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(54) FOCUSED ULTRASOUND SYSTEM FOR SURROUNDING A BODY TISSUE MASS

FOKUSSIERTES ULTRASCHALLSYSTEM ZUM UMSCHLIESSEN EINER KÖRPERGEWEBEMASSE

SYSTEME FOCALISE A ULTRASONS DESTINE A ENTOURER UNE MASSE DE TISSU DE L'ORGANISME

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Description

FIELD OF INVENTION

[0001] This invention relates generally to apparatus for delivering diagnostic and/or therapeutic ultrasound energy from a transducer disposed outside a body.

BACKGROUND

[0002] Devices and systems using acoustic energy, particularly within the ultrasonic range, i.e., acoustic waves with a frequency greater than about twenty kilohertz (20kHz), and more typically between fifty kiloHertz and ten MegaHertz (0.05-10 MHz), have been used to diagnose and treat patients. Ultrasonic energy may be employed to obtain images of a patient during a diagnostic or therapeutic procedure. In addition, ultrasound systems have been used for treating tissue, e.g., by directing acoustic energy towards a target tissue region within a patient, such as a cancerous or benign tumor, to coagulate, necrose, generate mechanical damage (by cavitation) or otherwise heat the tissue region. For example, one or more piezoelectric transducers may be disposed adjacent a patient's body and used to deliver high intensity acoustic waves, such as ultrasonic waves, at an internal tissue region of a patient to treat the tissue region. An exemplary focused ultrasound system is disclosed in U.S. Patent No. 4,865,042 issued to Umemura et al. The acoustic energy emitted from such a system may be focused at a desired focal zone to deliver thermal energy to the target tissue region.

[0003] Focused ultrasound procedures may allow a patient to be treated while avoiding invasive surgery. For example, a focused ultrasound system that includes a single concave transducer has been used to treat breast, uterine and other tumors. Such transducer transmits an acoustic beam, which converges into a focus in target tissue to treat tissue. However, the acoustic beam may transverse through an organ, such as a breast nipple, or other sensitive areas, either before the beam converges into the focus (i.e., in a near field) or beyond the target tissue (i.e., in a far field). These areas have a high absorption coefficient compared to regular tissue, thereby risking damage to non targeted tissue at the near field and/or the far field. Also, in some cases, the acoustic beam may impinge on a tissue (e.g., bone tissue) that would not allow the beam to pass through by reflecting and/or absorbing most of the impinging energy. As a result, the acoustic beam may not reach the target tissue, and may generate undesired heating at the tissue surface that is blocking or interfering the acoustic beam. In some cases, the heating of bone tissue may also heat, and adversely affect, a nerve that is adjacent the bone tissue. A similar situation could happen with volumes in the body that are filled with air acting as total reflector for acoustic beam, thereby blocking the beam from propagating to the target tissue region.

[0004] Certain physical anatomy, e.g., a breast or an arm, can impose special problems in positioning an ultrasound transducer to effectively direct the ultrasound energy at the target tissue mass (e.g., a tumor underlying a nipple, or along one side of a bone), while reducing the risk of adversely impacting nearby healthy tissue.

[0005] Examples of prior art focused ultrasound system are disclosed in US-A- 4 478 083 and FR-A-2 806 611.

[0006] In WO 02/43805, there is described a focused ultrasound system configured for treatment of a body part according to the preamble of claim 1. This document WO 02/43805 discloses a focused ultrasound system for steering a focused ultrasound array including a plurality of transducer sub-arrays with a plurality of transducer elements thereon. A controller is coupled to the sub-arrays for moving the sub-arrays to adjust an orientation of the acoustic emission surfaces of respective sub-arrays to facilitate steering of acoustic energy emitted by the transducer elements towards a target tissue region.

[0007] It is against this background, and the limitations and problems associated therewith, that the present invention has been developed. To achieve this, the focused ultrasound system of the invention is characterized by the features claimed in the characterizing part of claim 1.

[0008] In the invention, a focused ultrasound system includes an ultrasound transducer device forming an opening, the ultrasound device having a plurality of transducer elements positioned at least partially around the opening.

[0009] A focused ultrasound system includes a structure having a first end configured to allow an object to be inserted there through, and a second end configured for allowing the object to exit there through, the structure defining an aperture, and a plurality of transducer elements coupled to the structure, the transducer elements positioned relative to each other in a formation such that acoustic energy emitted from the transducer elements converges at a focal zone located in the aperture.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Various embodiments of the invention are described hereinafter with reference to the figures. It should be noted that the figures are not drawn to scale and elements of similar structures or functions are represented by like reference numerals throughout the figures, and in which:

FIG. 1 illustrates an ultrasound system having a transducer device in accordance with some embodiments of the invention;

FIG. 1B illustrates a transducer device having a plurality of rows of transducer elements in accordance with other embodiments of the invention;

FIG. 2 illustrates a transducer device in accordance with still other embodiments of the invention;

FIG. 3 illustrates a transducer device in accordance with yet further embodiments of the invention, showing the transducer device having spaced apart transducer elements;

FIG. 4 illustrates a transducer device in accordance with still further embodiments of the invention, showing the transducer device having transducer elements that do not face each other;

FIG. 5 illustrates a transducer device in accordance with yet further embodiments of the invention, showing the transducer device having a coupling membrane;

FIG. 6 illustrates the treatment of breast tissue using the transducer device of FIG. 1, for purposes of demonstration;

FIG. 7 illustrates treating tissue within an arm using the transducer device of FIG. 1, for purposes of demonstration;

FIG. 8 illustrates treating tissue within a body using the transducer device of FIG. 1, for purposes of demonstration; and

FIG. 9 illustrates treatment of brain tissue using the transducer device of FIG. 1, for purposes of demonstration.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0011] FIG. 1 illustrates a focused ultrasound system 5 that includes a transducer device 10 constructed in accordance with some embodiments of the invention. The focused ultrasound system 5 includes a drive circuitry 16 coupled to the transducer device 10, and a controller 18 coupled to the drive circuitry 16. The transducer device 10 is configured to deliver acoustic energy (represented by beam 15) to a target tissue region located inside a patient. The acoustic energy 15 may be used to coagulate, necrose, heat, or otherwise treat the target tissue region, which may be a benign or malignant tumor within an organ or other tissue structure (not shown).

[0012] In the illustrated embodiments, the transducer device 10 includes a structure 20 and a plurality of transducer elements 12 secured to the structure 20. The transducer elements 12 are positioned in an arrangement or formation to thereby define an opening 22. During use, the opening 22 allows at least a portion of an object, such as a breast, be inserted from a first side 28 of the transducer device 10 and exit from a second side 29 of the transducer device 10. For examples, the opening 22 can have a cross sectional dimension that is between 50 cm to 100 cm (e.g., for accommodating a body), or between 10 cm to 50 cm (e.g., for accommodating a breast, an arm, a leg, or a head). Although the arrangement of the transducer elements 12 is shown to have a closed ring-configuration, in other embodiments, the arrangement can have an opened ring-configuration or a partial ring configuration. Also, instead of arranging the transducer elements 12 in a slanted orientation to form a partial conical configuration, in other embodiments, the transducer elements 12 can be oriented in a partial tube configuration (FIG. 2). In the illustrated embodiments, the arrangement of the transducer elements 12 has a circular ring-like configuration. Alternatively, the arrangement of the transducer elements 12 can also have a variety of shapes, such as an elliptical ring-shape, a rectangular ring-shape, or other customized shapes (e.g., a conformal shape that will follow the body contour within a tolerance). In the illustrated embodiments, the structure 20 has a ring-like configuration, but alternatively, can also have other shapes, forms, and/or configurations so long as it is capable of providing a platform or area to which the transducer elements 12 can be secured. The structure 20 may be substantially rigid, semirigid, or substantially flexible, and can be made from a variety of materials, such as plastics, polymers, metals, and alloys. The structure 20 can be manufactured as a single unit, or alternatively, be assembled from a plurality of components that are parts of the transducer device 10. Electrodes and conducting wires (not shown) may also be provided in a known manner for coupling the transducer elements 12 to the driver 16. The electrodes for the transducer elements 12 are preferably housed within the structure 20, and exit from the structure 20 for coupling to the driver 16 and/or the controller 18.

[0013] The transducer elements 12 are coupled to the driver 16 and/or controller 18 for generating and/or controlling the acoustic energy emitted by the transducer elements 12. For example, the driver 16 may generate one or more electronic drive signals, which may be controlled by the controller 18. The transducer elements 12 convert the drive signals into acoustic energy 15, which may be focused using conventional methods. The controller 18 and/or driver 16 may be separate or integral components. It will be appreciated by one skilled in the art that the operations performed by the controller 18 and/or driver 16 may be performed by one or more controllers, processors, and/or other electronic components, including software and/or hardware components. The terms controller and control circuitry may be used herein interchangeably, and the terms driver and drive circuitry may be used herein interchangeably.

[0014] The driver 16, which may be an electrical oscillator, may generate drive signals in the ultrasound frequency spectrum, e.g., as low as twenty kilohertz (20KHz), and as high as ten Megahertz (10 MHz). Preferably, the driver 16 provides drive signals to the transducer elements 12 at radio frequencies (RF), for example, between about 100 Kilohertz to ten Megahertz (0.1-10 MHz), and more preferably between about two hundreds Kilohertz and three Megahertz (0.2 and 3.0 MHz), which corresponds to wavelengths in tissue of approximately 7.5 to 0.5 mm. However, in other embodiments, the driver 16 can also be configured to operate in other ranges of frequencies. When the drive signals are provided to the transducer elements 12, the transducer elements 12 emit acoustic energy 15 from its exposed surface, as is well known to those skilled in the art.

[0015] The controller 18 may control the amplitude, and therefore the intensity or power of the acoustic waves transmitted by the transducer elements 12. The controller 18 may also control a phase component of the drive signals to respective transducer elements 12 of the transducer device 10, e.g., to control a shape of a focal zone 38 generated by the transducer elements 12 and/or to move the focal zone 38 to a desired location. For example, as is well known to those skilled in the art, the location of the focus can be determined by adjusting the phases of the individual elements in such a way that constructive interference is generated at the desired location, provided the sizes of the individual elements are small enough to allow significant contribution to the energy at the focus at high steering angles and keep aberrations at an acceptable level.

[0016] As explained above, the transducer elements 12 convert the drive signals into acoustic energy, represented by energy beam 15. As the acoustic energy 15 passes through the patient's body, the acoustic energy 15 is absorbed in the tissue and converted to heat in the pass zone and at the focal zone within target region thereby raising the temperature of tissue within the target region. The tissue temperature rise depends on the intensity (energy/cm2) in situ. The acoustic energy 15 may be focused on the target region to raise the temperature of the tissue to coagulate the tissue while minimizing damage to surrounding healthy tissue. Exemplary apparatus for measuring and/or calibrating the energy output of a transducer device are described in U.S. Patent Application Publication Number 2003-0105398-A1.

[0017] In the illustrated embodiments, each of the transducer elements 12 may be a one-piece piezoceramic part, or alternatively, be composed of a mosaic arrangement of a plurality of small piezoceramic elements (e.g., phased array). The piezoceramic parts or the piezoceramic elements may have a variety of geometric shapes, such as hexagons, triangles, squares, and the like.

[0018] The transducer elements 12 can be individually controlled to change, e.g., a respective phase and/or amplitude of the respective acoustic waves in order to create a desired focal zone. If the transducer elements 12 include a plurality of piezoceramic elements, each of the piezoceramic elements may be coupled to a respective timing or delay element. The timing or delay elements may be implemented as a part of the ultrasound transducer device 10, the driver 16, or the controller 18.

[0019] In the illustrated embodiments, the transducer elements 12 are arranged in a formation about a circumference of the opening 22, and each transducer element 12 has a surface 24 that forms an angle 26 with a plane 23 in which the structure 20 approximately lies. In the example shown in FIG. 1, the angle 26 is approximately 300, but can also be other angles, such as 60° or 90° (FIG. 2), in other embodiments. Also, in the illustrated embodiments, the transducer elements 12 are fixedly secured to the structure 20 such that the angle 26 does not vary during use. In other embodiments, the transducer elements 12 can be rotatably secured to the structure 20 such that the angle 26 can be adjusted during use. In such cases, the transducer device 10 further includes a positioner for moving the transducer elements 12. The positioner can, for examples, include a motor, such as an electric motor or a piezoelectric motor, a hydraulic, or a gimbal system, for changing the angle 26. In some embodiments, the structure 20 can include a plurality of movable sections to which one or more of the transducer elements 12 are secured. In such cases, the movable sections are installed on respective gimbals, and the transducer elements 12 are movable by operation of the gimbals. Also, in other embodiments, instead of positioning the transducer elements 12 in one degree of freedom, the transducer elements 12 can configured to move in multiple degree of freedoms (e.g., two or up to six degree of freedoms relative to the opening 26).

[0020] In the illustrated embodiments, the transducer device 10 includes a single row (ring) of transducer elements 12. However, the scope of the invention should not be so limited. In alternative embodiments, the transducer device 10 can include a plurality of rows (e.g., adjacent rings) of transducer elements 12 (FIG. 1B). As shown in FIG. 1B, the transducer device 10 has four rows/rings of transducer elements 12, with each ring having twenty-nine transducer elements 12 for focusing and steering the beam. In some embodiments, the opening has a 10 cm cross sectional dimension, and the number of transducer elements 12 per ring could be 300 to 700. It should be noted that the number of rows (rings) of transducer elements 12, and the number of transducer elements 12 per row should not be limited to that shown in the example, and that in alternative embodiments, the transducer device 10 can have other numbers of rows and other numbers of transducer elements per row.

[0021] In the illustrated embodiments, the transducer elements 12 of the transducer device 10 substantially abut against adjacent transducer elements 12 such that the transducer elements 12 collectively define a substantially complete opening. In other embodiments, the transducer elements 12 can be spaced apart from adjacent transducer elements 12 to partially define the opening 22 (FIG. 3). Such configuration may be beneficial because, while it still allows acoustic energy from different angles to converge, it reduces the number of transducer elements 12, thereby reducing cost. Also, the spacing between adjacent transducer elements 12 can be used to house mechanical and/or electrical components of the transducer device 10. In the illustrated embodiments, the transducer device 10 further includes a guide rail 100 to which the transducer elements 12 are slidably coupled. Such configuration allows the positions of the transducer elements 12 about the perimeter of the opening 22 be adjusted by sliding the transducer elements 12 along the guide rail 100. The transducer elements 12 can also be movably coupled to the structure 20 using other mechanical joints, connections, and configurations. In other embodiments, the transducer elements 12 are fixedly secured to the structure 20, in which cases, the transducer device 10 does not include the guide rail 100 or similar mechanisms.

[0022] Also, in other embodiments, the transducer elements 12 can be so positioned such that each of the transducer elements 12 does not face another transducer elements 12 (FIG. 4). As shown in FIG. 4, the transducer device 10 includes three transducer elements 12a-12c, with each transducer element 12 having a surface 24 that forms approximately a 90° angle 26 with the plane 23. Alternatively, the angle 26 can be different from 90°. Although three transducer elements 12 are shown, in other embodiments, the transducer device 10 can have more or less than three transducer elements 12. In the illustrated embodiments, the transducer elements 12a-12c do not face each other, thereby allowing beam emerging from respective surfaces 24 of the transducer elements 12 to pass through the spacing between the transducer elements 12. Such configuration has the advantage of preventing emerging beam from one transducer element from damaging another (e.g., opposing) transducer element. Such configuration also prevents beam emitted by one transducer element from being reflected by another transducer element. Also, in the illustrated embodiments, the structure 10 includes a plurality of openings 200 that allow beams emitted by the transducer elements 12 to exit, thereby preventing the beams from being reflected by the structure 10. Although the openings 200 are each shown to have a shape that resembles a rectangle, in other embodiments, the openings 200 can have other shapes. Also, in other embodiments, the transducer elements 12a-c are oriented at an angle (such as that similarly shown in FIG. 1), in which cases, the openings 200 can provide a similar advantage as that discussed previously.

[0023] Any embodiments of the transducer device described herein can further include a coupling membrane. FIG. 5 illustrates a transducer device 400 in accordance with other embodiments of the invention. The transducer device 400 is similar to the transducer device 10 of FIG. 1 except that it further includes a coupling membrane 402. The coupling membrane 402 can be, for examples, an inflatable body or a balloon. The coupling membrane 402 has an opening (not shown) adapted for receiving a medium for inflation of the membrane 402. After the coupling membrane 402 is inflated by the medium, it may be used to press against a surface of an object for acoustic coupling. The medium may be a liquid acoustic propagation medium for propagating or transmitting generated ultrasound from the transducer elements 12. The coupling membrane 402 and the medium preferably exhibit an acoustic impedance that essentially corresponds to that of body tissue. For example, the coupling membrane 402 is preferably made from a polymer or a rubber, and degassed water is preferably used as the medium. During use, the coupling membrane 402 provides or improves an acoustic coupling between the transducer elements 12 and an object, such as a skin of a patient, while focused ultrasound energy is being delivered. In some embodiments, a cool medium can be used to inflate and/or circulate within the coupling membrane 402, thereby preventing excessive heat from being created at an interface between the coupling membrane 402 and a patient's skin, or by the transducer.

[0024] For purposes of demonstrating the forms and functionality of embodiments of the invention, various uses will now be described. Referring to FIG. 6, a method of using the system 5 to treat tissue within a breast 500 is illustrated. First, a coupling gel is applied on a breast skin 502. If the transducer device 10 includes the coupling membrane 402, the coupling membrane 402 is then inflated with a medium, such as degassed water. Next, the breast 500 is at least partially inserted into the opening 22 such that the transducer elements 12 at least partially circumscribe a portion of the breast 500. In the illustrated embodiments, the transducer device 10 is secured to a patient support (not shown) having an opening. The patient support supports the patient in a face-down position, while the opening of the patient support allows the patient's breast 500 to exit and be placed on the transducer device 10. In other embodiments, the transducer device 10 can be secured to a frame in an upright position such that the patient's breast 500 can be placed onto the transducer device 10 while the patient is in his/her upright position. The transducer device 10 can also be implemented as a hand-held instrument, thereby allowing a physician to place the transducer device 10 onto the patient.

[0025] If the transducer elements 12 are movable relative to the structure 20, the position and/or the orientation of the transducer elements 12 can be adjusted. After the transducer elements 12 have been desirably positioned relative to the breast 500, the transducer device 10 then delivers focused ultrasound energy to target tissue within the breast 500. As can be appreciated by those skilled in the art, delivering focused ultrasound energy from a wide angle (e.g., from different positions around the breast 500) increases the surface area of the breast skin 502 through which beam energy from the transducer elements 12 is passing. This, in turn, prevents, or at least reduces the risk of, excessive energy density at a patient's skin and tissue, thereby preventing injury to the patient's skin or non targeted tissue. Also, because beam energy is being delivered from the transducer elements 12 in a direction that is not directly towards a rib cage (e.g., beam energy is delivered in a direction approximately parallel to the rib cage), heating of the rib cage is prevented or at least reduced.

[0026] During the procedure, the driver 16 and/or the controller 18 may be used to generate and/or to control the acoustic energy emitted by the transducer device 10. For example, the driver 16 and/or the controller 18 can control a phase of the transducer elements 12 to thereby adjust a position of the focal zone 38 and/or to change a shape of the focal zone 38 during use. If the transducer device 10 includes the positioner for moving the transducer elements 12, the driver 16 and/or the controller 18 can be used to control the positioner to thereby adjust the position and/or shape of the focal zone. In some embodiments, the driver 16 and/or the controller 18 can cause the transducer elements 12 to deliver beam(s) for creating multiple focal zones 38, thereby allowing treatment of multiple target region simultaneously.

[0027] Also, in some embodiments, a feedback mechanism is provided to measure one or more of a size, shape, location, and intensity of the focal zone 38. For example, MRI simultaneous thermal imaging can be used to thermally map the focal zones. The measured size, shape, location, or density is then compared (e.g., by human operator or a processor, such as that described in U.S. Patent No. 6,618,620) with a desired size, shape, location, or intensity, respectively, of the focal zone 38. Based on the comparison, the phase and/or amplitude of the drive signals is changed to adjust a size, shape, location, and/or intensity of the focal zone 38. A position of one or more of the transducer elements 12 can also be changed in response to a result of the comparison. After a desired amount of ultrasound energy has been delivered, the breast 500 is then removed from the transducer device 10, or vice versa.

[0028] For further examples, the transducer device can be used to treat tissue within an arm (FIG. 7), within a body (FIG. 8), or within a head (FIG. 9) of a patient. As shown in FIGS. 7-9, delivering focused ultrasound energy from a wide angle (e.g., from different positions around the arm, the body, or the head) increases the surface area of the skin to which beam energy from the transducer elements is directed, and decreases energy density in the tissue pass zone. This, in turn, prevents, or at least reduces the risk of, excessive energy density at a patient's skin, at internal sensitive organs, or at bony surfaces, at the far field, thereby preventing injury to the patient's skin or internal non targeted organs. Any of the ultrasound devices described herein may also be used to treat tissues at other parts of a body, such as bone tissue, muscle tissue, tissue within a neck, or brain tissue. Besides treating tissue, the same ultrasound device may also be used to deliver diagnostic ultrasound for imaging tissue.

[0029] Further, in other embodiments, any of the transducer devices described herein can be coupled to a positioner for controlling a position of the transducer device relative to a patient. For example, the transducer device 10 of FIG. 8 can be positioned by a positioner to move along a length of the arm to treat different tissue, including bone tissue, along the arm. Similarly, the transducer devices 10 of FIGS. 8 and 9 can be positioned along the body and the head, respectively, to treat different tissue, or the beam could be steered electronically using transducer elements phase control.

Claims

1. A focused ultrasound system (5) configured for treatment of a body part, comprising:

   an ultrasound transducer device (10) having a ring configuration and forming an opening (22) sized to allow a portion of the body to pass through and exit the opening (22), the ultrasound device (10) having a plurality of transducer elements (12) disposed on an inner surface of the ring and arranged about a circumference of the opening (22); and
   a controller (18) for operating the transducer elements (12) to focus ultrasound waves transmitted by the transducer elements (12),
   characterized in that each of the ultrasound transducer elements (12) is configured so as to not face other transducer elements (12) to prevent the transmitted ultrasound waves from damaging an opposed transducer element during operation.

2. The system of claim 1, **characterized in that** the opening (22) has a cross sectional dimension between 10 cm and 100 cm.

3. The system of claim 1, **characterized in that** the opening (22) has a cross sectional dimension that allows at least a part of an object to be accommodated therein.

4. The system of claim 3, **characterized in that** the object is selected from the group consisting of a breast, an arm, a leg, a body, and a head.

5. The system of claim 1, **characterized in that** each one of the plurality of the transducer elements (12) abuts against another one of the plurality of the transducer elements (12).

6. The system of claim 1, **characterized in that** each one of the plurality of the transducer elements (12) is spaced from other ones of the plurality of transducer elements (12).

7. The system of claim 1, **characterized in that** the opening (22) has a shape that is approximately circular.

8. The system of claim 1, **characterized in that** the opening (22) has a shape, at least a portion of the shape having a contour that resembles a part of a body contour.

9. The system of claim 1, **characterized in** further comprising a positioner for positioning one or more of the plurality of the transducer elements (12) relative to

another one or more of the plurality of transducer elements (12).

10. The system of claim 9, **characterized in that** the positioner comprises a gimbal system.

11. The system of claim 9, **characterized in that** the positioner comprises a piezoelectric motor.

12. The system of claim 1, **characterized in that** the controller (18) controls phases of the plurality of transducer elements (12).

13. The system of claim 1, **characterized in** further comprising a coupling membrane (402) coupled to the ultrasound transducer device (10).

14. The system of claim 1, **characterized in that** the transducer elements (12) are arranged in a plurality of rows.

15. The system of claim 1, **characterized in that** the transducer focuses the ultrasound waves at a location (38) axially displaced from the opening (22).

16. The system of claim 1, **characterized in that** the transducer elements (12) are arranged in a slanted orientation to form a partial conical configuration.

17. The system of claim 1, **characterized in that** the ultrasound transducer device (10) comprises openings (200) opposite the transducer elements (12).

18. The system of claim 1, **characterized in that** the transducer elements are slidably coupled to a guide rail (100) along a perimeter of the opening (22) of the ring configuration.

Patentansprüche

1. Ultraschallfokussiersystem (5), das zur Behandlung eines Körperteils ausgelegt ist und umfasst:

eine Ultraschallwandlervorrichtung (10), die eine Ringform aufweist und eine Öffnung (22) bildet, die so bemessen ist, dass sie es einem Teil des Körpers ermöglicht, durch die Öffnung (22) durch- und daraus auszutreten, wobei die Ultraschallvorrichtung (10) eine Mehrzahl von Wandlerelementen (12) aufweist,
die auf einer Innenfläche des Rings eingerichtet und um einen Umfang der Öffnung (22) angeordnet sind; und
eine Steuerung (18) zum Betreiben der Wandlerelemente (12), um durch die Wandlerelemente (12) gesendete Ultraschallwellen zu fokussieren,

dadurch gekennzeichnet, dass jedes der Ultraschallwandlerelemente (12) so ausgelegt ist, dass es keinen anderen Wandlerelementen (12) gegenüberliegt, um zu verhindern, dass die gesendeten Ultraschallwellen während des Betriebs ein gegenüberliegendes Wandlerelement beschädigen.

2. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Öffnung (22) ein Querschnittsmaß von 10 cm bis 100 cm aufweist.

3. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Öffnung (22) ein Querschnittsmaß aufweist, dass es wenigstens einem Teil eines Objekts ermöglicht, darin untergebracht zu werden.

4. System nach Anspruch 3, **dadurch gekennzeichnet, dass** das Objekt aus der Gruppe bestehend aus einer Brust, einem Arm, einem Bein, einem Körper und einem Kopf ausgewählt ist.

5. System nach Anspruch 1, **dadurch gekennzeichnet, dass** jedes der Mehrzahl der Wandlerelemente (12) an einem anderen der Mehrzahl der Wandlerelemente (12) anliegt.

6. System nach Anspruch 1, **dadurch gekennzeichnet, dass** jedes der Mehrzahl der Wandlerelemente (12) von anderen der Mehrzahl von Wandlerelementen (12) beabstandet ist.

7. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Öffnung (22) eine Form aufweist, die ungefähr kreisförmig ist.

8. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Öffnung (22) eine Form aufweist, wobei wenigstens ein Teil der Form eine Kontur aufweist, die einem Teil einer Körperkontur ähnelt.

9. System nach Anspruch 1, **dadurch gekennzeichnet, dass** es ferner eine Positioniervorrichtung zum Positionieren eines oder mehrerer der Mehrzahl der Wandlerelemente (12) in Bezug auf ein anderes oder mehrere andere der Mehrzahl von Wandlerelementen (12) umfasst.

10. System nach Anspruch 9, **dadurch gekennzeichnet, dass** die Positioniervorrichtung ein Tragrahmensystem umfasst.

11. System nach Anspruch 9, **dadurch gekennzeichnet, dass** die Positioniervorrichtung einen piezoelektrischen Motor umfasst.

12. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Steuerung (18) Phasen der Mehrzahl von Wandlerelementen (12) steuert.

13. System nach Anspruch 1, **dadurch gekennzeichnet, dass** es ferner eine Kopplungsmembran (402) umfasst, die mit der Ultraschallwandlervorrichtung (10) gekoppelt ist.

14. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Wandlerelemente (12) in einer Mehrzahl von Reihen angeordnet sind.

15. System nach Anspruch 1, **dadurch gekennzeichnet, dass** der Wandler die Ultraschallwellen an einer Stelle (38) fokussiert, die von der Öffnung (22) axial versetzt ist.

16. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Wandlerelemente (12) in einer geneigten Ausrichtung angeordnet sind, um eine Teilkegelform zu bilden.

17. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Ultraschallwandlervorrichtung (10) Öffnungen (200) gegenüber den Wandlerelementen (12) umfasst.

18. System nach Anspruch 1, **dadurch gekennzeichnet, dass** die Wandlerelemente entlang eines Umfangs der Öffnung (22) der Ringform verschiebbar an eine Führungsschiene (100) gekoppelt sind.

Revendications

1. Système à ultrasons focalisés (5) configuré pour le traitement d'une partie du corps, comprenant :

un dispositif transducteur à ultrasons (10) ayant une configuration en anneau et formant une ouverture (22) dimensionnée pour permettre à une partie du corps de traverser l'ouverture (22) et de sortir de celle-ci, le dispositif à ultrasons (10) comportant une pluralité d'éléments transducteurs (12) disposés sur une surface interne de l'anneau et disposés autour d'une circonférence de l'ouverture (22) ; et
un contrôleur (18) pour amener les éléments transducteurs (12) à focaliser les ondes ultrasonores transmises par les éléments transducteurs (12),
caractérisé en ce que chacun des éléments transducteurs à ultrasons (12) est configuré de manière à ne pas faire face à d'autres éléments transducteurs (12) pour empêcher les ondes ultrasonores transmises d'endommager un élément transducteur opposé au cours du fonctionnement.

2. Système selon la revendication 1, **caractérisé en ce que** l'ouverture (22) a une dimension en section transversale entre 10 cm et 100 cm.

3. Système selon la revendication 1, **caractérisé en ce que** l'ouverture (22) a une dimension en section transversale qui permet à au moins une partie d'un objet d'être logée à l'intérieur.

4. Système selon la revendication 3, **caractérisé en ce que** l'objet est choisi dans le groupe constitué d'un sein, d'un bras, d'une jambe, d'un corps et d'une tête.

5. Système selon la revendication 1, **caractérisé en ce que** chacun de la pluralité des éléments transducteurs (12) vient en butée contre un autre de la pluralité des éléments transducteurs (12).

6. Système selon la revendication 1, **caractérisé en ce que** chacun de la pluralité des éléments transducteurs (12) est espacé par rapport aux autres éléments de la pluralité d'éléments transducteurs (12).

7. Système selon la revendication 1, **caractérisé en ce que** l'ouverture (22) a une forme qui est approximativement circulaire.

8. Système selon la revendication 1, **caractérisé en ce que** l'ouverture (22) présente une forme, au moins une partie de la forme ayant un contour qui ressemble à une partie d'un contour du corps.

9. Système selon la revendication 1, **caractérisé en ce qu'**il comprend en outre un positionneur destiné au positionnement d'un ou plusieurs de la pluralité d'éléments transducteurs (12) par rapport à un ou plusieurs autre(s) de la pluralité d'éléments transducteurs (12).

10. Système selon la revendication 9, **caractérisé en ce que** le positionneur comprend un système de cardans.

11. Système selon la revendication 9, **caractérisé en ce que** le positionneur comprend un moteur piézoélectrique.

12. Système selon la revendication 1, **caractérisé en ce que** le contrôleur (18) contrôle les phases de la pluralité d'éléments transducteurs (12).

13. Système selon la revendication 1, **caractérisé en ce qu'**il comprend en outre une membrane de couplage (402) couplée au dispositif transducteur à ultrasons (10).

14. Système selon la revendication 1, **caractérisé en**

ce que les éléments transducteurs (12) sont agencés en une pluralité de rangs.

15. Système selon la revendication 1, **caractérisé en ce que** le transducteur focalise les ondes ultrasonores au niveau d'un emplacement (38) décalé axialement par rapport à l'ouverture (22).

16. Système selon la revendication 1, **caractérisé en ce que** les éléments transducteurs (12) sont agencés selon une orientation oblique pour former une configuration conique partielle.

17. Système selon la revendication 1, **caractérisé en ce que** le dispositif transducteur à ultrasons (10) comprend des ouvertures (200) opposées aux éléments transducteurs (12).

18. Système selon la revendication 1, **caractérisé en ce que** les éléments transducteurs sont couplés de façon coulissante à un rail de guidage (100) le long d'un périmètre de l'ouverture (22) de la configuration en anneau.

FIG. 1A

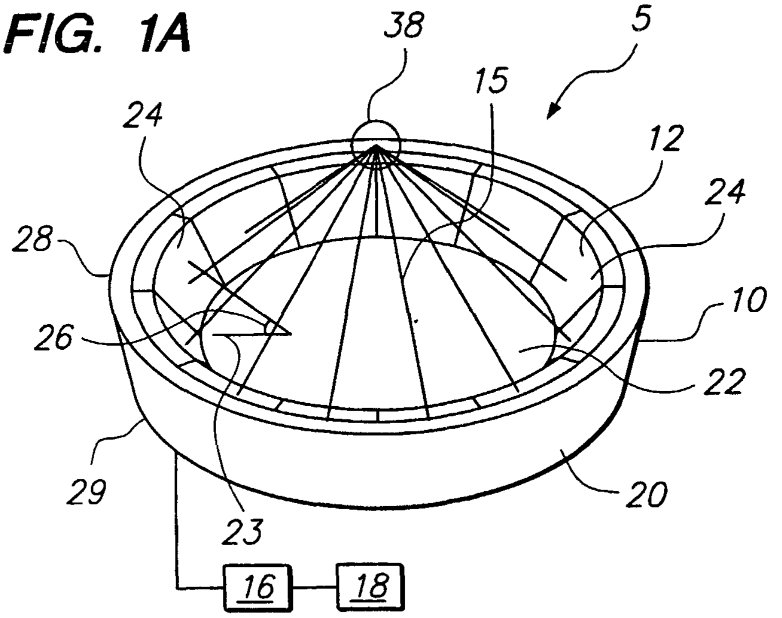


FIG. 1B

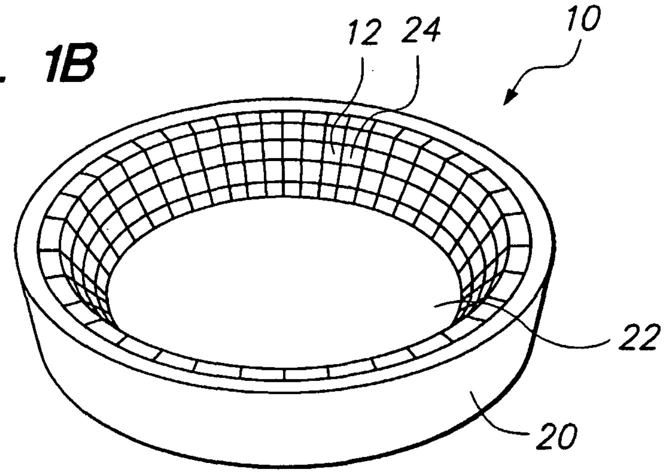


FIG. 2

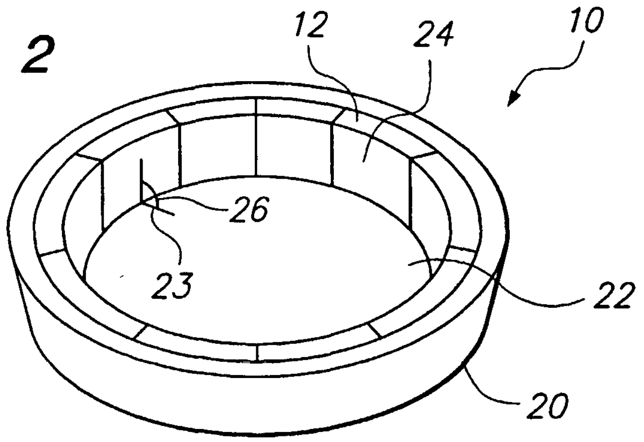


FIG. 3

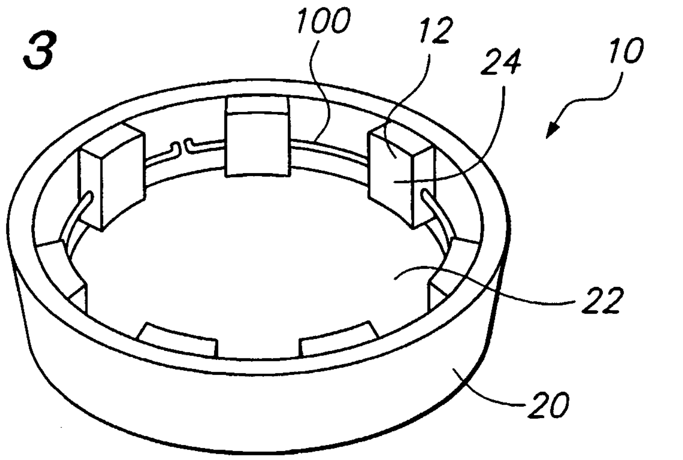


FIG. 4

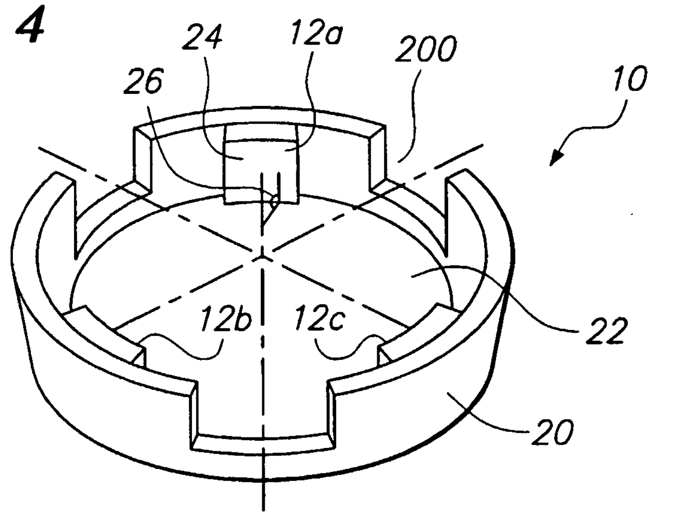


FIG. 5

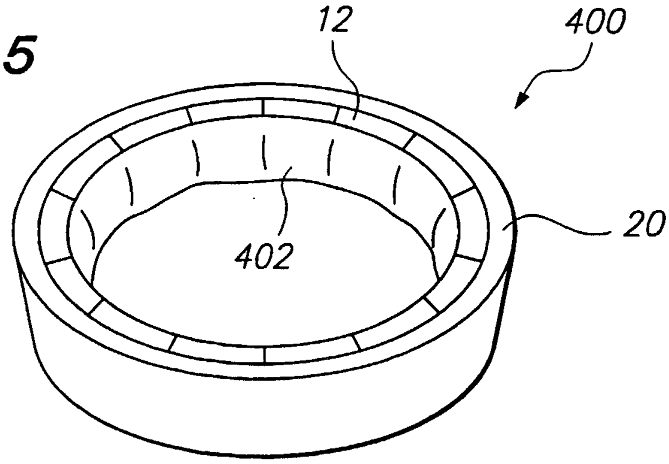


FIG. 6

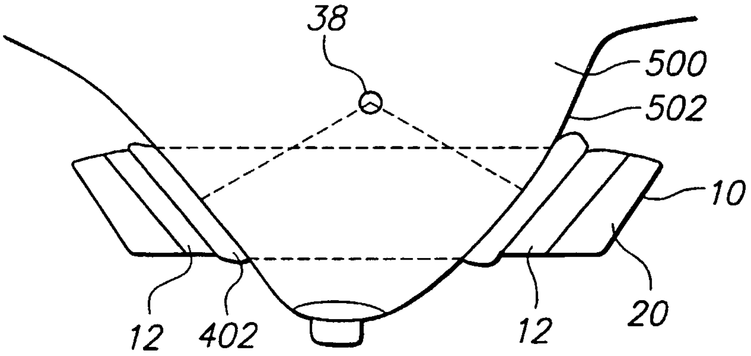


FIG. 7

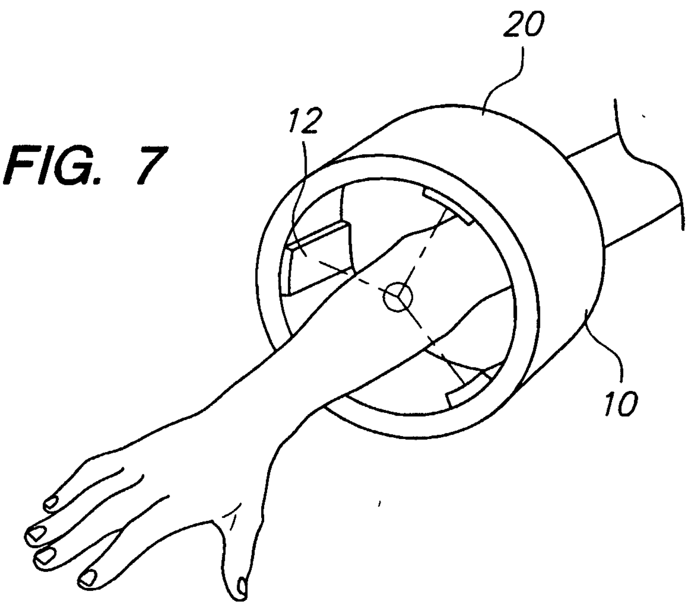


FIG. 9

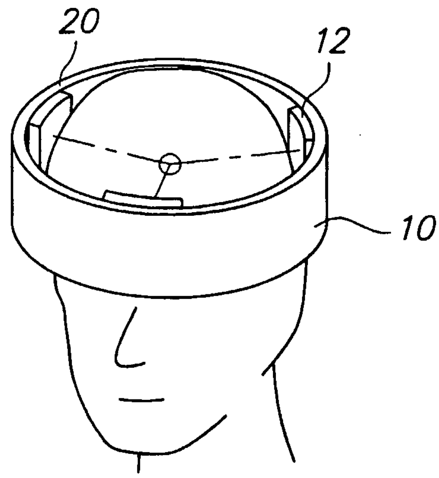
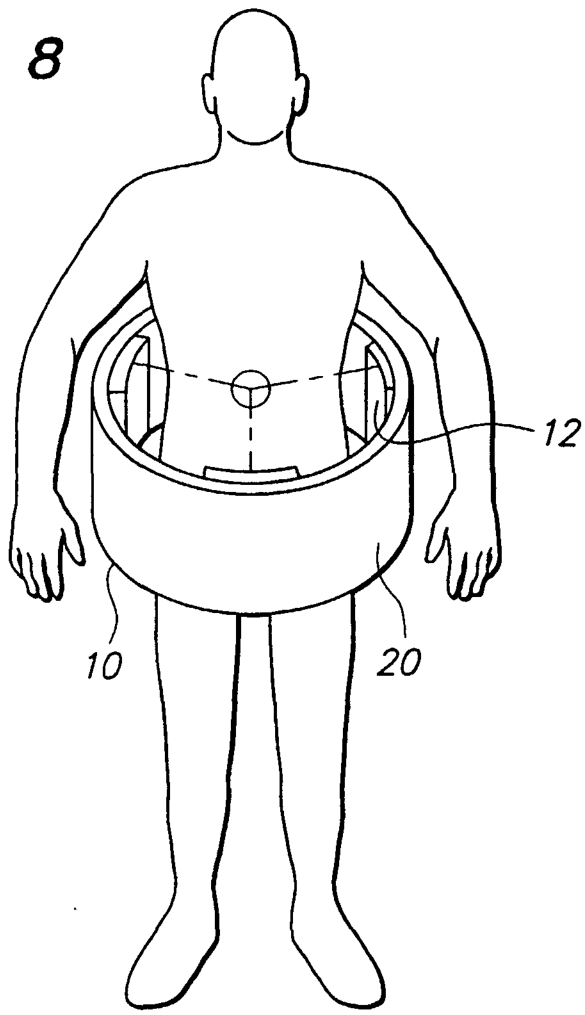


FIG. 8



REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	用于围绕身体组织块的聚焦超声系统		
公开(公告)号	EP1796545B1	公开(公告)日	2014-10-01
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申请(专利权)人(译)	InSightec的，图像引导治疗.，LTD.		
当前申请(专利权)人(译)	InSightec的有限公司.		
[标]发明人	VITEK SHUKI VORTMAN KOBI		
发明人	VITEK, SHUKI VORTMAN, KOBI		
IPC分类号	A61B8/00 A61N7/00 A61B18/12		
CPC分类号	A61B8/4281 A61B8/0808 A61B8/0825 A61B8/4483 A61B8/4494 A61N7/02 A61N2007/0078 B06B1/0633		
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优先权	10/927772 2004-08-26 US		
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外部链接	Espacenet		

摘要(译)

聚焦超声系统包括形成开口的超声换能器装置，并且具有至少部分地围绕开口定位的多个换能器元件。聚焦超声系统包括具有用于允许物体插入的第一端和用于允许物体离开的第二端的结构，以及耦合到该结构的多个换能器元件，换能器元件相对于彼此定位在至少部分地限定开口的构造，其中换能器元件配置成发射在聚焦区域会聚的声能。