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(54) METHOD AND APPARATUS FOR CONNECTING AN ULTRASOUND PROBE TO AN IMAGING SYSTEM

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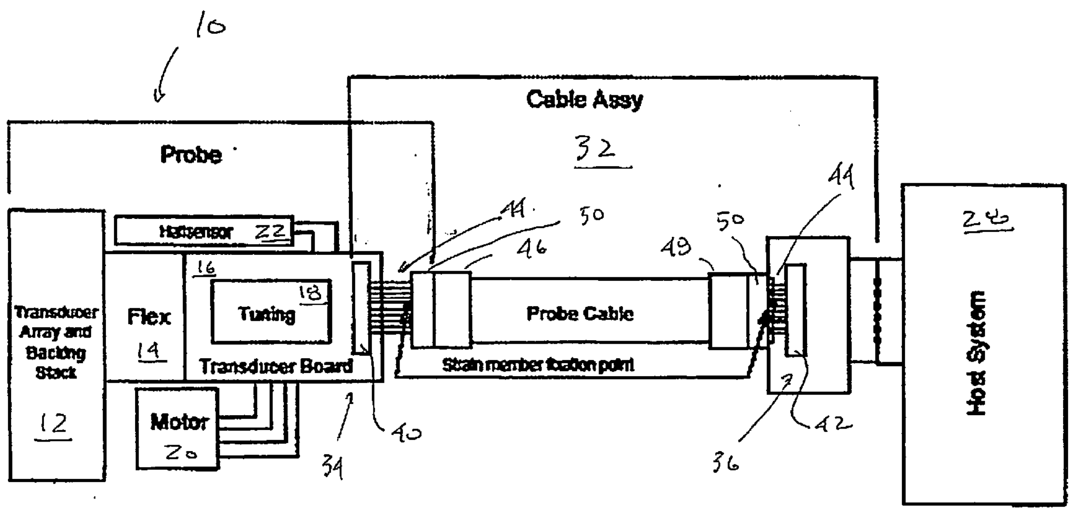
(57) ABSTRACT

A connector assembly for coupling an coaxial cable to an ultrasound probe includes a cable clamp having an opening extending therethrough, the opening sized to receive a coaxial cable therethrough, the coaxial cable including a strain member and a plurality of coaxial cables extending therethrough, and a collet configured to couple to the cable clamp, the collet including an arbor that is configured to tension the strain member to a predetermined tension. A method of fabricating a connector assembly and an ultrasound imaging system are also described herein.



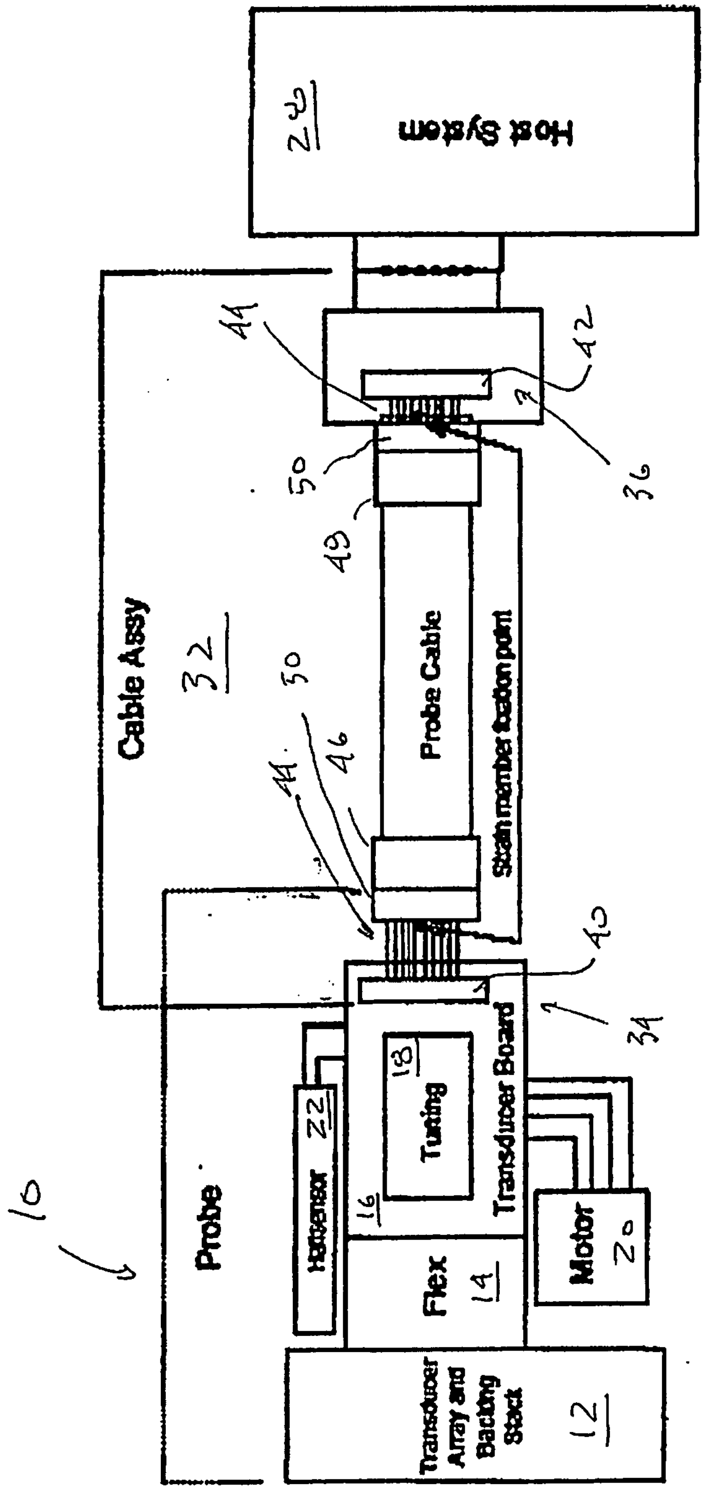

Host System
28
Cable Assy
32
Probe Cable
Strain member fixation point
44
42
36
50
48
46
40
34
Probe
Transducer Board
Tuning
18
16
Hallsensor
22
Flex
14
Motor
20
Transducer Array and Backing Stack
12
10

FIGURE 1

METHOD AND APPARATUS FOR CONNECTING AN ULTRASOUND PROBE TO AN IMAGING SYSTEM

BACKGROUND OF THE INVENTION

[0001] The subject matter disclosed herein relates generally to ultrasound imaging systems, and more particularly, to a method and apparatus for connecting an ultrasound probe to an ultrasound imaging system.

[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] The ultrasound system communicates with and controls the ultrasound probe to control the operation of the transducer elements within the ultrasound probe via a flexible cable. The flexible cable may include, for example, a plurality of (coaxial cables) that couple the transducer elements to the ultrasound system. In operation, the flexible cable experiences different torsional strains that are caused by the operator when moving the ultrasound probe to perform the ultrasound scans. More specifically, the flexible cable may be subjected to flexure-induced stresses that are concentrated at a point where the flexible cable exits the ultrasound probe. As a result, the coaxes may be subjected to stresses that are concentrated at the point where the flexible cable exits the ultrasound probe. The concentrated forces may cause cable fatigue that may result in the breakage of at least some of the coaxes within the flexible cable.

[0004] To facilitate reducing theses stresses strain relief devices may be used. However, conventional strain relief devices are typically designed to be utilized with a specific cable. As a result, it may be difficult, for example, for a hospital to maintain and repair a variety of different ultrasound probes.

BRIEF DESCRIPTION OF THE INVENTION

[0005] In one embodiment, a connector assembly for coupling an coaxial cable to an ultrasound probe is provided. The connector assembly includes a cable clamp having an opening extending therethrough, the opening sized to receive a coaxial cable therethrough, the coaxial cable including a strain member and a plurality of coaxial cables extending therethrough, and a collet configured to couple to the cable clamp, the collet including an arbor that is configured to tension the strain member to a predetermined tension.

[0006] In another embodiment, a method of fabricating a coaxial cable assembly is provided. The method includes inserting a coaxial cable through a cable clamp, the coaxial cable including a strain member and a plurality of coaxial cables extending therethrough, inserting the coaxial cable through a collet, the collet including an arbor, coupling the collet to the cable clamp, coupling the strain member to the arbor, and .rotating the arbor to tension the strain member to a predetermined tension.

[0007] In a further embodiment, an ultrasound imaging system is provided. The ultrasound imaging system includes an ultrasound probe, a system cable coupled between the ultrasound probe and a host system, and a connector assembly for coupling the ultrasound probe to the system cable. The connector assembly includes a cable clamp having an opening extending therethrough, the opening sized to receive the system cable therethrough, the system cable including a strain member and a plurality of coaxial cables extending therethrough, and a collet configured to couple to the cable clamp, the collet including an arbor that is configured to tension the strain member to a predetermined tension.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a block diagram of an ultrasound probe formed in accordance with various embodiments.

[0009] FIG. **2** is a side view of a portion of the system cable shown in FIG. **1** with a portion of the jacket removed.

[0010] FIG. **3** is a cross-sectional view of an exemplary connector that may be formed in accordance with various embodiments.

[0011] FIG. **4** is a side perspective view of the exemplary connector shown in FIG. **3**.

[0012] FIG. **5** is a side view of an exemplary system cable in an initial assembly stage.

[0013] FIG. **6** is a side view of the exemplary system cable shown in FIG. **5** in a subsequent assembly stage.

[0014] FIG. **7** is a side view of the exemplary system cable shown in FIG. **5** in another subsequent assembly stage.

[0015] FIG. **8** is a side view of the exemplary system cable shown in FIG. **5** in another subsequent assembly stage.

[0016] FIG. **9** is a side view of the exemplary system cable shown in FIG. **5** in another subsequent assembly stage.

[0017] FIG. **10** is a side view of the exemplary system cable shown in FIG. **5** in still another subsequent assembly stage.

[0018] FIG. **11** is a block diagram of an exemplary medical imaging system formed in accordance with various embodiments.

[0019] FIG. **12** is a block diagram illustrating a portion of the imaging system shown in FIG. **11** in accordance with various embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0020] The foregoing summary, as well as the following detailed description of certain embodiments, will be better understood when read in conjunction with the appended drawings. To the extent that the figures illustrate diagrams of the functional blocks of various embodiments, the functional blocks are not necessarily indicative of the division between hardware circuitry. Thus, for example, one or more of the functional blocks (e.g., processors, controllers or memories) may be implemented in a single piece of hardware (e.g., a general purpose signal processor or random access memory, hard disk, or the like) or multiple pieces of hardware. Similarly, the programs may be stand alone programs, may be incorporated as subroutines in an operating system, may be functions in an installed software package, and the like. It should be understood that the various embodiments are not limited to the arrangements and instrumentality shown in the drawings.

[0021] As used herein, an element or step recited in the singular and proceeded with the word "a" or "an" should be understood as not excluding plural of said elements or steps, unless such exclusion is explicitly stated. Furthermore, references to "one embodiment" are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. Moreover, unless explicitly stated to the contrary, embodiments "comprising" or "having" an element or a plurality of elements having a particular property may include additional such elements not having that property.

[0022] Also as used herein, the phrase "reconstructing an image" is not intended to exclude embodiments of the present invention in which data representing an image is generated, but a viewable image is not. Therefore, as used herein the term "image" broadly refers to both viewable images and data representing a viewable image. However, many embodiments generate, or are configured to generate, at least one viewable image.

[0023] Described herein are various embodiments for a connector assembly. The connector assembly includes a strain relief assembly that is aligned such that the pull force of the strain relief assembly is proximately aligned with a centerline of the system cable. The strain relief assembly may be assembled and disassembled without the need for spare parts and may be utilized with a variety of different ultrasound probes.

[0024] Various embodiments described herein may be implemented with an ultrasound probe **10** as shown in FIG. **1**. More specifically, FIG. **1** is a block diagram of an exemplary ultrasound probe that is constructed in accordance with various embodiments. The ultrasound probe **10** includes a transducer array and backing stack **12** (the "transducer array **12**"), a plurality of transducer flex cables **14**, which may be formed as a scan head cable, and a transducer board **16** that support processing electronics. The processing electronics may include, for example, a tuning circuit **18** for providing impedance tuning from the transducer array **12** to the cable of each channel. In various embodiments, the tuning circuit **18** may be implemented as a passive inductor. The ultrasound probe **10** may also include a motor **20** that is utilized to position the transducer array **12** in various operational configurations. The ultrasound probe **10** may further include a Hall effect sensor **22** that is utilized to

[0025] In operation, the ultrasound probe communicates with a host system **28** via a system cable **32**. The system cable **32** may be embodied as a coaxial cable having a first end **34** that is configured to couple to the ultrasound probe **10** and a second end **36** that is configured to couple to the host system **28**. More specifically, the system cable **32** includes a connector **40** that is disposed proximate to the first end **34** and is utilized to couple the system cable **32** to the ultrasound probe **10**. Moreover, the system cable **32** includes a second connector **42** that is disposed proximate to the second end **36** and is utilized to couple the system cable **32** to the host system **28**. In various embodiments, the system cable **32** includes a plurality of coaxial cables **44** that connect the ultrasound probe **10** to the host system **28**. The system cable **32** also includes a first flex relief device **46** that is coupled proximate to the first end **34** and a second flex relief device **48** that is coupled proximate to the second end **36**. The system cable **32** further includes a pair of connectors **50** that are discussed in more detail below.

[0026] FIG. **2** is a side perspective view of a portion of the system cable **32** shown in FIG. **1**. In various embodiments, the system cable **32** includes the plurality of coaxes **44**, also referred to herein as inner conductors, and may include other cables, such as for example, the communication line **30**. Each coax **44** may be formed to include a central conductor (not shown) and a flexible insulating sheath (not shown) that surrounds the central conductor. The system cable **32** further includes a strain member **100**. The strain member **100** is generally disposed along a longitudinal axis of the system cable **32** and generally located at a center point of the system cable **32**. Thus, in the exemplary embodiment, the strain member **100** is disposed radially inwardly from the plurality of coaxes **44** such that the coaxes **44** substantially circumscribe the strain member **100**. In various embodiments, the strain member **100** may be fabricated from, for example, a single strand of Kevlar or Aramid material. Optionally, the strain member **100** may be fabricated from a plurality of strands of Kevlar or Aramid material. In further embodiments, the strain member **100** may be fabricated from any suitable non-conductive material.

[0027] The system cable **32** may also include a supporting member such as a tape **102** that substantially circumscribes the strain member **100**, the coaxes **44**, and the communication line **30**. In operation, the tape **102** facilitates securing the coaxes **44**, the communication line **30** and the strain member **100** in a substantially fixed position with respect to each other. The system cable **32** further includes a shield **104** and a jacket **106**. The shield **104**, also referred to herein as an outer conductor, may be embodied as a tubular conducting shield that may be fabricated using a plurality of metallic wires that are braided together to form the shield **104**. The jacket **106** is a tubular jacket that encases the shield **104** and the various other components located internally within the jacket **106**. In various embodiments, the jacket **106** is fabricated using a flexible insulating material. In operation, the system cable **32** conducts electrical signals using the inner conductors while the outer conductor or shield **104** is kept at ground potential. Accordingly, a voltage is applied across the inner conductors and the outer conductor or shield **104** to carry the electrical signals.

[0028] FIG. **3** is a side cut-away view of the exemplary connector **50** that is utilized to couple the system cable **32** to the ultrasound probe **10** as shown in FIG. **1**. FIG. **4** is a side view of the connector **50** shown in FIG. **3** after assembly of the connector **50**. In various embodiments, the connector **50** is fabricated using a non-conductive material, such as for example, a plastic material. Optionally, portions of the connector **50** may be fabricated from materials other than plastic. The connector **50** includes a substantially cylindrical cable clamp **150**. The cable clamp **150** is hollow to form and opening that is sized to receive the system cable **32** therethrough. The cable clamp **150** has a first end **152** and an opposite second end **154**. The first end **152** forms a ferrule **156** that is configured to be inserted into an opening formed in the flex relief device **46**. In operation, the flex relief device **46** is secured around the system cable **32** and provides support to the system cable **32** to facilitate preventing the system cable **32** from being flexed beyond a point that may result in damage to the various conductors housed within the system cable **32**. Moreover, the ferrule **156** is generally formed as a cylindrical device, having an opening at each end that is attached to system cable **32** and configured to protect the system cable **32** from fraying or other damage.

[0029] The cable clamp second end **154** is formed to include a plurality of threads **160**. In the exemplary embodiment, the threads **160** are formed on an inner surface **162** of the cable clamp **150** proximate to the second end **154**. Thus, in the exemplary embodiment, the inner surface **162** gradually tapers from the threads **160** to the first end **152** to form the ferrule portion **156** of the cable clamp **150**. The cable clamp **150** also includes a slot **164** that is formed in an outer surface **166** of the cable clamp **150**. In the exemplary embodiment, the slot **164** extends radially around the outer surface **166** and is disposed radially outwardly from the threads **160**. To secure the cable clamp **150** to the flex relief device **46**, the flex relief device **46** includes a tab **168** that extends radially around an inner surface **170** of the flex relief device **46**. Accordingly, during assembly, the cable clamp **150** is positioned such that the ferrule **156** extends at least partially into the flex relief device **46**. The flex relief device **46** is then expanded to enable the tab **168** to be inserted into the slot **164**. Thus, the combination of the tab **168** and the slot **164** enables the cable clamp **150** to be secured to the flex relief device **46**. In various embodiments, a user may utilize a tool or fixture **172** to facilitate expanding the flex relief device **46** and thus enable the tab **168** to be inserted into the slot **164**.

[0030] The connector **50** also includes a collet **180**. The collet **180** is generally formed as a cylindrical sleeve that is configured to circumscribe the system cable **32** and facilitated securing the system cable **32** in a fixed position. The collet **180** includes a first end **182** and a second end **184**. In various embodiments, the collet first end **182** includes a plurality of threads **186** that are formed on an external surface **188** of the collet **180**. The collet **180** may also include a slot **190** that is formed in the external surface **188** of the collet **180**. In the exemplary embodiment, the slot **190** extends radially around the external surface **188** and is disposed radially proximate to the second end **184**. During assembly, the collet **180** is positioned such that the collet threads **186** are substantially aligned with the threads **160** formed in the cable clamp **150**. A tool or fixture **192** is then utilized to thread the collet **180** into the cable clamp **150**. In various other embodiments, described below, the collet **180** may have a tapered shape and may be secured to the cable clamp **150** using a clip.

[0031] In various embodiments, and as shown in FIG. **4**, the collet **180** further includes a strain relief assembly **200** that functions as a winch and is formed integrally with the collet **180**. Accordingly, the collet second end **184** includes a slot **202** and an opening **204**. The slot **202** is disposed on an opposite side of the collet **180** from the opening **204**. In various embodiments, the slot **202** has a substantially C-shape and the opening **204** is substantially circular. The slot **202** is flexible to enable an arbor **206** to be inserted therein. More specifically, the arbor **206** has a first end **208** that is configured to be secured within the slot **202**. The arbor **206** also has a second end **210** that is configured to be secured within the opening **204**.

[0032] During assembly, the arbor first end **208** is inserted into the opening **204**. Moreover, the arbor second end **210** is depressed into the slot **202**. The pressure applied to the arbor second end **210** causes the sides of the C-shaped slot to expand. Continued pressure enables the arbor second end **210** to be depressed within the slot **202**. After the arbor second end **210** is fully inserted within the slot **202**, the sides of the slot **202** contact to secure the arbor **206** to the collet **180**. Thus, the combination of the slot **202** and the opening **204** enable the arbor **206** to be secured to the collet **180** and also remain rotatable with respect to the collet **180**. In various embodiments, the arbor first end **208** and/or the arbor second end **210** may have a slot **212** formed therein. During assembly, the slot **212** enables the arbor **206** to be rotated with respect to the collet **180**.

[0033] FIG. **5** to FIG. **9** are side views of the system cable **32** is a various stages of assembly in accordance with various embodiments described herein. For example, as shown in FIG. **5**, initially the first end **34** of the system cable **32** is inserted through the flex relief device **46**. An o-ring **250** is then placed around the system cable **32** and the cable clamp **150**, which forms a portion of the connector **50**, is placed on the system cable **32** such that the o-ring **250** is disposed between the flex relief device **46** and the cable clamp **150**. In various embodiments, the system cable **32** is inserted though the flex relief device **46**, the o-ring **250** and the cable clamp **150** such that a portion **252** of the system cable **32** extends past the connector **50** as shown in FIG. **5**. In operation, the o-ring **250** facilitates inhibiting fluids from entering either the system cable **32** or the ultrasound probe **10**.

[0034] As shown in FIG. **6**, the jacket **106** is moved in a direction **260**. A section of shrink tube **262** is then disposed over a portion of the system cable **32**. The jacket **106** is then moved in a direction **264** such that the jacket **106** substantially covers the shrink tube **262**.

[0035] As shown in FIG. **7**, the collet **180** is placed around the system cable **32** and coupled with the cable clamp **150**. As discussed above, the collet **180** may be secured to the cable clamp **150** using the collet threads **186** and the threads **160** formed in the cable clamp **150**. A tool or fixture **192** is then utilized to thread the collet **180** into the cable clamp **150**. In various other embodiments, the collet **180** may be secured to the cable claim **150** using a clip **270**. More specifically, the clip **270** includes a pair of tabs **272** that are configured to engage and secure the collet **180** to the cable clamp **150**. Accordingly, during assembly, a user may depress the pair of tabs **272**, position the collet **180** at least partially over the cable clamp **150**, and the release the tabs **272**. Thus, the tabs **272**, in a relaxed position, facilitate locking the collet in a predetermined position.

[0036] As shown in FIG. **8**, the shield **104** is separated into at least two shield portions **280**. Thus, in various embodiments, each shield portion **280** includes a plurality of shield wires that are twisted to together to form a bundle.

[0037] As shown in FIG. **9**, the plurality of coax cables **44** and/or communication lines **30** are separated from the strain member **100** to expose the strain member **100**. The end of the strain member **100** is then at least partially wrapped around the arbor **206**. The arbor **206** is then operated to apply tension to the strain member **100**. More specifically, as discussed above, the arbor **206** includes the slot **212**. Accordingly, to increase the tension on the strain member **100**, a tool **290**, such as a screw driver, may be inserted into the slot **212**. The tool **290** is then rotated in a clockwise or counter-clockwise direction to either increase or decrease the tension on the strain member **100**. After the strain member **100** has been adjusted to a predetermined tension, an adhesive (not shown) may be applied to a surface of the arbor **206** to secure the strain member **100** to the arbor **206**. Moreover, to facilitate preventing the arbor **206** from moving after the predetermined strain has been achieved, the arbor **206** may include a locking device **292**. The locking device **292** may be embodied as a protrusion that is formed on the arbor **206** that is configured to interlock with the opening formed on the collet **180**.

[0038] In operation, the strain relief assembly **200**, which includes the arbor **206** and the associated openings and slots in the collet **180** allow for flexible length adaption of the strain member **100** to ensure the fibers forming the strain member **100** are tensioned for proper functionality. Moreover, because the strain member **100** is centrally located within the system cable **32**, the strain relief assembly **200** is aligned such that the pull force of the arbor **206** is also in the center of the system cable **32**. The strain relief assembly **200** may be assembled and disassembled without the need for spare parts. Moreover, by bending the coaxes cables **44** sideways at the point where the connector **50** couples to the system cable **32**, the connector **50** may be moved through relatively small openings which allow the connector to be assembled at the point where the coax cables **44** terminate.

[0039] The connector described herein may be fabricated using, for example, plastic parts. Moreover, the connector may be utilized with different ultrasound probes and thus may provide increased logistic advantages over conventional connectors. More specifically, the connector described herein may be customized for specific ultrasound probes after cable assembly by allowing for assembly to probe specific parts such as for example, a plastic housing after coax cable termination.

[0040] Various embodiments described herein may be implemented in an ultrasound system such as the ultrasound system **300** as shown in FIG. **11**. More specifically, FIG. **11** is a block diagram of an exemplary ultrasound imaging system **300** that is constructed in accordance with various embodiments. The ultrasound system **300** is capable of electrical or mechanical steering of a soundbeam (such as in 3D space) and is configurable to acquire information (e.g., image slices) corresponding to a plurality of 2D representations or images of a region of interest (ROI) in a subject or patient, which may be defined or adjusted as described in more detail herein. The ultrasound system **300** is configurable to acquire 2D images in one or more planes of orientation. The ultrasound system **300** may be embodied in a small-sized system, such as laptop computer, a portable imaging system, a pocket sized system as well as in a larger console-type system.

[0041] The ultrasound system **300** includes a transmitter **302** that, under the guidance of a beamformer **304**, drives an array of elements **306** (e.g., piezoelectric elements) within a probe **308** to emit pulsed ultrasonic signals, i.e. sound waves, into a body. A variety of geometries may be used. As shown in FIG. **11**, the probe **308** may be coupled to the transmitter **302** via the system cable **32** and the connector **50**. The sound waves are back-scattered from structures in the body, like blood cells flowing through a blood vessel, to produce echoes that return to the elements **306**. The echoes are received by a receiver **310**. The received echoes are passed through the beamformer **304**, which performs receive beamforming and outputs an RF signal. The RF signal then passes through an RF processor **312**. Optionally, the RF processor **312** 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 may then be routed directly to a buffer **314** for storage.

[0042] In the above-described embodiment, the beamformer **304** operates as a transmit and receive beamformer. Optionally, the probe **308** includes a 2D array with sub-aperture receive beamforming inside the probe **308**. The beamformer **304** may delay, apodize and/or sum each electrical signal with other electrical signals received from the probe **308**. The summed signals represent echoes from the ultrasound beams or lines. The summed signals are output from the beamformer **304** to the RF processor **312**. The RF processor **312** may generate different data types, e.g. B-mode, color Doppler (velocity/power/variance), tissue Doppler (velocity), and Doppler energy, for multiple scan planes or different scanning patterns. For example, the RF processor **312** may generate blood flow Doppler data for multi-scan planes. The RF processor **312** gathers the information (e.g. I/Q, B-mode, color Doppler, tissue Doppler, and Doppler energy information) related to multiple data slices and stores the data information, which may include time stamp and orientation/rotation information, in the buffer **314**.

[0043] The ultrasound system **300** also includes a processor **316** to process the acquired ultrasound information (e.g., RF signal data or IQ data pairs) and prepare frames of ultrasound information for display on a display **318**. The processor **316** is adapted to perform one or more processing operations according to a plurality of selectable ultrasound modalities on the acquired ultrasound data. Acquired ultrasound data may be processed and displayed in real-time during a scanning session as the echo signals are received. Additionally or alternatively, the ultrasound data may be stored temporarily in the buffer **314** during a scanning session and then processed and displayed in an off-line operation.

[0044] The processor **316** is connected to a user interface **320** that may control operation of the processor **316** as explained below in more detail. The display **318** may include one or more monitors that present patient information, including diagnostic ultrasound images to the user for diagnosis and analysis. The buffer **314** and/or a memory **322** may store two-dimensional (2D) or three-dimensional (3D) data sets of the ultrasound data, where such 2D and 3D data sets are accessed to present 2D (and/or 3D images). The images may be modified and the display settings of the display **318** may also be manually adjusted using the user interface **320**.

[0045] The various components of the ultrasound system **300** may have different configurations. For example, FIG. **12** illustrates an exemplary block diagram of an ultrasound processor module **350**, which may be embodied as a portion of the processor **316** shown in FIG. **11**. The ultrasound processor module **350** is illustrated conceptually as a collection of sub-modules, but may be implemented utilizing any combination of dedicated hardware boards, DSPs, processors, etc. Alternatively, the sub-modules of FIG. **12** may be implemented utilizing an off-the-shelf PC with a single processor or multiple processors, with the functional operations distributed between the processors. As a further option, the sub-modules of FIG. **12** may be implemented utilizing a hybrid configuration in which certain modular functions are performed utilizing dedicated hardware, while the remaining modular functions are performed utilizing an off-the shelf PC and the like. The sub-modules also may be implemented as software modules within a processing unit.

[0046] The operations of the sub-modules illustrated in FIG. **12** may be controlled by a local ultrasound controller **352** or by the processor **316**. The sub-modules **354-366** perform mid-processor operations. The ultrasound processor module **350** may receive ultrasound data **370** in one of several forms. In the embodiment of FIG. **12**, the received ultrasound data **370** constitutes I,Q data pairs representing the real and imaginary components associated with each data sample. The I,Q data pairs are provided to one or more of a color-flow sub-module **354**, a power Doppler sub-module **356**, a B-mode sub-module **358**, a spectral Doppler sub-module **360** and an M-mode sub-module **362**. Optionally, other sub-modules may be included such as an Acoustic Radiation Force Impulse (ARFI) sub-module **364** and a Tissue Doppler (TDE) sub-module **366**, among others.

[0047] Each of sub-modules **354-366** are configured to process the I,Q data pairs in a corresponding manner to generate color-flow data **372**, power Doppler data **374**, B-mode data **376**, spectral Doppler data **378**, M-mode data **380**, ARFI data **382**, and tissue Doppler data **384**, all of which may be stored in a memory **390** (or memory **314** or memory **322** shown in FIG. **11**) temporarily before subsequent processing. For example, the B-mode sub-module **358** may generate B-mode data **376** including a plurality of B-mode image planes.

[0048] The data **372-484** may be stored, for example, as sets of vector data values, where each set defines an individual ultrasound image frame. The vector data values are generally organized based on the polar coordinate system.

[0049] A scan converter sub-module **392** accesses and obtains from the memory **390** the vector data values associated with an image frame and converts the set of vector data values to Cartesian coordinates to generate an ultrasound image frame **393** formatted for display. The ultrasound image frames **393** generated by the scan converter module **392** may be provided back to the memory **390** for subsequent processing or may be provided to the memory **314** or **322**.

[0050] Once the scan converter sub-module **392** generates the ultrasound image frames **393** associated with, for example, B-mode image data, and the like, the image frames **393** may be restored in the memory **390** or communicated over a bus **396** to a database (not shown), the memory **314**, and the memory **322** and/or to other processors.

[0051] The scan converted data may be converted into an X,Y format for video display to produce ultrasound image frames. The scan converted ultrasound image frames are provided to a display controller (not shown) that may include a video processor that maps the video to a grey-scale mapping for video display. The grey-scale map may represent a transfer function of the raw image data to displayed grey levels. Once the video data is mapped to the grey-scale values, the display controller controls the display **318** (shown in FIG. **11**), which may include one or more monitors or windows of the display, to display the image frame. The image displayed in the display **318** is produced from image frames of data in which each datum indicates the intensity or brightness of a respective pixel in the display.

[0052] Referring again to FIG. **12**, a 2D video processor sub-module **394** combines one or more of the frames generated from the different types of ultrasound information. For example, the 2D video processor sub-module **394** may combine a different image frames by mapping one type of data to a grey map and mapping the other type of data to a color map for video display. In the final displayed image, color pixel data may be superimposed on the grey scale pixel data to form a single multi-mode image frame **398** (e.g., functional image) that is again re-stored in the memory **390** or communicated over the bus **396**. Successive frames of images may be stored as a cine loop in the memory **390** or memory **390**. The cine loop represents a first in, first out circular image buffer to capture image data that is displayed to the user. The user may freeze the cine loop by entering a freeze command at the user interface **320**. The user interface **320** may include, for example, a keyboard and mouse and all other input controls associated with inputting information into the ultrasound system **300** (shown in FIG. **11**).

[0053] A 3D processor sub-module **400** is also controlled by the user interface **320** and accesses the memory **390** to obtain 3D ultrasound image data and to generate three dimensional images, such as through volume rendering or surface rendering algorithms as are known. The three dimensional images may be generated utilizing various imaging techniques, such as ray-casting, maximum intensity pixel projection and the like.

[0054] The various embodiments and/or components, for example, the modules, or components and controllers therein, such as of the imaging system **300**, also may be implemented as part of one or more computers or processors. The computer or processor may include a computing device, an input device, a display unit and an interface, for example, for accessing the Internet. The computer or processor may include a microprocessor. The microprocessor may be connected to a communication bus. The computer or processor may also include a memory. The memory may include Random Access Memory (RAM) and Read Only Memory (ROM). The computer or processor further may include a storage device, which may be a hard disk drive or a removable storage drive such as an optical disk drive, solid state disk drive (e.g., flash RAM), and the like. The storage device may also be other similar means for loading computer programs or other instructions into the computer or processor.

[0055] As used herein, the term "computer" or "module" may include any processor-based or microprocessor-based system including systems using microcontrollers, reduced instruction set computers (RISC), application specific integrated circuits (ASICs), logic circuits, and any other circuit or processor capable of executing the functions described herein. The above examples are exemplary only, and are thus not intended to limit in any way the definition and/or meaning of the term "computer".

[0056] The computer or processor executes a set of instructions that are stored in one or more storage elements, in order to process input data. The storage elements may also store data or other information as desired or needed. The storage element may be in the form of an information source or a physical memory element within a processing machine.

[0057] The set of instructions may include various commands that instruct the computer or processor as a processing machine to perform specific operations such as the methods and processes of the various embodiments of the invention. The set of instructions may be in the form of a software program, which may form part of a tangible non-transitory computer readable medium or media. The software may be in various forms such as system software or application software. Further, the software may be in the form of a collection of separate programs or modules, a program module within a larger program or a portion of a program module. The software also may include modular programming in the form of object-oriented programming. The processing of input data by the processing machine may be in response to operator commands, or in response to results of previous processing, or in response to a request made by another processing machine.

[0058] As used herein, the terms "software" and "firmware" may include any computer program stored in memory for execution by a computer, including RAM memory, ROM memory, EPROM memory, EEPROM memory, and non-volatile RAM (NVRAM) memory. The above memory types are exemplary only, and are thus not limiting as to the types of memory usable for storage of a computer program.

[0059] It is to be understood that the above description is intended to be illustrative, and not restrictive. For example, the above-described embodiments (and/or aspects thereof) may be used in combination with each other. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the various embodiments without departing from their scope. While the dimensions and types of materials described herein are intended to define the parameters of the various embodiments, they are by no means limiting and are merely exemplary. Many other embodiments will be apparent to those of skill in the art upon reviewing the above description. The scope of the various embodiments should, therefore, be determined with reference to the appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein." Moreover, in the following claims, the terms "first," "second," and "third," etc. are used merely as labels, and are not intended to impose numerical requirements on their objects. Further, the limitations of the following claims are not written in means-plus-function format and are not intended to be interpreted based on 35 U.S.C. §112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function void of further structure.

[0060] This written description uses examples to disclose the various embodiments, including the best mode, and also to enable any person skilled in the art to practice the various embodiments, including making and using any devices or systems and performing any incorporated methods. The patentable scope of the various embodiments is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if the examples have structural elements that do not differ from the literal language of the claims, or the examples include equivalent structural elements with insubstantial differences from the literal languages of the claims.

What is claimed is:

1. A connector assembly for coupling an coaxial cable to an ultrasound probe, said connector assembly comprising:
- a cable clamp having an opening extending therethrough, the opening sized to receive a coaxial cable therethrough, the coaxial cable including a strain member and a plurality of coaxial cables extending therethrough; and
- a collet configured to couple to the cable clamp, the collet including an arbor that is configured to tension the strain member to a predetermined tension.

2. The connector assembly of claim **1**, wherein the collet is threadably coupled to the cable clamp.

3. The connector assembly of claim **1**, wherein the collet is coupled to the cable clamp using a clip assembly.

4. The connector assembly of claim **1**, wherein the cable clamp and the collect are fabricated from a plastic material.

5. The connector assembly of claim **1**, wherein the cable clamp comprises a ferrule that is configured to couple to a flexible relief device.

6. The connector assembly of claim **1**, wherein the collet includes an opening and a slot, a first end of the arbor configured to insert into the opening and a second end of the arbor configured to insert into the slot.

7. The connector assembly of claim **1**, wherein the arbor is rotatable with respect to the collet to tension the strain member to the predetermined tension.

8. The connector assembly of claim **1**, further comprising an adhesive to couple the strain member to the arbor.

9. The connector assembly of claim **1**, further comprising a locking device to secure the arbor at the predetermined tension.

10. The connector assembly of claim **1**, wherein the cable clamp comprises a slot formed therein, the slot being configured to receive a tab therein to couple the cable clamp to a flexible relief device.

11. The connector assembly of claim **1**, wherein the plurality of coaxial cables extend between the arbor and the cable clamp.

12. A method of fabricating a coaxial cable assembly, said method comprising:
- inserting a coaxial cable through a cable clamp, the coaxial cable including a strain member and a plurality of coaxial cables extending therethrough;
- inserting the coaxial cable through a collet, the collet including an arbor;
- coupling the collet to the cable clamp;
- coupling the strain member to the arbor; and
- rotating the arbor to tension the strain member to a predetermined tension.

13. The method of claim **12**, further comprising threadably coupling the cable clamp to the collet.

14. The method of claim **12**, further comprising coupling the cable clamp to the collet using a clip assembly.

15. The method of claim **12**, wherein the cable clamp and the collect are fabricated from a plastic material.

16. The method of claim **12**, wherein the cable clamp comprises a ferrule that is configured to couple to a flexible relief device.

17. The method of claim **12**, wherein the collet includes an opening and a slot, the method further comprising inserting a first end of the arbor into the opening and a second end of the arbor into the slot.

18. An ultrasound imaging system comprising:
- an ultrasound probe;
- a system cable coupled between the ultrasound probe and a host system; and
- a connector assembly for coupling the ultrasound probe to the system cable, the connector assembly including
  - a cable clamp having an opening extending therethrough, the opening sized to receive the system cable therethrough, the system cable including a strain member and a plurality of coaxial cables extending therethrough; and
  - a collet configured to couple to the cable clamp, the collet including an arbor that is configured to tension the strain member to a predetermined tension.

19. The ultrasound imaging system of claim **18**, wherein the cable clamp and the collect are fabricated from a plastic material.

20. The ultrasound imaging system of claim **18**, wherein the cable clamp comprises a ferrule that is configured to couple to a flexible relief device.

* * * * *

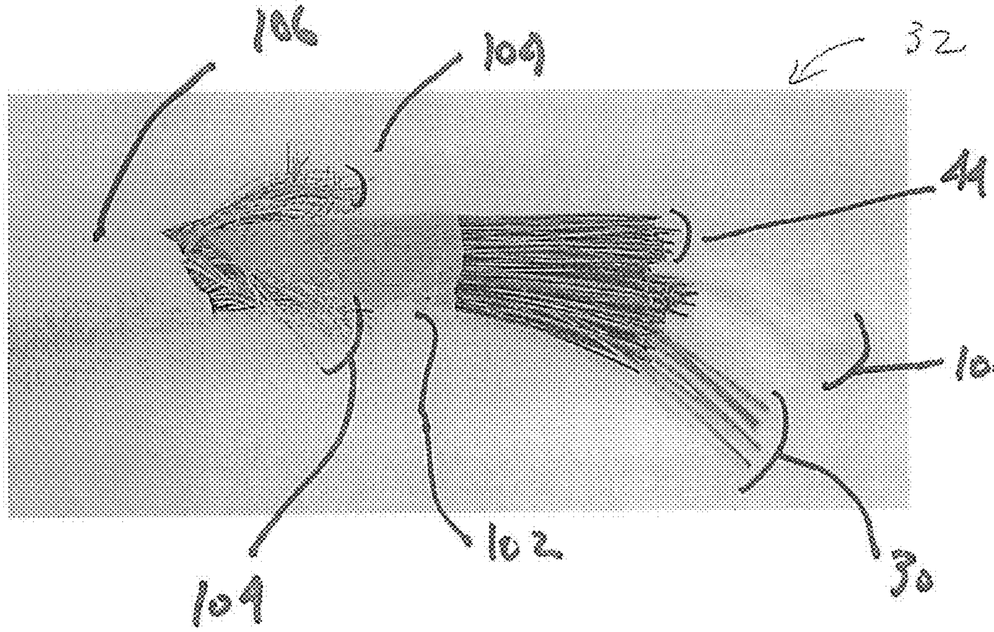


FIGURE 2

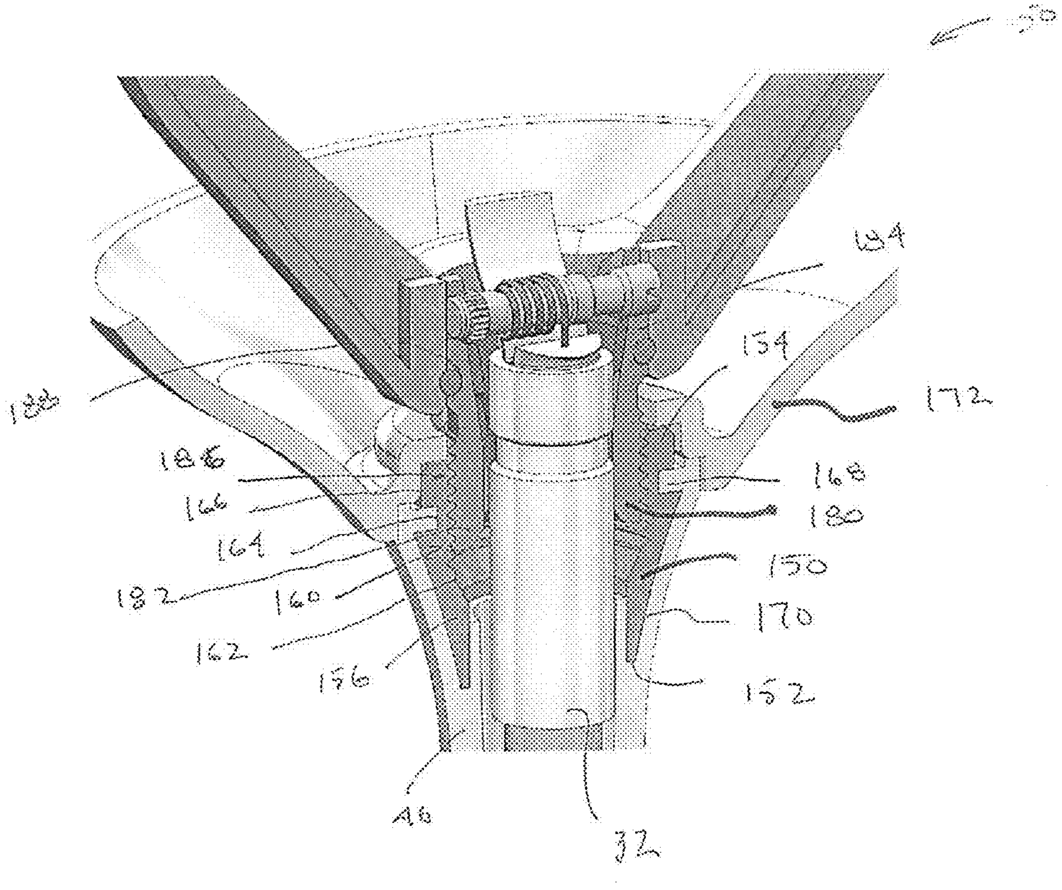

50
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FIGURE 3

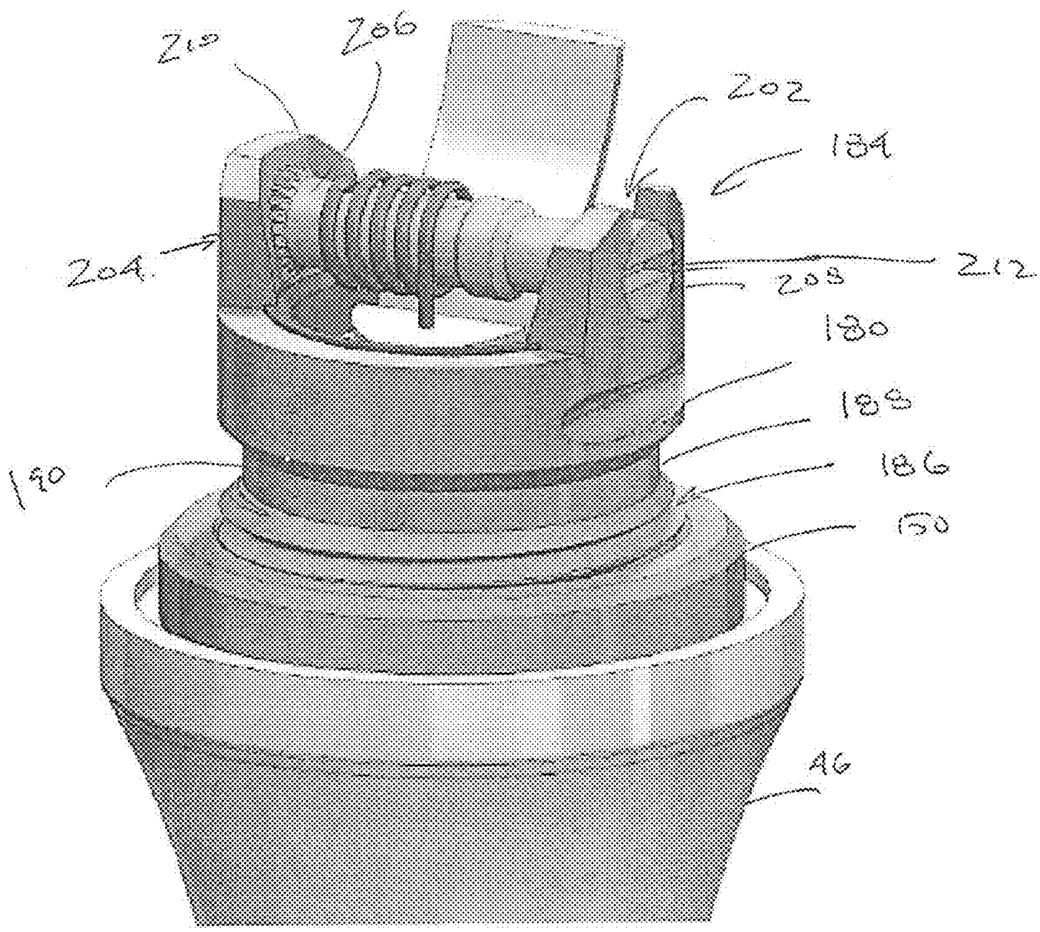
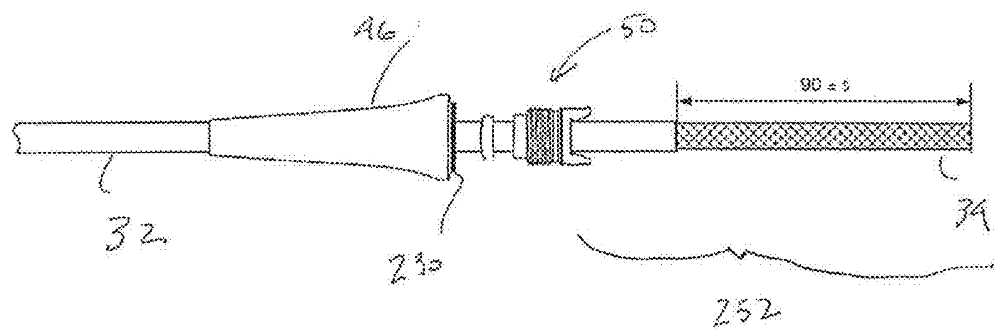


FIGURE 4



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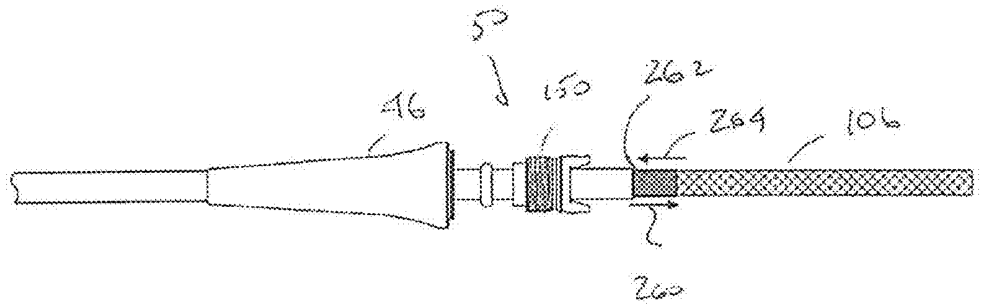

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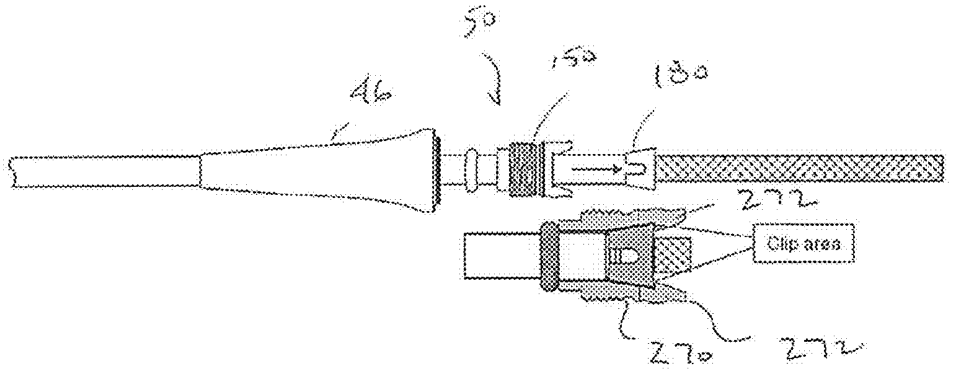

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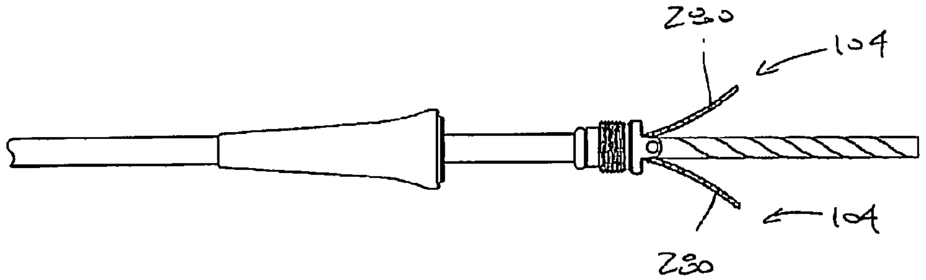


FIGURE 8

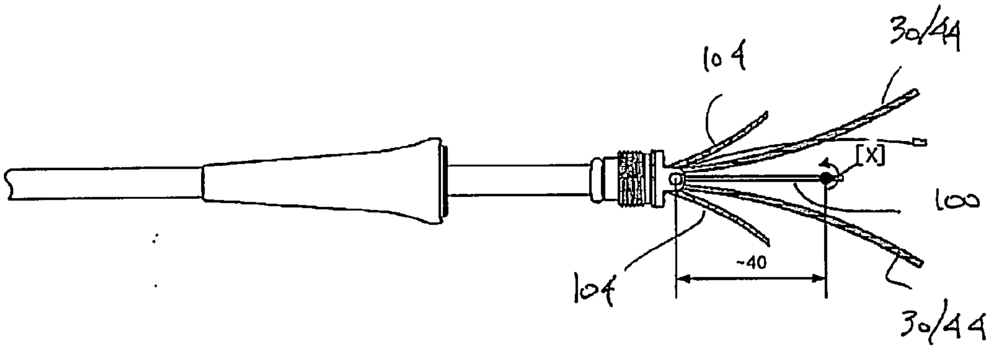


FIGURE 9

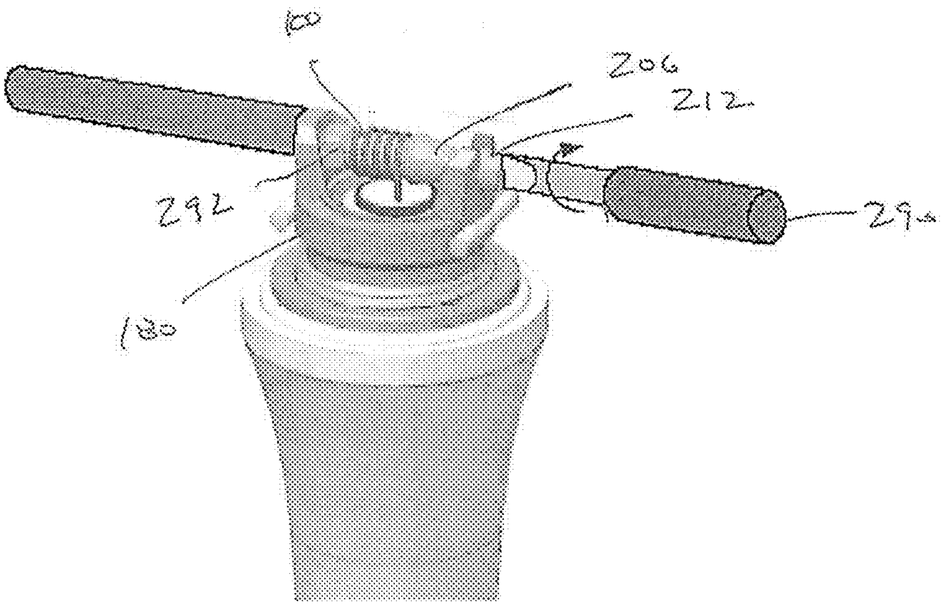
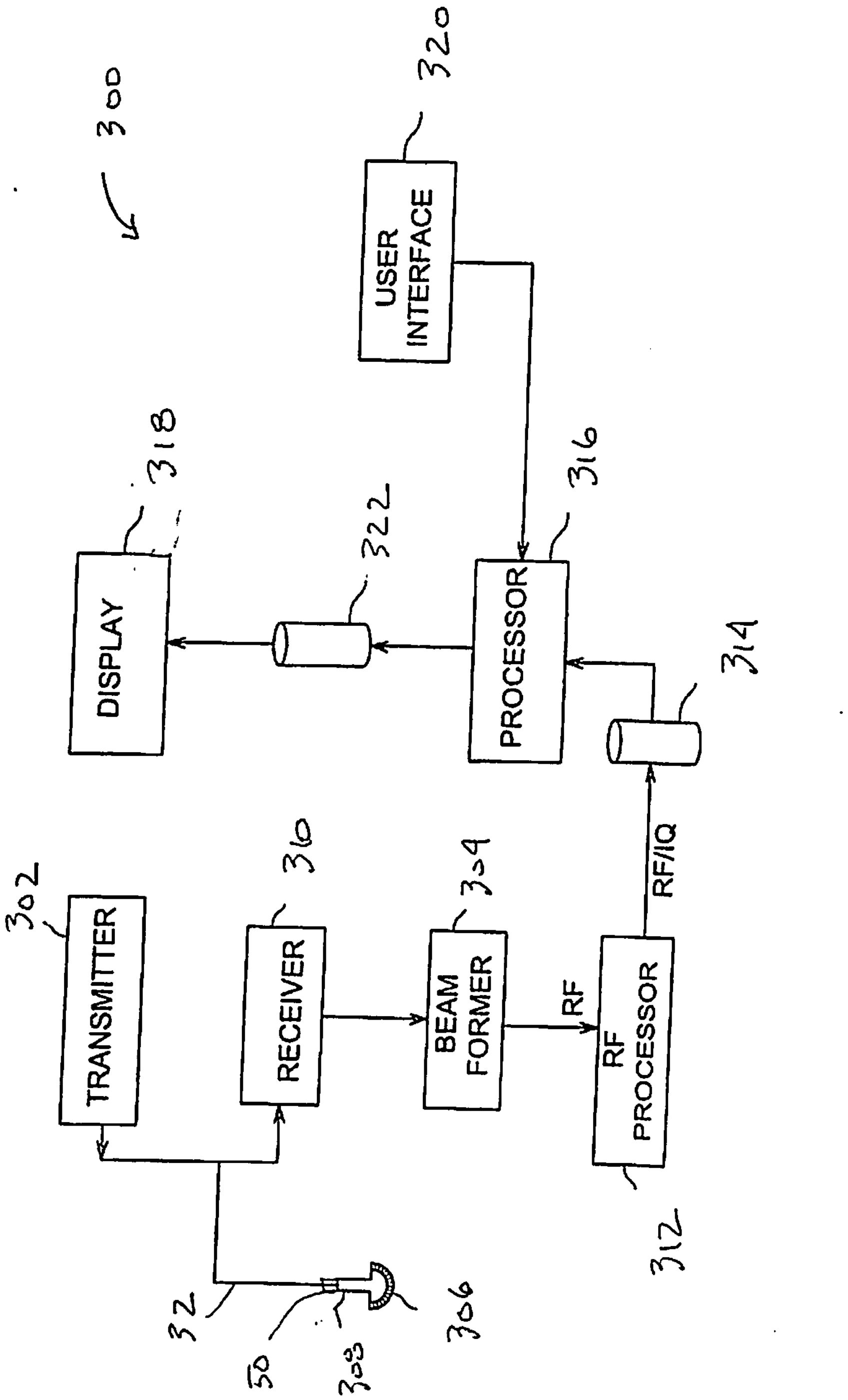


FIGURE 10


300
TRANSMITTER
302
RECEIVER
310
BEAM FORMER
304
RF
RF PROCESSOR
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RF/IQ
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PROCESSOR
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USER INTERFACE
320
322
DISPLAY
318
32
50
308
306

FIGURE 11

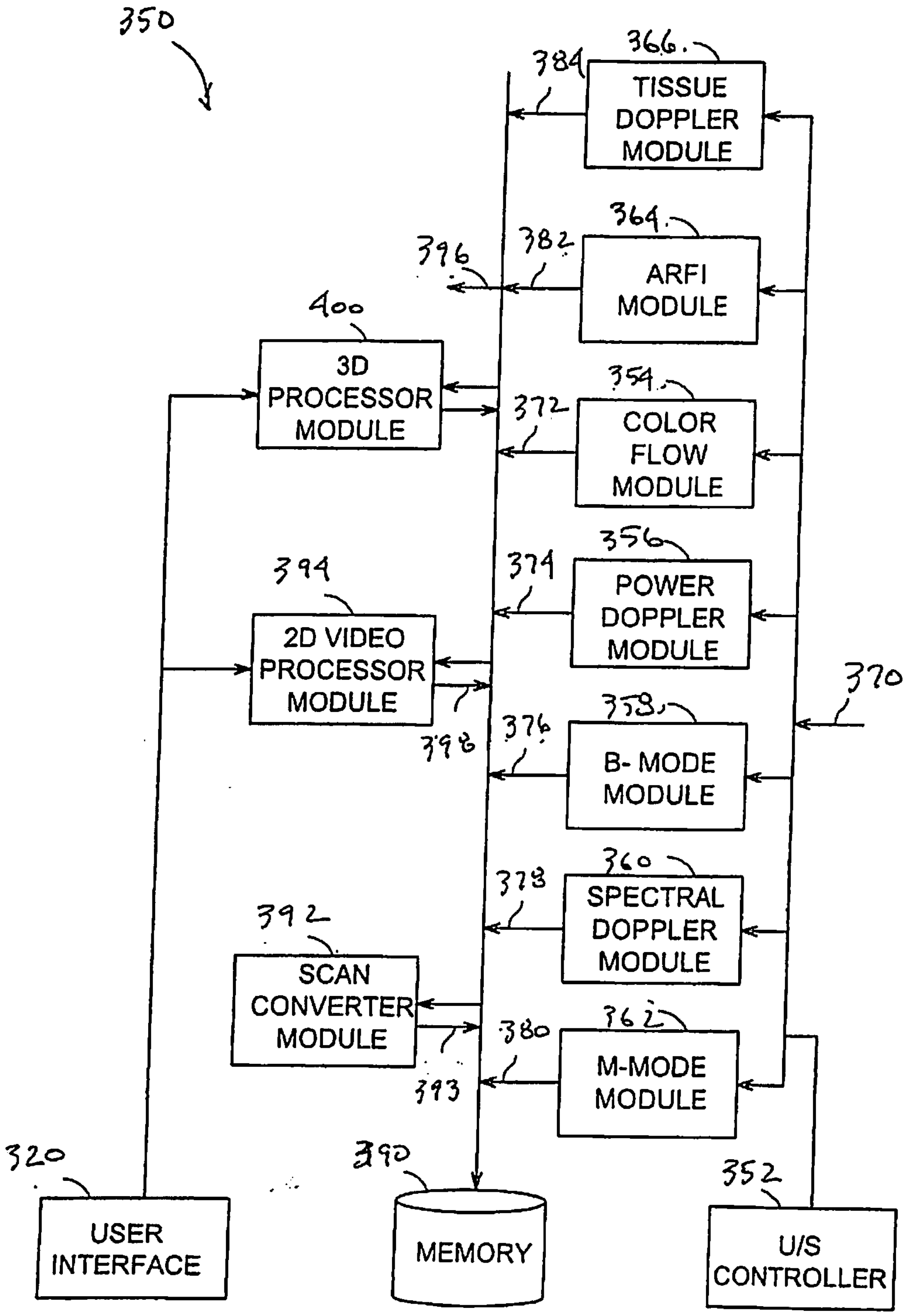
350
366
384
TISSUE DOPPLER MODULE
364
396
382
ARFI MODULE
400
3D PROCESSOR MODULE
354
372
COLOR FLOW MODULE
394
356
374
POWER DOPPLER MODULE
2D VIDEO PROCESSOR MODULE
370
358
398
376
B- MODE MODULE
360
378
392
SPECTRAL DOPPLER MODULE
SCAN CONVERTER MODULE
362
380
M-MODE MODULE
393
320
390
352
USER INTERFACE
MEMORY
U/S CONTROLLER

FIGURE 12

专利名称(译)	用于将超声探头连接到成像系统的方法和设备		
公开(公告)号	[US20130165794A1](US20130165794A1)	公开(公告)日	2013-06-27
申请号	US13/334294	申请日	2011-12-22
[标]申请(专利权)人(译)	KNOLL WOLFGANG BRUESTLE REINHOLD BIRGLEHNER ERICH 海因里希CHRISTIAN HOLL CHRISTIAN		
申请(专利权)人(译)	诺尔WOLFGANG BRUESTLE，REINHOLD BIRGLEHNER，ERICH 海因里希，CHRISTIAN HOLL，CHRISTIAN		
当前申请(专利权)人(译)	通用电气公司		
[标]发明人	KNOLL WOLFGANG BRUESTLE REINHOLD BIRGLEHNER ERICH HEINRICH CHRISTIAN HOLL CHRISTIAN		
发明人	KNOLL, WOLFGANG BRUESTLE, REINHOLD BIRGLEHNER, ERICH HEINRICH, CHRISTIAN HOLL, CHRISTIAN		
IPC分类号	A61B8/00 H01R13/58 H01R43/00		
CPC分类号	H01R13/567 H01R2201/12 H01R13/58 A61B8/4411 Y10T29/49174 A61B8/466 A61B8/5246 A61B8 /483 A61B8/4444		
其他公开文献	US8657620		
外部链接	Espacenet USPTO		

摘要(译)

一种用于将同轴电缆连接到超声探头的连接器组件，包括具有穿过其延伸的开口的电缆夹，该开口的尺寸适于接收穿过其中的同轴电缆，该同轴电缆包括应变构件和穿过其延伸的多个同轴电缆，以及夹头构造成连接到电缆夹，夹头包括心轴，该心轴构造成将应变构件张紧到预定的张力。本文还描述了制造连接器组件和超声成像系统的方法。