



EP 2 544 594 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
10.07.2013 Bulletin 2013/28

(51) Int.Cl.:
A61B 8/00 (2006.01) **G01N 29/24 (2006.01)**
A61B 8/08 (2006.01) **A61B 5/20 (2006.01)**

(21) Application number: **11753817.3**

(86) International application number:
PCT/US2011/026923

(22) Date of filing: **02.03.2011**

(87) International publication number:
WO 2011/112404 (15.09.2011 Gazette 2011/37)

(54) ULTRASOUND IMAGING PROBE AND METHOD

ULTRASCHALLBILDGEBUNGSSONDE UND VERFAHREN DAFÜR

SONDE ET PROCEDE D'IMAGERIE PAR ULTRASONS

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**

• **SHINE, David, Bartholomew**
Littleton
Colorado 80127 (US)

(30) Priority: **10.03.2010 US 312363 P**
17.11.2010 US 948622 P

(74) Representative: **Moore, Barry et al**
Hanna Moore & Curley
13 Lower Lad Lane
Dublin 2 (IE)

(43) Date of publication of application:
16.01.2013 Bulletin 2013/03

(56) References cited:
WO-A1-2008/146203 US-A- 5 699 805
US-A1- 2003 073 907 US-A1- 2007 167 813
US-A1- 2008 312 536 US-B1- 6 213 948
US-B1- 6 689 066

(73) Proprietor: **DBMedx Inc.**
Littleton, Colorado 80127 (US)

(72) Inventors:
• **BARNARD, William**
Maple Valley
Washington 98038 (US)

EP 2 544 594 B1

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

Description**BACKGROUND****Technical Field**

[0001] This disclosure generally relates to ultrasound probes, and more particularly to ultrasound probes having volume scanning capabilities and methods of using ultrasound probes for diagnostic purposes, such as, for example, determining bladder volume.

Description of the Related Art

[0002] Traditional three-dimensional (C-mode) ultrasound has been accomplished by sweeping a single scanline through target tissue with some combination of mechanical and electronic beam formation. For example, one method is to use a two-axis mechanical stepper motor configuration to move a single piston transducer. Other approaches have been to use electronic B-mode scanheads and add a single motor or a human operator to address the third dimension. Still another approach is to use a full up three dimensional electronically steered phased-array transducer.

[0003] Since ultrasound is a pulse-echo technology, the frame rate is limited by the transit time of the pulse-echo cycle. This constraint on frame rate can become overly restrictive as desired resolution increases and even more so when moving from two dimensional (B-mode) to three dimensional (C-mode) imaging. Reduced frame rates increase the likelihood of image blurring from operator movement, patient movement or patient anatomical movement, such as, for example, blood flow or respiration.

[0004] For certain diagnostic methods, such as, for example, bladder volume measurements, a single piston transducer swept through spherical coordinates with a multi-angular stepper motor has been used for years. While reasonably inexpensive to manufacture, this topology suffers from several deficiencies that compromise the accuracy of obtained data. For example, with respect to bladder volume measurements, the volumetric resolution of the system typically decreases in both angular directions with depth. Further, bladders that are closer to the patient's skin surface have a much smaller probability of fitting within the total scan solid angle of the system. This is because the bladder is anatomically located beneath the pubic bone where smaller scan cone angles of the system (which are typically less than 90 degrees) are unable to reach. Still further, the center of the cone has redundant scan lines which create processing inefficiencies and increase the maximum ultrasound exposed tissue which may decrease safety to some extent. Further, with systems that utilize a two-axis mechanical stepper topology, the result is one of the slowest frame rates available which increases image blurring and hence measurement accuracy. The combined effect of

these deficiencies is an increased reliance on operator training and proper aiming of ultrasound imaging devices.

[0005] US 2007167813 discloses a catheter tip that is adapted for mating attachment to a catheter body. In an embodiment, the catheter tip comprises a transducer array in electrical communication with an interconnect and in a mechanical driven relationship with an actuator, also in the catheter tip, via a drive shaft. The transducer array is encapsulated in a potting material body providing a desired ultrasound acoustical transmission. A defined annular space exists between an outer capsule of the catheter tip and the potting material body. Oscillating back and forth motion of the transducer array provides ultrasonic imaging functionality that may include real time three-dimensional imaging. Other embodiments of the catheter tip and methods of fabrication also are provided.

[0006] Consequently, Applicant believes improved diagnostic ultrasound imaging probes and methods are desirable. The ultrasound probes should be easier to aim and use to obtain accurate imaging results for diagnostic purposes. The ultrasound probes should also have a small, robust form factor or package.

BRIEF SUMMARY

[0007] The invention is set out in independent claims 1 and 9.

[0008] The diagnostic ultrasound imaging probes and methods described herein provide for the efficient and accurate collection of three dimensional data representative of a target biological sample in a particularly small, robust form factor. In various embodiments, the ultrasound imaging probes and methods are well adapted for automatically determining the volume of a human bladder irrespective of operator skill in aiming or manipulating the ultrasound probe.

[0009] At least one embodiment of an ultrasound probe adapted for efficiently and accurately obtaining three dimensional data of a target biological sample may be summarized as including a housing having a longitudinal axis; an ultrasound module received in the housing, the ultrasound module having a plurality of transducers longitudinally spaced apart within the housing and a control and processing system communicatively coupled to the transducers and operable to cause the transducers to emit ultrasound waves and to process ultrasound signals received via the transducers to collect ultrasonic data representative of a target biological tissue when the ultrasound probe is in operation; a motor received in the housing and drivingly coupled to rotate the ultrasound module about the longitudinal axis of the housing; and a coupling fluid received in the housing to at least partially surround the ultrasound module and the motor. The motor may be a DC motor driven to continuously rotate the ultrasound module about the longitudinal axis of the housing. The motor may be a stepper motor driven to sweep the ultrasound module back and forth about the longitudinal axis of the housing. The coupling fluid may

be a non-corrosive, bio-compatible fluid. The housing may be cylindrical. The housing may be an optically and acoustically transparent thermoplastic elastomer. A surface of the housing may include a curvilinear profile such that scan lines of the transducers are redirected when passing through the housing. The curvilinear profile of the surface of the housing may include a periodic sequence of generally symmetric profile segments, a pitch of the segments equal to a pitch of the transducers. The ultrasound module and motor may be hermetically sealed in a common chamber of the housing. The control and processing system may include a wireless communication device to transmit the ultrasonic data representative of the target biological tissue to a remote device. The control and processing system may include a sensor to measure at least one of a rotational position or a rotational speed of the ultrasonic module.

[0010] The ultrasound probe may further include a battery, the battery, a base of the motor and the ultrasound module rigidly coupled together to rotate or pivot about the longitudinal axis in unison. The motor may be a dual motion linear and rotary actuator, the dual motion linear and rotary actuator drivingly coupled to the housing to move the ultrasound module relative to the housing linearly along the longitudinal axis and rotationally about the longitudinal axis, either simultaneously or independently. The battery, the base of the motor and the ultrasound module may rotate and translate in unison within a common chamber of the housing filled with coupling fluid.

[0011] The ultrasound probe may further include a slip ring coupled to the motor to provide power to the control and processing system of the ultrasound module as the ultrasound module rotates about the longitudinal axis of the housing.

[0012] The ultrasound probe may further include a number of flexible electrical conductors electrically coupled to the motor to transmit power to the control and processing system of the ultrasound module as the ultrasound module sweeps back and forth about the longitudinal axis of the housing, the flexible electrical conductors winding and unwinding about the longitudinal axis as the ultrasound module sweeps back and forth.

[0013] The ultrasound probe may further include a plurality of LEDs communicatively coupled to the control and processing system to controllably illuminate as the ultrasound module rotates about the longitudinal axis to visually communicate information to a user through the housing.

[0014] The ultrasound probe may further include a support structure, the transducers pivotably coupled to the support structure to tilt in parallel about a respective tilt axis perpendicular to the longitudinal axis of the housing. The ultrasound probe may further include a shaft received in the support structure and coupled to the transducers to tilt the transducers about a respective tilt axis perpendicular to the longitudinal axis of the housing as the shaft is translated along the longitudinal axis of the

housing.

[0015] The ultrasound probe may further include a screw-type shaft coupled to the electric motor to simultaneously rotate and translate the ultrasound module about and along the longitudinal axis, respectively.

[0016] An ultrasound probe may be summarized as including a housing having a longitudinal axis; an ultrasound module, the ultrasound module having a plurality of transducers longitudinally spaced apart within the housing and a control and processing system communicatively coupled to the transducers and operable to cause the transducers to emit ultrasound waves and to process ultrasound signals received via the transducers to collect ultrasonic data representative of a target biological tissue when the ultrasound probe is in operation; a battery to power the ultrasound module; and a motor having a base and a drive shaft, the drive shaft of the motor drivingly coupled to the housing, either directly or indirectly, to rotate the ultrasound module, the battery and the base of the motor in unison about the longitudinal axis of the housing. The motor may be a dual motion linear and rotary actuator, the dual motion linear and rotary actuator drivingly coupled to the housing to move the ultrasound module relative to the housing linearly along the longitudinal axis and rotationally about the longitudinal axis, either simultaneously or independently.

[0017] A method of obtaining ultrasonic data representative of a target biological tissue, such as a bladder, for diagnostic purposes, may be summarized as including rotating an ultrasound module contained in a housing about a longitudinal axis, the ultrasound module including a plurality of transducers longitudinally spaced apart within the housing and a control and processing system electrically coupled to the transducers, the transducers and the control and processing system of the ultrasound module sealed in a common fluid chamber; firing the ultrasound transducers to emit ultrasound waves while the ultrasound module rotates about the longitudinal axis; and receiving the ultrasonic data representative of the target biological tissue. Receiving the ultrasonic data representative of the target biological tissue may include receiving information indicative of a volume of a bladder.

Rotating the ultrasound module contained in the housing about the longitudinal axis of the housing may include continuously rotating the ultrasound module around the longitudinal axis. Rotating the ultrasound module contained in the housing about the longitudinal axis of the housing may include pivoting the ultrasound module back and forth about the longitudinal axis in opposite rotational directions.

Rotating the ultrasound module contained in the housing about the longitudinal axis may include moving the ultrasound module, a battery and a base of a motor in unison about the longitudinal axis. Rotating the ultrasound module contained in the housing about the longitudinal axis may include rotating and translating the ultrasound module axially about and along the longitudinal axis, respectively. Rotating and translating the ultrasound module axially about and along the longitudinal

axis may include translating the ultrasound module along the longitudinal axis beneath a curvilinear profile of the housing.

[0018] The method may further include wirelessly transmitting the ultrasonic data representative of the target biological tissue to a device remote from the ultrasound module. 5

[0019] The method may further include selectively illuminating a plurality of LEDs electrically coupled to the ultrasound module as the ultrasound module moves about the longitudinal axis to visually communicate information to a user through the housing. 10

[0020] The method may further include sensing a rotational position of the ultrasound module; and coordinating a collection of ultrasonic data from the transducers with the position of the ultrasound module. 15

[0021] The method may further include tilting the transducers about a respective tilt axis perpendicular to the longitudinal axis of the housing.

[0022] The method may further include simultaneously translating the ultrasound module along the longitudinal axis of the housing as the ultrasound module rotates.

[0023] The method may further include prior to rotating the ultrasound module, independently translating the ultrasound module along the longitudinal axis of the housing. 20

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0024] In the drawings, identical reference numbers identify similar elements or acts. The sizes and relative positions of elements in the drawings are not necessarily drawn to scale. For example, the shapes of various elements and angles may not be drawn to scale, and some of these elements may be arbitrarily enlarged and positioned to improve drawing legibility.

Figure 1 is an isometric view of an ultrasound probe according to one embodiment.

Figure 2 is a side elevation view of the ultrasound probe of Figure 1.

Figure 3 is an isometric view of the ultrasound probe of Figure 1 illustrating scan planes.

Figure 4 is a side elevation view of the ultrasound probe of Figure 1 illustrating a scan plane sweeping through a target sample.

Figure 5 is a block diagram illustrating an example ultrasound module rotatably coupled to a motor and powered by a battery.

Figure 6 is a front elevation view of a housing and internal components of the ultrasound probe of Figure 1.

Figure 7 is a side elevation view of the housing and internal components of Figure 6.

Figure 8 is a bottom plan view of the housing and internal components of Figure 6.

Figure 9 is a bottom plan view of a housing and in-

ternal components according to another embodiment.

Figure 10 is a bottom plan view of a housing and internal components according to yet another embodiment.

Figure 11 A is a front elevation view of a housing and internal components of an ultrasound probe in a first position, according to another embodiment.

Figure 11 B is a front elevation view of the housing and internal components of the ultrasound probe of Figure 11 A in a second position.

Figure 12 is a partial isometric view of an ultrasound module according to another embodiment.

Figure 13 is a partial front elevation view of the ultrasound module of Figure 12.

Figure 14 is a partial isometric view of an ultrasound module and motors according to yet another embodiment.

DETAILED DESCRIPTION

[0025] In the following description, certain specific details are set forth in order to provide a thorough understanding of various disclosed embodiments. However, one skilled in the relevant art will recognize that embodiments may be practiced without one or more of these specific details. In other instances, well-known structures, manufacturing techniques and diagnostic methods associated with ultrasound probes may not be shown or described in detail to avoid unnecessarily obscuring descriptions of the embodiments.

[0026] Unless the context requires otherwise, throughout the specification and claims which follow, the word "comprise" and variations thereof, such as, "comprises" and "comprising" are to be construed in an open, inclusive sense, that is as "including, but not limited to."

[0027] Reference throughout this specification to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0028] As used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless the content clearly dictates otherwise. It should also be noted that the term "or" is generally employed in its sense including "and/or" unless the content clearly dictates otherwise.

[0029] Figures 1 through 4 show an ultrasound imaging probe 10 according one embodiment. The ultrasound imaging probe 10 includes a main housing 12 coupled to a base or grip 14 for positioning the housing 12 proximate a target sample. Alternatively, the housing 12 may not be coupled to a base or grip 14. The housing 12 can be

positioned proximate a target sample directly. Positioning devices, such as, for example, fixtures, belts, straps or the like, may also be provided in certain diagnostic applications to assist in locating the probe 10 relative to a target sample.

[0030] The ultrasound imaging probe 10 enables a user to quickly and accurately obtain three dimensional data representative of a target sample with minimal skill required in aiming and manipulating the probe 10. The user need only place the probe 10 proximate the target sample and activate the probe 10 to automatically collect data representative of the target sample. The probe 10 may be activated by a switch (not shown), such as a push button switch, on an end or side of the housing 12. As another example, the switch may be a wireless switch, such as, for example, a hall effect switch, so as to allow activation of the ultrasound probe without the need for electrical connections or components of the switch to penetrate an inner chamber of the housing 12.

[0031] According to the illustrated embodiment of Figure 1, the housing 12 of the probe 10 contains an ultrasound module 16 including a plurality of transducers 18, a motor 20 and a power source in the form of a battery 22. The motor 20 is mechanically and electrically coupled to the ultrasound module 16 to rotate or oscillate the ultrasound module 16 about a longitudinal axis 24 of the housing 12 in the direction indicated by the arrow labeled 26, for example. This can be accomplished, for example, by the motor 20 rotating or pivoting a drive shaft 21 thereof that is fixedly coupled to the housing 20 either directly or indirectly. The motor 20 may be a DC motor controllable to rotate the ultrasound module 16 continuously about the longitudinal axis 24 when in a data collection mode. In such embodiments, since the transducers 18 are swept a full, continuous 360 degree rotation, the B-mode images are maximally wide, thus relieving the need for skilled aiming of the probe 10. In other embodiments, the motor 20 may be a stepper motor controllable to sweep the ultrasound module 16 back and forth (*i.e.*, oscillate) about the longitudinal axis 24. Embodiments featuring a back and forth oscillating or pivoting motion may achieve suitable speed and field of view, but may not be as fast or provide as much field of view as embodiments that rotate the ultrasound module 16. Irrespective of rotational capabilities, the ultrasound module 16, motor 20 and battery 22 are contained within a common internal chamber 28 of the housing 12 and surrounded with an ultrasound coupling fluid 30. The coupling fluid 30 is preferably a non-corrosive, bio-compatible fluid, such as, for example, mineral oil.

[0032] The housing 12 may be cylindrical or some other suitable shape. The cylindrical shape presents a consistent ultrasound path with some inherent advantageous focusing. In addition, the cylindrical shape is easy to manufacture, is mechanically robust and provides a convenient vessel in which to seal in the coupling fluid 30. The cylindrical shape may also limit the number of edges, which might otherwise present a source of dis-

comfort or even injury to a patient or medical care provider. The housing 12 is made of a material that is acoustically transparent and in some embodiments optically transparent or translucent. For example, the housing 12 may be an acoustically and optically transparent thermoplastic elastomer, such as, for example, a material available from Arkema Inc. under the name PEBAK®. Alternatively, the housing 12 may be acrylic or another plastic material.

[0033] Figure 2 shows an end view of the ultrasound probe 10 and illustrates sequential A-mode scan lines 32 radiating from the transducers 18. These A-mode scan lines 32 are combined to form B-mode images as the transducers 18 rotate as represented by the scan planes

[0034] Although the illustrated embodiment shows five transducers (*i.e.*, ultrasound transducers) 18 of generally rectangular shape, it is appreciated that more or fewer transducers 18 may be provided and that the transducers 18 may vary in shape and size. In addition, the transducers 18 may be spaced regularly or irregularly along a length of the ultrasound module 16. Still further, the transducers 18 may vary in frequency and focusing capability.

[0035] For example, the ultrasound module 16 may include eight 3.7 Mhz transducers 18 equally spaced along a length of the ultrasound module 16, for instance, at about 10 mm apart, to form eight parallel B-mode slices that combine to create a C-mode image that ensonifies a sector volume. The transducers 18 may have a rectangular profile of about 11 mm x 8mm which provide excellent 25λ (3.7 MHz) focusing in a phi axis of rotation and reasonable 18λ (3.7 Mhz) focusing in the z axis between scan planes. Slightly less focusing may be designed into the z axis since the least amount of spatial resolution exists between scan planes. It is noted that a 3.7 Mhz

[0036] Advantageously, in various embodiments the sweep of the B-mode image generated by a corresponding transducer 18 can be varied by gating the number of A-mode scan lines that are collected. For example, in

[0037] embodiments featuring continuous rotation of the ultrasound module 16, the transducers 18 of the ultrasound module 16 may be activated throughout 360 degrees of rotation, or over a portion of the same, to collect three dimensional data over varying ranges. In an example, the transducers 18 are active over about 180 degrees of rotation to create a hemicylindrical scan volume, as illustrated in Figures 3 and 4. Similarly, when oscillated or swept back and forth, the transducers 18 may be swept

through various angle ranges, such as, for example, 120, 150, and 180 degrees or more.

[0037] Figure 5 shows an ultrasound module 16 which is rotated within the housing 12 of the ultrasound probe 10 by a motor 20 and powered by a battery 22 according to one illustrated embodiment. In particular, the illustrated example of Figure 5 includes a control and processing system 50 with various electrical components that enable functionality of the ultrasound probe 10. For example, one or more application specific integrated circuits (ASICs) programmable gate or arrays (PGAs) 52 may be coupled to a microprocessor 54 for controlling and coordinating the various functions of the ultrasound probe 10, including rotation of the ultrasound module 16 and transmitting and receiving of high frequency sound waves from each of the transducers 18. The control and processing system 50 may include discrete analog to digital converters (ADCs) and/or discrete digital to analog converters (DACs). Alternatively, the ADC and/or DAC functions may be implemented in the ASIC or PGA. The control and processing system 50 may further include power supply circuitry, for example an inverter, rectifier, step up or step down converter, transformer, etc. The control and processing system 50 may further include transmit and timing control circuitry to control waveform timing, aperture and focusing of the ultrasound pressure waves.

[0038] The control and processing system 50 further includes a storage device 56 (e.g., serial flash), a rotational position sensor 58 (e.g., hall-effect sensor, optical encoder) and a wireless communication device 60 (e.g., Bluetooth radio module or other suitable short-range wireless device). The storage device 56 enables temporary storage of data, control signals, instructions and the like. The position sensor 58 enables the control and processing system 50 to coordinate the transmitting and receiving of high frequency sound waves from each of the transducers 18 with the rotational position of the ultrasound module 16. The wireless communication device 60 enables data output from the ultrasound module 16 to remote devices for further processing or evaluation, such as, for example, a remote evaluation device 62 (Figure 4) having components such as a monitor or other display devices, a keyboard, a printer and/or other input and output devices. In this manner, diagnostic data may be collected with the probe 10 in a particularly small form factor of package, such that the user may obtain such data with minimal bother or inconvenience to the host of the target sample and without interference from otherwise bulky components or cables. Of course, in some embodiments an extensive user interface, including for example a display, keypad, printer and/or other input and output devices may be integrated with the probe 10 for further evaluation or processing onboard.

[0039] By containing the entire analog and digital processing circuitry of the control and processing system 50 in a small form factor which can be spun by the motor 20, the number of electrical connections which are main-

tained across a static/dynamic (rotational or oscillating) interface can be minimized or even eliminated. For example, the motor 20, the power source (e.g., battery 22) and the ultrasound module 16 (including the control and processing system 50) may be rigidly coupled together to rotate or pivot about the longitudinal axis 24 in unison. Also for example, the motor 20 may be a dual motion linear and rotary actuator drivingly coupled to the housing 12 to move the ultrasound module 16 (and hence control and processing system 50) relative to the housing 12 both linearly along the longitudinal axis 24 and rotationally about the longitudinal axis 24, either simultaneously or independently. In this manner, the battery 22, motor 20 and ultrasound module 16 may rotate and/or translate in unison within a common chamber 28 of the housing 12 such that all electrical connections for enabling the functionality of the probe 10 remain static relative to each other.

Alternatively, the motor 20 and battery 22 may remain fixed relative to the housing 12 and drivingly rotate and/or translate the ultrasound module 16. In such embodiments, particularly those featuring continuous rotation of the ultrasound module 16, a slip ring or similar device may be coupled to the motor 20 to transmit electrical power to the control and processing system 50 of the ultrasound module 16 as the ultrasound module 16 rotates about the longitudinal axis 24 of the housing 12. In those embodiments featuring an oscillating, pivoting or back and forth sweeping motion of the ultrasound module 16, a slip ring or similar device may likewise be provided. In some instances, the number of slip ring connections may be reduced to only power and ground such that the entire ultrasound module 16 is relatively immune from conducted noise sources. Since only power and ground are provided, the slip ring does not need to be exceptionally electrically quiet and even a ball bearing race can be sufficient to transmit power as well as provide a nice stable mechanism for rotatably supported the ultrasound module 16. In these embodiments, the electrical connections between the power source (e.g., battery 22), motor 20 and ultrasound module 16 may be through wires, wiping blades, ball-bearing connections, concentric sleeves or other direct connections. Alternatively, power may be provided to the ultrasound module 16 inductively, thereby eliminating all direct electrical connections at the static/dynamic (i.e., rotational or oscillating) interface that may be present between the motor 20 and ultrasound module 16.

[0040] In some embodiments in which the motor 20 and power source 22 do not rotate with the ultrasound module 16, wires or a flex circuit may be directly connected to the control and processing system 50 to wind and unwind about the rotational axis as the ultrasound module 16 and hence control and processing system 50 rotate relative to the other components. In these embodiments in particular, the housing 12 may include a data transfer port, such as a USB port, in addition to or in lieu of the wireless communication device 60. However, pro-

viding such a port is mechanically more complicated and increases susceptibility of the ultrasound probe 10 to static interference and conducted noise interference from the additional connections.

[0041] The control and processing system 50 may further include or be communicatively coupled to an LED bank 70 to create a display viewable to a user through a surface of the housing 12. For example, an LED bank 70 in the form of a linear arrangement of individual LEDs may be provided to rotate with the ultrasound module 16 to create a multi-character display that is visible as the LEDs rotate. In this arrangement, two dimensional characters can be formed via the LEDs by controllably illuminating the LEDs to create a transverse dimension of the characters as the module 16 rotates or pivots. In other words, the control and processing system 50 controls which LEDs are lit as the LED bank 70 rotates such that a given character or series of characters are projected in a readable form. In this manner, error codes, instructional codes, diagnostic test results or other information may be communicated to a user before, during or after use of the ultrasound probe 10. The control and processing system 50 may automatically evaluate collected ultrasonic data and generate diagnostic information, such as, for example, the volume of the target biological sample. This diagnostic information may be displayed directly to a user through the housing 12. In some embodiments, a larger array of LEDs or other display devices may be coupled to the rotating module 16. Alternatively, a display (e.g., LCD, LED, OLED) may be integrated into the static housing 12, although additional electrical connections would then be required through the static/dynamic interface.

[0042] As depicted in Figures 6 through 8, the various components described above may be received within a common chamber 28 of the housing 12 of the ultrasound probe 10 that is filled with a coupling fluid 30. The coupling fluid 30 advantageously provides lubrication to moving components, a heat sink for electronic components and also ultrasonic coupling between the transducers 18, housing 12 and ultimately the target biological sample 40. As previously described, the coupling fluid 30 may be mineral oil or an equivalent non-corrosive, bio-compatible, ultrasonic coupling fluid.

[0043] With continued reference to Figures 6 through 8, the ultrasound module 16 is shown longitudinally adjacent the motor 20 and battery 22. As previously described, the battery 22 supplies power to the motor 20 to rotate the entire ultrasound module 16, battery 22 and motor 20 combination about the longitudinal axis of rotation 24 during operation, according to the illustrated embodiment. The ultrasound module 16 includes longitudinally spaced transducers 18 electrically and mechanically coupled to the control and processing system 50. The control and processing system 50 enables collection and subsequent transmission of ultrasonic data indicative of a three dimensional representation of a target sample within the confines of the rotating ultrasound module

16 itself.

[0044] The ultrasound module 16 may be attached to a frame 71 which in turn supports the various electrical components of the control and processing system 50, including one or more integrated circuit boards thereof. The frame 71 may be rotatably supported by bearings or guides 72 to maintain the ultrasound module 16 centered within the housing 12 throughout rotational or pivotal movement of the ultrasound module 16. The frame 71 may also support or be rigidly coupled to the battery 22, and a base of the motor 22 such that the ultrasound module 16, battery 22 and motor 20 rotate or pivot in unison during operation. In this manner, as previously described, all functional components and electrical connections between these components remain static relative to each other. Consequently, no electrical connections are required to be maintained across a static/dynamic interface. This is particularly advantageous in that the integrity of the chamber 28 containing the components can remain intact. In addition, mechanisms for transmitting electrical signals or power across a static/dynamic interface can be eliminated. Details of the frame 71 and connections to specific components have not been shown or described in detail to avoid unnecessarily obscuring descriptions of the embodiments.

[0045] Alternatively, a base of the motor 20 and the battery 22 may be held static with respect to the housing 12 to drivingly rotate or pivot the ultrasound module 16 with respect thereto. In such embodiments, the ultrasound module 16 may be coupled to the motor 20 via a slip ring or similar connection such that the battery 22 is able to supply power to the control and processing system 50 via the static/dynamic interface of the motor 20 and ultrasound module 16. In one embodiment, electrical connections maintained through the dynamic interface of the motor 20 and ultrasound module 16 are limited to power and ground. In this manner, the entire ultrasound module 16 is relatively immune from conducted noise sources.

[0046] Although the transducers 18 may be located on the ultrasound module 16 in a common plane, it is appreciated that the orientation and placement of the transducers 18 within the housing 12 may vary. For example, as illustrated in Figure 9, the transducers 18 may be arranged on a convex surface and splayed outwardly to adjust the scanning profile of the ultrasound probe 10. In addition, as illustrated in Figure 10, it is appreciated that a profile of the housing 12 may be varied to redirect, steer and/or focus the scanning profile of the ultrasound probe 10. Alternatively, the transducers 18 may be focused or steered electronically without modifications to the profile of the housing 12.

[0047] Figures 11A and 11B illustrate an ultrasound probe 10 which advantageously enables both lateral and rotational movement of the ultrasound module 16 relative to the housing 12 in a particularly small form factor or package. The transducers 18, control and processing system 50, battery 22 and motor 20 are rigidly coupled

together to move in unison during operation via a frame 71 or similar structure. The motor 20 may be a dual motion linear and rotary actuator, the dual motion linear and rotary actuator drivingly coupled to the transducers 18 and other components to move the transducers 18 relative to the housing 12 via a drive shaft 21. The motor 20 may drive the transducers 18 linearly along the longitudinal axis and rotationally about the longitudinal axis, either simultaneously or independently. Consequently, the transducers 18 may advantageously collect additional three dimensional data in an efficient manner. Alternatively, a secondary motor (not shown) may be provided to control translational movement, while the primary motor controls rotational or pivotal movement. The motors may be sequenced or linked to operate simultaneously or the motors may operate independently.

[0048] The profile of the housing 12 may be varied to include a curvilinear profile to further enhance the scanning profile of the transducers 18. For example, an interior surface 74 of the housing 12 may include regularly spaced undulations with a pitch corresponding to a pitch of the transducers 18. The profile of the undulations can be shaped for example to redirect scan lines from each of the transducers 18 as they radiate from the housing 12. For example, a central profile of the undulations may be shaped such that a direction of the scan lines is substantially unaffected when the transducers 18 are aligned therewith, while opposing side portions of the undulations may direct the scan lines to varying degrees, such as, for example, up to 45 degrees or more from an axis perpendicular to the longitudinal axis 24. As such, the housing 12 may effectively tilt or sweep the scan lines radiating from the transducers 18 fore and aft as the transducers 18 translate along the longitudinal axis 24, as indicated by the arrows labeled 76. In this manner, the probe 10 is able to advantageously collect three dimensional data of a target biological sample in a particularly efficient and consistent manner. For example, in one embodiment, the probe 10 is able to collect sufficient three dimensional data of a target bladder to calculate a volume of the same with acceptable accuracy via a low duty cycle scanning sequence that may last, for example, in the range of about 5 seconds. This capability allows the probe 10 to make repeated measurements on a single charge of the battery 22. It also allows a user to obtain diagnostic information with minimal bother or inconvenience to the host of the target sample. The battery 22 and hence probe 10 can be recharged inductively by placing the probe 10 in a base charger (not shown) for subsequent and repeated use.

[0049] Additionally, although the transducers 18 may be rigidly attached to the ultrasound module 16, it is appreciated that in some embodiments the transducers 18 may be movably coupled to the ultrasound module 16. For example, as illustrated in Figures 12 and 13, an embodiment of an ultrasound module 80 may include transducers 82 operable to tilt fore and aft while the ultrasound module 80 rotates about a longitudinal axis 84 as indi-

cated by the arrow labeled 86. According to the illustrated embodiment, the ultrasound module 80 may include transducers 82 that are each pivotably coupled to a cylindrical support structure 88 about a respective tilt axis 89 oriented perpendicular to the longitudinal axis 84 of the ultrasound module 16 and pivotably coupled to a shaft 90 received in the support structure 88. In this manner, the transducers 82 are operable to tilt in parallel toward and away from longitudinal ends of the ultrasound module 80 by pivoting or oscillating about the respective tilt axes 89 as the shaft 90 translates back and forth in the direction indicated by the arrow labeled 92. As such, the transducers 82 may be held in one position while a data set is collected and then tilted slightly in parallel with each other while another data set is collected. This process can be repeated multiple times with the transducers 82 tilted to varying degrees to create a complete high resolution three dimensional data set. In some embodiments, the shaft 90 may be translated and hence transducers 82 tilted independent of the rotational motion of the ultrasound module 80. In other embodiments, the shaft 90 may be coupled or linked to the rotation of the ultrasound module 80 such that the shaft is automatically advanced back and forth in a coordinated manner, such as, for example, after each revolution.

[0050] As another example, transducers 100 may be coupled to a frame or sheath 102 having internal screw-like features that engage a corresponding screw-like rotational shaft 104, as illustrated in Figure 14. As the shaft 104 rotates in a first direction, the frame or sheath 102 translates the transducers 100 forward. As the shaft 104 rotates in the opposite direction, the frame or sheath 102 draws the transducers 100 back, as indicated by the arrows labeled 106. In such an embodiment, one motor 108 may be used to drive the screw-like shaft 104 to advance and retreat the transducers longitudinally while another motor 110 moves the transducers 100 rotationally. Alternatively, a single motor may be configured or drivingly coupled to perform both rotation and translation of the transducers 100. Wires or a flexible circuit can be attached to electrical components maintained on the frame or sheath 102 to wind and unwind about the rotational shaft 106 as needed; however, in embodiments wherein all functional electrical components rotate or pivot in unison the need for moving wires or a flexible circuit is advantageously eliminated.

[0051] Although embodiments of the diagnostic ultrasound imaging probes and methods disclosed herein have been described in connection with ultrasound diagnostic equipment and methods for imaging target biological samples, including bladders in particular, and for determining the volume of the same, it will be apparent to those skilled in the art that these systems, methods and aspects of the same may be applied to other diagnostic imaging applications. Further, it is appreciated that embodiments of the diagnostic ultrasound imaging probes may be designed to be serviceable, such as to enable replacement of the battery or other internal components.

A removable housing end cap (not shown) with appropriate seals may be provided for this purpose. Alternatively, the functional components of the probe (*i.e.*, the ultrasound module, motor and power source) may be hermetically and permanently sealed in the housing for disposable use applications.

[0052] Moreover, aspects of the various embodiments described above can be combined to provide further embodiments. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.

[0053] These and other changes can be made to the embodiments in light of the above-detailed description.

Claims

1. An ultrasound probe (10) comprising:

a housing (12) having a longitudinal axis; an ultrasound module (16) received in the housing (12), the ultrasound module (16) having a plurality of transducers (18) longitudinally spaced apart within the housing (12) and a control and processing system (50) communicatively coupled to the transducers (18) and operable to cause the transducers (18) to emit ultrasound waves and to process ultrasound signals received via the transducers (18) to collect ultrasonic data representative of a target biological tissue when the ultrasound probe is in operation; a motor (20) received in the housing (12) and drivingly coupled to rotate the ultrasound module (16) about the longitudinal axis of the housing (12); and a coupling fluid (30) received in the housing (12) to at least partially surround the ultrasound module (16) and the motor (20).

2. The ultrasound probe (10) of claim 1, further comprising:

a battery (22), the battery (22), a base of the motor (20) and the ultrasound module (16) rigidly coupled together to rotate about the longitudinal axis in unison.

3. The ultrasound probe (10) of claim 2 wherein the motor (20) is a dual motion linear and rotary actuator, the dual motion linear and rotary actuator drivingly coupled to the housing (12) to move the ultrasound module (16) relative to the housing (12) linearly along the longitudinal axis and rotationally about the longitudinal axis.

4. The ultrasound probe (10) of claim 3 wherein the battery (22), the base of the motor (20) and ultra-

sound module (16) rotate and translate in unison within a common chamber of the housing (12), the chamber filled with the coupling fluid (30).

5. The ultrasound probe (10) of claim 1 wherein the motor (20) is a DC motor driven to continuously rotate the ultrasound module (16) about the longitudinal axis of the housing (12) or the motor is a stepper motor driven to sweep the ultrasound module (16) back and forth about the longitudinal axis of the housing (12).

10 6. The ultrasound probe (10) of claim 1 wherein the control and processing system includes a wireless communication device to transmit the ultrasonic data representative of the target biological tissue to a remote device.

15 7. The ultrasound probe (10) of claim 1 wherein the control and processing system includes a sensor to measure at least one of a rotational position or a rotational speed of the ultrasonic module.

20 8. The ultrasound probe (10) of claim 1, further comprising:

25 a plurality of LEDs communicatively coupled to the control and processing system to controllably illuminate as the ultrasound module (16) rotates about the longitudinal axis to visually communicate information to a user through the housing (12).

30 9. The ultrasound probe (10) of claim 1, further comprising:

35 a support structure, the transducers (18) pivotably coupled to the support structure to tilt in parallel about a respective tilt axis perpendicular to the longitudinal axis of the housing (12).

40 10. The ultrasound probe (10) of claim 1 wherein a surface of the housing (12) includes a curvilinear profile such that scan lines of the transducers (18) are redirected when passing through the housing (12).

45 11. A method of obtaining ultrasonic data representative of a target biological tissue, the method comprising:

50 rotating an ultrasound module (16) contained in a housing (12) about a longitudinal axis of the housing (12) using a motor (20) received in the housing (12), the ultrasound module (16) including a plurality of transducers (18) longitudinally spaced apart within the housing (12) and a control and processing system electrically coupled to the transducers, the transducers (18) and the control and processing system of the ultrasound

module (16) sealed in a common fluid chamber; firing, by the control and processing system, the ultrasound transducers (18) to emit ultrasound waves while the ultrasound module (16) rotates about the longitudinal axis; and processing, by the control and processing system, ultrasonic data received via the transducers (18) to collect ultrasonic data representative of the target biological tissue.

5

12. The method of claim 11 wherein rotating the ultrasound module (16) contained in the housing (12) about the longitudinal axis includes: rotating the ultrasound module (16), a battery (22) and a base of the motor (20) in unison about the longitudinal axis; 15 rotating and translating the ultrasound module (16) axially about and along the longitudinal axis, respectively; and/or pivoting the ultrasound module (16) back and forth about the longitudinal axis in opposite rotational directions.

10

13. The method of claim 11, further comprising:

wirelessly transmitting the ultrasonic data representative of the target biological tissue to a 25 device remote from the ultrasound module (16) and/or

selectively illuminating a plurality of LEDs electrically coupled to the ultrasound module (16) as the ultrasound module (16) rotates about the longitudinal axis to visually communicate information to a user through the housing (12).

25

14. The method of claim 11, further comprising:

sensing a rotational position of the ultrasound module (16); and 35 coordinating a collection of ultrasonic data from the transducers (18) with the position of the ultrasound module (16).

35

15. The method of claim 11, further comprising:

simultaneously translating the ultrasound module (16) along the longitudinal axis of the housing (12) as the ultrasound module (16) rotates.

45

Patentansprüche

1. Ultraschallsonde (10), aufweisend:

ein Gehäuse (12) mit einer Längsachse; ein in dem Gehäuse (12) aufgenommenes Ultraschallmodul (16), welches Ultraschallmodul (16) eine Mehrzahl von Transducer (18) hat, die in Längsrichtung innerhalb des Gehäuses (12) beabstandet sind, sowie ein Steuer- und Ver-

55

arbeitungssystem (50), das in kommunikativer Weise an den Transducern (18) angekoppelt ist und betrieben, werden kann, um die Transducer (18) zu veranlassen, Ultraschallwellen zu emittieren und Ultraschallsignale zu verarbeiten, die von den Transducern (18) aufgenommen wurden, um Ultraschalldaten zu sammeln, die repräsentativ für ein Träger eines biologischen Gewebes stehen, wenn die Ultraschallsonde in Betrieb ist;

ein in dem Gehäuse (12) aufgenommener Motor (20), der antriebsfunktional angekoppelt ist, um das Ultraschallmodul (16) um die Längsachse des Gehäuses (12) zu rotieren; und ein Kopplungsfluid (30), das in dem Gehäuse (12) aufgenommen ist, um zumindest teilweise das Ultraschallmodul (16) und den Motor (20) zu umgeben.

20

2. Ultraschallsonde (10) nach Anspruch 1, ferner aufweisend:

eine Batterie (22), wobei die Batterie (22), eine Basis des Motors (20) und das Ultraschallmodul (16) feststehend miteinander zur Rotation um die Längsachse als eine Einheit verbunden sind.

30

3. Ultraschallsonde (10) nach Anspruch 2, wobei der Motor (20) ein Rotationsantrieb und linearer Bewegungsantrieb in zwei Richtungen ist, wobei der besagte Antrieb fahrfunktional an das Gehäuse (12) ungekoppelt ist, um das Ultraschallmodul (16) relativ zu dem Gehäuse (12) linear entlang der Längsachse und drehfunktional um die Längsachse zu bewegen.

35

4. Ultraschallsonde (10) nach Anspruch 3, wobei die Batterie (22), die Basis des Motors (20) und das Ultraschallmodul (16) als eine Einheit innerhalb einer gemeinsamen Kammer des Gehäuses (12) rotieren und translatorisch verfahren werden, und die Kammer mit dem Kopplungsfluid (30) gefüllt ist.

40

5. Ultraschallsonde (10) nach Anspruch 1, wobei der Motor (20) ein Gleichstrommotor ist, der zur kontinuierlichen Rotation des Ultraschallmoduls (16) um die Längsachse des Gehäuses (12) vorgesehen ist oder der Motor ein Schrittmotor ist, der zum Schwingen des Ultraschallmoduls (16) zurück und vor um die Längsachse des Gehäuses (12) angetrieben ist.

50

6. Ultraschallsonde (10) nach Anspruch 1, wobei das Steuer- und Verarbeitungssystem eine drahtlose Kommunikationsvorrichtung aufweist, um die Ultraschalldaten an eine ferne Vorrichtung zu übertragen, welche Daten repräsentativ für das Träger biologischen Gewebes stehen.

7. Ultraschallsonde (10) nach Anspruch 1, wobei das Steuer- und Verarbeitungssystem einen Sensor aufweist, um zumindest entweder eine Rotationsposition oder eine Rotationsgeschwindigkeit des Ultraschallmoduls zu messen.

8. Ultraschallsonde (10) nach Anspruch 1, ferner aufweisend:

eine Mehrzahl an LEDs, die kommunikativ an dem Steuer- und Verarbeitungssystem angekoppelt sind, um in steuernder Weise aufzuleuchten, sowie das Ultraschallmodul (16) um die Längsachse rotiert, um visuell Informationen an einen Anwender durch das Gehäuse (12) zu kommunizieren.

9. Ultraschallsonde (10) nach Anspruch 1, ferner aufweisend:

eine Tragstruktur, wobei die Transducer (18) drehbar an die Tragstruktur gekoppelt sind, um parallel um eine entsprechende Neigungsachse geneigt zu werden, die senkrecht zur Längsachse des Gehäuses (12) steht.

10. Ultraschallsonde (10) nach Anspruch 1, wobei eine Fläche des Gehäuses (12) ein gekrümmtes Profil aufweist, derart, dass Scanlinien der Transducer (18) rückgerichtet werden, wann sie durch das Gehäuse (12) verlaufen,

11. Verfahren zum Erhalten von Ultraschalldaten, die ein Target eines biologischen Gewebes repräsentieren, wobei das Verfahren aufweist:

Rotieren eines Ultraschallmoduls (16), das in einem Gehäuse (12) aufgenommen ist, um eine Längsachse des Gehäuses (12) unter Verwendung eines Motors (20), der in dem Gehäuse (12) aufgenommen ist, wobei das Ultraschallmodul (16) eine Mehrzahl von Transducern (18) umfasst, die in Längsrichtung innerhalb des Gehäuses (12) beabstandet sind, sowie ein Steuer- und Verarbeitungssystem, das elektrisch an die Transducer angekoppelt ist, wobei die Transducer (18) und das Steuer- und Verarbeitungssystem des Ultraschallmoduls (16) in einer gemeinsamem Fluidkammer abgedichtet sind; Auflösen durch das Steuer- und Verarbeitungssystem einer Abgabe von Ultraschallwellen durch die Ultraschall-Transducer (18) während das Ultraschallmodul (16) um die Längsachse rotiert,; und Verarbeiten durch das Steuer- und Verarbeitungssystem die Ultraschalldaten, wie sie über die Transducer (18) empfangen werden, am Ultraschalldaten zu sammeln, die repräsentativ für

5 das Target an biologischem Gewebe stehen.

12. Verfahren nach Anspruch 11, wobei ein Rotieren des Ultraschallmoduls (16), das in dem Gehäuse (12) aufgenommen ist, um die Längsachse beinhaltet: Rotieren des Ultraschallmoduls (16), eine Batterie (22) und eine Basis des Motors (20) als Einheit um die Längsachse; jeweiliges Rotieren und translatorisches Bewegen des Ultraschallmoduls (16) axial um und entlang der Längsachse; und/oder Drehen des Ultraschallmoduls zu zurück und vor um die Längsachse in entgegengesetzten Rotationsrichtungen.

10 15 13. Verfahren nach Anspruch 11, ferner aufweisend:

Eine drahtlose Übertragung der Ultraschalldaten, die das Target an biologischem Gewebe repräsentieren, an eine Ferneinrichtung abseits von dem Ultraschallmodul (16) und/oder selektives Beleuchten einer Mehrzahl von LEDs, die elektrisch an dem Ultraschallmodul (16) angeschlossen sind, sowie das Ultraschallmodul um die Längsachse rotiert, um Information an einen Anwender durch das Gehäuse (12) zu kommunizieren.

20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210 215 220 225 230 235 240 245 250 255 260 265 270 275 280 285 290 295 300 305 310 315 320 325 330 335 340 345 350 355 360 365 370 375 380 385 390 395 400 405 410 415 420 425 430 435 440 445 450 455 460 465 470 475 480 485 490 495 500 505 510 515 520 525 530 535 540 545 550 555 560 565 570 575 580 585 590 595 600 605 610 615 620 625 630 635 640 645 650 655 660 665 670 675 680 685 690 695 700 705 710 715 720 725 730 735 740 745 750 755 760 765 770 775 780 785 790 795 800 805 810 815 820 825 830 835 840 845 850 855 860 865 870 875 880 885 890 895 900 905 910 915 920 925 930 935 940 945 950 955 960 965 970 975 980 985 990 995 1000 1005 1010 1015 1020 1025 1030 1035 1040 1045 1050 1055 1060 1065 1070 1075 1080 1085 1090 1095 1100 1105 1110 1115 1120 1125 1130 1135 1140 1145 1150 1155 1160 1165 1170 1175 1180 1185 1190 1195 1200 1205 1210 1215 1220 1225 1230 1235 1240 1245 1250 1255 1260 1265 1270 1275 1280 1285 1290 1295 1300 1305 1310 1315 1320 1325 1330 1335 1340 1345 1350 1355 1360 1365 1370 1375 1380 1385 1390 1395 1400 1405 1410 1415 1420 1425 1430 1435 1440 1445 1450 1455 1460 1465 1470 1475 1480 1485 1490 1495 1500 1505 1510 1515 1520 1525 1530 1535 1540 1545 1550 1555 1560 1565 1570 1575 1580 1585 1590 1595 1600 1605 1610 1615 1620 1625 1630 1635 1640 1645 1650 1655 1660 1665 1670 1675 1680 1685 1690 1695 1700 1705 1710 1715 1720 1725 1730 1735 1740 1745 1750 1755 1760 1765 1770 1775 1780 1785 1790 1795 1800 1805 1810 1815 1820 1825 1830 1835 1840 1845 1850 1855 1860 1865 1870 1875 1880 1885 1890 1895 1900 1905 1910 1915 1920 1925 1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010 2015 2020 2025 2030 2035 2040 2045 2050 2055 2060 2065 2070 2075 2080 2085 2090 2095 2100 2105 2110 2115 2120 2125 2130 2135 2140 2145 2150 2155 2160 2165 2170 2175 2180 2185 2190 2195 2200 2205 2210 2215 2220 2225 2230 2235 2240 2245 2250 2255 2260 2265 2270 2275 2280 2285 2290 2295 2300 2305 2310 2315 2320 2325 2330 2335 2340 2345 2350 2355 2360 2365 2370 2375 2380 2385 2390 2395 2400 2405 2410 2415 2420 2425 2430 2435 2440 2445 2450 2455 2460 2465 2470 2475 2480 2485 2490 2495 2500 2505 2510 2515 2520 2525 2530 2535 2540 2545 2550 2555 2560 2565 2570 2575 2580 2585 2590 2595 2600 2605 2610 2615 2620 2625 2630 2635 2640 2645 2650 2655 2660 2665 2670 2675 2680 2685 2690 2695 2700 2705 2710 2715 2720 2725 2730 2735 2740 2745 2750 2755 2760 2765 2770 2775 2780 2785 2790 2795 2800 2805 2810 2815 2820 2825 2830 2835 2840 2845 2850 2855 2860 2865 2870 2875 2880 2885 2890 2895 2900 2905 2910 2915 2920 2925 2930 2935 2940 2945 2950 2955 2960 2965 2970 2975 2980 2985 2990 2995 3000 3005 3010 3015 3020 3025 3030 3035 3040 3045 3050 3055 3060 3065 3070 3075 3080 3085 3090 3095 3100 3105 3110 3115 3120 3125 3130 3135 3140 3145 3150 3155 3160 3165 3170 3175 3180 3185 3190 3195 3200 3205 3210 3215 3220 3225 3230 3235 3240 3245 3250 3255 3260 3265 3270 3275 3280 3285 3290 3295 3300 3305 3310 3315 3320 3325 3330 3335 3340 3345 3350 3355 3360 3365 3370 3375 3380 3385 3390 3395 3400 3405 3410 3415 3420 3425 3430 3435 3440 3445 3450 3455 3460 3465 3470 3475 3480 3485 3490 3495 3500 3505 3510 3515 3520 3525 3530 3535 3540 3545 3550 3555 3560 3565 3570 3575 3580 3585 3590 3595 3600 3605 3610 3615 3620 3625 3630 3635 3640 3645 3650 3655 3660 3665 3670 3675 3680 3685 3690 3695 3700 3705 3710 3715 3720 3725 3730 3735 3740 3745 3750 3755 3760 3765 3770 3775 3780 3785 3790 3795 3800 3805 3810 3815 3820 3825 3830 3835 3840 3845 3850 3855 3860 3865 3870 3875 3880 3885 3890 3895 3900 3905 3910 3915 3920 3925 3930 3935 3940 3945 3950 3955 3960 3965 3970 3975 3980 3985 3990 3995 4000 4005 4010 4015 4020 4025 4030 4035 4040 4045 4050 4055 4060 4065 4070 4075 4080 4085 4090 4095 4100 4105 4110 4115 4120 4125 4130 4135 4140 4145 4150 4155 4160 4165 4170 4175 4180 4185 4190 4195 4200 4205 4210 4215 4220 4225 4230 4235 4240 4245 4250 4255 4260 4265 4270 4275 4280 4285 4290 4295 4300 4305 4310 4315 4320 4325 4330 4335 4340 4345 4350 4355 4360 4365 4370 4375 4380 4385 4390 4395 4400 4405 4410 4415 4420 4425 4430 4435 4440 4445 4450 4455 4460 4465 4470 4475 4480 4485 4490 4495 4500 4505 4510 4515 4520 4525 4530 4535 4540 4545 4550 4555 4560 4565 4570 4575 4580 4585 4590 4595 4600 4605 4610 4615 4620 4625 4630 4635 4640 4645 4650 4655 4660 4665 4670 4675 4680 4685 4690 4695 4700 4705 4710 4715 4720 4725 4730 4735 4740 4745 4750 4755 4760 4765 4770 4775 4780 4785 4790 4795 4800 4805 4810 4815 4820 4825 4830 4835 4840 4845 4850 4855 4860 4865 4870 4875 4880 4885 4890 4895 4900 4905 4910 4915 4920 4925 4930 4935 4940 4945 4950 4955 4960 4965 4970 4975 4980 4985 4990 4995 5000 5005 5010 5015 5020 5025 5030 5035 5040 5045 5050 5055 5060 5065 5070 5075 5080 5085 5090 5095 5100 5105 5110 5115 5120 5125 5130 5135 5140 5145 5150 5155 5160 5165 5170 5175 5180 5185 5190 5195 5200 5205 5210 5215 5220 5225 5230 5235 5240 5245 5250 5255 5260 5265 5270 5275 5280 5285 5290 5295 5300 5305 5310 5315 5320 5325 5330 5335 5340 5345 5350 5355 5360 5365 5370 5375 5380 5385 5390 5395 5400 5405 5410 5415 5420 5425 5430 5435 5440 5445 5450 5455 5460 5465 5470 5475 5480 5485 5490 5495 5500 5505 5510 5515 5520 5525 5530 5535 5540 5545 5550 5555 5560 5565 5570 5575 5580 5585 5590 5595 5600 5605 5610 5615 5620 5625 5630 5635 5640 5645 5650 5655 5660 5665 5670 5675 5680 5685 5690 5695 5700 5705 5710 5715 5720 5725 5730 5735 5740 5745 5750 5755 5760 5765 5770 5775 5780 5785 5790 5795 5800 5805 5810 5815 5820 5825 5830 5835 5840 5845 5850 5855 5860 5865 5870 5875 5880 5885 5890 5895 5900 5905 5910 5915 5920 5925 5930 5935 5940 5945 5950 5955 5960 5965 5970 5975 5980 5985 5990 5995 6000 6005 6010 6015 6020 6025 6030 6035 6040 6045 6050 6055 6060 6065 6070 6075 6080 6085 6090 6095 6100 6105 6110 6115 6120 6125 6130 6135 6140 6145 6150 6155 6160 6165 6170 6175 6180 6185 6190 6195 6200 6205 6210 6215 6220 6225 6230 6235 6240 6245 6250 6255 6260 6265 6270 6275 6280 6285 6290 6295 6300 6305 6310 6315 6320 6325 6330 6335 6340 6345 6350 6355 6360 6365 6370 6375 6380 6385 6390 6395 6400 6405 6410 6415 6420 6425 6430 6435 6440 6445 6450 6455 6460 6465 6470 6475 6480 6485 6490 6495 6500 6505 6510 6515 6520 6525 6530 6535 6540 6545 6550 6555 6560 6565 6570 6575 6580 6585 6590 6595 6600 6605 6610 6615 6620 6625 6630 6635 6640 6645 6650 6655 6660 6665 6670 6675 6680 6685 6690 6695 6700 6705 6710 6715 6720 6725 6730 6735 6740 6745 6750 6755 6760 6765 6770 6775 6780 6785 6790 6795 6800 6805 6810 6815 6820 6825 6830 6835 6840 6845 6850 6855 6860 6865 6870 6875 6880 6885 6890 6895 6900 6905 6910 6915 6920 6925 6930 6935 6940 6945 6950 6955 6960 6965 6970 6975 6980 6985 6990 6995 7000 7005 7010 7015 7020 7025 7030 7035 7040 7045 7050 7055 7060 7065 7070 7075 7080 7085 7090 7095 7100 7105 7110 7115 7120 7125 7130 7135 7140 7145 7150 7155 7160 7165 7170 7175 7180 7185 7190 7195 7200 7205 7210 7215 7220 7225 7230 7235 7240 7245 7250 7255 7260 7265 7270 7275 7280 7285 7290 7295 7300 7305 7310 7315 7320 7325 7330 7335 7340 7345 7350 7355 7360 7365 7370 7375 7380 7385 7390 7395 7400 7405 7410 7415 7420 7425 7430 7435 7440 7445 7450 7455 7460 7465 7470 7475 7480 7485 7490 7495 7500 7505 7510 7515 7520 7525 7530 7535 7540 7545 7550 7555 7560 7565 7570 7575 7580 7585 7590 7595 7600 7605 7610 7615 7620 7625 7630 7635 7640 7645 7650 7655 7660 7665 7670 7675 7680 7685 7690 7695 7700 7705 7710 7715 7720 7725 7730 7735 7740 7745 7750 7755 7760 7765 7770 7775 7780 7785 7790 7795 7800 7805 7810 7815 7820 7825 7830 7835 7840 7845 7850 7855 7860 7865 7870 7875 7880 7885 7890 7895 7900 7905 7910 7915 7920 7925 7930 7935 7940 7945 7950 7955 7960 7965 7970 7975 7980 7985 7990 7995 8000 8005 8010 8015 8020 8025 8030 8035 8040 8045 8050 8055 8060 8065 8070 8075 8080 8085 8090 8095 8100 8105 8110 8115 8120 8125 8130 8135 8140 8145 8150 8155 8160 8165 8170 8175 8180 8185 8190 8195 8200 8205 8210 8215 8220 8225 8230 8235 8240 8245 8250 8255 8260 8265 8270 8275 8280 8285 8290 8295 8300 8305 8310 8315 8320 8325 8330 8335 8340 8345 8350 8355 8360 8365 8370 8375 8380 8385 8390 8395 8400 8405 8410 8415 8420 8425 8430 8435 8440 8445 8450 8455 8460 8465 8470 8475 8480 8485 8490 8495 8500 8505 8510 8515 8520 8525 8530 8535 8540 8545 8550 8555 8560 8565 8570 8575 8580 8585 8590 8595 8600 8605 8610 8615 8620 8625 8630 8635 8640 8645 8650 8655 8660 8665 8670 8675 8680 8685 8690 8695 8700 8705 8710 8715 8720 8725 8730 8735 8740 8745 8750 8755 8760 8765 8770 8775 8780 8785 8790 8795 8800 8805 8810 8815 8820 8825 8830 8835 8840 8845 8850 8855 8860 8865 8870 8875 8880 8885 8890 8895 8900 8905 8910 8915 8920 8925 8930 8935 8940 8945 8950 8955 8960 8965 8970 8975 8980 8985 8990 8995 9000 9005 9010 9015 9020 9025 9030 9035 9040 9045 9050 9055 9060 9065 9070 9075 9080 9085 9090 9095 9100 9105 9110 9115 9120 9125 9130 9135 9140 9145 9150 9155 9160 9165 9170 9175 9180 9185 9190 9195 9200 9205 9210 9215 9220 9225 9230 9235 9240 9245 9250 9255 9260 9265 9270 9275 9280 9285 9290 9295 9300 9305 9310 9315 9320 9325 9330 9335 9340 9345 9350 9355 9360 9365 9370 9375 9380 9385 9390 9395 9400 9405 9410 9415 9420 9425 9430 9435 9440 9445 9450 9455 9460 9465 9470 9475 9480 9485 9490 9495 9500 9505 9510 9515 9520 9525 9530 9535 9540 9545 9550 9555 9560 9565 9570 9575 9580 9585 9590 9595 9600 9605 9610 9615 9620 9625 9630 9635 9640 9645 9650 9655 9660 9665 9670 9675 9680 9685 9690 9695 9700 9705 9710 9715 9720 9725 9730 9735 9740 9745 9750 9755 9760 9765 9770 9775 9780 9785 9790 9795 9800 9805 9810 9815 9820 9825 9830 9835 9840 9845 9850 9855 9860 9865 9870 9875 9880 9885 9890 9895 9900 9905 9910 9915 9920 9925 9930 9935 9940 9945 9950 9955 9960 9965 9970 9975 9980 9985 9990 9995 10000 10005 10010 10015 10020 10025 10030 10035 10040 10045 10050 10055 10060 10065 10070 10075 10080 10085 10090 10095 10100 10105 10110 10115 10120 10125 10130 10135 10140 10145 10150 10155 10160 10165 10170

res reçus par l'intermédiaire des transducteurs (18) pour collecter des données ultrasonores représentatives d'un tissu biologique cible lorsque la sonde ultrasonore fonctionne ;
un moteur (20) reçu dans le logement (12) et couplé de manière entraînante pour faire tourner le module ultrasonore (16) autour de l'axe longitudinal du logement (12); et
un fluide de couplage (30) reçu dans le logement (12) de manière à entourer au moins partiellement le module ultrasonore (16) et le moteur (20).
5

2. Sonde ultrasonore (10) selon la revendication 1, comprenant en outre :
15 une batterie (22), la batterie (22), une base du moteur (20) et le module ultrasonore (16) étant couplés rigidement les uns aux autres pour tourner autour de l'axe longitudinal à l'unisson.

3. Sonde ultrasonore (10) selon la revendication 2, dans laquelle le moteur (20) est un actionneur linéaire et rotatif à double mouvement, l'actionneur linéaire et rotatif à double mouvement étant couplé de manière entraînante au logement (12) pour déplacer le module ultrasonore (16) par rapport au logement (12) linéairement le long de l'axe longitudinal et en rotation autour de l'axe longitudinal.
20

4. Sonde ultrasonore (10) selon la revendication 3, dans laquelle la batterie (22), la base du moteur (20) et le module ultrasonore (16) tournent et effectuent un mouvement de translation à l'unisson à l'intérieur d'une chambre commune du logement (12), la chambre étant remplie du fluide de couplage (30).
25

5. Sonde ultrasonore (10) selon la revendication 1, dans laquelle le moteur (20) est un moteur à courant continu entraîné pour faire tourner en continu le module ultrasonore (16) autour de l'axe longitudinal du logement (12) ou le moteur est un moteur pas à pas entraîné pour balayer le module ultrasonore (16) d'avant en arrière autour de l'axe longitudinal du logement (12).
30

6. Sonde ultrasonore (10) selon la revendication 1, dans laquelle le système de commande et de traitement comprend un dispositif de communication sans fil pour transmettre les données ultrasonores représentatives du tissu biologique cible à un dispositif à distance.
35

7. Sonde ultrasonore (10) selon la revendication 1, dans laquelle le système de commande et de traitement comprend un capteur pour mesurer au moins l'une d'une position de rotation ou d'une vitesse de rotation du module ultrasonore.
40

8. Sonde ultrasonore (10) selon la revendication 1, comprenant en outre :
45 une pluralité de DEL couplées en communication avec le système de commande et de traitement pour éclairer de manière contrôlable alors que le module ultrasonore (16) tourne autour de l'axe longitudinal pour communiquer visuellement des informations à un utilisateur à travers le logement (12).

9. Sonde ultrasonore (10) selon la revendication 1, comprenant en outre :
50 une structure de support, les transducteurs (18) étant couplés de manière pivotante à la structure de support pour s'incliner en parallèle autour d'un axe d'inclinaison respectif perpendiculaire à l'axe longitudinal du logement (12).

10. Sonde ultrasonore (10) selon la revendication 1, dans laquelle une surface du logement (12) comprend un profil curviligne de sorte que les lignes de balayage des transducteurs (18) sont redirigées lorsqu'ils passent à travers le logement (12).
55

11. Procédé d'obtention de données ultrasonores représentatives d'un tissu biologique cible, le procédé comprenant :
60 la rotation d'un module ultrasonore (16) contenu dans un logement (12) autour d'un axe longitudinal du logement (12) en utilisant un moteur (20) reçu dans le logement (12), le module ultrasonore (16) comprenant une pluralité de transducteurs (18) espacés longitudinalement à l'intérieur du logement (12) et un système de commande et de traitement couplé électriquement aux transducteurs, les transducteurs (18) et le système de commande et de traitement du module ultrasonore (16) étant enfermés hermétiquement dans une chambre de fluide commune ;
65 le déclenchement, par le système de commande et de traitement, des transducteurs ultrasonores (18) pour émettre des ondes ultrasonores alors que le module ultrasonore (16) tourne autour de l'axe longitudinal ; et
70 le traitement, par le système de commande et de traitement, des données ultrasonores reçues par l'intermédiaire des transducteurs (18) pour collecter des données ultrasonores représentatives du tissu biologique cible.
75

12. Procédé selon la revendication 11, dans lequel la rotation du module ultrasonore (16) contenu dans le logement (12) autour de l'axe longitudinal comprend :
80

la rotation du module ultrasonore (16), d'une batterie (22) et d'une base du moteur (20) à l'unisson autour de l'axe longitudinal ; la rotation et la translation du module ultrasonore (16) axialement autour et le long de l'axe longitudinal, respectivement ; et/ou le pivotement du module ultrasonore (16) d'avant en arrière autour de l'axe longitudinal dans des directions de rotation opposées.

10

13. Procédé selon la revendication 11, comprenant en outre :

la transmission sans fil des données ultrasonores représentatives du tissu biologique cible à un dispositif à distance du module ultrasonore (16), et/ou

l'éclairage de manière sélective d'une pluralité de DEL couplées électriquement au module ultrasonore (16) alors que le module ultrasonore (16) tourne autour de l'axe longitudinal pour communiquer visuellement des informations à un utilisateur à travers le logement (12).

14. Procédé selon la revendication 11, comprenant en outre :

la détection d'une position de rotation du module ultrasonore (16) ; et

la coordination de la collecte des données ultrasonores à partir des transducteurs (18) avec la position du module ultrasonore (16).

15. Procédé selon la revendication 11, comprenant en outre :

la translation simultanée du module ultrasonore (16) le long de l'axe longitudinal du logement (12) alors que le module ultrasonore (16) tourne.

40

45

50

55

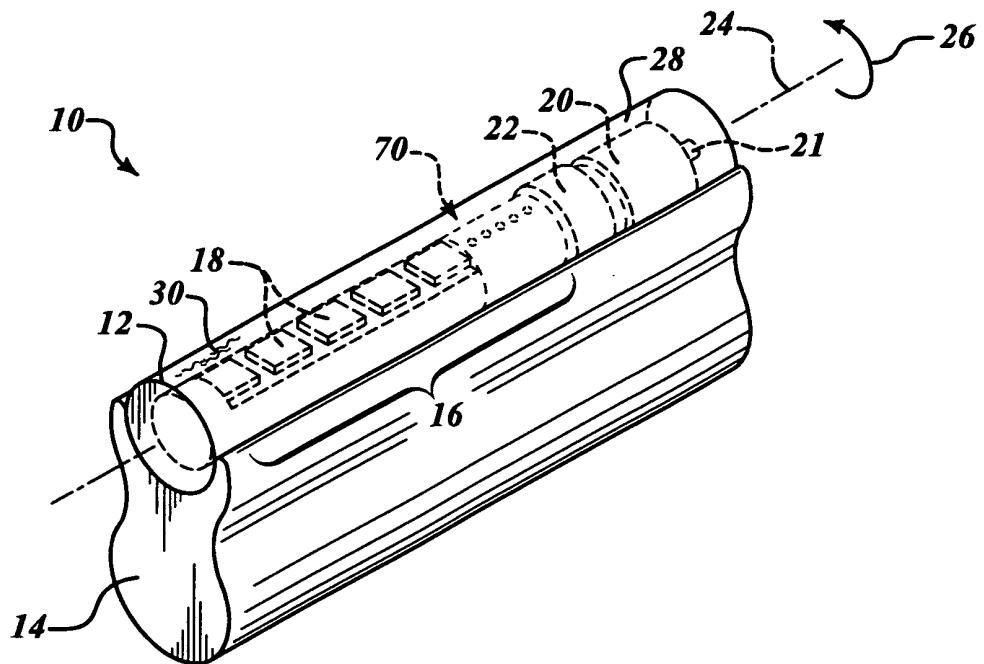


FIG.1

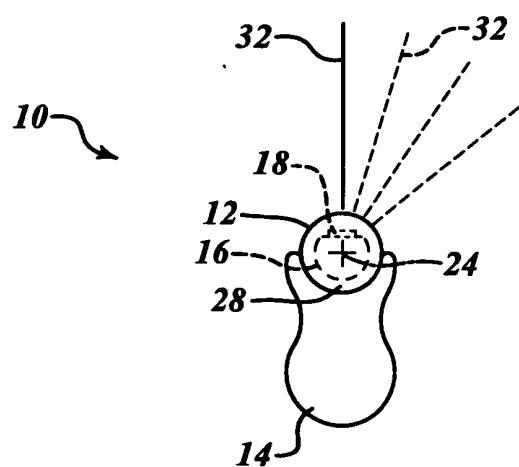


FIG.2

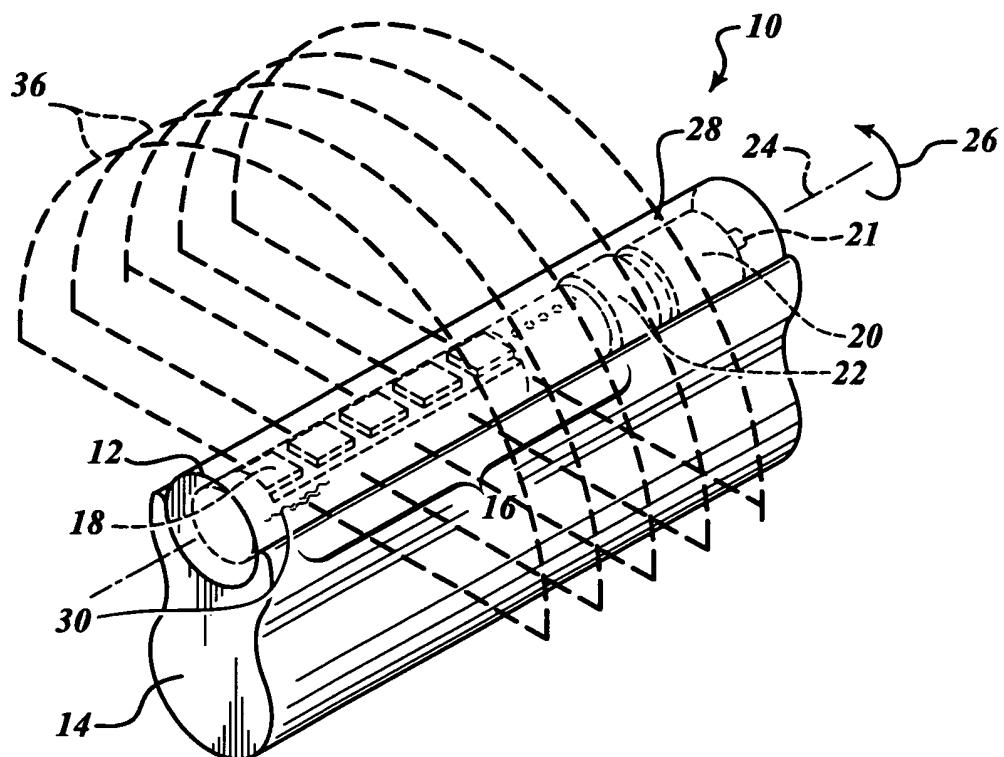


FIG.3

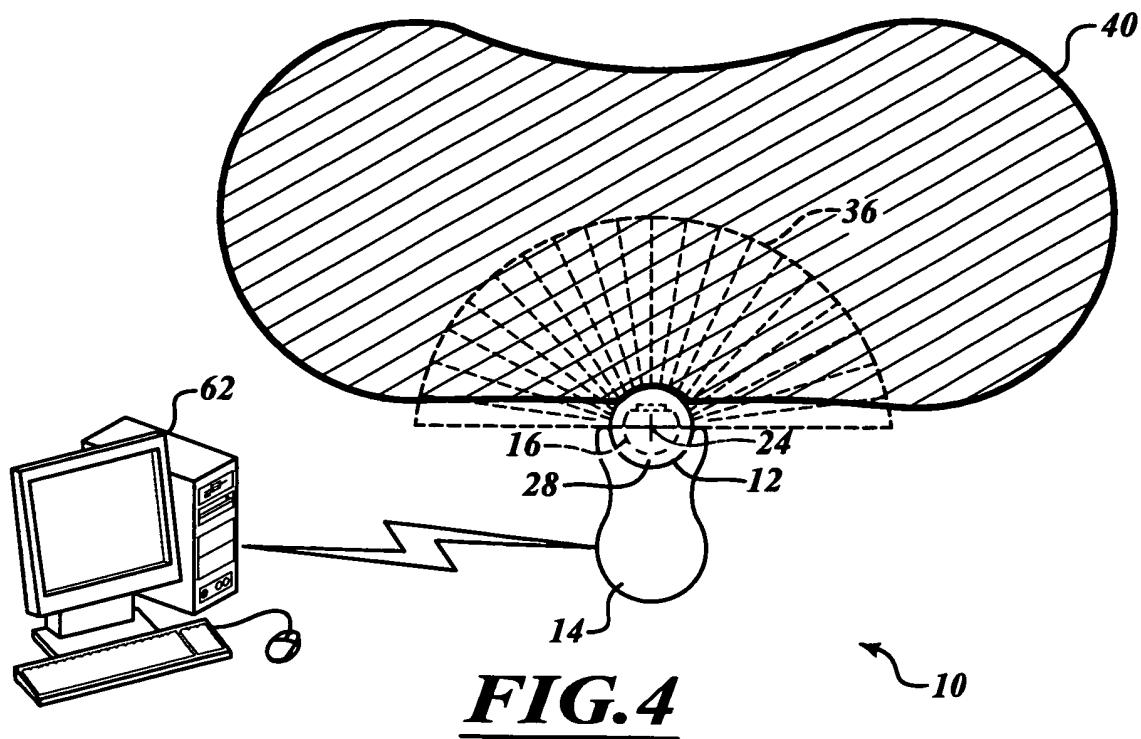


FIG.4

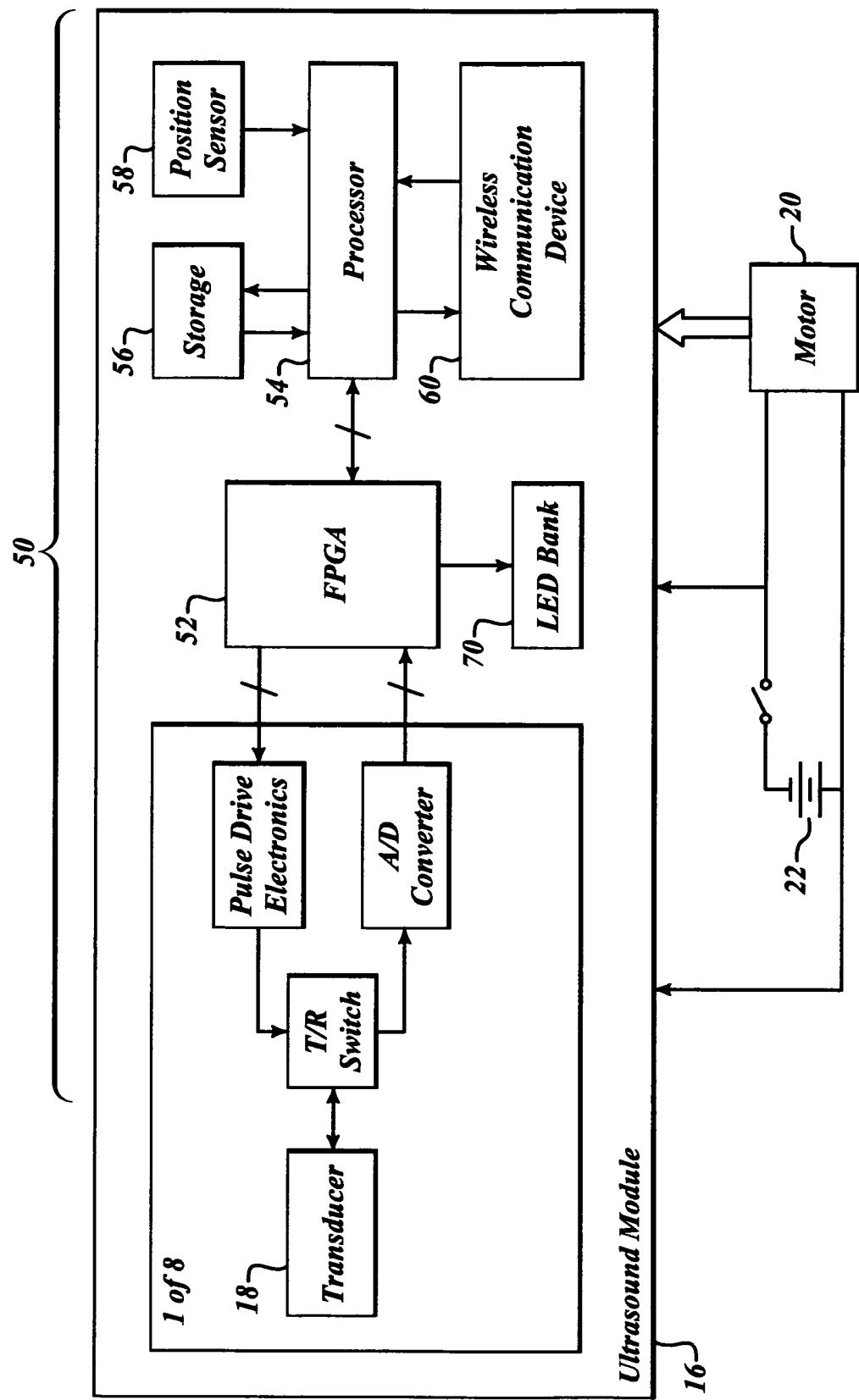


FIG.5

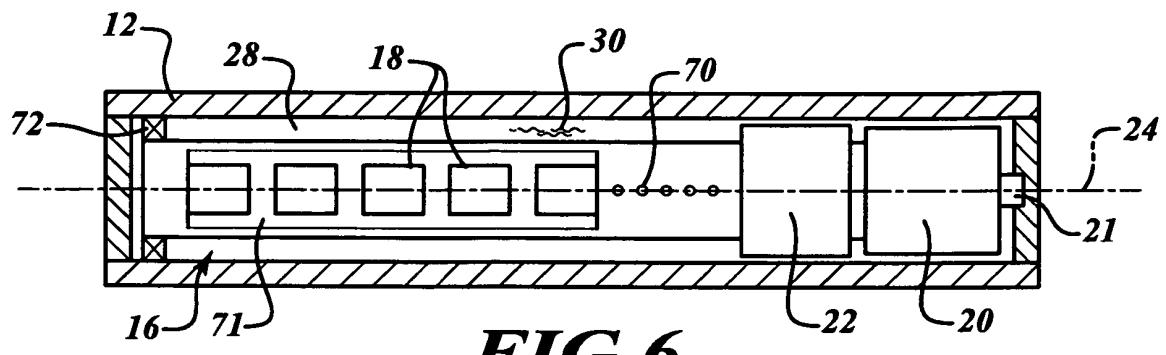


FIG. 6

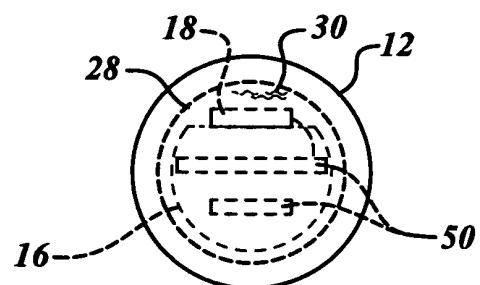


FIG. 7

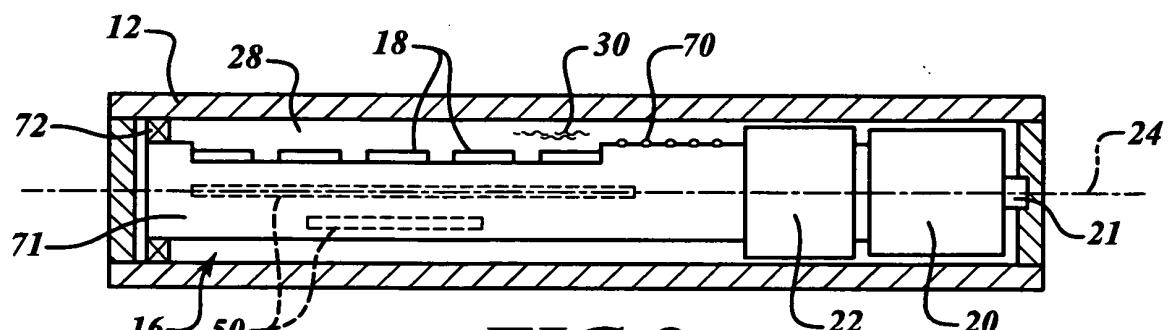


FIG. 8

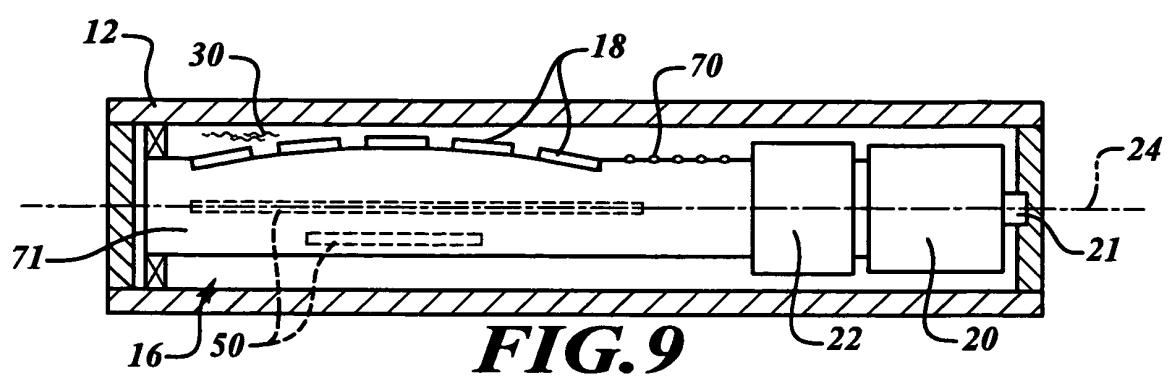
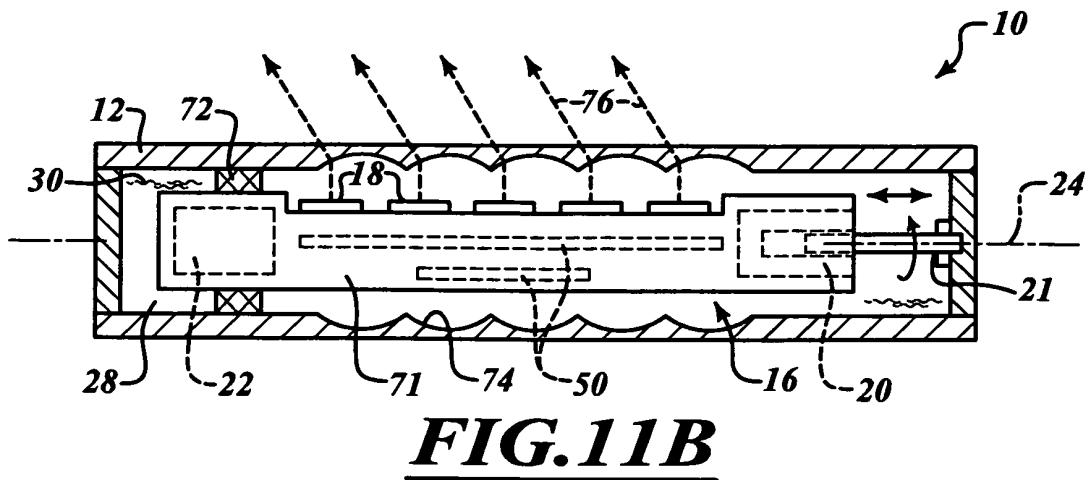
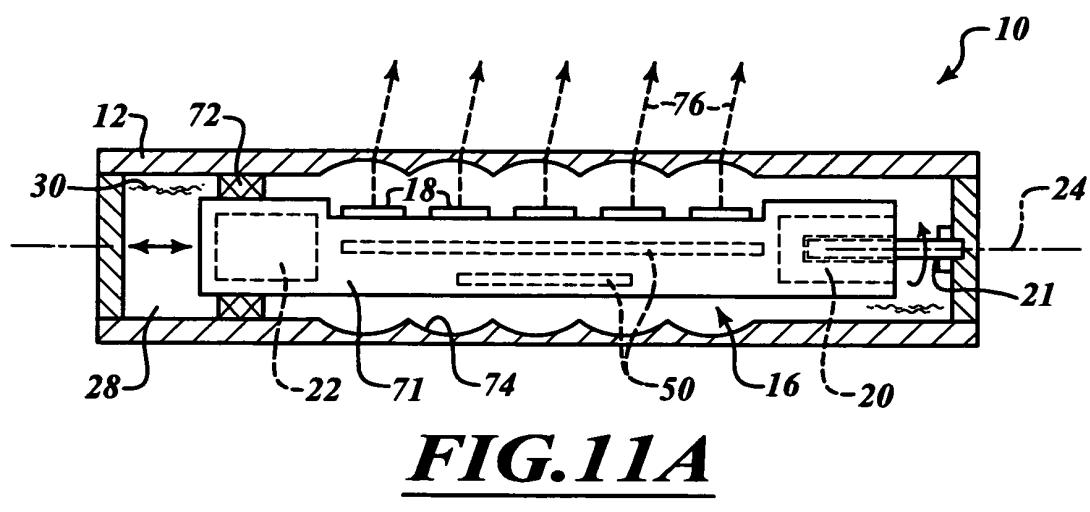
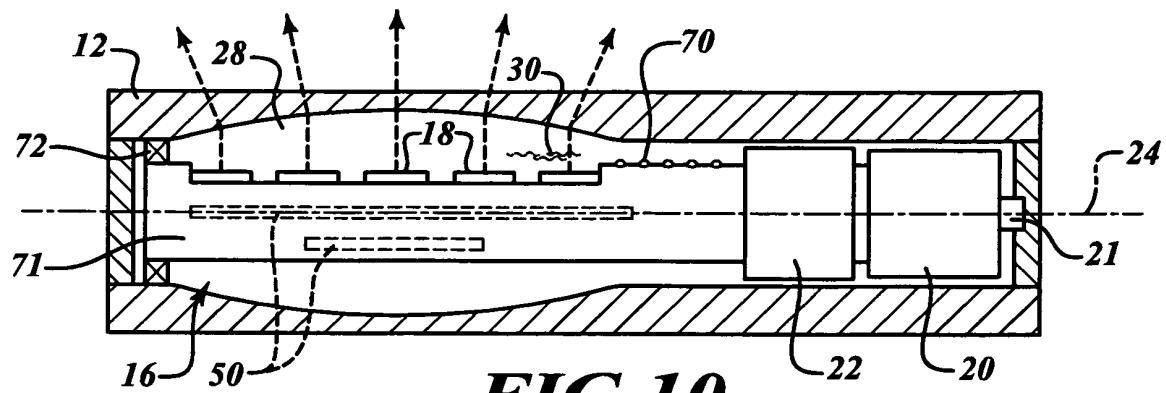
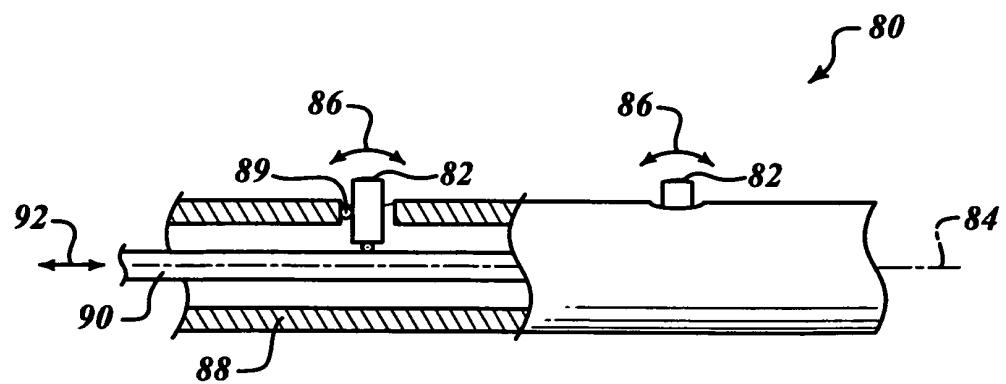
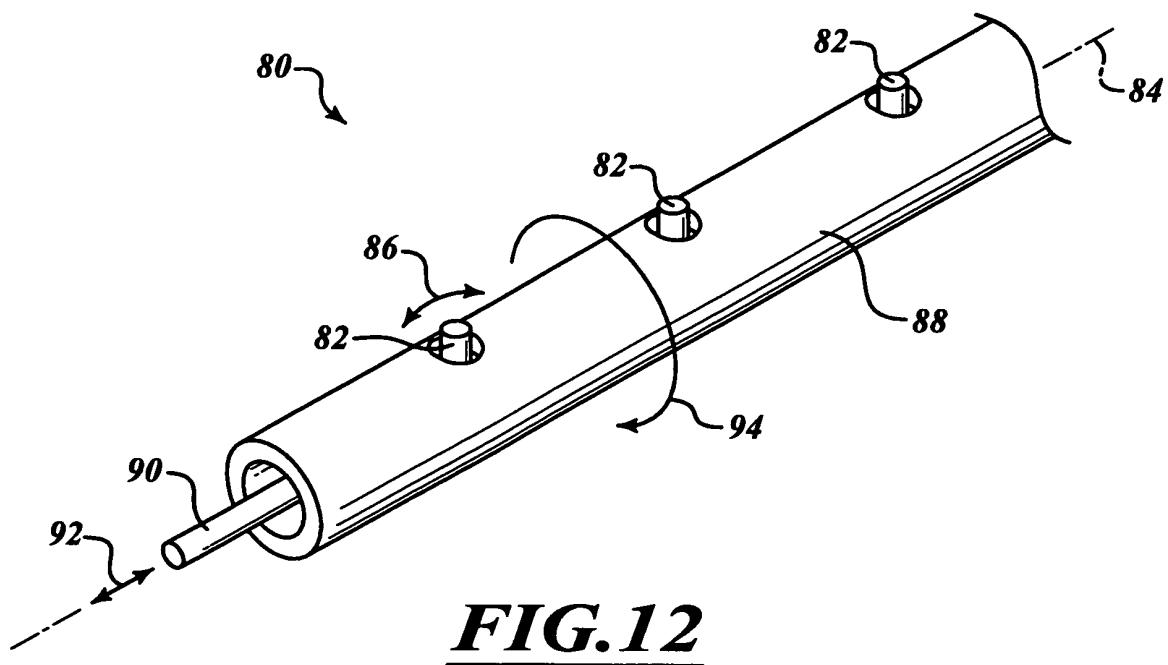


FIG. 9





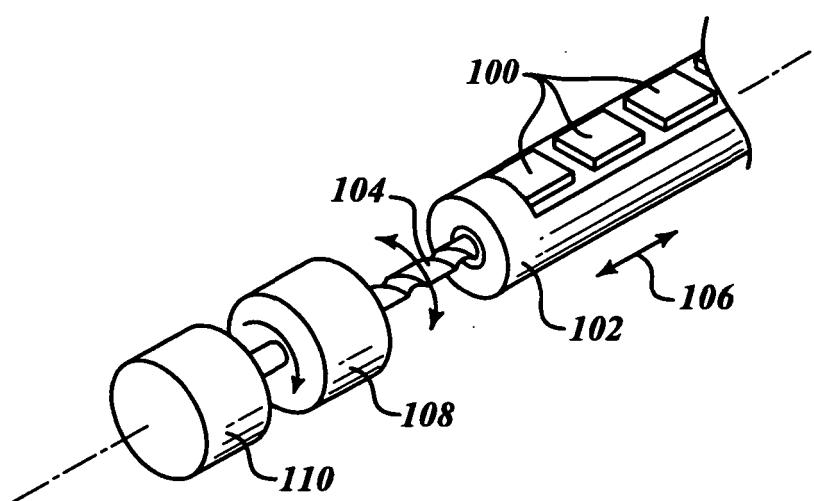


FIG.14

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 2007167813 A [0005]

专利名称(译)	超声成像探头和方法		
公开(公告)号	EP2544594B1	公开(公告)日	2013-07-10
申请号	EP2011753817	申请日	2011-03-02
申请(专利权)人(译)	DBMEDX INC.		
当前申请(专利权)人(译)	DBMEDX INC.		
[标]发明人	BARNARD WILLIAM SHINE DAVID BARTHOLOMEW		
发明人	BARNARD, WILLIAM SHINE, DAVID, BARTHOLOMEW		
IPC分类号	A61B8/00 G01N29/24 A61B8/08 A61B5/20		
CPC分类号	A61B8/4455 A61B5/204 A61B8/08 A61B8/4281 A61B8/4461 A61B8/4472 A61B8/461 A61B8/483 A61B8/56		
代理机构(译)	MOORE , BARRY		
优先权	61/312363 2010-03-10 US 12/948622 2010-11-17 US		
其他公开文献	EP2544594A2 EP2544594A4		
外部链接	Espacenet		

摘要(译)

提供一种超声探头，其具有容纳在其壳体中的超声模块，超声模块包括在壳体内纵向间隔开的多个换能器，以及电耦合到换能器的控制和处理系统，用于收集代表目标生物组织的超声数据。超声探头运行时。同样地，电动机容纳在壳体中，以在数据收集模式中旋转，振荡和/或平移超声模块。耦合流体被接收在壳体中以至少部分地围绕超声模块和马达。还提供了一种获得代表目标生物组织（例如膀胱）的超声数据以用于诊断目的的方法。

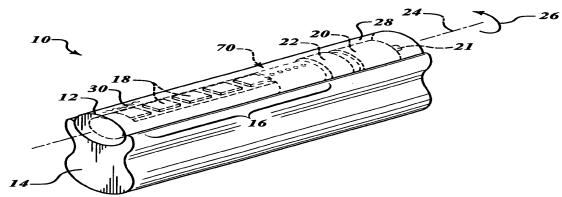


FIG. 1

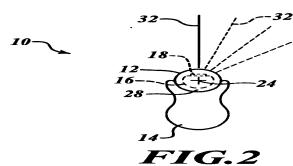


FIG. 2