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Bruestle

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(54) **CONNECTION APPARATUS AND METHOD FOR CONTROLLING AN ULTRASOUND PROBE**

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(51) **Int. Cl.**
A61B 8/14 (2006.01)

(52) **U.S. Cl.** **600/459**; 600/472; 367/119; 367/153

(58) **Field of Classification Search** 600/459, 600/472; 367/119, 153; 73/596
See application file for complete search history.

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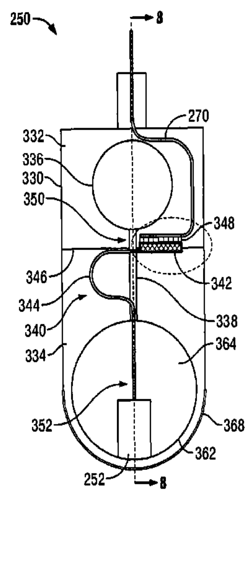
(57) **ABSTRACT**

A connection apparatus and method for controlling an ultrasound probe are provided. The ultrasound probe includes a first chamber, a second chamber and a sealing member between the first and second chambers. The ultrasound probe further includes a connection member within the second chamber having a rigid portion and a flexible portion, with the rigid portion forming at least part of the sealing member.

22 Claims, 8 Drawing Sheets



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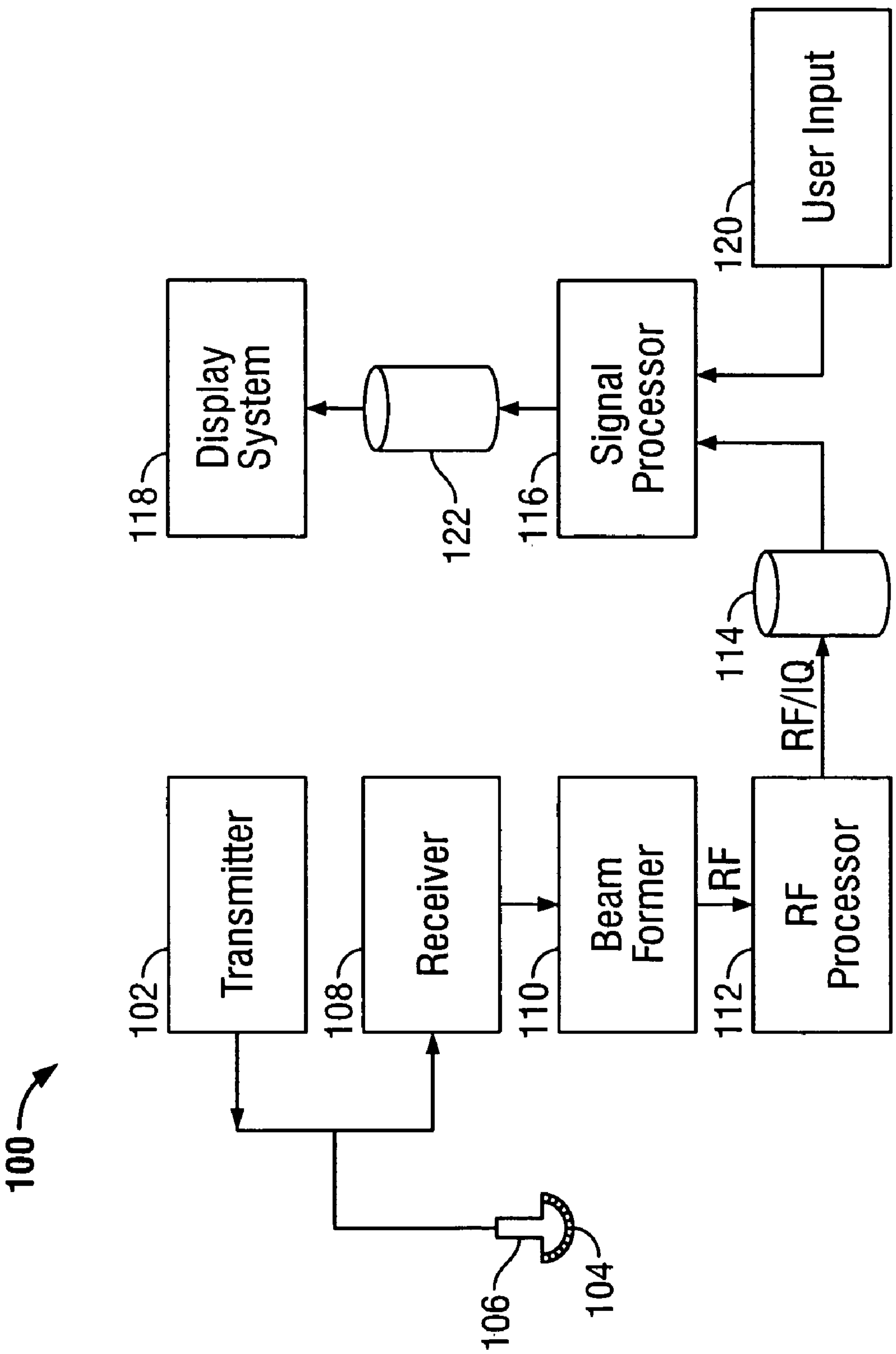
100
Transmitter
102
Receiver
108
Beam Former
110
RF
RF Processor
112
RF/IQ
114
Signal Processor
116
122
Display System
118
User Input
120
106
104

FIG. 1

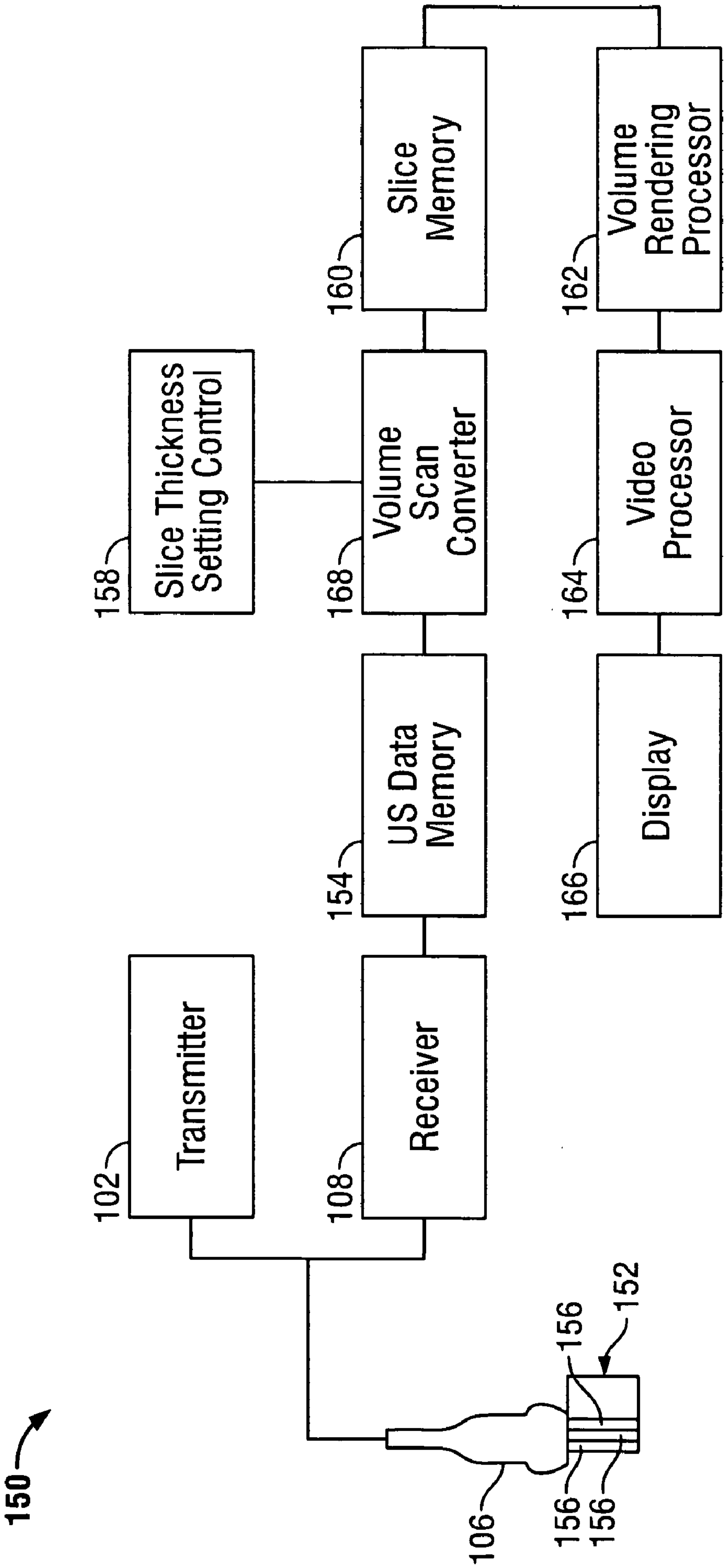
150
106
156
156
156
152
102
Transmitter
108
Receiver
154
US Data Memory
166
Display
158
Slice Thickness Setting Control
168
Volume Scan Converter
164
Video Processor
160
Slice Memory
162
Volume Rendering Processor

FIG. 2

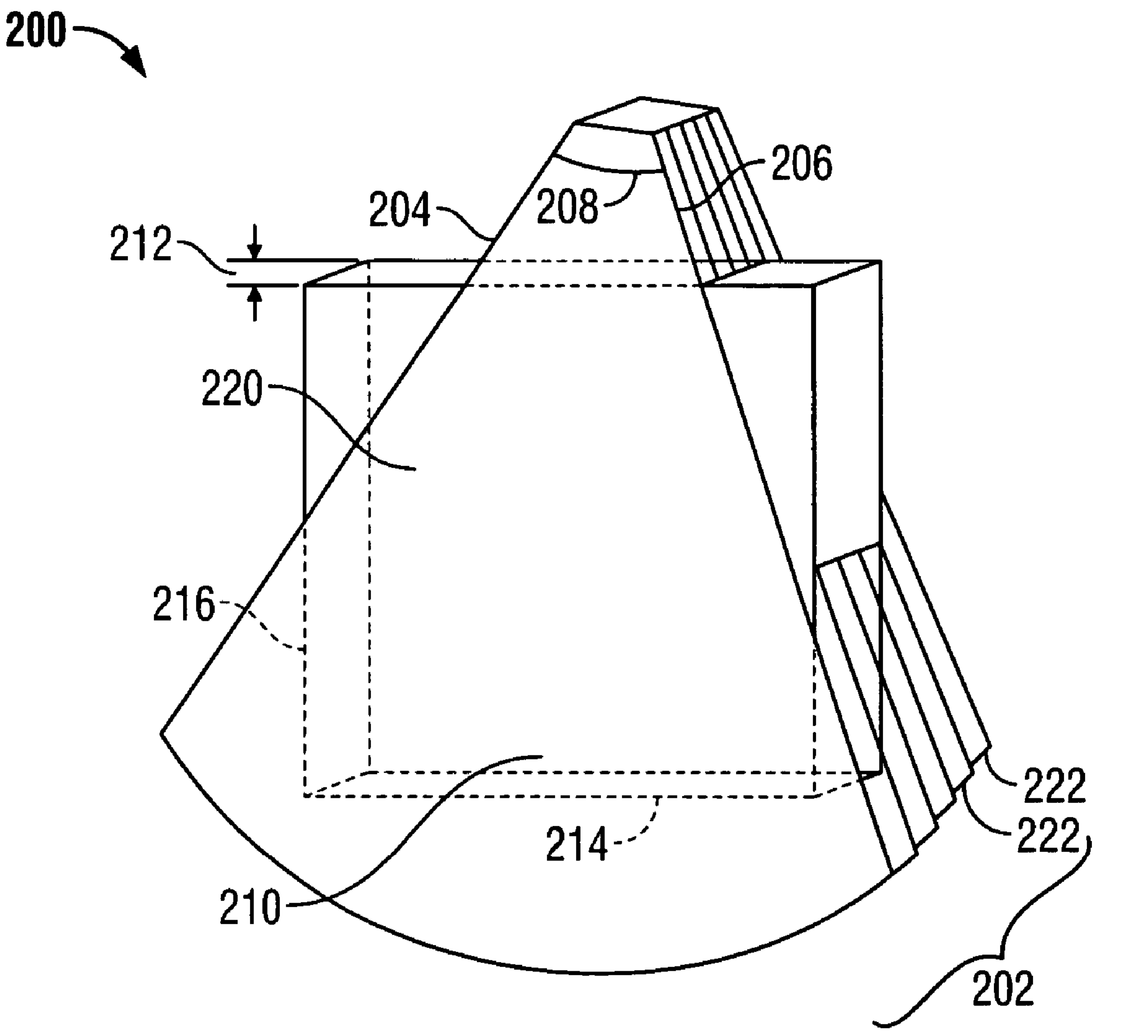

FIG. 3

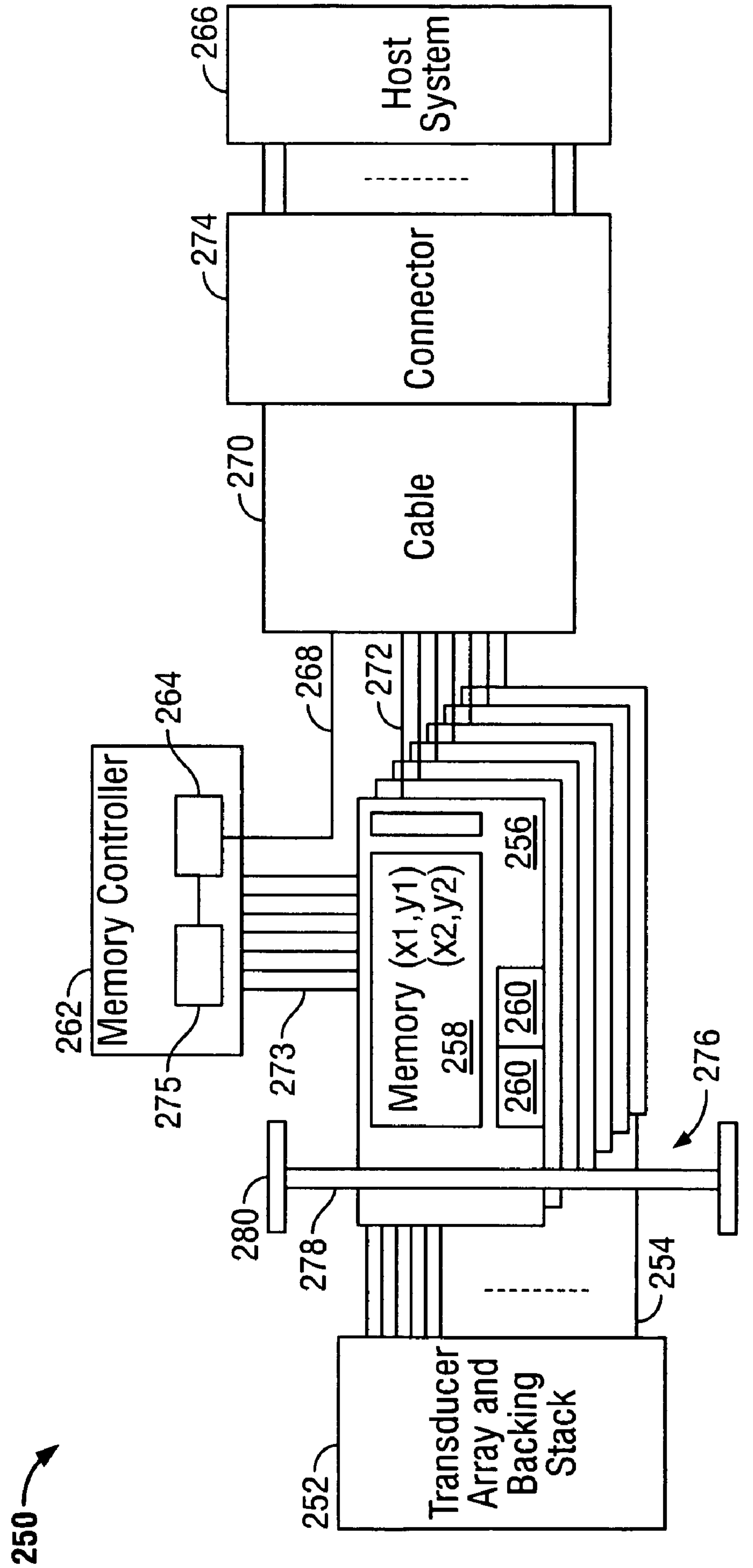
Host System
266
Connector
274
Cable
270
268
272
Memory Controller
262
264
275
273
Memory
258
(x1,y1)
(x2,y2)
256
260
260
276
280
278
254
Transducer Array and Backing Stack
252
250

FIG. 4

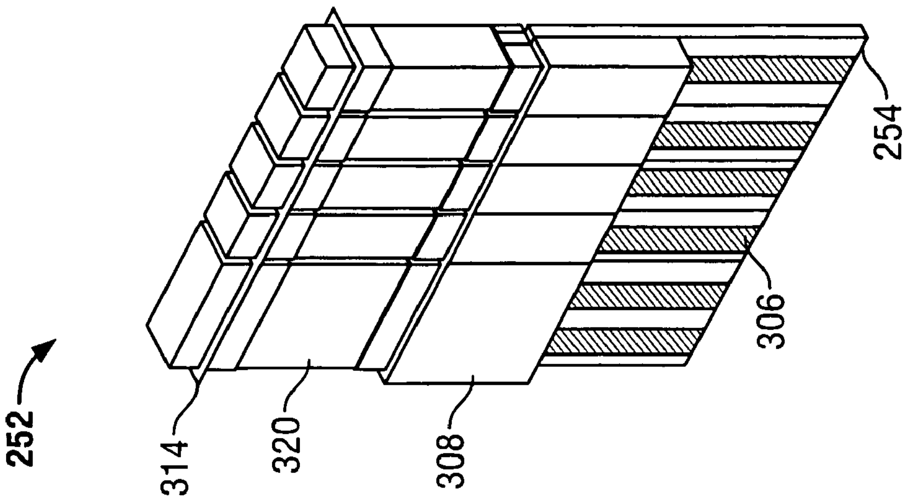
252
314
320
308
306
254

FIG. 6

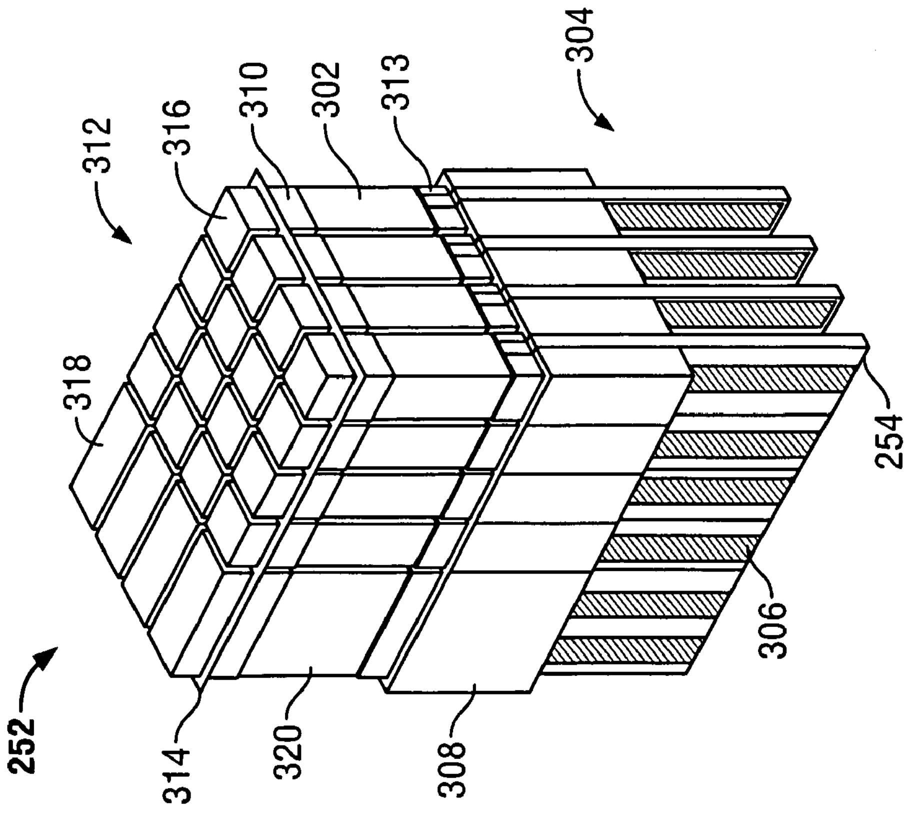
252
314
320
308
318
312
316
310
302
313
304
306
254

FIG. 5

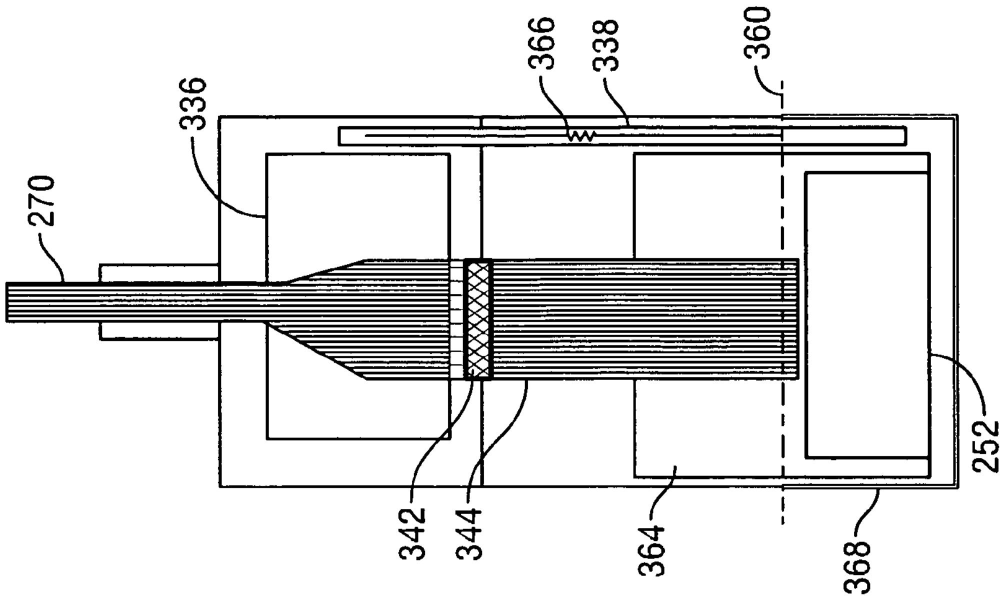
270
336
366
338
360
342
344
364
368
252

FIG. 8

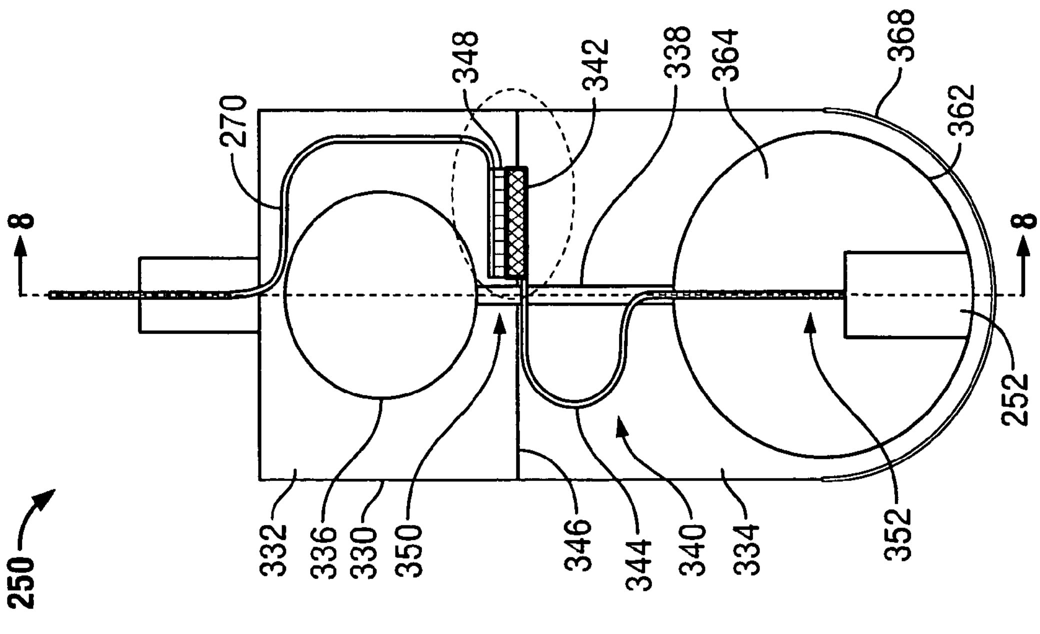
250
8
270
348
342
338
364
368
362
8
332
336
330
350
346
344
340
334
352
252

FIG. 7

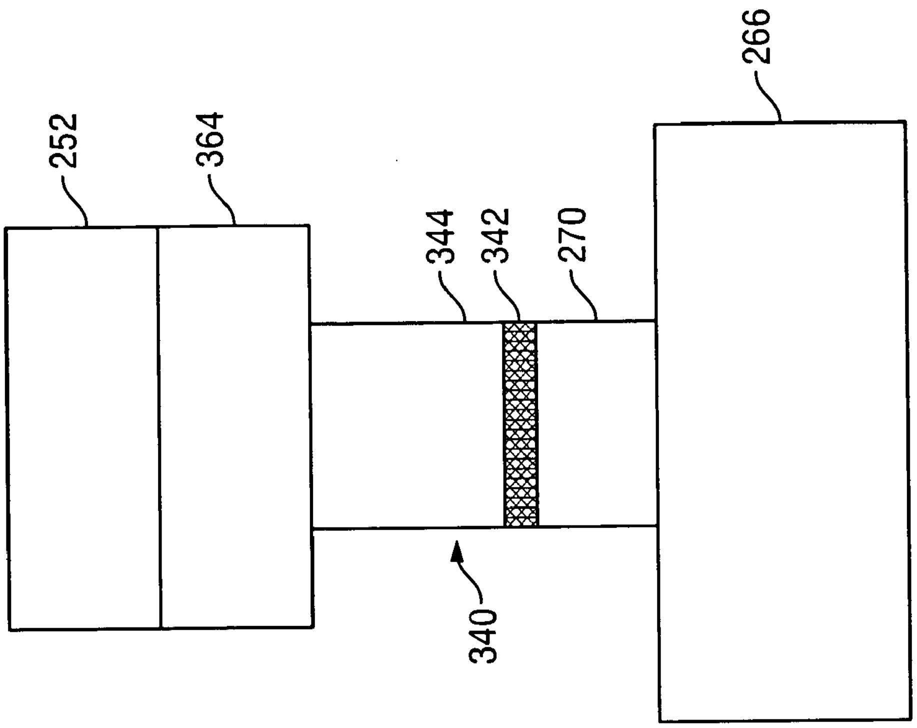
252
364
266
344
342
270
340

FIG. 10

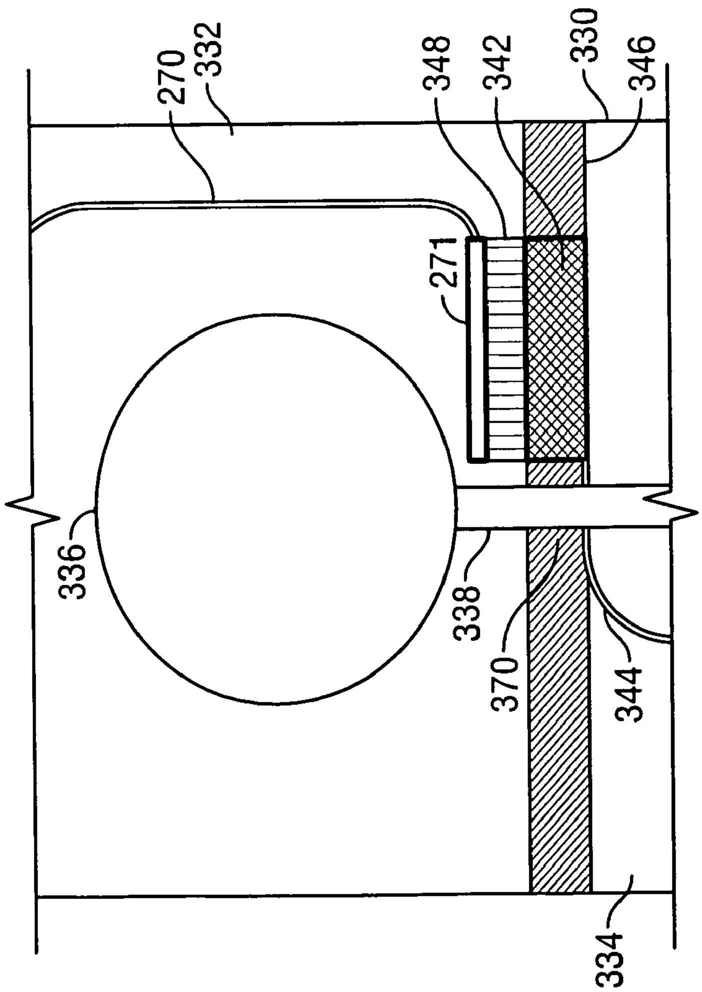
270
332
348
342
330
346
271
336
338
370
344
334

FIG. 9

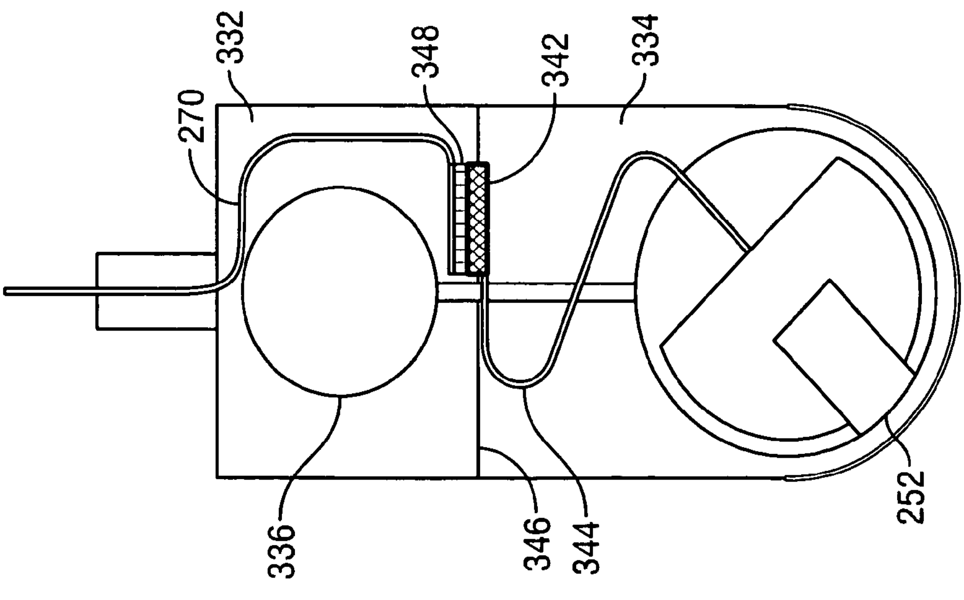

FIG. 11

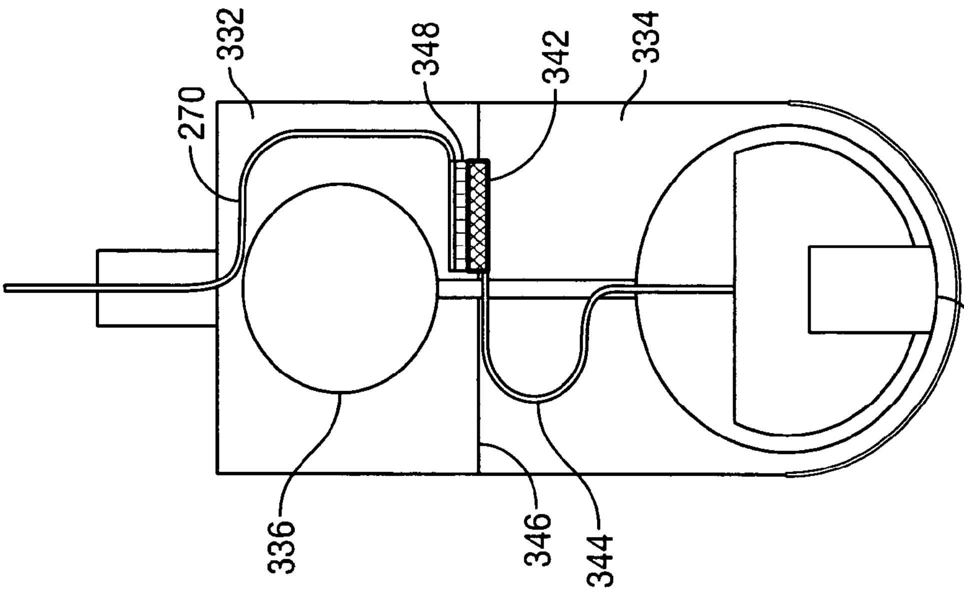

FIG. 12

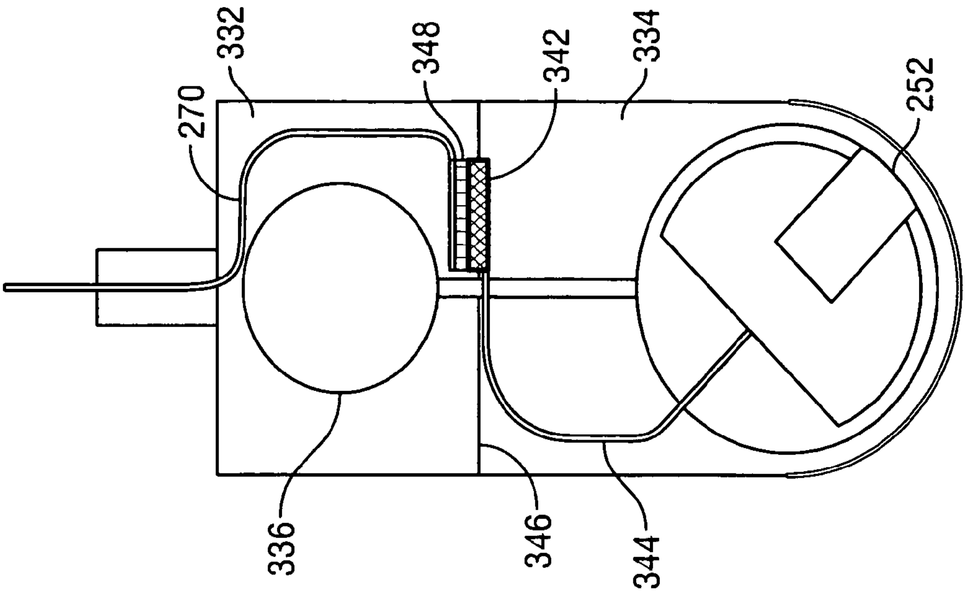

FIG. 13

CONNECTION APPARATUS AND METHOD FOR CONTROLLING AN ULTRASOUND PROBE

CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part and claims priority to U.S. patent application Ser. No. 10/756,231 filed Jan. 13, 2004 for "APPARATUS AND METHOD FOR CONTROLLING AN ULTRASOUND PROBE," which is hereby incorporated by reference herein in its entirety.

BACKGROUND OF THE INVENTION

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

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.

In volume probes, wherein the scan head mechanically moves during scan operation, a separate wet and dry chamber are typically provided. In particular, the scan head moves (e.g. rotates) in a sealed wet chamber having an acoustic membrane surrounding a scan head housing that contacts a patient during a scan. The wet chamber is typically filled with an acoustic liquid to allow acoustic coupling during scanning (e.g., during transmissions). The wet chamber is sealed from the dry chamber and may include control components for controlling the operation of the scan head in the wet chamber. The control components communicate with and control the scan head, for example, control the operation of transducer elements within the scan head. The communication between the control components and scan head may be provided by different communication lines (e.g., coaxial or other flexible cable). These communication lines traverse the seal between the wet and dry chambers, requiring the use of sealing members to maintain the liquid tight seal between the chambers. Each sealing member that is required increases the likelihood of a failure, for example, an increased likelihood of liquid leaking into the dry chamber through one of the sealing members. Further, the sealing members add complexity in design and cost to the probe. For example, additional components (e.g., brackets) between the wet and dry chambers may be needed to maintain the position and sealing engagement of the sealing members.

BRIEF DESCRIPTION OF THE INVENTION

In one exemplary embodiment, an ultrasound probe is provided. The ultrasound probe includes a first chamber, a second chamber and a sealing member between the first and second chambers. The ultrasound probe further includes a connection member within the second chamber having a rigid

portion and a flexible portion, with the rigid portion forming at least part of the sealing member.

In another exemplary embodiment, a method for controlling an ultrasound probe is provided. The method includes communicating between at least one transducer array and a host system via a connection member, with the connection member formed of a rigid portion and a flexible portion. The flexible portion is configured to connect to the at least one transducer array and the rigid portion forms at least part of a wall between a wet chamber having the at least one transducer array therein and a dry chamber having a system cable therein. The rigid portion is also configured to connect to the system cable, with the system cable connected to the host system. The method further includes controlling elements of the at least one transducer array with the communicating.

BRIEF DESCRIPTION OF THE DRAWINGS

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

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

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.

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.

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**.

FIG. **6** is a perspective view of another exemplary transducer stack including an array of transducer elements that may be used in the ultrasound probe shown in FIG. **4**.

FIG. **7** is a cross-sectional elevation view of a probe in accordance with an exemplary embodiment of the present invention.

FIG. **8** is an elevation view taken along the line **8-8** of FIG. **7**.

FIG. **9** is a partial cross-sectional elevation view of an ultrasound probe in accordance with an exemplary embodiment of the present invention showing a rigid portion of a connection member forming part of a wall between chambers of the ultrasound probe.

FIG. **10** is a block diagram showing a connection arrangement for an ultrasound probe in accordance with an exemplary embodiment of the present invention.

FIGS. **11-13** are cross-sectional elevation views of an ultrasound probe in accordance with an exemplary embodiment of the present invention showing a moving scan head.

DETAILED DESCRIPTION OF THE INVENTION

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 improving the sealing arrangement between chambers of an ultrasound probe and allowing for easier maintenance and assembly of the ultrasound probe.

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).

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.

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 frame-rate. 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.

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.

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.

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**.

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**.

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.

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**.

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**.

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.

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**.

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**.

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**.

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.

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.

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**.

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.

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.

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).

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**.

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**.

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**.

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.

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, as shown in FIG. **6**, 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.

FIGS. **7** and **8** illustrate an exemplary embodiment of the probe **250**, and in particular, a volume imagining probe, having a transducer array **252** in communication with a host system **266** (shown in FIG. **4**). The probe **250** includes a housing **330** having a first chamber **332** (e.g., a dry chamber) and a second chamber **334** (e.g., a wet chamber). The first chamber **332** and second chamber **334** may be formed as a single unit (e.g., unitary construction) or may be formed as separate units connected together (e.g. modular design). In an exemplary embodiment, the first chamber **332** 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 **336** (e.g., stepper motor) and a gear arrangement **338**, such as a two-stage gear arrangement having a belt drive and a rope drive. The communication means generally includes the system cable **270** that communicates with the host system **266** to drive the elements of the transducer array **252** (e.g., selectively activate the elements of the transducer array **252**).

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.

In this exemplary embodiment, the second chamber **334** 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 **360** in connection with a scan head housing **362**, supported, for example, on brackets (not shown), that operates to move the transducer array **252** as part of a scan head **364** when driven by the drive means. A support member (not shown) also may be provided for supporting the scan head housing **362** and a biasing spring **366** 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 **368** may be provided surrounding the scan head housing **362** and formed as part of the housing **330**.

The transducer control means generally includes a connection member **340** having one or more communication lines for connecting the system cable **270** and the transducer array **252**, and providing communication therebetween. In one exemplary embodiment, the connection member **340** is formed from a printed circuit board having a rigid portion **342** (e.g., rigid printed circuit board portion) and a flexible portion **344** (e.g., flexible printed circuit board portion). However, it should be noted that the connection member **340** may be formed of any suitable material and/or component parts as desired or needed. In general, the rigid portion **342** and the flexible portion **344** are formed to have a flexibility/rigidity as desired or needed, for example, based upon the type of probe or application. For example, the elastic modulus or mean elastic modulus of the rigid portion **342** and the flexible portion **344** may be determined by the wiring layout of the printed circuit board portion as a result of the distribution of metal layers on the printed circuit board, which may be selected based upon the type of probe. Thus, the material flexibility/rigidity of the rigid portion **342** and flexible portion **344** may be varied as desired or needed. In general, the rigid portion **342** is formed such that it provides sufficient stability from it's stiffness or rigidity (e.g., rigid printed circuit board portion) to ensure proper sealing and/or functioning of a probe (e.g., fluid impervious seal between the first chamber **332** and the second chamber **334**). In general, the flexible portion **344** is formed such that it provides sufficient flexibility and durability to ensure proper functioning and/or operation of a probe (e.g., to ensure proper and reliable interconnection between the rigid portion **342** and a moving transducer array **252**).

The rigid portion **342** forms part of a sealing member **346**, such as, for example, a wall (e.g., fluid impervious wall) between the first chamber **332** and second chamber **334**. The rigid portion **342** may be integrally formed with the sealing member **346** or may be provided in sealing engagement therewith, for example, using adhesive sealing (e.g., epoxy) or other sealing members (e.g., O-rings). In the various exemplary embodiments, the rigid portion **342** and sealing member **346** are a single unitary structure. It should be noted that additional members (e.g., brackets) may be provided in connection with the sealing member **346** to provide mechanical stability for bearing mechanical loads that may be applied to the rigid portion **342** and provide additional pressure on the sealing member **346**. For example, a mechanical load may be applied to the rigid portion **342** by the flexible portion **344** or an interconnection member **348**. The mechanical load may result, for example, from the movement of the flexible portion **344** as described herein, by a differential pressure between the first chamber **332** and second chamber **334**, and by tensions of the system cable **270** that are induced into the rigid portion **342** via the interconnection member **348**, among others.

At a first portion **350** (e.g., first end) of the connection member **340**, the rigid portion **342** is connected via the interconnection member **348** (e.g., board-to-board connector) to the system cable **270**. At a second portion **352** (e.g., second end) of the connection member **340**, the flexible portion **344** is connected to the transducer array **252**. It should be noted that additional or different connectors may be used to connect to the first portion **350** and second portion **352**. The connection member **340** thereby provides communication between the transducer array **252** and the host system **266** via the system cable **270**. However, additional or different control members may be provided, such as, for example, multiplexing circuits connected to the transducer array **252** for controlling the operation of the elements of the transducer array **252**.

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**.

In an exemplary embodiment, and as shown in FIG. **9**, the first chamber **332** and second chamber **334** are separated by the sealing member **346** (e.g., fluid impervious wall), with the rigid portion **342** forming a part of the sealing member **346**. The sealing member **346** provides a liquid tight sealing arrangement between the first chamber **332** and the second chamber **334** and may be integrally formed as part of one of the first and second chambers **332** and **334**. One or more slots or openings **370** may be provided as part of the sealing member **346** to allow for passage therethrough, for example, of a portion of the drive means (e.g., rope portion of a rope drive). The slots or openings **370** are sealed, for, example, with a sealing gasket, epoxy or other suitable sealing member to ensure proper sealing between the first chamber **332** and second chamber **334**. It should be noted that the system cable **270** may include a connector end **271** for connection to the interconnection member **348**.

Thus, as shown in FIG. **10**, the transducer array **252** is connected via the connection member **340** to the system cable **270**. Specifically, the flexible portion **344** connects to the transducer array **252** and the rigid portion **342** connects to the system cable **270**. The system cable **270** then connects to the host system **266**.

The connection member **340** allows for communication with and control of the operation of the elements of a moving transducer array **252** (e.g., selectively driving the elements of the transducer array **252**) as shown in FIGS. **11-13**. The connection member **340** also provides an improved sealing arrangement and more modular probe design (e.g., two chambers removably connectable). 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.

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 first chamber;

a second chamber; and

a sealing member between the first and second chambers, wherein the second chamber includes only a single connection member, the single connection member being only within the second chamber and having a rigid portion and a flexible portion, the rigid portion forming at least part of the sealing member and wherein the connection member comprises a printed circuit board.

2. An ultrasound probe in accordance with claim **1** wherein the sealing member comprises a wall between the first and second chambers.

3. An ultrasound probe in accordance with claim **1** wherein the first chamber is a dry chamber and the second chamber is a wet chamber.

4. An ultrasound probe in accordance with claim **1** wherein the rigid portion comprises a rigid printed circuit board and the flexible portion comprises a flexible printed circuit board.

5. An ultrasound probe in accordance with claim **1** wherein the rigid portion is configured to connect to a system cable in the first chamber and the flexible portion is configured to connect to a transducer array in the second chamber, the transducer array provided as part of a scan head configured to move within the second chamber.

6. An ultrasound probe in accordance with claim **1** wherein the rigid portion is integrally formed with the sealing member.

7. An ultrasound probe in accordance with claim **1** wherein the rigid portion is sealingly engaged with the sealing member.

8. An ultrasound probe in accordance with claim **1** further comprising an interconnection member to connect the rigid portion to a system cable within the first chamber.

9. An ultrasound probe in accordance with claim **1** wherein the sealing member comprises at least one opening.

10. An ultrasound probe in accordance with claim **1** wherein the first and second chambers are formed in a unitary construction.

11. An ultrasound probe in accordance with claim **1** wherein the first and second chambers are formed in a modular construction.

12. An ultrasound probe in accordance with claim **1** wherein the ultrasound probe is configured to operate in at least one of a 1D, 1.25D, 1.5D, 1.75D and 2D mode of operation.

13. An ultrasound probe comprising:

a transducer array;

a first chamber;

a second chamber; and

a sealing member between the first and second chambers, wherein the second chamber includes only a single connection member, the single connection member being only within the second chamber and having a rigid portion and a flexible portion, the rigid portion forming at least part of the sealing member, wherein the rigid portion is configured to connect to a system cable in the first chamber and the flexible portion is configured to connect to the transducer array in the second chamber.

14. An ultrasound probe comprising:

at least one transducer;

a dry chamber having drive means for mechanically controlling the at least one transducer and communication means for electrically controlling the at least one transducer; and

a wet chamber having a connection member formed of a rigid portion and a flexible portion, the rigid portion forming at least part of a wall between the wet and dry chambers and configured to connect to the communication means, and the flexible portion configured to connect to the at least one transducer.

15. An ultrasound probe in accordance with claim **14** wherein the communication means comprises a system cable.

16. An ultrasound probe in accordance with claim **14** wherein the drive means comprises a motor and gear arrangement.

17. An ultrasound probe in accordance with claim **14** wherein the connection member further comprises a printed circuit board.

18. An ultrasound probe in accordance with claim **14** wherein the dry and wet chambers are configured to connect in a modular arrangement.

19. A connection member for an ultrasound probe, the connection member comprising:

a wet chamber;

a dry chamber;

at least one transducer in the wet chamber;

a flexible portion within only the wet chamber configured to connect to the at least one transducer; and

a rigid portion forming at least part of a sealing member between the wet chamber and the dry chamber, the rigid portion configured to connect to a system cable in the dry chamber, the flexible and rigid portions being a single member.

20. A connection member in accordance with claim **19** wherein the flexible portion and rigid portion each comprise a printed circuit board.

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

communicating between at least one transducer array and a host system via a connection member, the connection member comprising a rigid portion and a flexible portion that form a single member, the flexible portion being entirely within a wet chamber and configured to connect to the at least one transducer array, the rigid portion forming at least part of a wall between the wet chamber having the at least one transducer array therein and a dry chamber having a system cable therein, the rigid portion configured to connect to the system cable, with the system cable connected to the host system; and

controlling elements of the at least one transducer array with the communicating.

22. A method in accordance with claim **21** wherein the connection member comprises a printed circuit board.

* * * * *

专利名称(译)	连接装置和用于控制超声探头的方法		
公开(公告)号	US7494469	公开(公告)日	2009-02-24
申请号	US10/767585	申请日	2004-01-29
[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		
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摘要(译)

提供了一种用于控制超声探头的连接装置和方法。超声探头包括第一腔室，第二腔室和位于第一腔室和第二腔室之间的密封构件。超声探头还包括在第二腔室内的连接构件，该连接构件具有刚性部分和柔性部分，刚性部分形成密封构件的至少一部分。