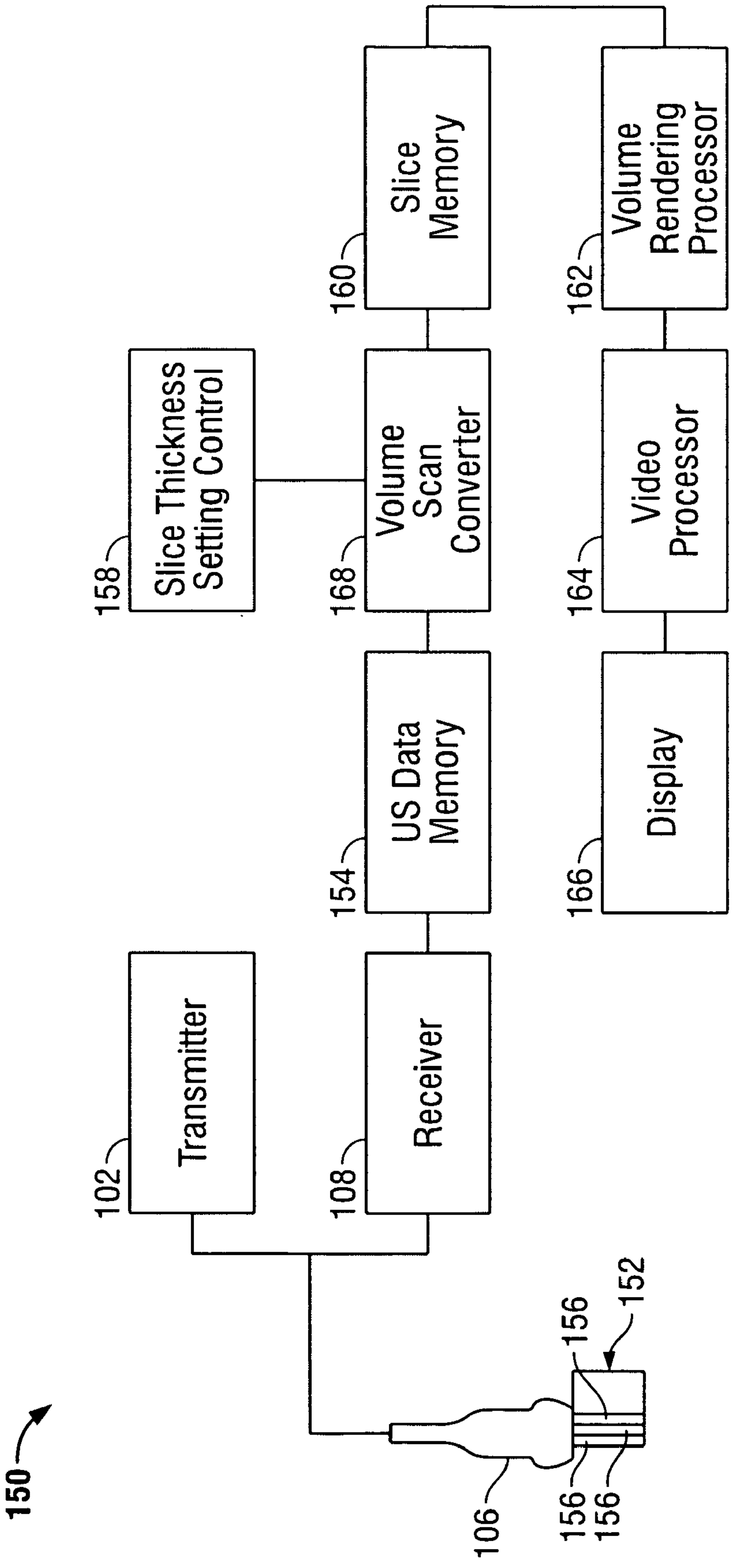

150
106
156
156
156
152
102
Transmitter
108
Receiver
154
US Data Memory
168
Volume Scan Converter
158
Slice Thickness Setting Control
160
Slice Memory
162
Volume Rendering Processor
164
Video Processor
166
Display

FIG. 2

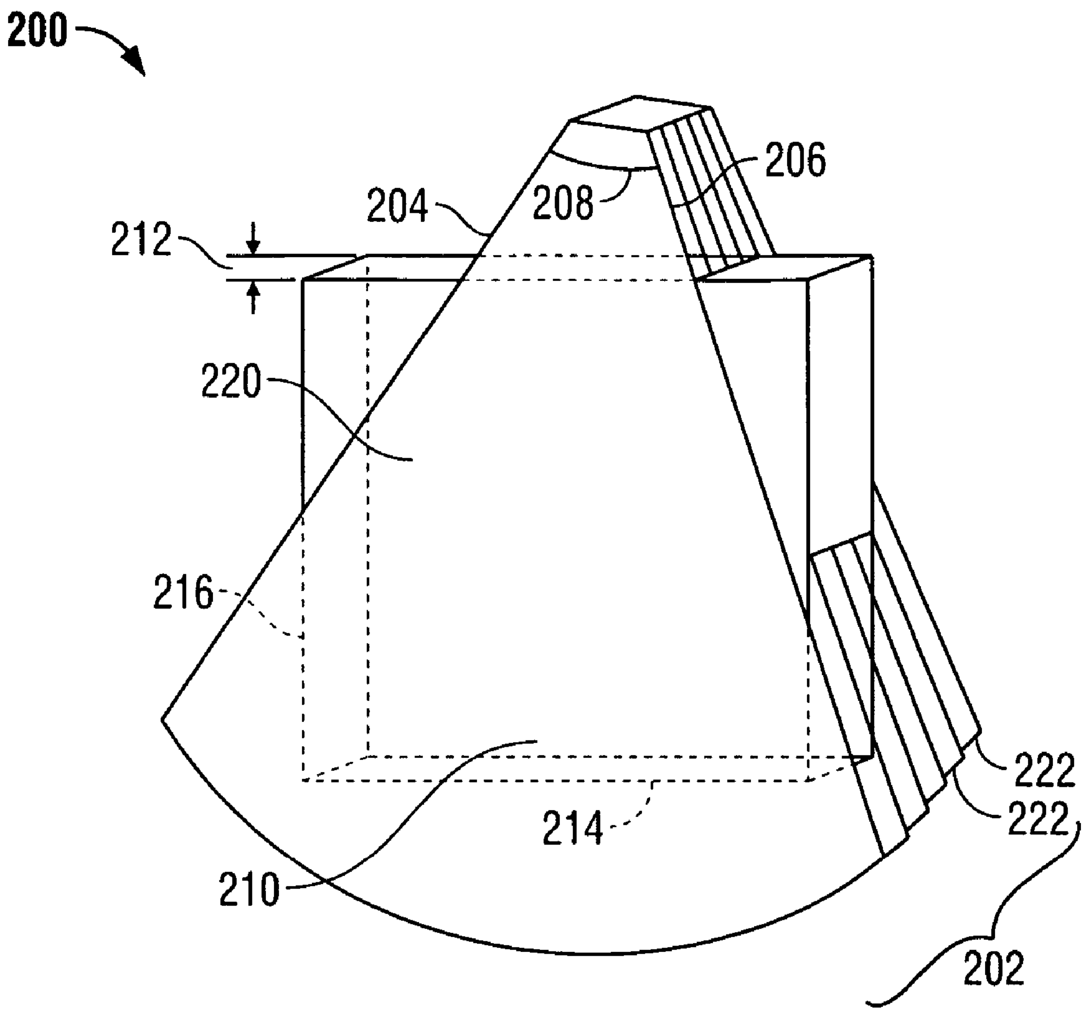


FIG. 3

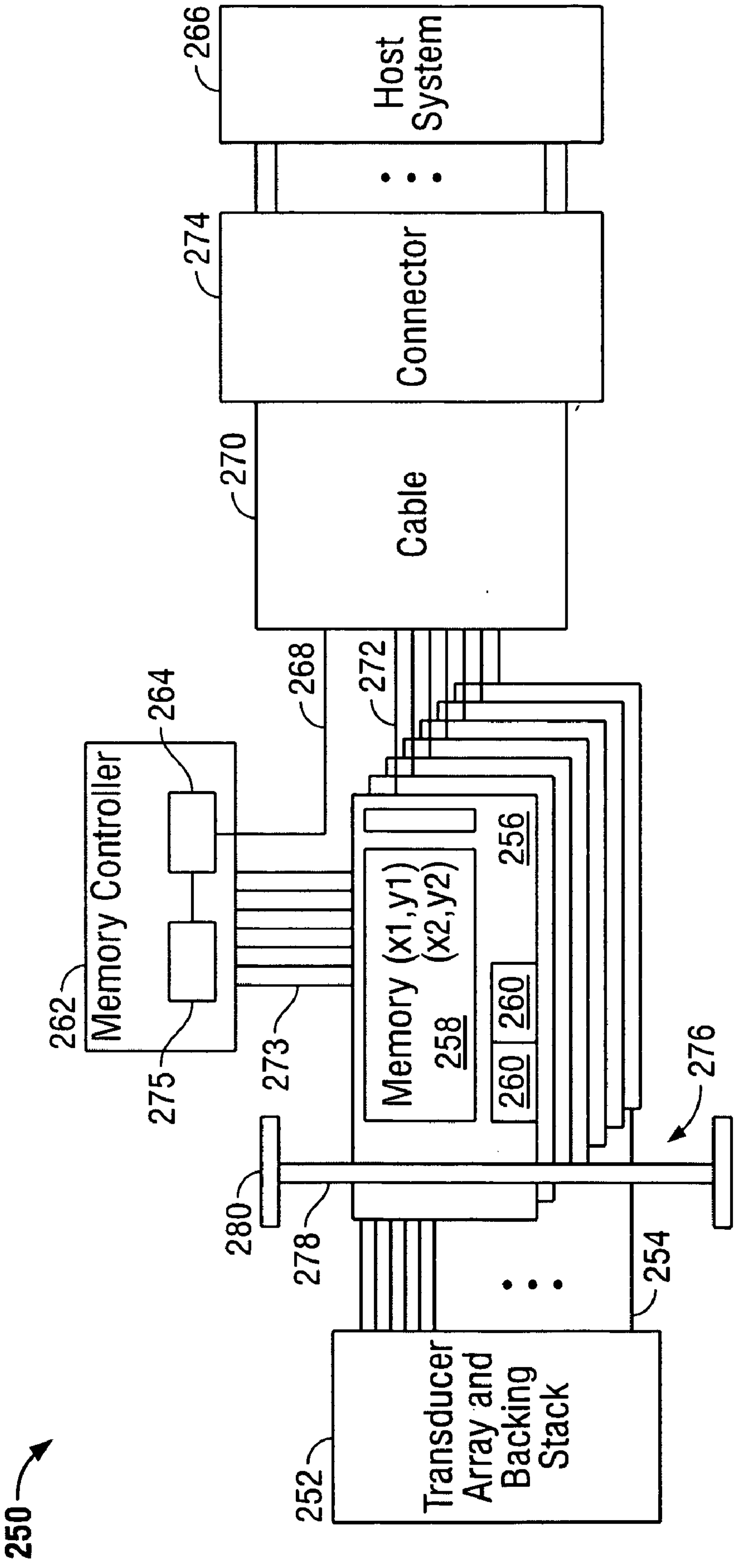

250
252
Transducer Array and Backing Stack
254
276
278
280
262
Memory Controller
264
275
273
268
272
Memory (x1,y1) (x2,y2)
258
256
260
260
270
Cable
274
Connector
266
Host System

FIG. 4

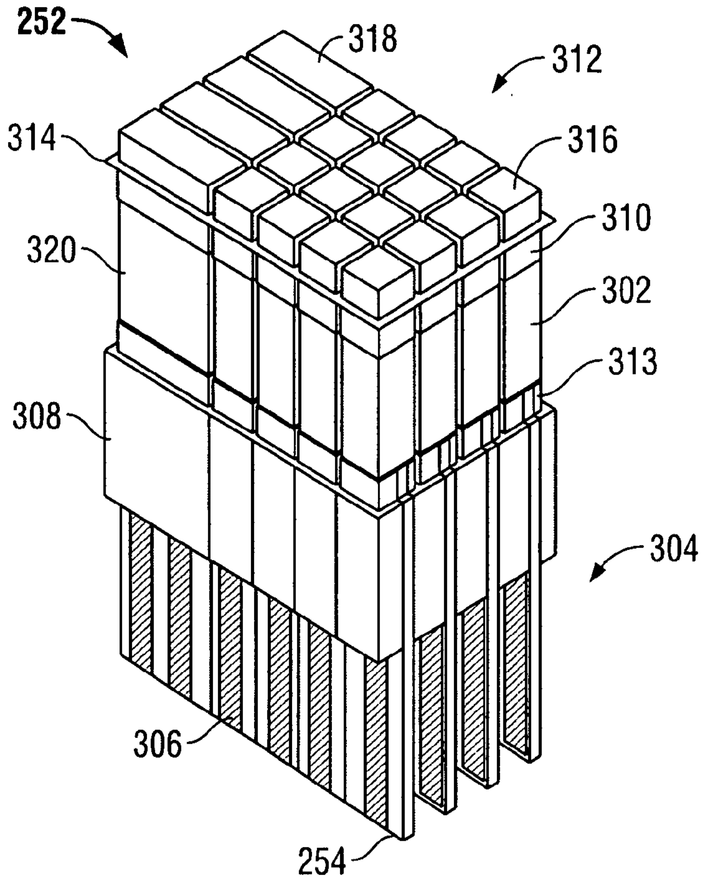

252
318
312
314
316
310
320
302
313
308
304
306
254

FIG. 5

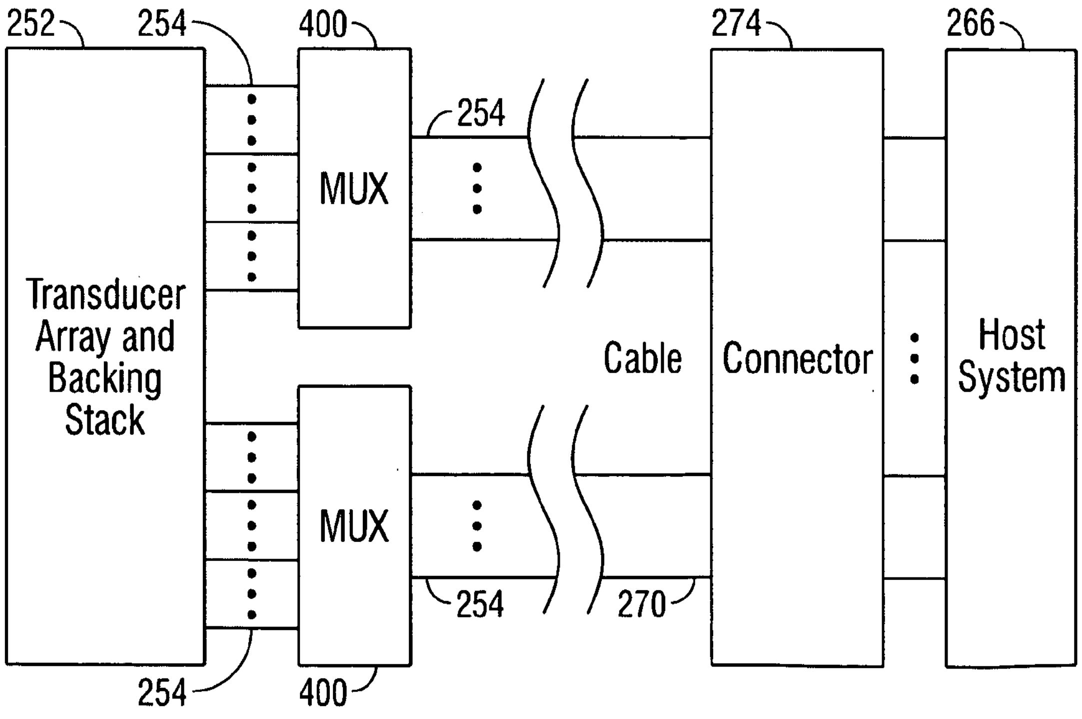

252
254
400
274
266
Transducer Array and Backing Stack
MUX
254
MUX
Cable
Connector
Host System
254
270
254
400

FIG. 6

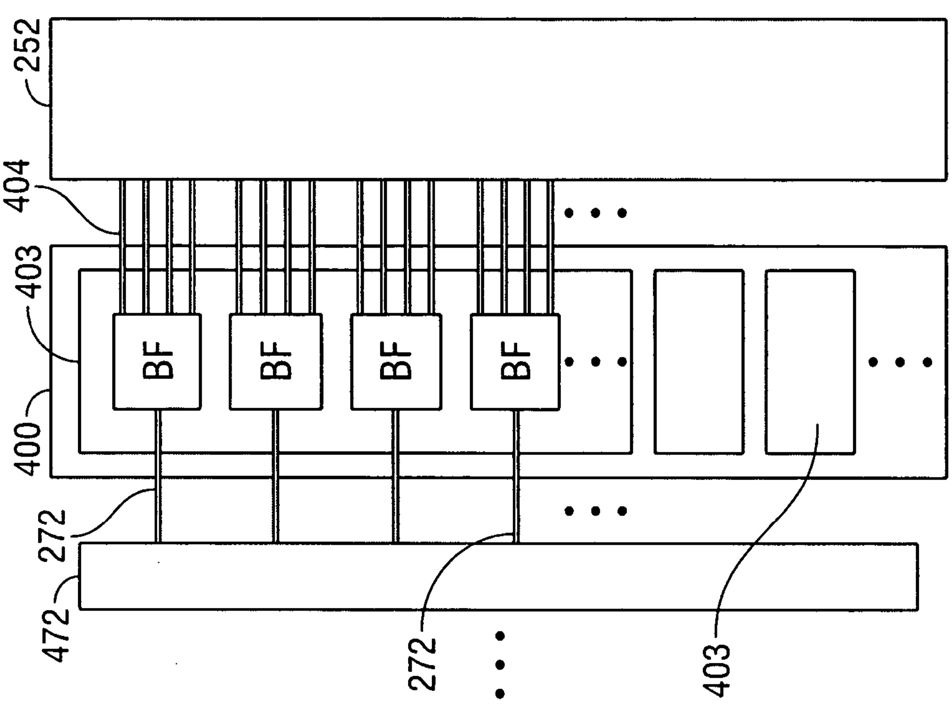

252
404
403
400
272
472
BF
BF
BF
BF
272
403

FIG. 8

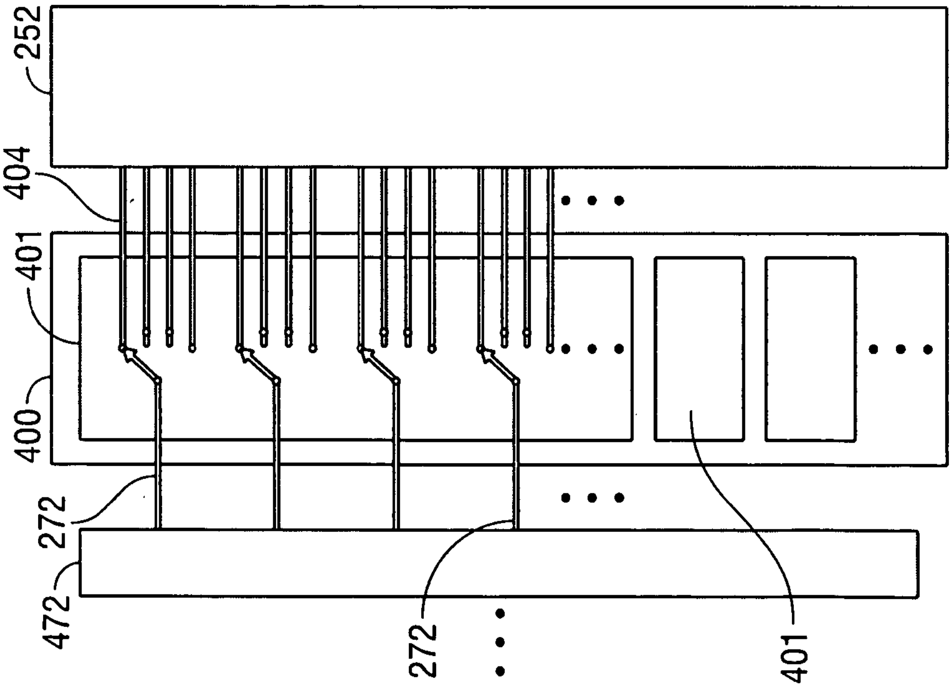

252
404
401
400
272
472
272
401

FIG. 7

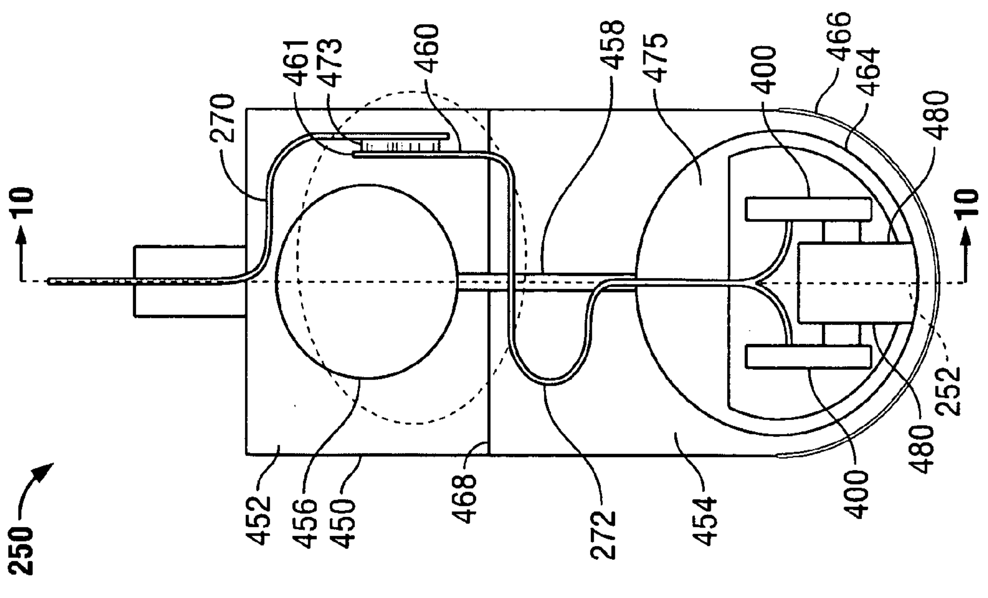

250
10
10
270
461
473
460
458
475
400
466
464
480
452
456
450
468
272
454
400
480
252

FIG. 9

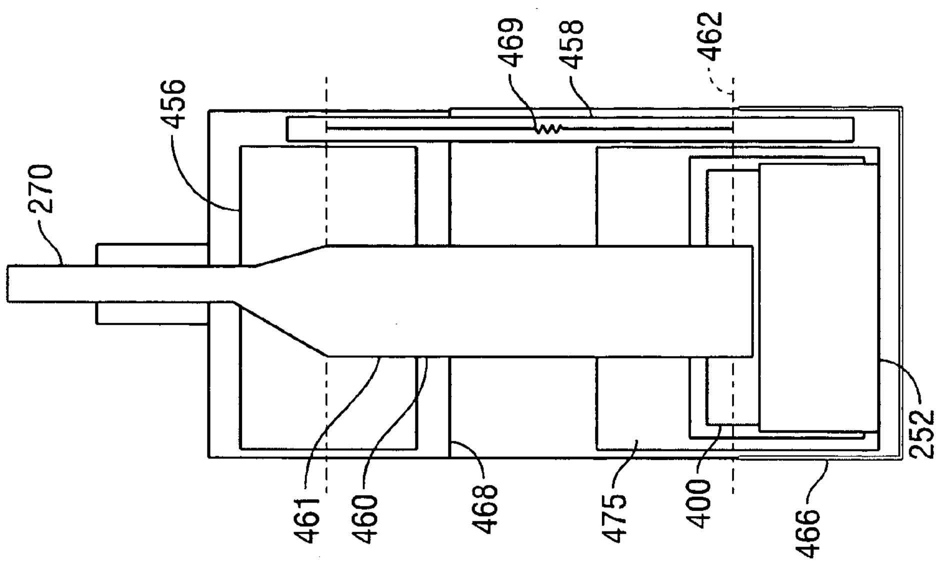

270
456
469
458
462
461
460
468
475
400
466
252

FIG. 10

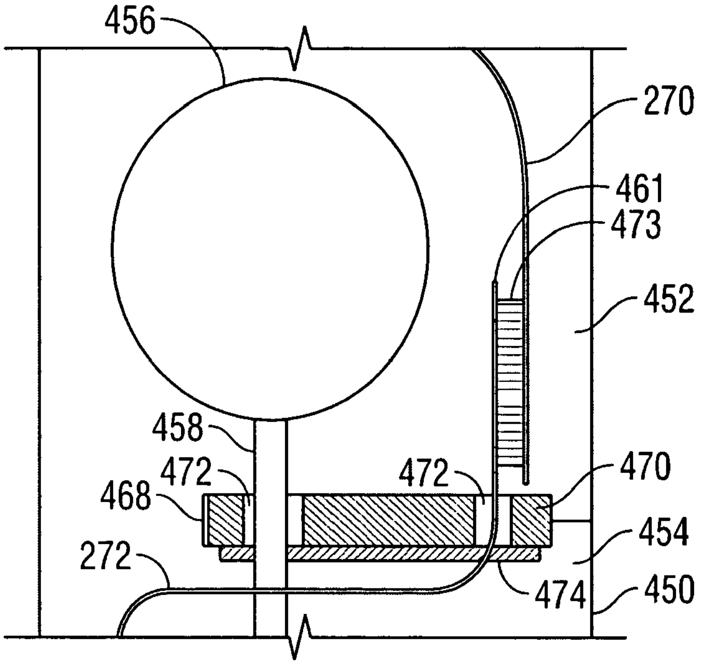

456
270
461
473
452
458
472
472
470
468
454
272
474
450

FIG. 11

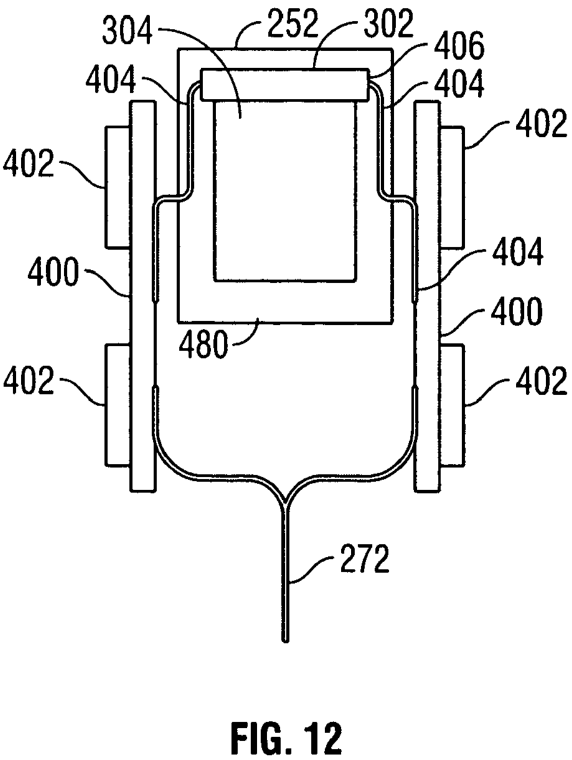

304
252
302
406
404
404
402
402
400
404
400
480
402
402
272

FIG. 12

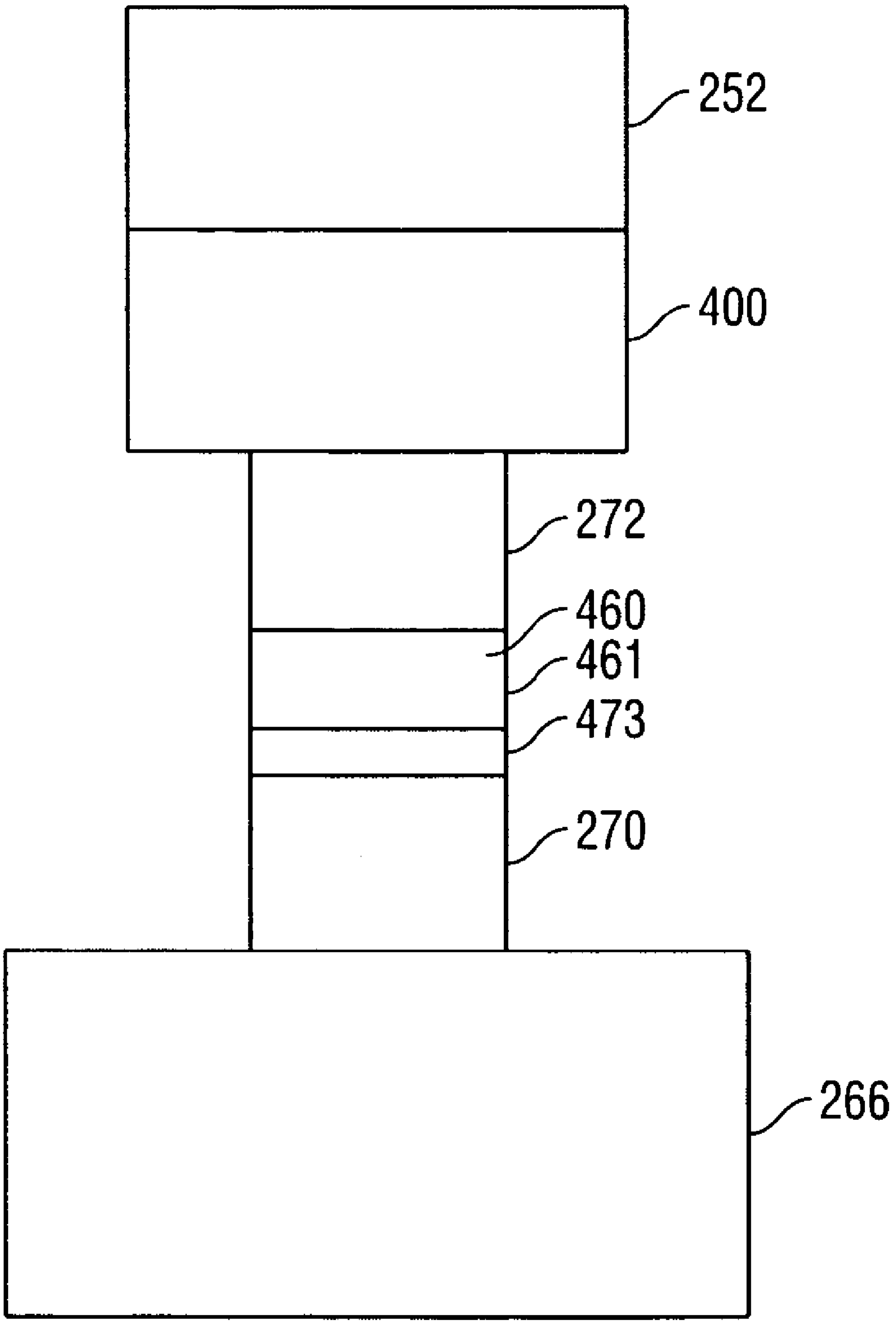


FIG. 13

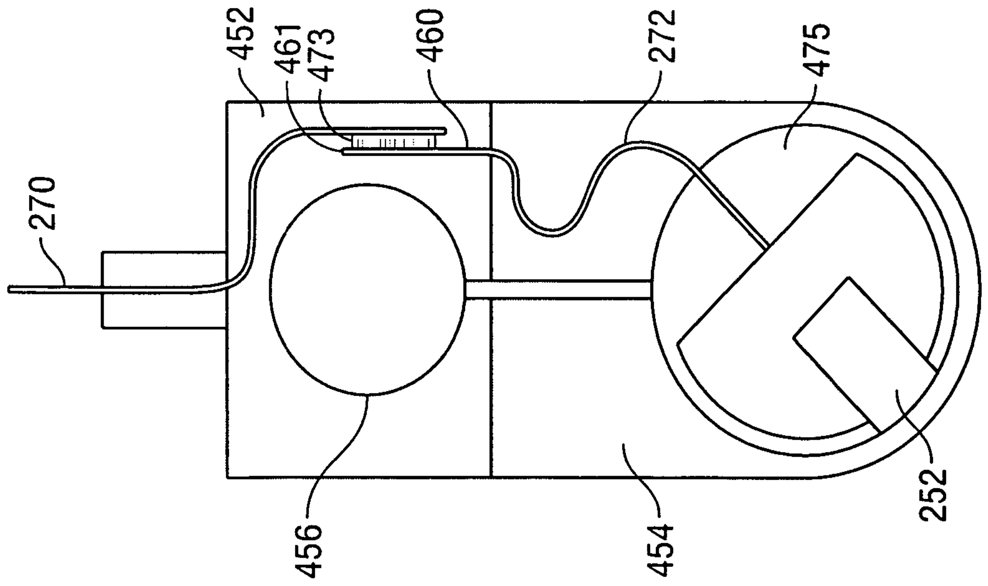

270
452
461
473
460
272
475
456
454
252

FIG. 14

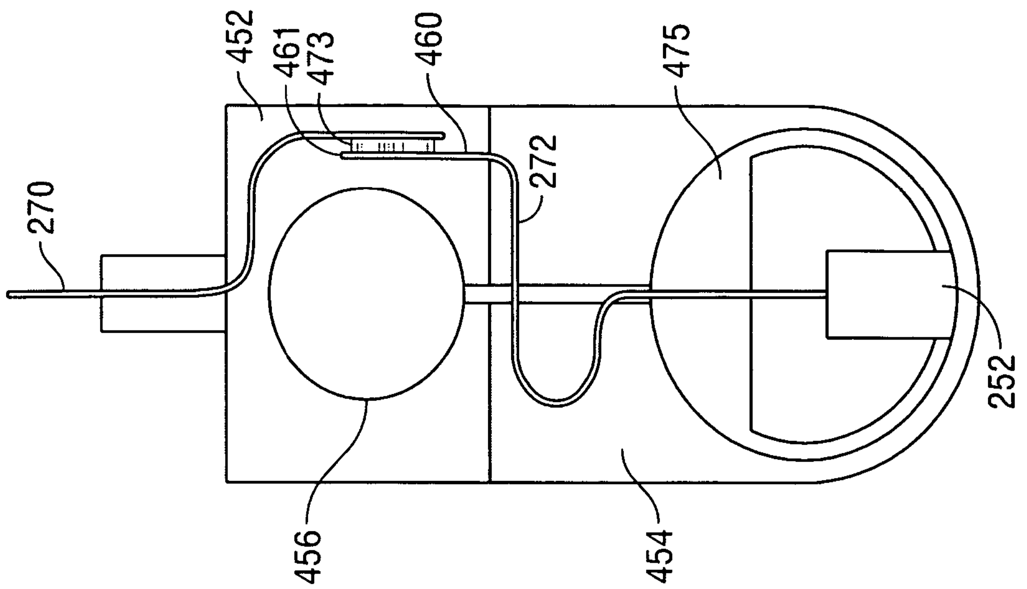

270
452
461
473
460
272
475
456
454
252

FIG. 15

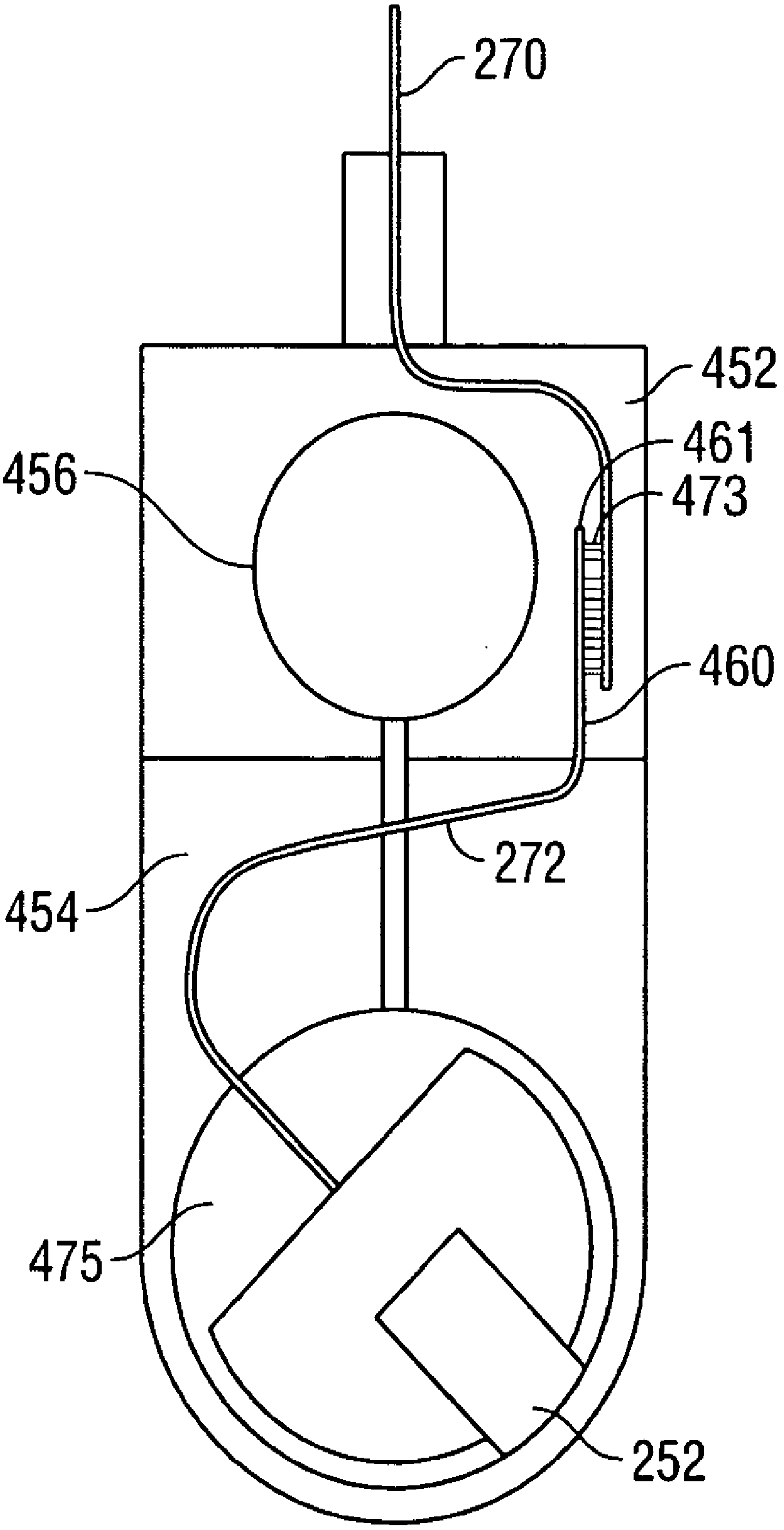


FIG. 16

APPARATUS AND METHOD FOR CONTROLLING AN ULTRASOUND PROBE

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to ultrasound systems and, more particularly, to probes for ultrasound medical imaging systems.

[0002] Ultrasound systems typically include ultrasound scanning devices, such as, ultrasound probes having different transducers that allow for performing various different ultrasound scans (e.g., different imaging of a volume or body). The ultrasound probes are typically connected to an ultrasound system for controlling the operation of the probes. The probes include a scan head having a plurality of transducer elements (e.g., piezoelectric crystals), which may be arranged in an array. The ultrasound system drives the transducer elements within the array during operation, such as, during a scan of a volume or body, which may be controlled based upon the type of scan to be performed. The ultrasound system includes a plurality of channels for communicating with the probe. For example, the channels may transmit pulses for driving the transducer elements and for receiving signals therefrom.

[0003] In volume probes, wherein the scan head moves during scan operation, and more particularly, wherein the transducer elements move, a connection cable between the scan head and a system cable must be flexible to accommodate the movement. As the number of transducer elements increases, the number of connections (e.g., connection cables) required to control the operation of the transducer elements increases. This results in an increased size of the connection cable between the scan head and the control system (e.g., connection to a system cable). As the scan head cable size increases, additional space for accommodating the increased cable dimensions within the probe is required and the likelihood of damage to the cables increases. For example, the likelihood of cables breaking increases as a result of the bending movement of the larger scan head cable. Thus, reliability of the ultrasound probe decreases. The cost of the probe and complexity of the controls also increase as the size of the connection cable increases. Further, the amount of motor power needed to move the scan head having this larger scan head cable connected thereto also increases.

BRIEF DESCRIPTION OF THE INVENTION

[0004] In one exemplary embodiment, an ultrasound probe is provided. The ultrasound probe includes a scan head configured for moveable operation within a housing and a signal control circuit within the scan head for controlling a transducer array. The signal control circuit is configured to provide multiplexing operation for controlling a plurality of transducer elements forming the transducer array.

[0005] In another exemplary embodiment, a method for controlling an ultrasound probe is provided. The method includes receiving at a scan head of an ultrasound probe control signals for controlling a transducer array having a plurality of transducer elements, multiplexing the control signals at the scan head, and selectively activating one or more of the transducer elements based upon the multiplexed signals.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] **FIG. 1** is a block diagram of an ultrasound system in accordance with one exemplary embodiment of the present invention.

[0007] **FIG. 2** is a block diagram of an ultrasound system in accordance with another exemplary embodiment of the present invention.

[0008] **FIG. 3** is a perspective view of an image of an object acquired by the systems of **FIGS. 1 and 2** in accordance with an exemplary embodiment of the present invention.

[0009] **FIG. 4** is a block diagram of an ultrasound probe in communication with a host system in accordance with an exemplary embodiment of the present invention.

[0010] **FIG. 5** is a perspective view of an exemplary transducer stack including an array of transducer elements that may be used in the ultrasound probe shown in **FIG. 4**.

[0011] **FIG. 6** is a block diagram showing a multiplexing arrangement in accordance with an exemplary embodiment of the present invention.

[0012] **FIG. 7** is a block diagram of an exemplary multiplexing circuit of the multiplexing arrangement shown in **FIG. 6**.

[0013] **FIG. 8** is a block diagram of another exemplary multiplexing circuit of the multiplexing arrangement shown in **FIG. 6**.

[0014] **FIG. 9** is a cross-sectional elevation view of a probe in accordance with an exemplary embodiment of the present invention.

[0015] **FIG. 10** is an elevation view taken along the line **10-10** of **FIG. 9**.

[0016] **FIG. 11** is a partial cross-sectional elevation view of a probe in accordance with an exemplary embodiment of the present invention showing a sealing arrangement.

[0017] **FIG. 12** is a partial cross-sectional elevation view of a probe in accordance with an exemplary embodiment of the present invention showing multiplexing circuits.

[0018] **FIG. 13** is a block diagram showing a connection arrangement for a probe in accordance with an exemplary embodiment of the present invention.

[0019] **FIGS. 14-16** are cross-sectional elevation views of a probe in accordance with an exemplary embodiment of the present invention showing a moving scan head.

DETAILED DESCRIPTION OF THE INVENTION

[0020] Exemplary embodiments of ultrasound systems and methods for controlling ultrasound probes are described in detail below. In particular, a detailed description of exemplary ultrasound systems will first be provided followed by a detailed description of various embodiments of methods and systems for controlling ultrasound probes. A technical effect of the various embodiments of the systems and methods described herein include at least one of reducing the number of control lines for controlling an ultrasound probe and selectively controlling transducer elements in the ultrasound probe.

[0021] **FIG. 1** illustrates a block diagram of an exemplary embodiment of an ultrasound system **100** that may be used, for example, to acquire and process ultrasonic images. The ultrasound system **100** includes a transmitter **102** that drives an array of elements **104** (e.g., piezoelectric crystals) within or formed as part of a transducer **106** to emit pulsed ultrasonic signals into a body or volume. A variety of geometries may be used and one or more transducers **106** may be provided as part of a probe (not shown). The pulsed ultrasonic signals are back-scattered from density interfaces and/or structures, for example, in a body, like blood cells or muscular tissue, to produce echoes that return to the elements **104**. The echoes are received by a receiver **108** and provided to a beamformer **110**. The beamformer performs beamforming on the received echoes and outputs an RF signal. The RF signal is then processed by an RF processor **112**. The RF processor **112** may include a complex demodulator (not shown) that demodulates the RF signal to form IQ data pairs representative of the echo signals. The RF or IQ signal data then may be routed directly to an RF/IQ buffer **114** for storage (e.g., temporary storage).

[0022] The ultrasound system **100** also includes a signal processor **116** to process the acquired ultrasound information (i.e., RF signal data or IQ data pairs) and prepare frames of ultrasound information for display on a display system **118**. The signal processor **116** is adapted to perform one or more processing operations according to a plurality of selectable ultrasound modalities on the acquired ultrasound information. Acquired ultrasound information may be processed in real-time during a scanning session as the echo signals are received. Additionally or alternatively, the ultrasound information may be stored temporarily in the RF/IQ buffer **114** during a scanning session and processed in less than real-time in a live or off-line operation.

[0023] The ultrasound system **100** may continuously acquire ultrasound information at a frame rate that exceeds fifty frames per second, which is the approximate perception rate of the human eye. The acquired ultrasound information is displayed on the display system **118** at a slower framerate. An image buffer **122** may be included for storing processed frames of acquired ultrasound information that are not scheduled to be displayed immediately. In an exemplary embodiment, the image buffer **122** is of sufficient capacity to store at least several seconds of frames of ultrasound information. The frames of ultrasound information may be stored in a manner to facilitate retrieval thereof according to their order or time of acquisition. The image buffer **122** may comprise any known data storage medium.

[0024] A user input device **120** may be used to control operation of the ultrasound system **100**. The user input device **120** may be any suitable device and/or user interface for receiving user inputs to control, for example, the type of scan or type of transducer to be used in a scan.

[0025] **FIG. 2** illustrates a block diagram of another exemplary embodiment of an ultrasound system **150** that may be used, for example, to acquire and process ultrasonic images. The ultrasound system **150** includes the transducer **106** in communication with the transmitter **102** and receiver **108**. The transducer **106** transmits ultrasonic pulses and receives echoes from structures inside a scanned ultrasound volume **152**. A memory **154** stores ultrasound data from the receiver **108** derived from the scanned ultrasound volume **152**. The scanned ultrasound volume **152** may be obtained by various techniques, including, for example, 3D scanning, real-time 3D imaging, volume scanning, scanning with transducers having positioning sensors, freehand scanning using a Voxel correlation technique, 2D scanning or scanning with a matrix of array transducers, among others.

[0026] The transducer **106** is moved, such as along a linear or arcuate path, while scanning a region of interest (ROI). At each linear or arcuate position, the transducer **106** obtains a plurality of scan planes **156**. The scan planes **156** are collected for a thickness, such as from a group or set of adjacent scan planes **156**. The scan planes **156** are stored in the memory **154**, and then provided to a volume scan converter **168**. In some exemplary embodiments, the transducer **106** may obtain lines instead of the scan planes **156**, with the memory **154** storing lines obtained by the transducer **106** rather than the scan planes **156**. The volume scan converter **168** receives a slice thickness setting from a slice thickness setting control **158**, which identifies the thickness of a slice to be created from the scan planes **156**. The volume scan converter **168** creates a data slice from multiple adjacent scan planes **156**. The number of adjacent scan planes **156** that are obtained to form each data slice is dependent upon the thickness selected by the slice thickness setting control **158**. The data slice is stored in a slice memory **160** and accessed by a volume rendering processor **162**. The volume rendering processor **162** performs volume rendering upon the data slice. The output of the volume rendering processor **162** is provided to a video processor **164** that processes the volume rendered data slice for display on a display **166**.

[0027] It should be noted that the position of each echo signal sample (Voxel) is defined in terms of geometrical accuracy (i.e., the distance from one Voxel to the next) and one or more ultrasonic responses (and derived values from the ultrasonic response). Suitable ultrasonic responses include gray scale values, color flow values, and angio or power Doppler information. It should be noted that the ultrasound system **150** also may include a user input or user interface for controlling the operation of the ultrasound system **150**.

[0028] It should be noted that the ultrasound systems **100** and **150** may include additional or different components. For example, the ultrasound system **150** may include a user interface or user input **120** (shown in **FIG. 1**) to control the operation of the ultrasound system **150**, including, to control the input of patient data, scan parameters, a change of scan mode, and the like.

[0029] **FIG. 3** illustrates an exemplary image of an object **200** that may be acquired by the ultrasound systems **100** and **150**. The object **200** includes a volume **202** defined by a plurality of sector shaped cross-sections with radial borders **204** and **206** diverging from one another at an angle **208**. The transducer **106** (shown in **FIGS. 1 and 2**) electronically focuses and directs ultrasound firings longitudinally to scan along adjacent scan lines in each scan plane **156** (shown in **FIG. 2**) and electronically or mechanically focuses and directs ultrasound firings laterally to scan adjacent scan planes **156**. The scan planes **156** obtained by the transducer **106**, and as illustrated in **FIG. 1**, are stored in the memory **154** and are scan converted from spherical to Cartesian coordinates by the volume scan converter **168**. A volume comprising multiple scan planes **156** is output from the volume scan converter **168** and stored in the slice memory **160** as a rendering region **210**. The rendering region **210** in the slice memory **160** is formed from multiple adjacent scan planes **156**.

[**0030**] The rendering region **210** may be defined in size by an operator using a user interface or input to have a slice thickness **212**, width **214** and height **216**. The volume scan converter **168** (shown in **FIG. 2**) may be controlled by the slice thickness setting control **158** (shown in **FIG. 2**) to adjust the thickness parameter of the slice to form a rendering region **210** of the desired thickness. The rendering region **210** defines the portion of the scanned ultrasound volume **152** that is volume rendered. The volume rendering processor **162** accesses the slice memory **160** and renders along the slice thickness **212** of the rendering region **210**.

[**0031**] Referring now to **FIGS. 1 and 2**, during operation, a slice having a pre-defined, substantially constant thickness (also referred to as the rendering region **210**) is determined by the slice thickness setting control **158** and is processed in the volume scan converter **168**. The echo data representing the rendering region **210** (shown in **FIG. 3**) may be stored in the slice memory **160**. Predefined thicknesses between about 2 mm and about 20 mm are typical, however, thicknesses less than about 2 mm or greater than about 20 mm may also be suitable depending on the application and the size of the area to be scanned. The slice thickness setting control **158** may include a control member, such as a rotatable knob with discrete or continuous thickness settings.

[**0032**] The volume rendering processor **162** projects the rendering region **210** onto an image portion **220** of an image plane(s) **222** (shown in **FIG. 3**). Following processing in the volume rendering processor **162**, pixel data in the image portion **220** may be processed by the video processor **164** and then displayed on the display **166**. The rendering region **210** may be located at any position and oriented at any direction within the volume **202**. In some situations, depending on the size of the region being scanned, it may be advantageous for the rendering region **210** to be only a small portion of the volume **202**.

[**0033**] **FIG. 4** illustrates a block diagram of an exemplary embodiment of an ultrasound probe **250** that may be used in connection with the ultrasound systems **100** or **150**. The ultrasound probe **250** includes a transducer array and backing stack **252** (the "transducer array **252**"), transducer flex cables **254**, which may be formed as a scan head cable, and multiple processing boards **256** that support processing electronics. Each processing board **256** may includes a location memory **258** (which may include geometry RAM, encoder RAM, location registers and control registers as noted below) and signal processors **260**. A location memory controller **262** (e.g., a general purpose CPU, microcontroller, PLD, or the like) also may be provided and includes a communication interface **264**.

[**0034**] The communication interface **264** establishes data exchange with a host system **266** over communication lines **268** (e.g., digital signal lines) and through a system cable **270**. Additionally, in an exemplary embodiment, the system cable **270** includes coaxial cables **272** that connect to the processing boards **256** to communicate transmit pulse waveforms to the transducer array **252** and communicate receive signals, after beamforming, to the host system **266**. The probe **250** also may include a connector **274**, through which the probe **250** connects to the host system **266**.

[**0035**] A clamp **276** may be provided to hold the transducer flex cables **254** against the processing boards **256**. The clamp **276** thereby aids in establishing electrical connectivity between the transducer flex cables **254** and the processing boards **256**. The clamp **276** may include a dowel pin **278** and a bolt **280**, although other implementations are also suitable.

[**0036**] The transducer array **252** is bonded onto the backing stack, as will be described in more detail below with regard to **FIG. 5**. The transducer flex cables **254** provide electrical signal connections through the backing stack. In one exemplary embodiment, there are forty-two transducer flex cables **254**, each with fifty signal connections. Thus, the transducer flex cables **254** support transmit and receive signal connections for as many as **2100** transducer elements in the transducer array **252**, although fewer may be used. For example, each processing board **256** may couple to six transducer flex cables **254**, and thereby includes signal connections for 300 transducer elements.

[**0037**] The processing boards **256** may, like the flex cables **254**, be formed from a flex material, such as, for example, polyimide, polyester, etc. The processing boards **256** include the processing electronics for the transducer array **252**, including the signal processors **260** that perform beamforming on the receive apertures in the transducer array **252**.

[**0038**] Each signal processor **260** may handle, for example, four receive apertures defined at selected spatial locations on the transducer array **252**. The receive apertures may be triangular apertures that include fifteen acoustic transducer elements arranged, for example, as a row of five elements above a row of four elements above a row of three elements above a row of two elements above a row of one element. Furthermore, each processing board **256** may include five signal processors **260**. Thus, in the receive direction, each processing board **256** may process twenty receive apertures, each including fifteen acoustic transducer elements.

[**0039**] For every ultrasound beam, the location memory controller **262** connects via digital signal lines **273** (e.g., carried by a separate flex cable) to each location memory **258** on each processing board **256**. The location memory controller **262** communicates the spatial location information into each location memory **258** for each receive aperture processed by the signal processors **260** on the processing boards **256**. The digital signal lines **273** may include, for example, a clock line for each processing board **256**, a serial command data line for each processing board **256**, two data lines (for a total of fourteen data lines) connected to each processing board **256**, an output enable for one or more of the signal processors **260**, and a test signal.

[**0040**] The location memory controller **262** communicates with the host system **266** over the digital signal lines **273** that may form part of, for example, a synchronous serial port. To that end, the communication interface **264** and digital signal lines **273** may implement a low voltage differential signal interface, for example, including a coaxial cable with a grounded shield and center signal wire. The location memory controller **262** includes a block of cache memory **275**, for example, 1-8 MBytes of static random access memory (SRAM).

[0041] **FIG. 5** shows one exemplary embodiment of the transducer array **252**. The transducer array **252** includes piezoelectric ceramic **302** that converts electrical-to-acoustic and acoustic-to-electrical energy. The piezoelectric ceramic **302** is located within the center of the transducer array **252**. On the signal side, the piezoelectric ceramic **302** is attached to a z-axis backing block **304** comprised of alternating layers of transducer flex cables **254** and acoustic absorbing material **308** bonded into the solid backing block **304**.

[0042] The backing block **304** is cut in a direction perpendicular to the orientation of the transducer flex cables **254** thereby exposing the ends of the individual transducer flex cable **254** circuit traces **306** to provide for high density signal connection. The ceramic **302**, an electrically conductive inner acoustic matching layer **310** (e.g., a metal filled graphite such as Antimony-Graphite), and the top surface of the backing block **304** are diced in one operation to form discrete acoustic transducer elements **312** centered over each of the flex circuit traces **306** in the transducer flex cables **254**. Thus, there is a signal plane **313** on the z-axis backing block **304**.

[0043] Each circuit trace **306** contacts the bottom, or signal side, of one transducer element **312**. A ground metal layer **314** is coated onto one side of the outer acoustic matching layer **316**, which may be formed from a plastic. This matching layer **316** is attached to the top of each element **312** to form a ground connection across the face of the transducer array **252**. The outer matching layer **316** is partially diced to separate it into discrete elements, thereby improving the acceptable angle of the transducer element **312**. In one exemplary embodiment, however, the dicing does not penetrate to the ground metal layer **314**.

[0044] The electrical ground connection to each transducer element **312** is made via the outermost elements **318** in the transducer. A wraparound ground **320** on the ceramic **302** is also provided. Once the transducer array **252** is mounted into a scan head or head shell, a thin silicone protective facing may be applied.

[0045] It should be noted that different transducer arrays that may have different interconnections may be used as desired or needed (e.g., based upon the probe type or application). For example, **FIG. 5** shows an interconnection configuration suitable for arrays requiring an electrical interface of very high density (e.g., two-dimensional (2D) arrays). However, other types of arrays, for example, one-dimensional (1D) arrays, do not require electrical interfaces of this high density and other interconnection configurations may be more suitable. For example, in a 1D array application, the 1D array includes a single transducer flex cable **254** wherein the circuit traces **306** contact the elements of the transducer array **252**. The elements of the transducer array **252** are positioned adjacent each other as the circuit traces **306** on the transducer flex cable **254** are positioned adjacent each other. Similar configurations with a single transducer flex cable **254** may be used, for example, with 1.25D, 1.5D or 1.75D arrays.

[0046] Various embodiments of the present invention include one or more signal control circuits for controlling the communication of signals between the host system **266** (shown in **FIG. 4**) and transducer array **252** (shown in **FIG. 4**). In one exemplary embodiment as shown in **FIG. 6**, the one or more signal control circuits include one or more multiplexing circuits **400** have connected thereto the transducer flex cables **254** from the transducer array **252** for multiplexing signals between the transducer array **252** and the host system **266**. For example, a printed circuit board having surface mounted integrated circuits housing switches therein (e.g., MOSFETs) may be used to control the switching of the transducer array **252**, and more specifically, the connection of transducer elements **312** (shown in **FIG. 5**) to one or more channels of the ultrasound system **100** or **150** (e.g., connected to one or more channels of the host system **266** (shown in **FIG. 4**)). Specifically, the multiplexing circuits **400** control the transmission of signal pulses to the transducer array **252** that drive the transducer elements, such as, for example, the piezoelectric ceramics **302**. The multiplexing circuits **400** also control the communication of ultrasound signals received by the piezoelectric ceramics **302** that are communicated to the host system **266**.

[0047] As shown in **FIGS. 7 and 8**, the multiplexing circuits **400** may be configured as a selector-switch multiplexing arrangement or a beamformer cell multiplexing arrangement, respectively. Specifically, as shown in **FIG. 7**, the multiplexing circuits **400** may include one or more selector-switch multiplexer cells **401** having one or more switches (e.g., MOSFETs) therein. Each of the multiplexer cells **401** may be provided as a separate integrated circuit. The multiplexer cells **401** provide multiplexing operation (e.g., switching operation) for controlling the transducer array **252**. As shown in **FIG. 8**, the multiplexing circuits **400** may include one or beamformer cells **403** having beamformer members therein. Each of the beamformer cells **403** may be provided as a separate integrated circuit. The beamformer cells **403** provide multiplexing operation (e.g., beamforming operation) for controlling the transducer array **252**.

[0048] **FIGS. 9 and 10** illustrate an exemplary embodiment of the probe **250**, and in particular, a volume imaging probe, having a transducer array **252** in communication with a host system **266** (shown in **FIG. 4**). The probe **250** includes a housing **450** having a first chamber **452** (e.g., a dry chamber) and a second chamber **454** (e.g., a wet chamber). The first chamber **452** and second chamber **454** may be formed as a single unit (e.g., unitary construction) or may be formed as separate units connected together. In an exemplary embodiment, the first chamber **452** is a dry or air chamber having contained therein drive means for mechanically controlling the transducer array **252** and communication means for electrically controlling the transducer array **252**. The drive means generally includes a motor **456** (e.g., stepper motor) and a gear arrangement **458**, such as a two-stage gear arrangement having a belt drive and a rope drive. The communication means generally includes one or more communication lines, for example, configured as one or more flexible printed circuit boards **460** that connect at one end to the system cable **270** (shown in **FIG. 4**), for example, via rigid printed circuit boards **461** connected to connection members **473**, and at the other end to the coaxial cables **272**. The communication means thereby provides communication between the transducer array **252** and the host system **266**.

[0049] It should be noted that although the drive means and communication means are described herein having specific component parts, they are not so limited. For example, the drive means may have a different gear arrangement and the communication means may have different connection members or transmission lines.

[0050] In this exemplary embodiment, the second chamber **454** is a wet chamber (e.g., chamber having acoustic liquid therein) having contained therein transducer driving means for moving (e.g., rotating) the transducer array **252** and transducer control means for selectively driving elements of the transducer array **252** (e.g., the piezoelectric ceramics **302**). The transducer driving means generally includes a drive shaft **462** in connection with a scan head housing **464**, supported, for example, on brackets (not shown), that operates to move the transducer array **252** as part of a scan head **475** when driven by the drive means. A support member (not shown) also may be provided for supporting the scan head housing **464** and a biasing spring **469** may be provided, for example, to ensure proper tension on the drive means and transducer drive means. It should be noted that an acoustic membrane **466** may be provided surrounding the scan head housing **464** and formed as part of the housing **450**. The transducer control means generally includes the coaxial cables **272** (e.g., three layers of sixty-four coaxial cables) and/or flexible printed circuit board **460**, and multiplexing circuits **400** connected to the transducer array **252** as described in more detail herein. The communication means are connected to the transducer driving means using any suitable connector, such as a complimentary pin connector arrangement.

[0051] It should be noted that although the transducer driving means and transducer control means are described herein having specific component parts, they are not so limited. For example, the transducer driving means may have a different shaft arrangement and the transducer control means may have different control circuits or transmission lines. It also should be noted that additional or different component parts may be provided in connection with the probe **250** as needed or desired, and/or based upon the particular type and application of the probe **250**. For example, a lens covering the transducer array **252** may be provided based upon the type of probe **250**.

[0052] In an exemplary embodiment, and as shown in **FIG. 11**, the first chamber **452** and second chamber **454** have one or more seals members **468** for providing a liquid tight sealing arrangement between the first chamber **452** and second chamber **454**. A bracket member **470** is provided between the first chamber **452** and second chamber **454** to allow for passage therethrough of a portion of the drive means (e.g., rope portion of a rope drive) or a portion of the communication means (e.g., flexible printed circuit board **460**). For example, one or more slots or openings **472** may be provided as part of the bracket member **470** with a sealing member **474** (e.g., aluminum plate) ensuring proper sealing between the first chamber **452** and second chamber **454**.

[0053] Referring again to **FIGS. 9 and 10**, and also to **FIG. 12**, one or more multiplexing circuits **400** are connected to the transducer array **252** for controlling the transducer array **252** as described in more detail herein. In an exemplary embodiment, a separate multiplexing circuit **400** is provided in connection with each side **480** of the transducer array **252**, for example, connected (e.g., epoxied) to the acoustic absorbing material **308** (shown in **FIG. 5**). However, it should be noted that more or less multiplexing circuits **400** may be used as desired or needed. Also, the multiplexing circuits **400** may be located at other positions within the scan head **475**.

[0054] In an exemplary embodiment, the multiplexing circuits **400** are connected to the transducer array **252** via a connection member **404** (e.g., flexible printed circuit board), which may also include a transducer flexible printed circuit board **406**. The multiplexing circuits **400** are also connected to the coaxial cables **272** (e.g., a multiplexing board to cable interconnection). The multiplexing circuits **400** are encased in a sealing material (e.g., epoxy) to seal the multiplexing circuits **400** from the liquid within the second chamber **454**. The multiplexing circuits **400** may include one more multiplexing members **402** (e.g., multiplexing cells).

[0055] Thus, as shown in **FIG. 13** the transducer array **252** is connected via the multiplexing circuits **400** to the coaxial cables **272**. The coaxial cables **272** are connected to the system cable **270** via the flexible printed circuit boards **460**, rigid printed circuit board **461** and connection members **473** as described herein. The system cable **270** is then connected to the host system **266**.

[0056] The multiplexing circuits **400** allow for controlling the operation of the transducer array **252** with a reduced number of communication lines (e.g., reduced number of coaxial cables **272**) from the moving scan head **475** as shown in **FIGS. 14-16**. It should be noted that the transducer array **252** may be configured for operation in different modes, such as, for example, a 1D, 1.25D, 1.5D, 1.75D and 2D mode of operation.

[0057] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.

What is claimed is:

1. An ultrasound probe comprising:

a scan head configured for moveable operation within a housing; and

a signal control circuit within the scan head for controlling a transducer array, the signal control circuit configured to provide multiplexing operation for controlling a plurality of transducer elements forming the transducer array.

2. An ultrasound probe in accordance with claim 1 wherein the transducer array is within the scan head.

3. An ultrasound probe in accordance with claim 1 wherein the signal control circuit comprises at least one multiplexing member.

4. An ultrasound probe in accordance with claim 1 wherein the signal control circuit is engaged with the transducer array.

5. An ultrasound probe in accordance with claim 1 wherein the signal control circuit is mounted to the transducer array.

6. An ultrasound probe in accordance with claim 1 wherein the signal control circuit is encased within a sealing material.

7. An ultrasound probe in accordance with claim 1 further comprising communication means and wherein the signal control circuit is configured for connection to the communication means to provide communication between the transducer array and a host system.

8. An ultrasound probe in accordance with claim 1 further comprising transducer driving means and wherein the signal control circuit is configured for connection to the transducer driving means.

9. An ultrasound probe in accordance with claim 1 wherein the signal control circuit is configured to connect to a side of the transducer array.

10. An ultrasound probe in accordance with claim 1 further comprising a first chamber and a second chamber, the scan head and signal control circuit contained within the second chamber and a drive means and communication means contained with the first chamber for controlling the scan head and signal control circuit.

11. An ultrasound probe in accordance with claim 10 wherein the first chamber is a dry chamber and the second chamber is a wet chamber.

12. An ultrasound probe in accordance with claim 10 wherein the first and second chambers are formed in a unitary construction.

13. An ultrasound probe in accordance with claim 1 wherein the transducer array is configured for volumetric imaging.

14. An ultrasound probe in accordance with claim 1 wherein the transducer array is configured for operation in at least one of a 1D, 1.25D, 1.5D, 1.75D and 2D mode of operation.

15. An ultrasound probe in accordance with claim 1 wherein the signal control circuit comprises at least one multiplexing circuit having at least one of a plurality of switches and a plurality of beamformer members.

16. A volumetric imaging probe comprising:

a transducer array having a plurality of transducer elements; and

at least one multiplexing circuit mounted to the transducer for controlling the operation of the plurality of transducer elements.

17. A volumetric probe in accordance with claim 16 wherein the at least one multiplexing circuit is mounted to a side of the transducer array.

18. A control circuit for an ultrasound probe, the control circuit comprising:

at least one multiplexing circuit configured for connection within a scan head of an ultrasound probe for controlling operation of a transducer array; and

a sealing member for sealing the multiplexing circuit in the scan head.

19. A method for controlling an ultrasound probe, the method comprising:

receiving at a scan head of an ultrasound probe control signals for controlling a transducer array having a plurality of transducer elements;

multiplexing the control signals at the scan head; and

selectively activating one or more of the transducer elements based upon the multiplexed signals.

20. A method in accordance with claim 19 wherein the control signals are received from a host system.

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专利名称(译)	用于控制超声探头的装置和方法		
公开(公告)号	US20050154310A1	公开(公告)日	2005-07-14
申请号	US10/756231	申请日	2004-01-13
[标]申请(专利权)人(译)	BRUESTLE REINHOLD		
申请(专利权)人(译)	BRUESTLE REINHOLD		
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		
[标]发明人	BRUESTLE REINHOLD		
发明人	BRUESTLE, REINHOLD		
IPC分类号	A61B8/00 A61B8/14 G01S7/521 G01S15/89 G10K11/35		
CPC分类号	A61B8/14 G01S7/52079 G01S15/8915 G10K11/352 G01S15/8925		
其他公开文献	US7431698		
外部链接	Espacenet USPTO		

摘要(译)

提供了一种用于控制超声探头的装置和方法。具有该装置的超声探头包括：扫描头，配置用于在壳体内的可移动操作;以及信号控制电路，用于控制换能器阵列。信号控制电路被配置为提供多路复用操作，用于控制形成换能器阵列的多个换能器元件。