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(54) ULTRASOUND EMITTING DEVICE COMPRISING A HEAD FRAME

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(52) **U.S. Cl.** **600/437**

(57) **ABSTRACT**

An ultrasound emitting device is disclosed. The ultrasound emitting device includes a sound head matrix comprising a first planar member, and a second planar member, wherein the first planar member is attached to the second planar member to form a V-shaped assembly comprising a first interior dihedral angle, where that first interior dihedral angle is between about 155 degrees and about 175 degrees. The ultrasound emitting device further comprises a first plurality of ultrasound transducers disposed on the first planar member, and a second plurality of ultrasound transducers disposed on the second planar member.

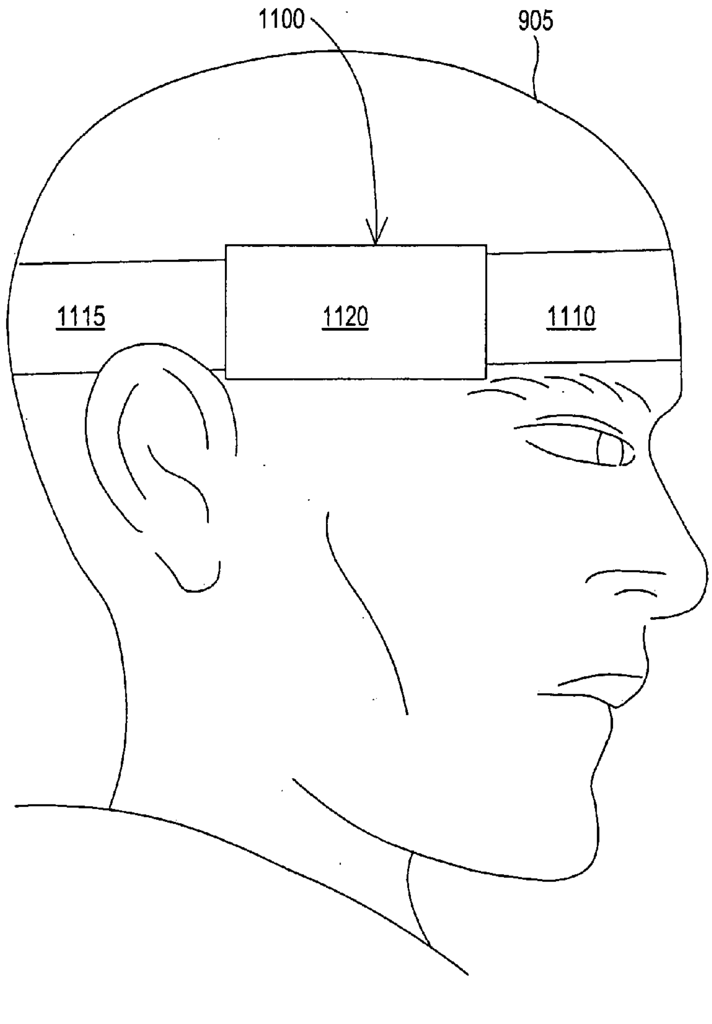

FIG. 1A

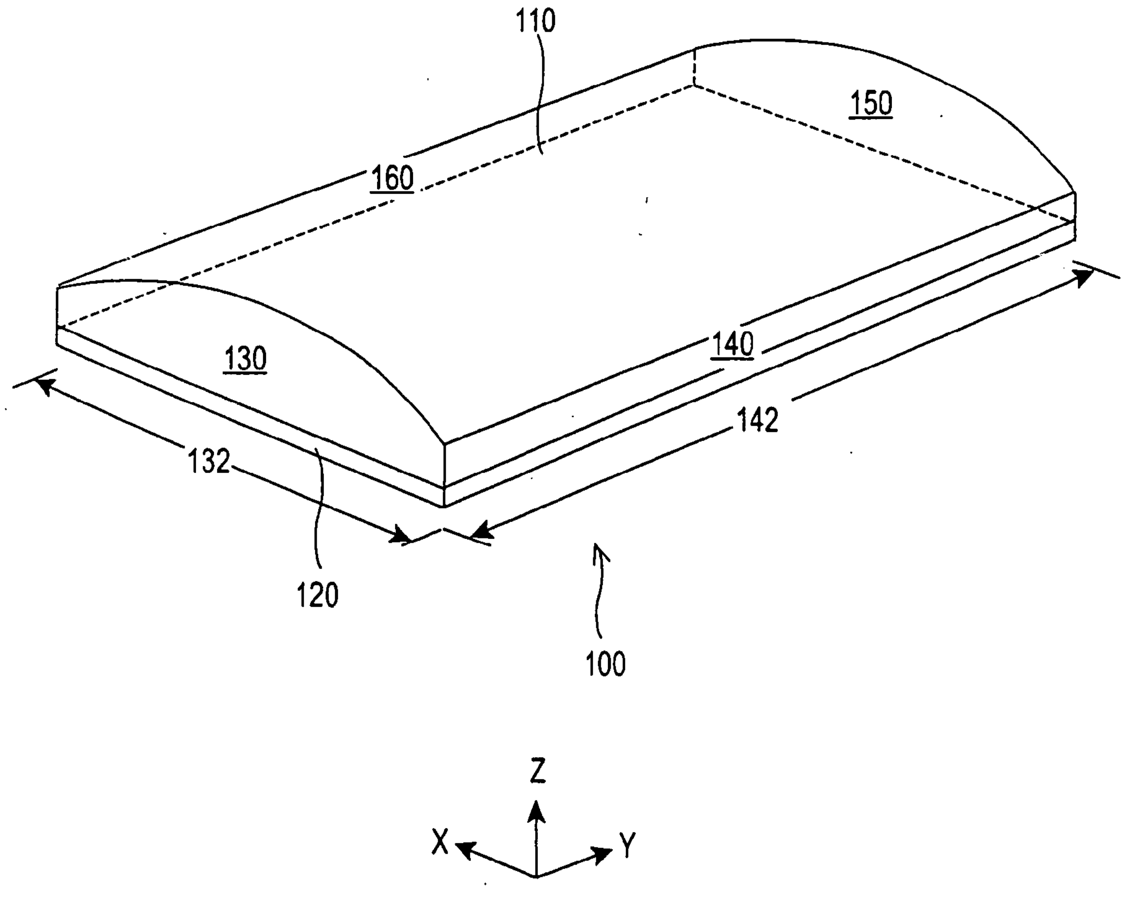

FIG. 1B

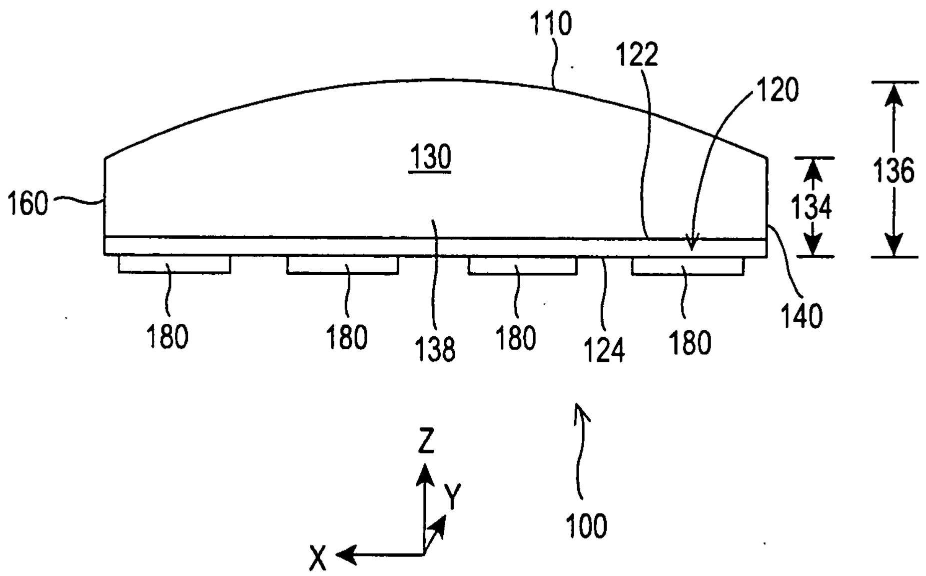

FIG. 1C

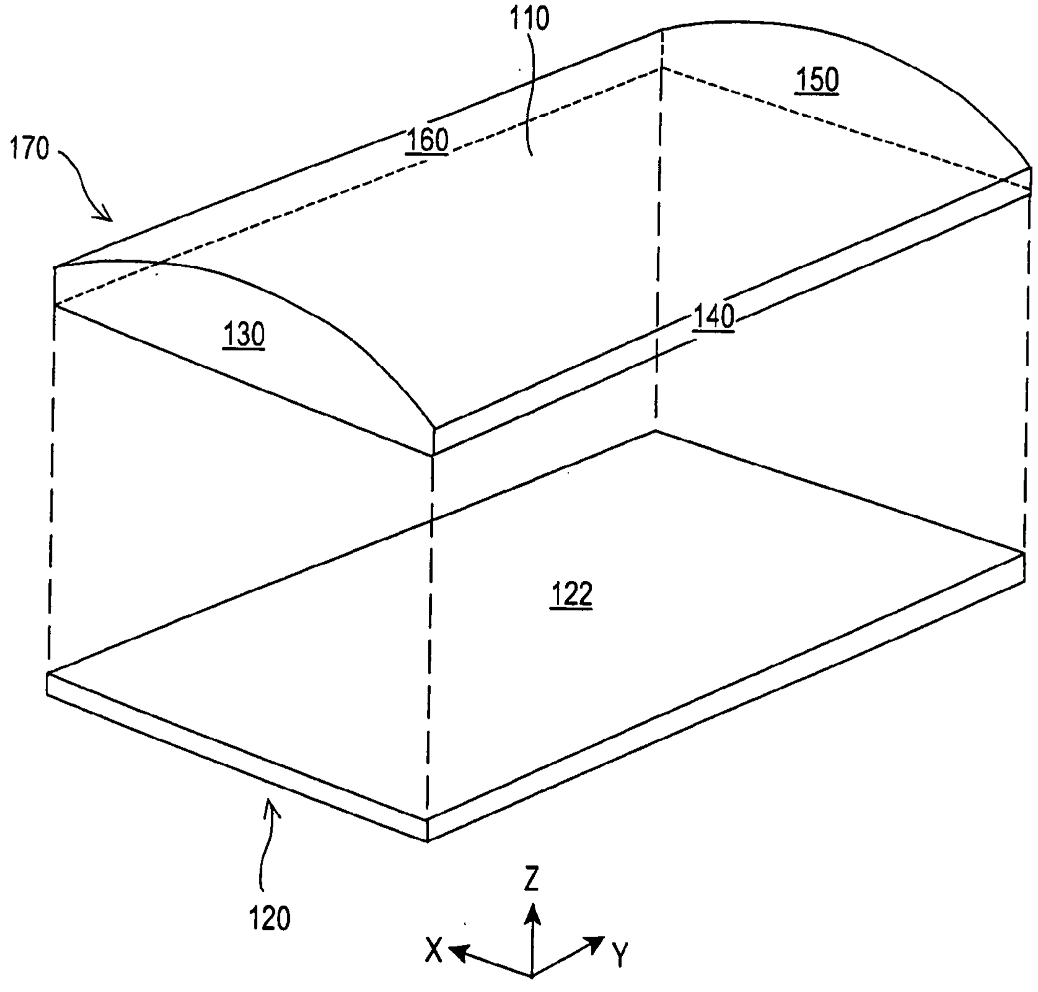

FIG. 2A

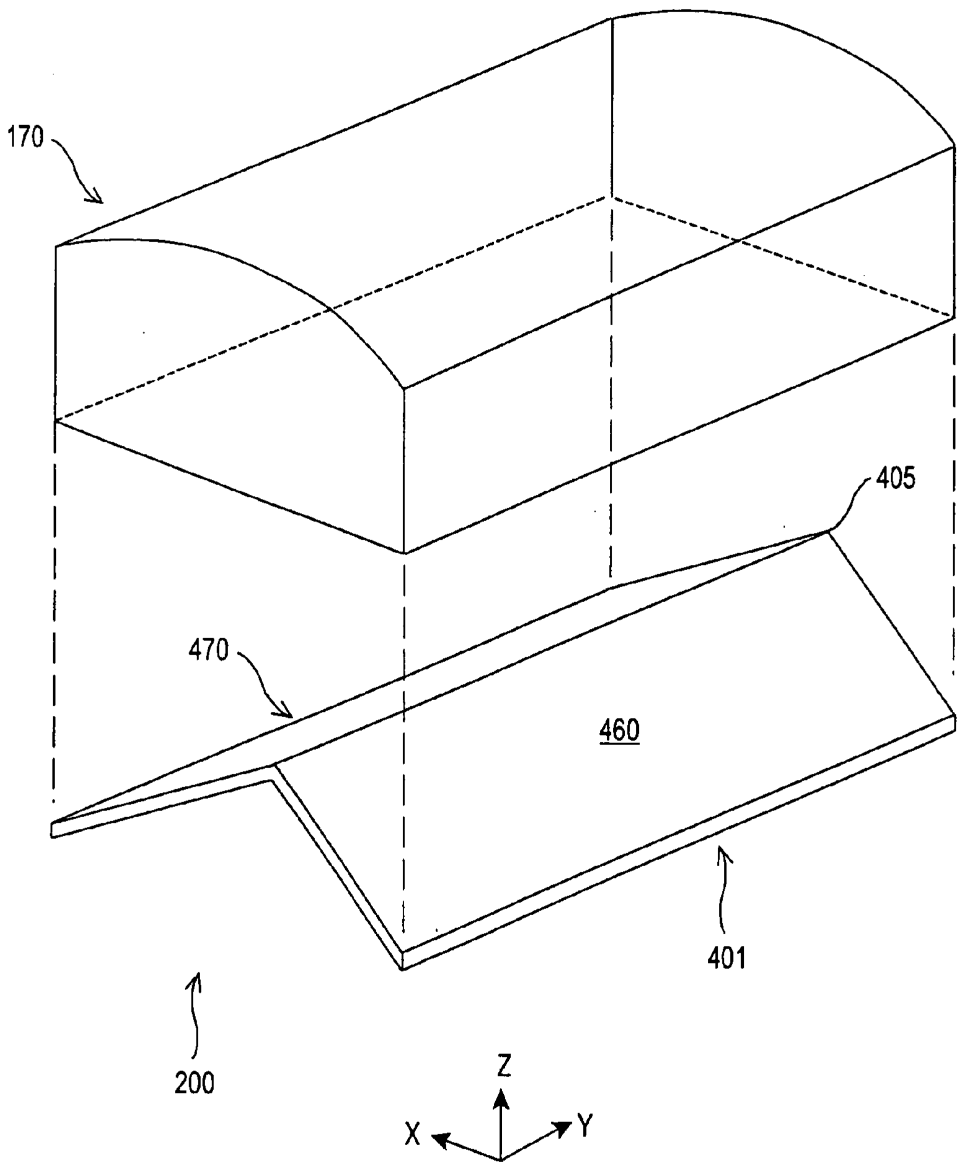

FIG. 2B

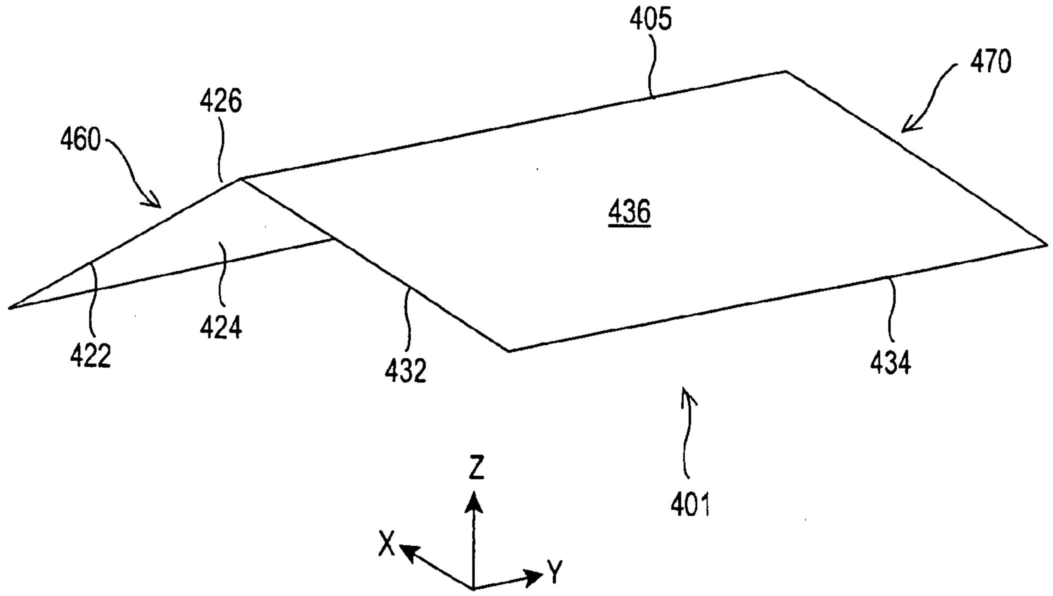

FIG. 2C

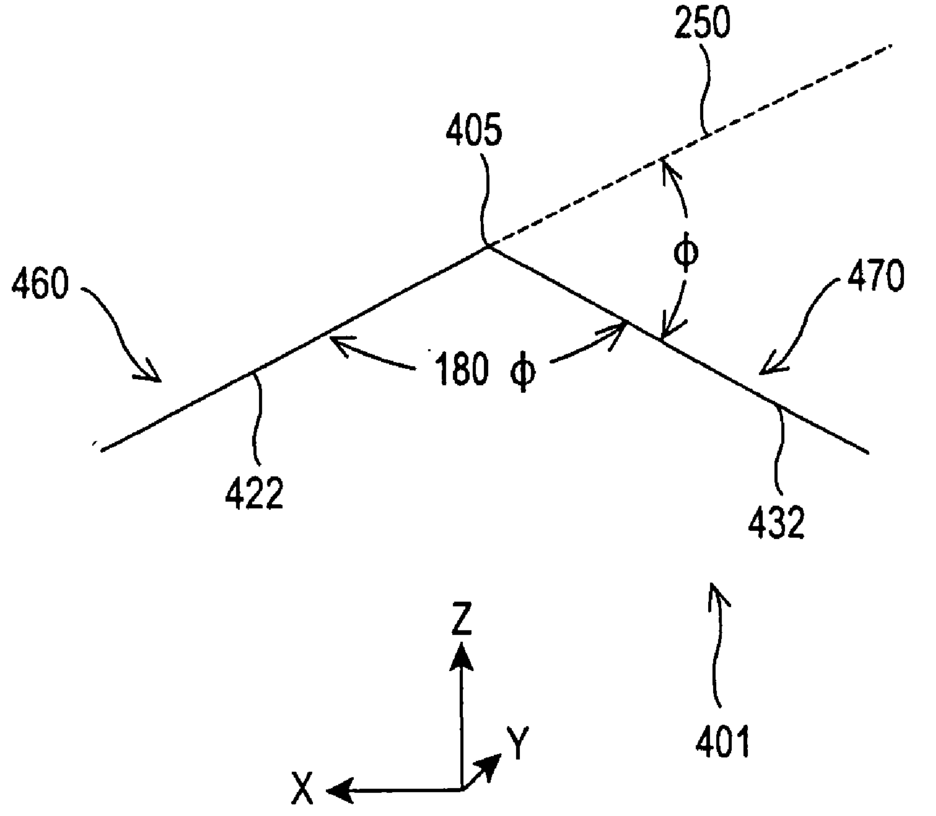

FIG. 3A

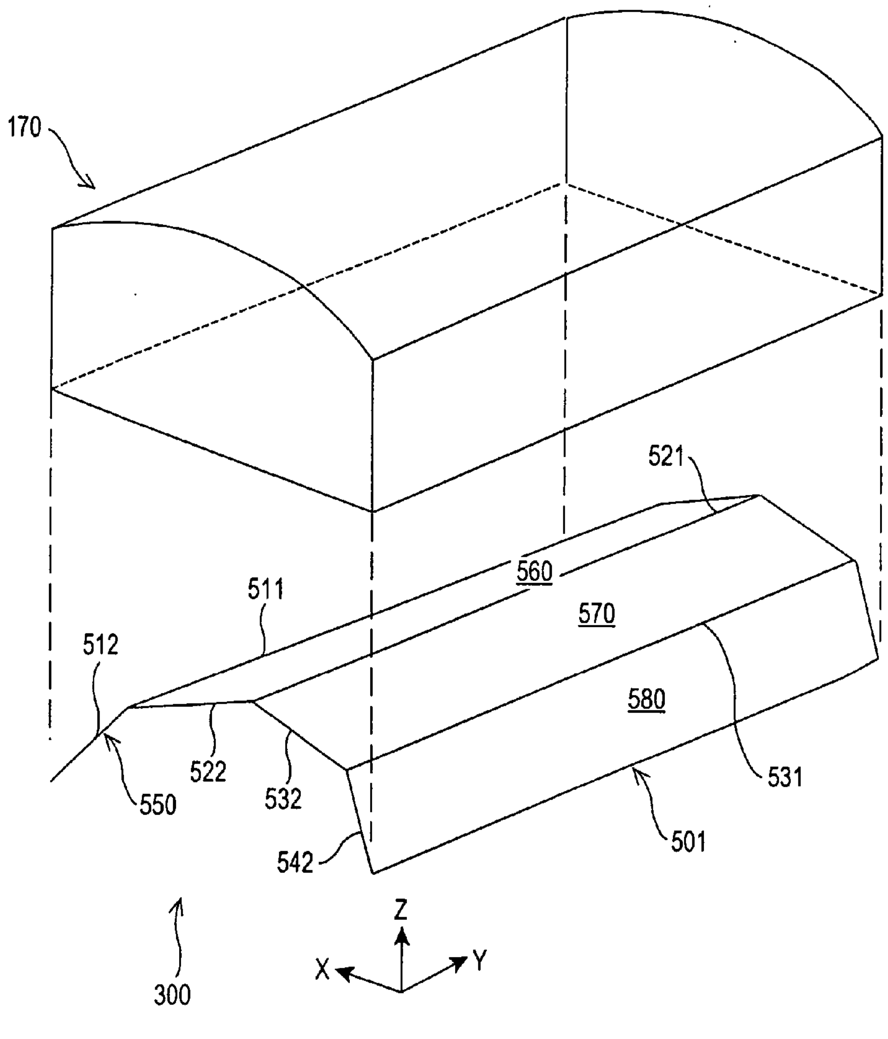

FIG. 3B

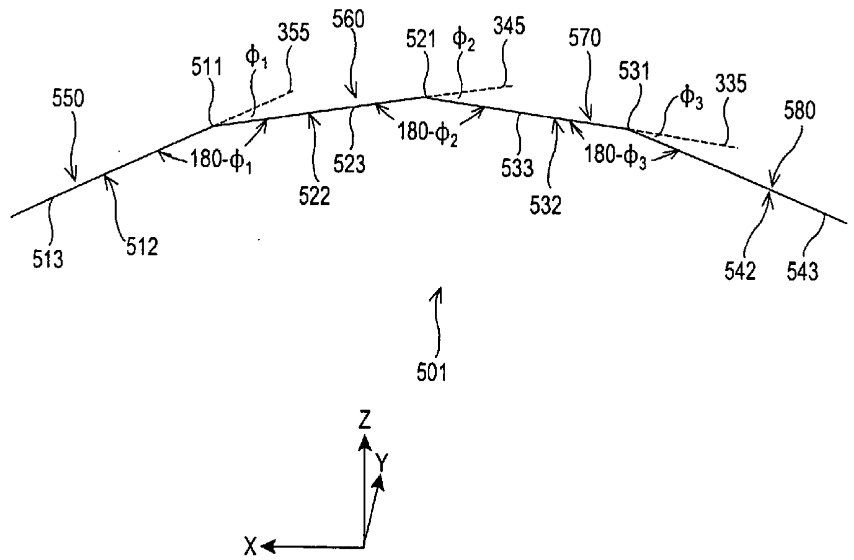
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FIG. 4A

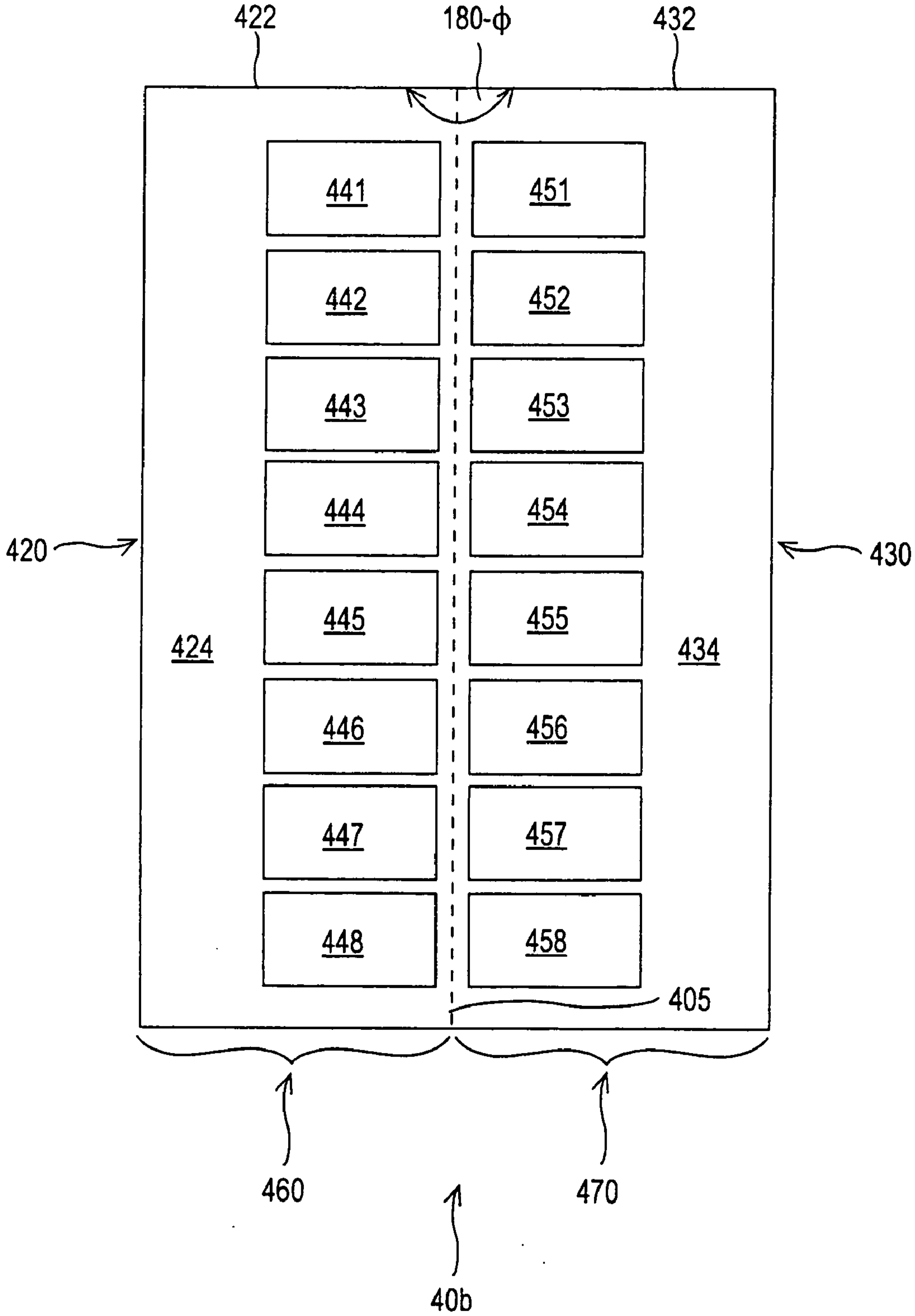

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FIG. 4B

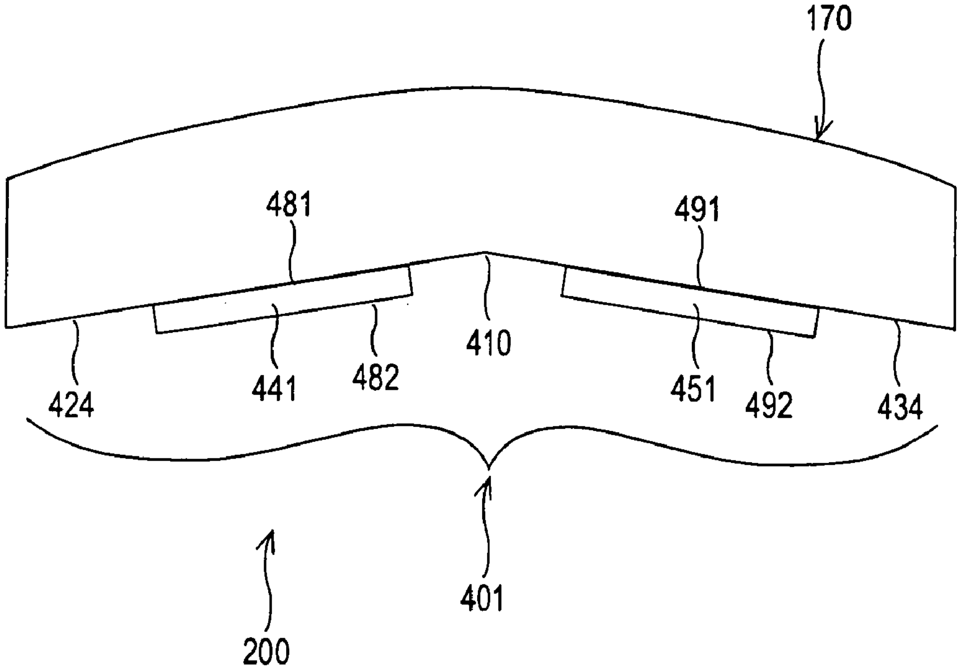
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FIG. 4C

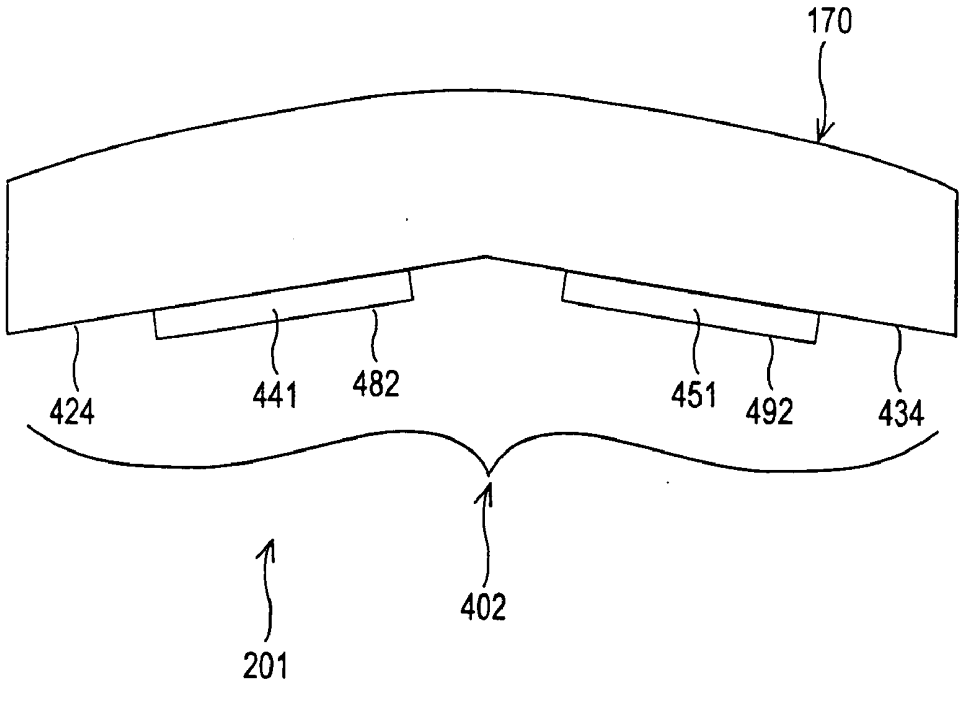
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FIG. 5A

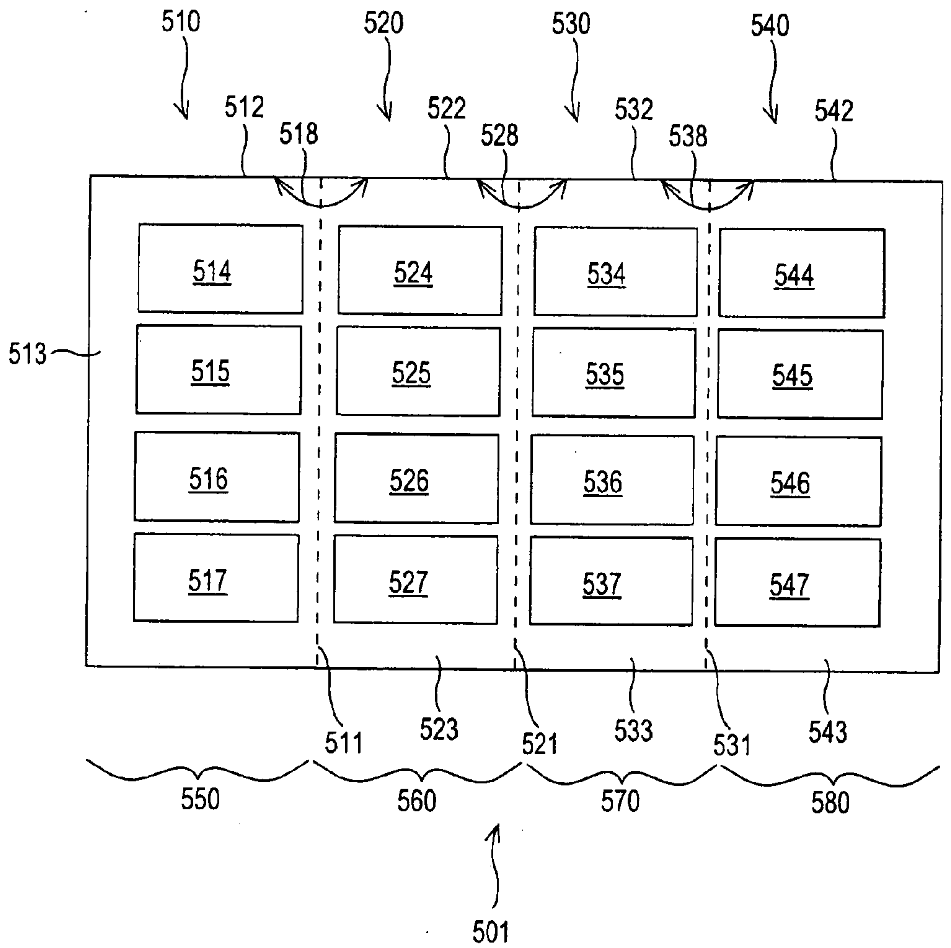
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FIG. 5B

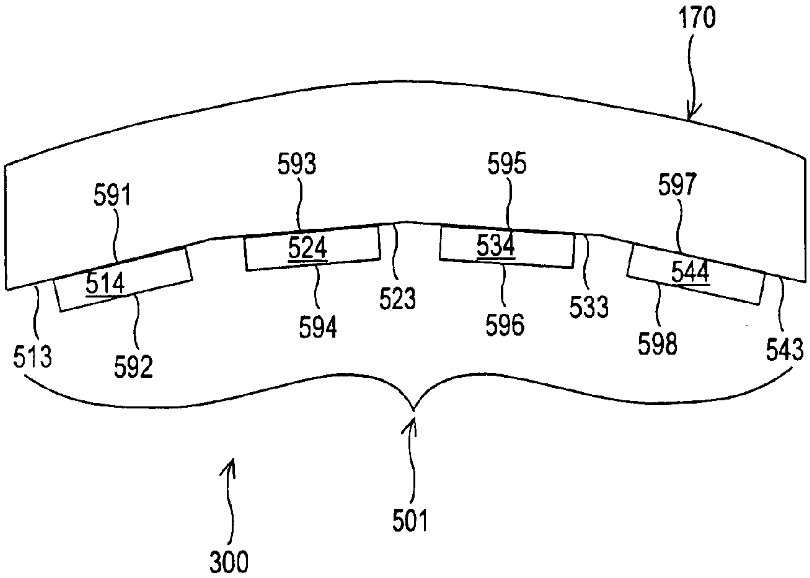
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FIG. 5C

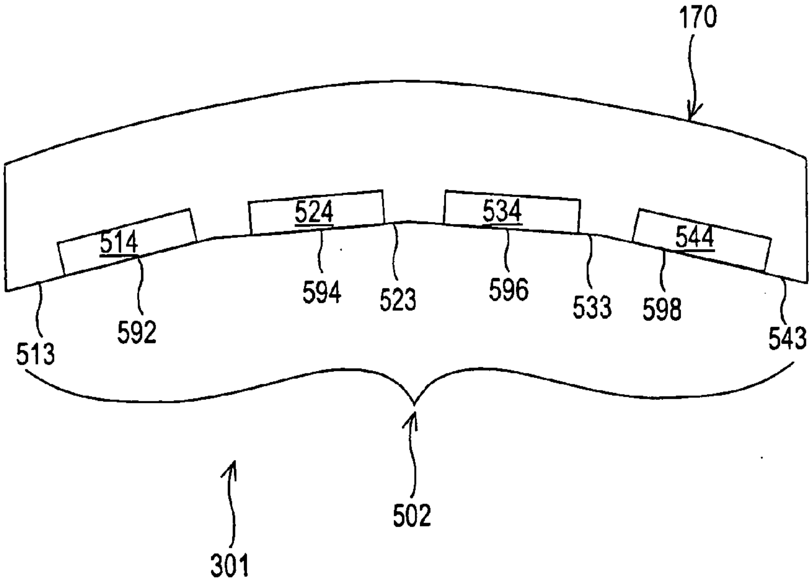
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FIG. 6

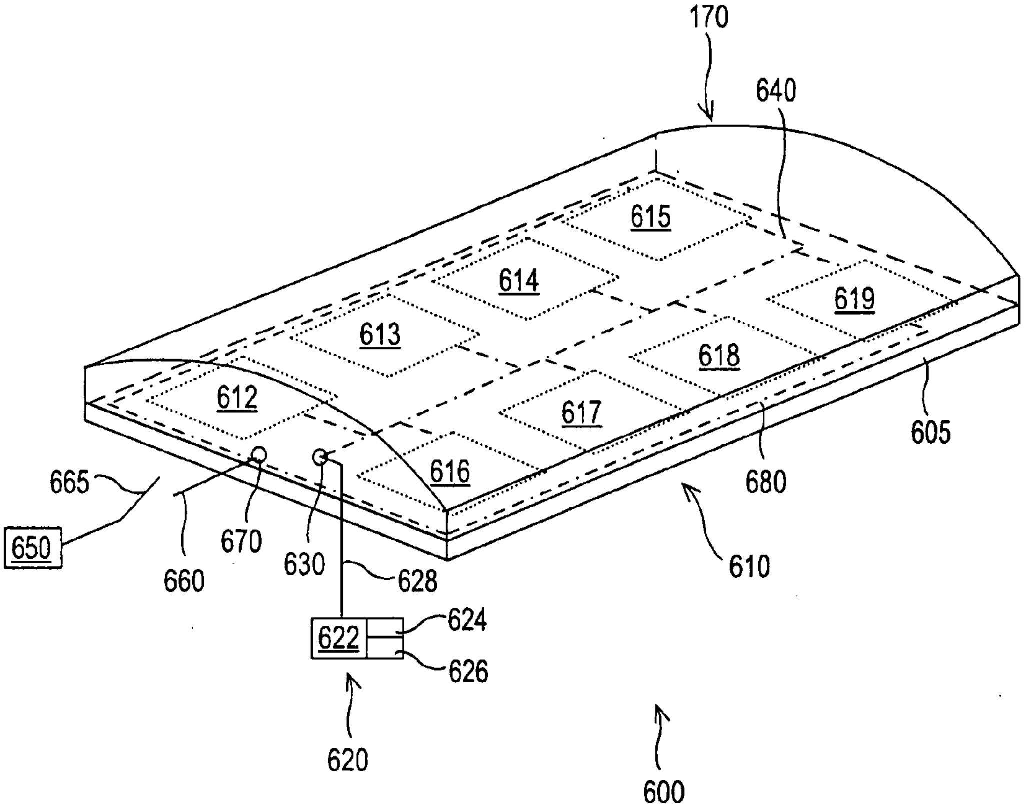

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FIG. 7A

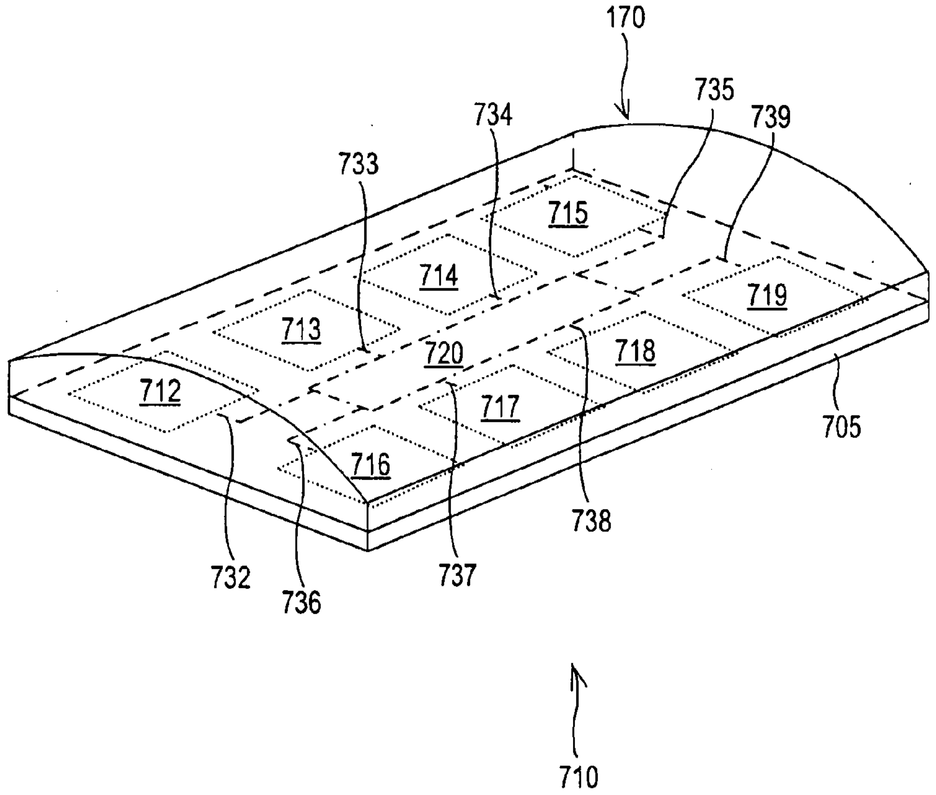
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FIG. 7B

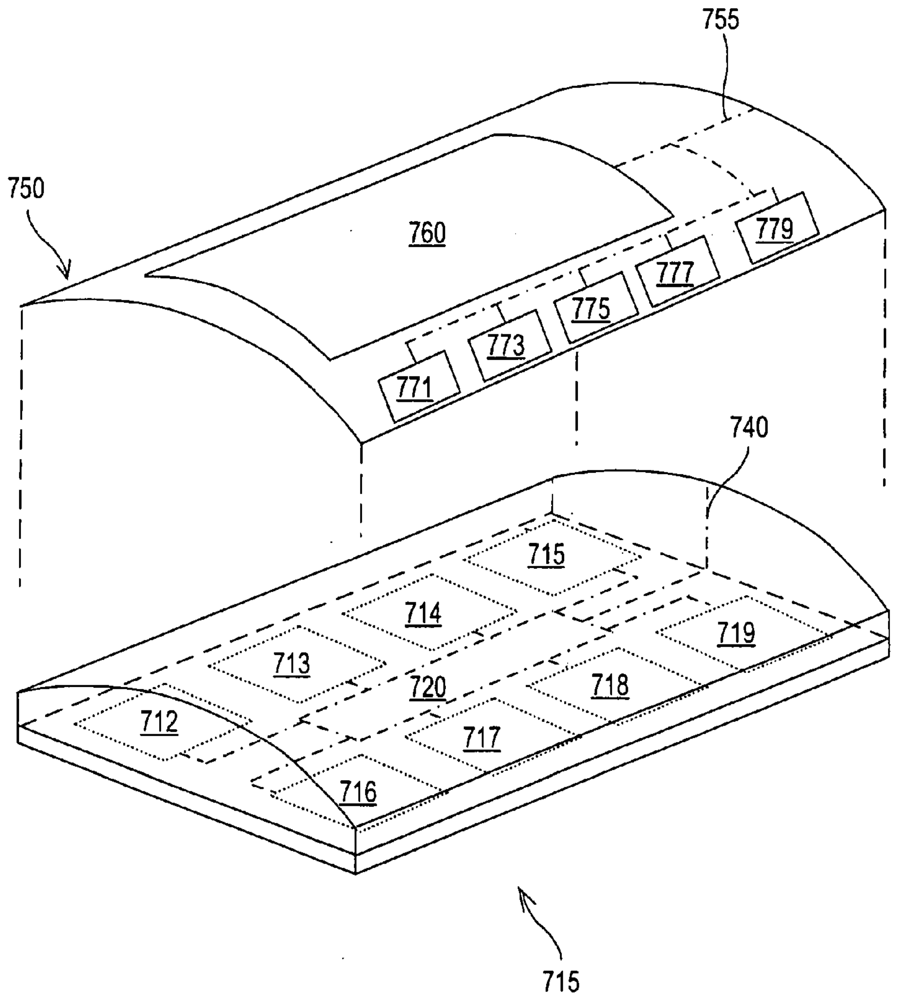
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FIG. 8A

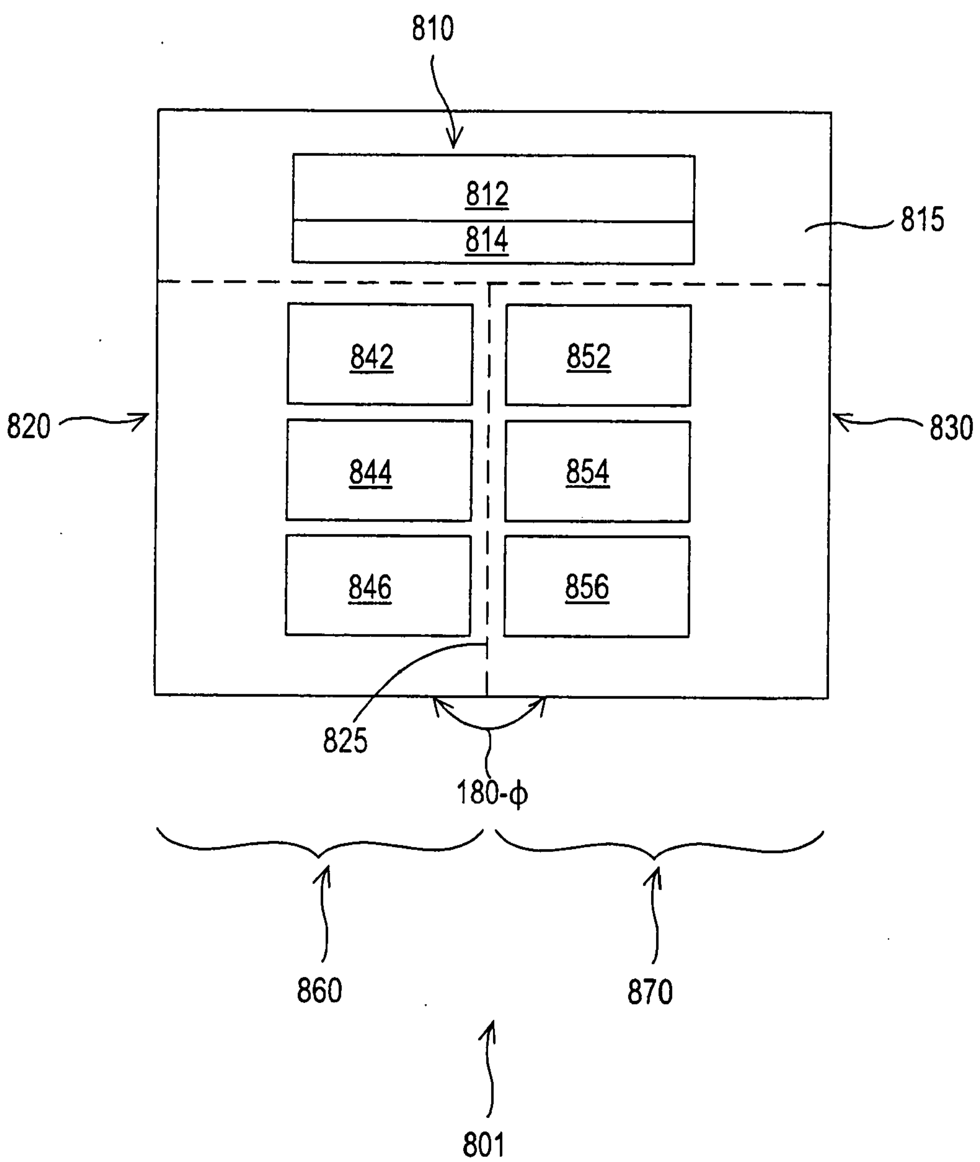
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FIG. 8B

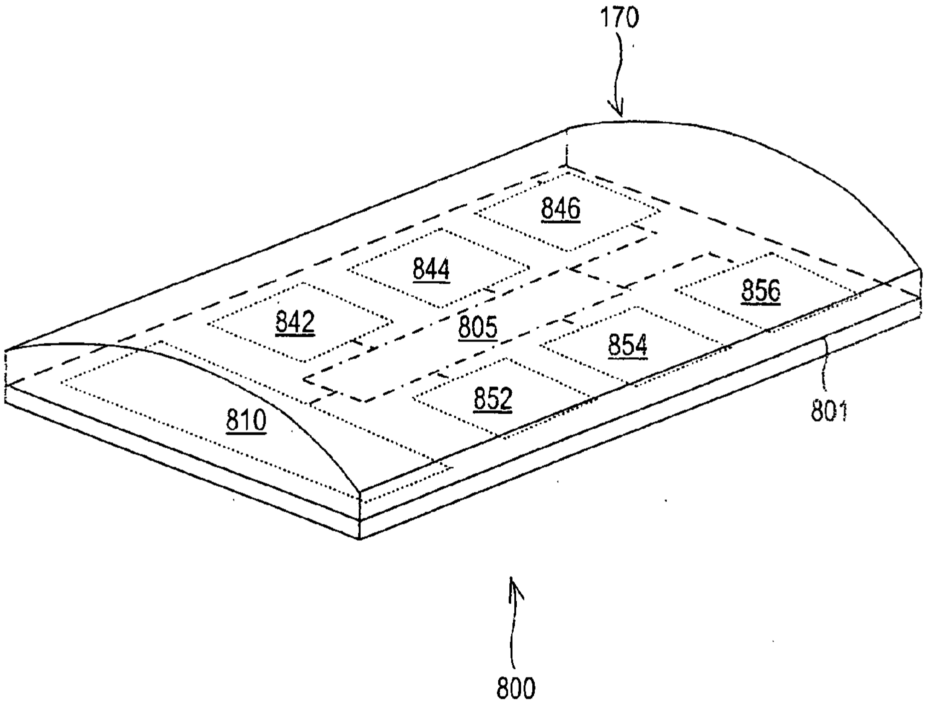


FIG. 8C

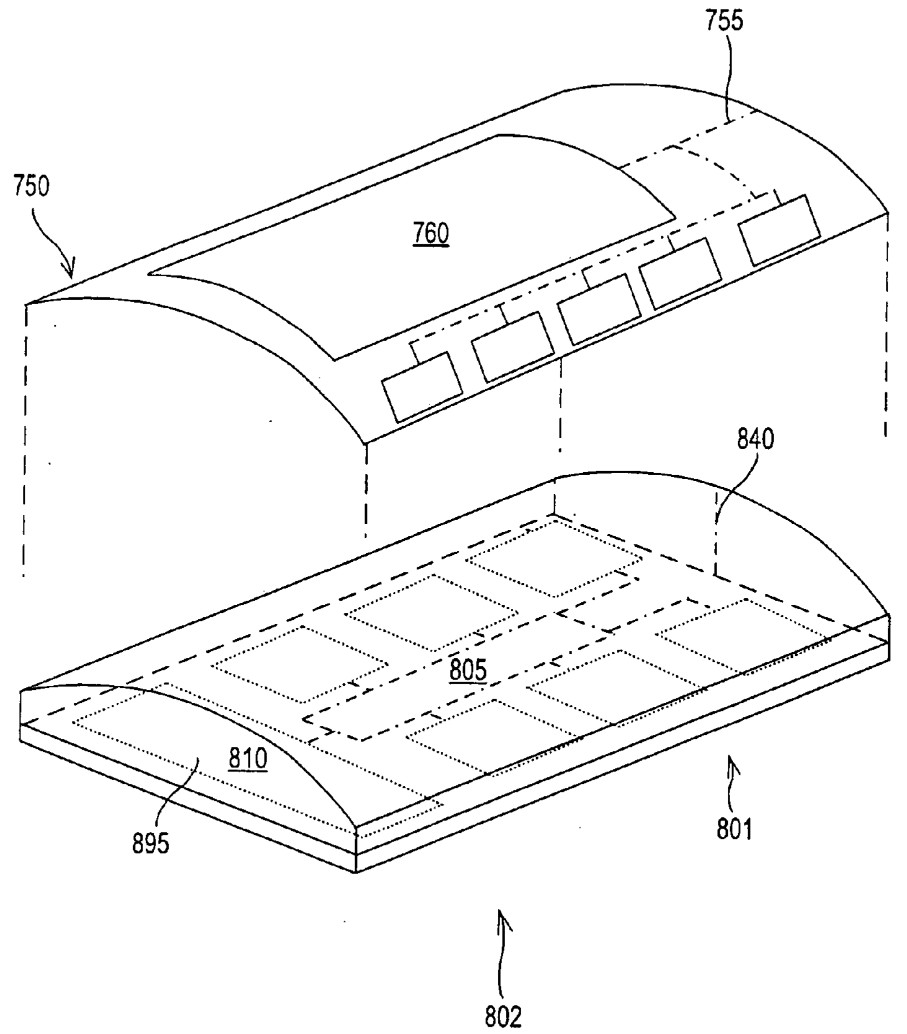


FIG. 9

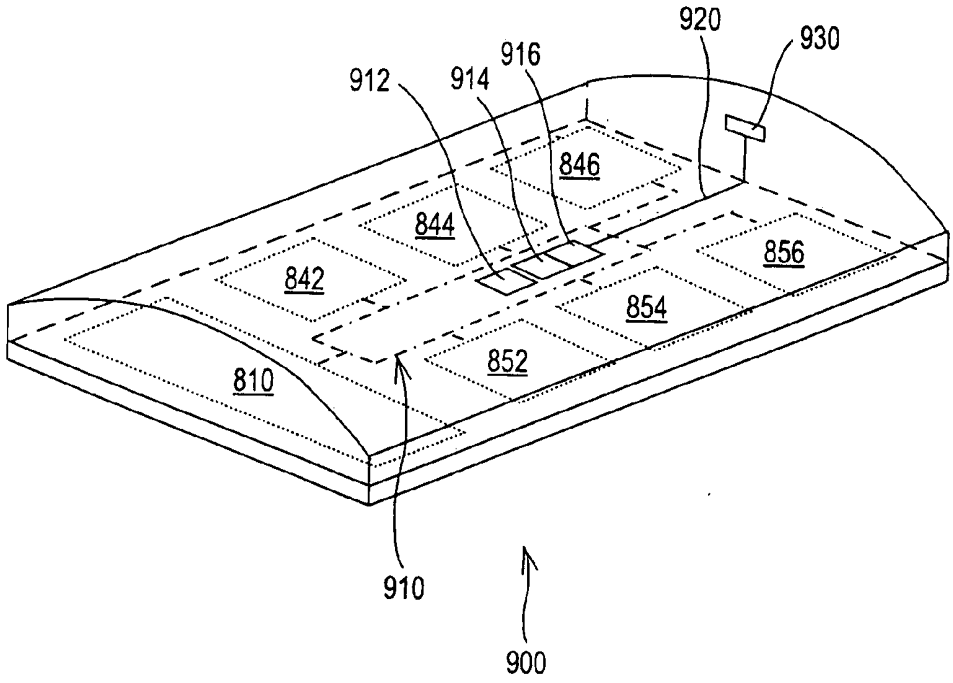


FIG. 10

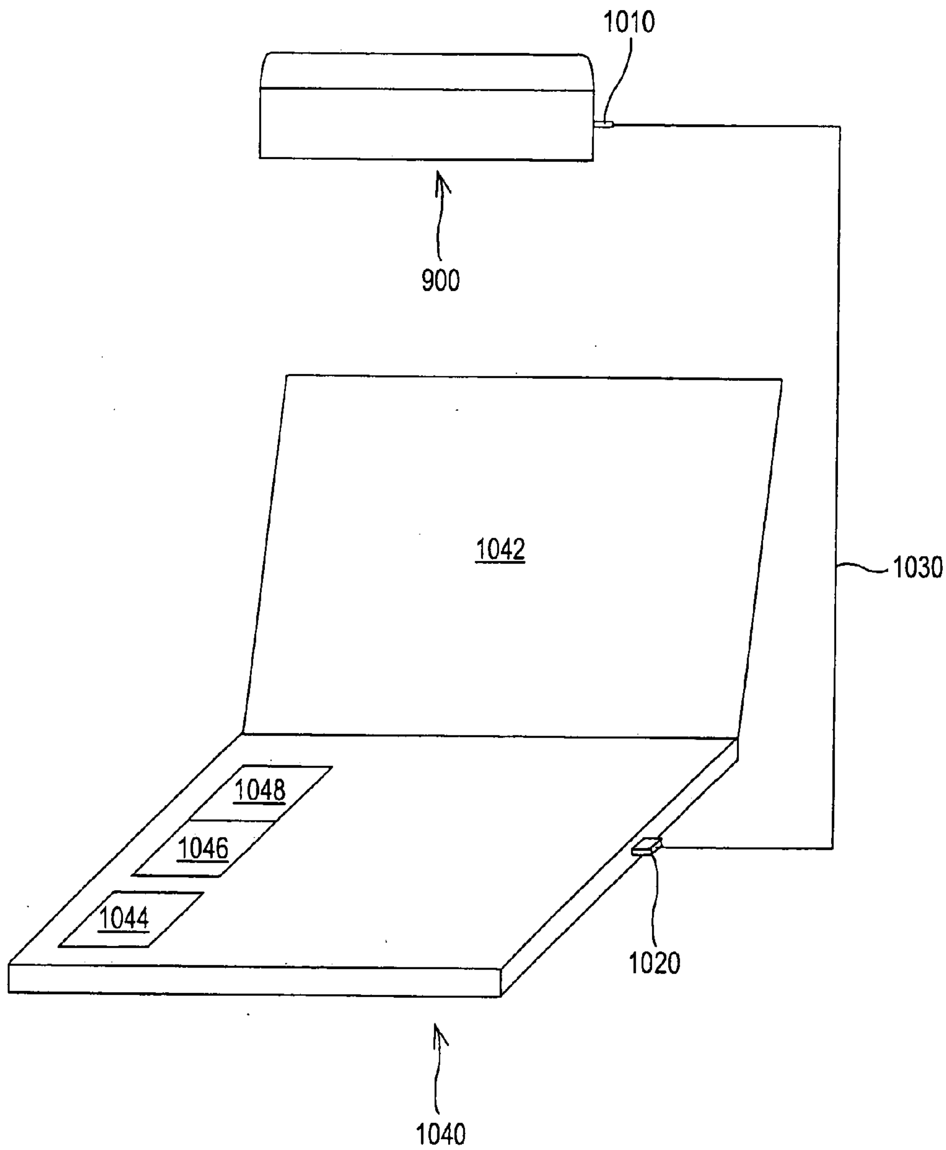


FIG. 11A

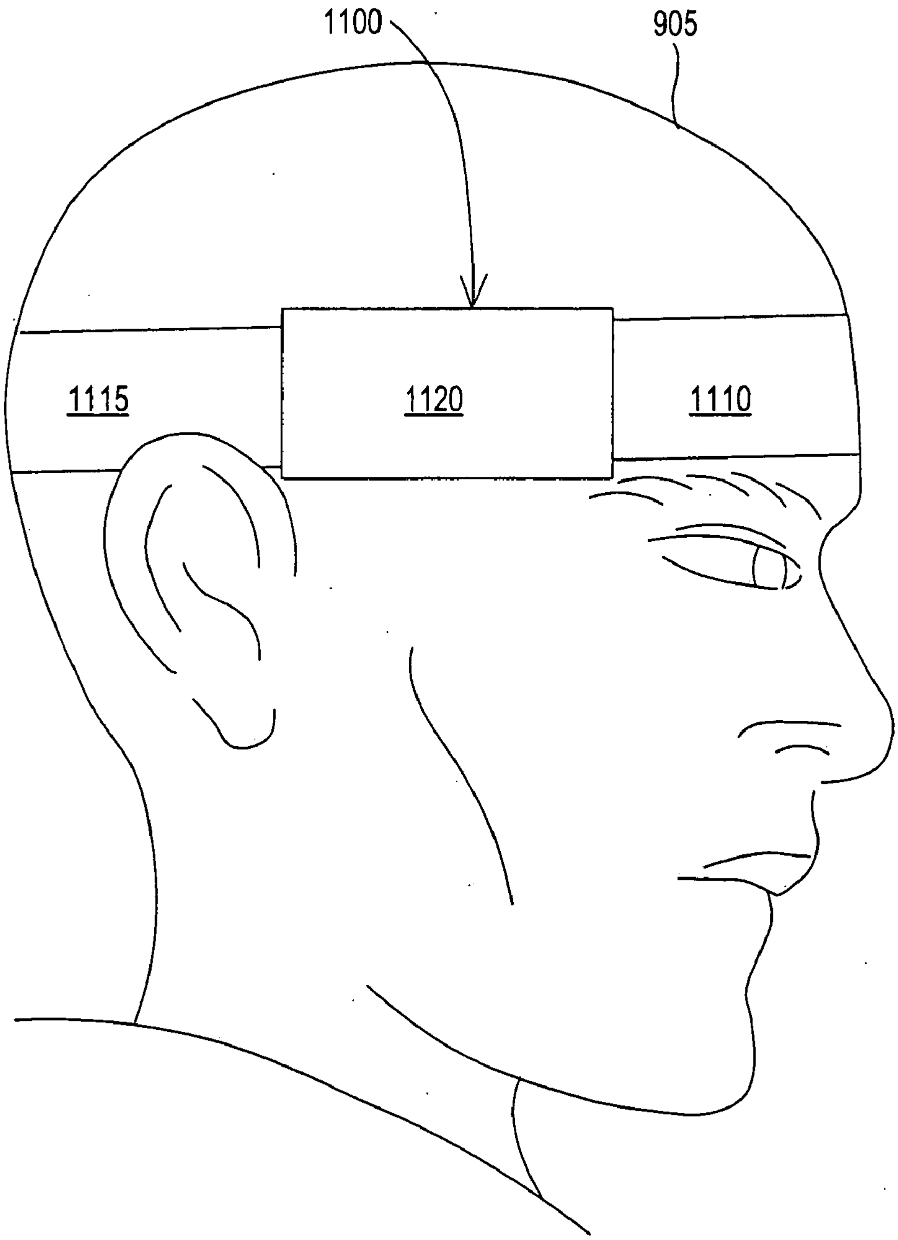


FIG. 11B

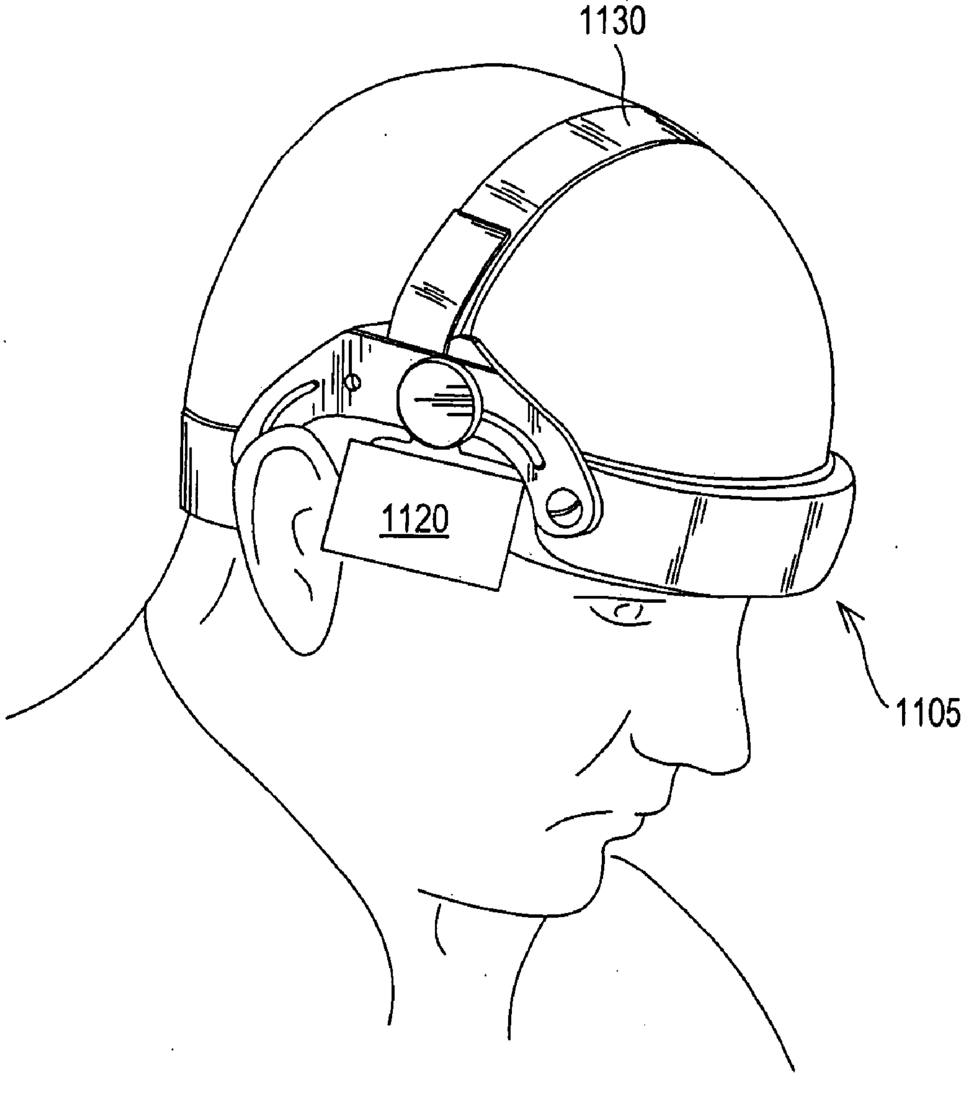


FIG. 12

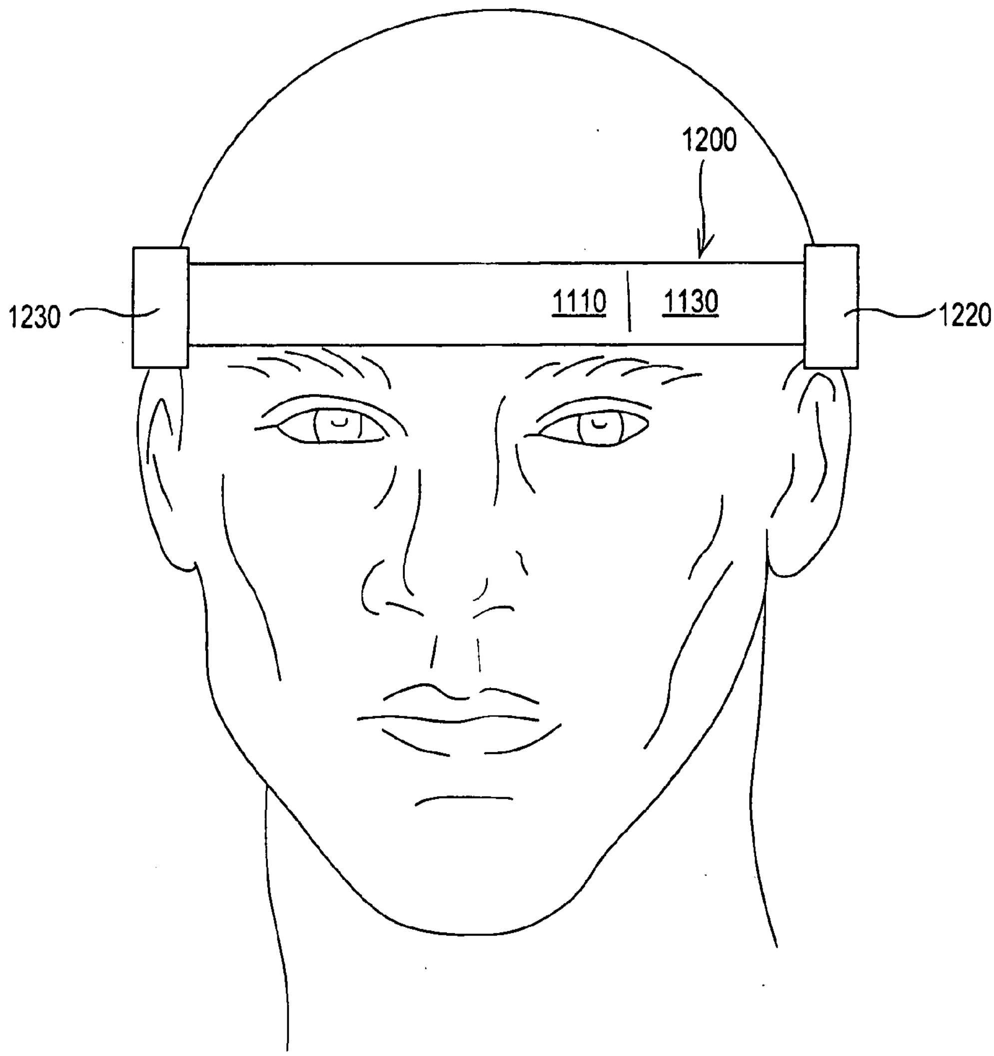


FIG. 13A

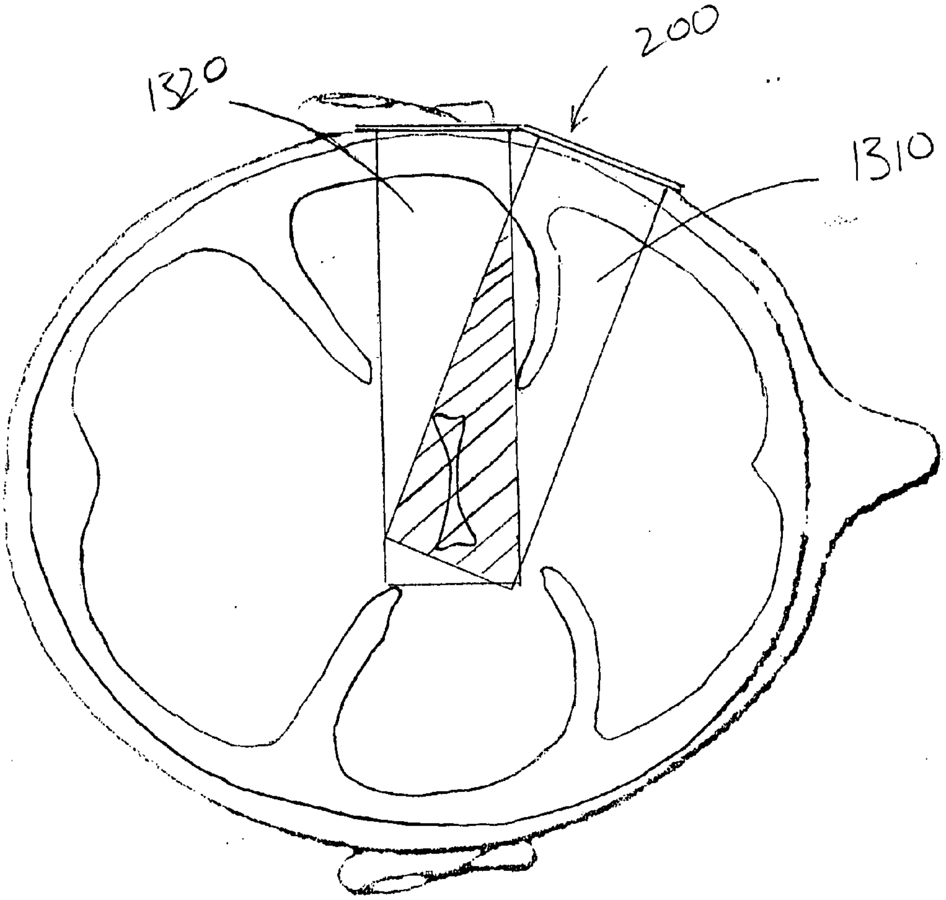


FIG. 13B

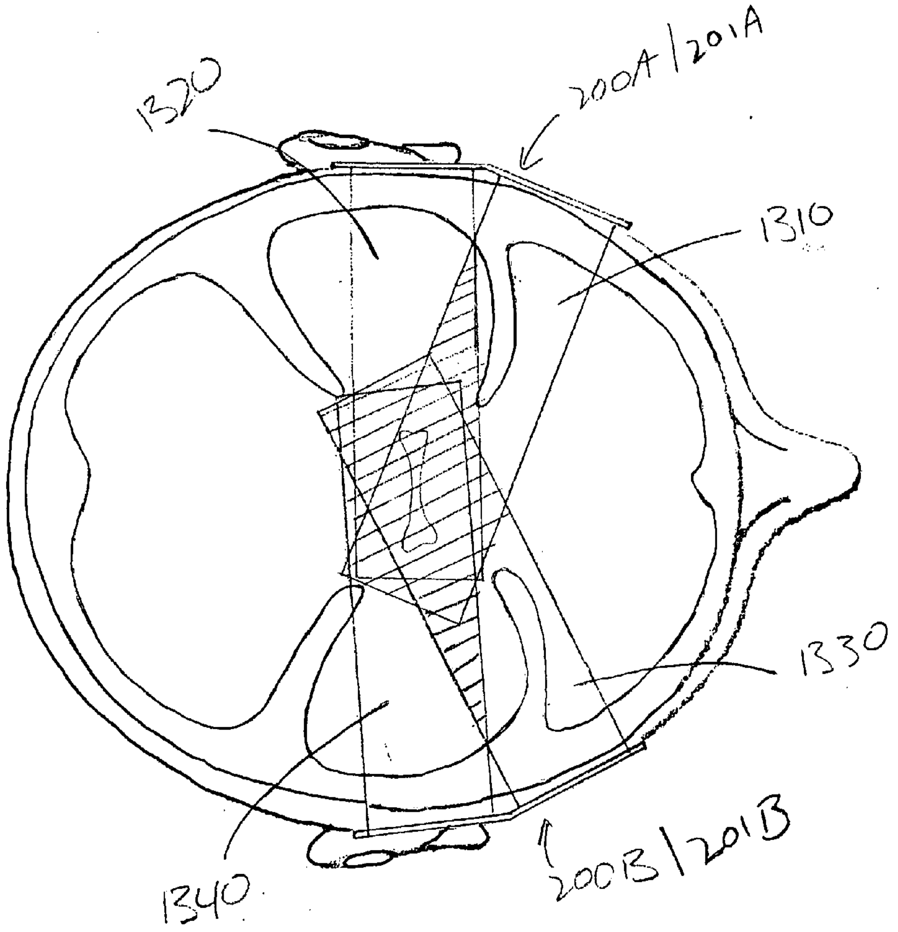


FIG. 14A

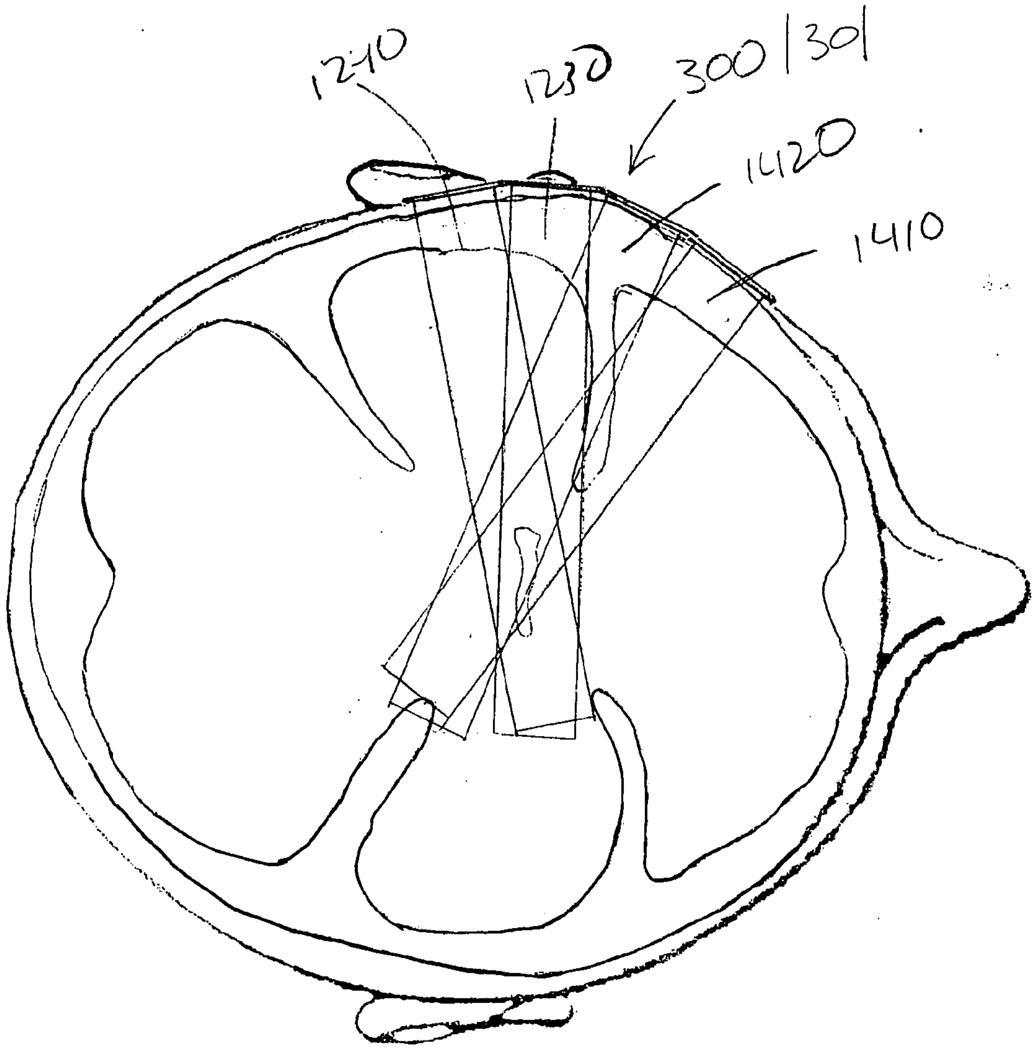
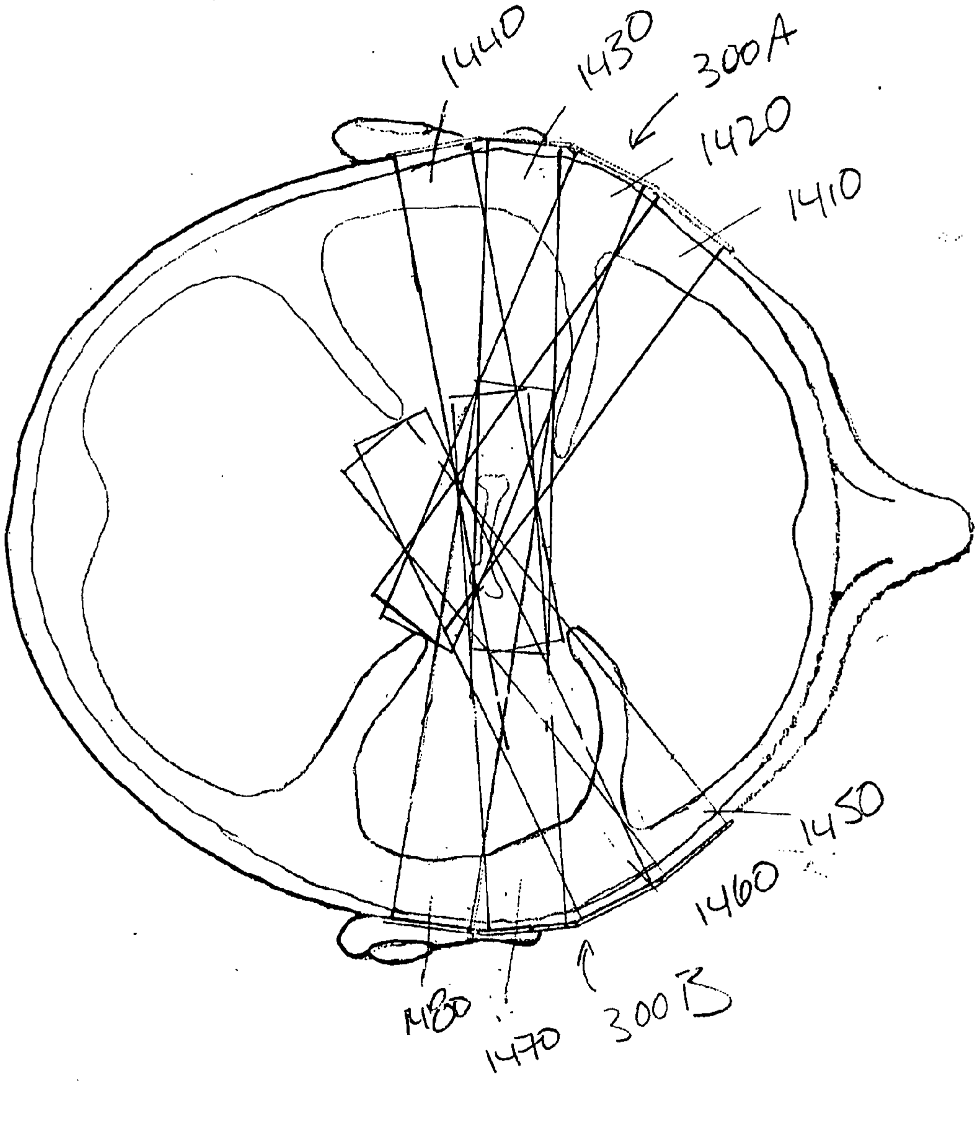


FIG. 14B



ULTRASOUND EMITTING DEVICE COMPRISING A HEAD FRAME

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Application claims priority from a U.S. Provisional Application having Ser. No. 60/737,980 filed Nov. 18, 2005, and from a U.S. Provisional Application having Ser. No. 60/738,080 filed Nov. 18, 2005.

FIELD OF THE INVENTION

[0002] Applicants' invention relates to an ultrasound emitting device comprising a head frame, and a method using that device.

BACKGROUND OF THE INVENTION

[0003] Thrombosis, the formation and development of a blood clot or thrombus within the vascular system, can be life threatening. The thrombus can block a vessel and stop blood supply to an organ or other body part. If detached, the thrombus can become an embolus and occlude a vessel distant from the original site.

[0004] Dissolution of thrombus using ultrasound is known in the art. Further, the ability of microbubbles to potentiate ultrasound-induced thrombolysis is known. The bubbles are destroyed by the ultrasound and the energy is released into the clot.

[0005] What is needed, however, is an ultrasound emitting device which can better direct the emitted ultrasound energy to an occlusion site, thereby enhancing the effectiveness of the ultrasound energy/microbubble interaction. Applicants' apparatus provides such an ultrasound emitting device.

SUMMARY OF THE INVENTION

[0006] Applicants' invention comprises an ultrasound emitting device, comprising a sound head matrix comprising a first planar member, and a second planar member, wherein the first planar member is attached to the second planar member to form a V-shaped assembly comprising a first interior dihedral angle, where that first interior dihedral angle is between about 155 degrees and about 175 degrees. The ultrasound emitting device further comprises a first plurality of ultrasound transducers disposed on the first planar member, and a second plurality of ultrasound transducers disposed on the second planar member. Applicants' ultrasound emitting device further comprises a head frame, where the sound head matrix is disposed adjacent a patient's head when said head frame is removeably disposed around the patient's head.

BRIEF DESCRIPTION OF THE DEAWINGS

[0007] The invention will be better understood from a reading of the following detailed description taken in conjunction with the drawings in which like reference designators are used to designate like elements, and in which:

[0008] FIG. **1**A is a perspective view of Applicants' ultrasound emitting device;

[0009] FIG. **1**B is a side view of the device of FIG. **1**A;

[0010] FIG. **1**C is a perspective view of the device of FIG. **1**A showing a housing portion and a bottom portion;

[0011] FIG. **2**A is a perspective view of an embodiment of Applicants' ultrasound emitting device comprising a bottom portion comprising two offset planar assemblies;

[0012] FIG. **2**B is a perspective view of the bottom portion of FIG. **2**A;

[0013] FIG. **2**C is a side view of the bottom portion of FIG. **2**A;

[0014] FIG. **3**A is a perspective view of an embodiment of Applicants' ultrasound emitting device comprising a bottom portion comprising four offset planar assemblies;

[0015] FIG. **3**B is a side view of the bottom portion of FIG. **3**A;

[0016] FIG. **4**A is a block diagram showing one embodiment of Applicants' sound head matrix;

[0017] FIG. **4**B is a side view of one embodiment of the sound head matrix of FIG. **4**A;

[0018] FIG. **4**C is a side view of a second embodiment of the sound head matrix of FIG. **4**A;

[0019] FIG. **5**A is a block diagram showing a second embodiment of Applicants' sound head matrix;

[0020] FIG. **5**B is a side view of one embodiment of the sound head matrix of FIG. **5**A;

[0021] FIG. **5**C is a side view of a second embodiment of the sound head matrix of FIG. **5**A;

[0022] FIG. **6** is a perspective view showing an external controller and power source for Applicants' ultrasound emitting device;

[0023] FIG. **7**A is a perspective view showing an embodiment of Applicants' ultrasound emitting device comprising an internal controller;

[0024] FIG. **7**B is a perspective view showing the device of FIG. **7**A in combination with an integrated input/output element;

[0025] FIG. **8**A is a block diagram showing an embodiment of Applicants' ultrasound emitting device which further comprises a diagnostic ultrasound transceiver;

[0026] FIG. **8**B is a perspective view of the device of FIG. **8**A further comprising an internal controller;

[0027] FIG. **8**C is a perspective view of the device of FIG. **8**B further comprising an integrated input/output element;

[0028] FIG. **9** is a perspective view of the ultrasound emitting device of FIG. **8**B or **8**C further comprising a communication port in bidirectional communication with an internal controller;

[0029] FIG. **10** is a block diagram showing the ultrasound emitting device of FIG. **9** interconnected with an external computing device;

[0030] FIG. **11**A is a side view showing Applicants' ultrasound emitting device removeably disposed adjacent a patient's head using a head band apparatus;

[0031] FIG. **11**B is a side view showing Applicants' ultrasound emitting device removeably disposed adjacent a patient's head using a head frame apparatus;

[0032] FIG. **12** is a front view showing two ultrasound emitting devices removeably disposed adjacent a patient's head using either the head band of FIG. **11**A or the head frame of FIG. **11**B;

[0033] FIG. **13**A shows the effective acoustic fields produced using Applicants' ultrasound emitting device comprising a sound head matrix comprising two planar arrays of transducers attached to one another to define an interior dihedral angle less than 180 degrees;

[0034] FIG. **13**B shows the effective acoustic fields produced using the apparatus of FIG. **11**B comprising two ultrasound emitting devices, wherein each device comprises a sound head matrix comprising two planar arrays of transducers attached to one another to define an interior dihedral angle less than 180 degrees;

[0035] FIG. **14**A shows the effective acoustic fields produced using Applicants' ultrasound emitting device comprising a sound head matrix formed using four offset planar arrays of transducers;

[0036] FIG. **14**B shows the effective acoustic fields produced using two ultrasound emitting devices, wherein each of those devices comprises a sound head matrix formed using four offset planar arrays of transducers.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0037] This invention is described in preferred embodiments in the following description with reference to the Figures, in which like numbers represent the same or similar elements. Reference throughout this specification to "one embodiment,""an embodiment," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment,""in an embodiment," and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[0038] The described features, structures, or characteristics of the invention may be combined in any suitable manner in one or more embodiments. In the following description, numerous specific details are recited to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention may be practiced without one or more of the specific details, or with other methods, components, materials, and so forth. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0039] Various embodiments of Applicants' ultrasound emitting apparatus are described herein as comprising sixteen (16) therapeutic ultrasound transducers. This description of Applicants' ultrasound emitting apparatus should not be interpreted to limit Applicants' ultrasound emitting assembly to a total of 16 ultrasound transducers. Rather, Applicants' ultrasound emitting assembly comprises (N) therapeutic ultrasound transducers, wherein (N) is greater than or equal to 1.

[0040] Referring to FIG. **1**A, Applicants' ultrasound emitting device **100** comprises a top **110**, bottom **120**, and sides **130**, **140**, **150**, and **160**. In certain embodiments, top **110** and sides **130**, **140**, **150**, and **160**, are formed from one or more rigid materials, including wood, metal, plastic, and combinations thereof. In certain embodiments, top **110**, and sides **130**, **140**, **150**, and **160**, are separately formed, and subsequent attached to one another as shown in FIG. **1** using conventional attachment methods, including welding, sonic welding, plastic welding, adhesive bonding, mechanical attachment, and the like.

[0041] Sides **140** and **160** have dimension **142** in the Y direction. In certain embodiments, dimension **142** is between about 10 cm and about 50 cm. Sides **130** and **150** have dimension **132** in the X direction. In certain embodiments, dimension **132** is between about 5 cm and about 25 cm.

[0042] FIG. **1**B is a side view of apparatus **100**. Apparatus **100** includes a plurality of therapeutic ultrasound transducers **180** disposed on, or through, bottom **120**. By "therapeutic ultrasound transducer," Applicants mean a device that is capable of operating at between a 0.1 percent and a 100 percent duty cycle, and that emits therapeutic ultrasound energy. By "therapeutic ultrasound energy," Applicants mean sound waves having a frequency between about 150 kilohertz and about 10 megahertz or higher, and a power level between about 0.1 watt/cm^2 and about 30 watts/cm^2. In certain embodiments, when operated continuously, the output power for each of the plurality of therapeutic ultrasound transducers can as great as about 50 watts. In other embodiments, the output power for each of the plurality of therapeutic ultrasound transducers is between about 6 to about 10 watts.

[0043] In the illustrated embodiment of FIG. **1**B, sides **130** and **150** vary in dimension along the Z direction, having dimension **134** at the attachment of sides **140** and **160**, and dimension **136** at mid point **138**. In certain embodiments, dimension **134** is between about 2 cm and about 4 cm. In certain embodiments, dimension **136** is between about 3 cm and about 8 cm. In other embodiments, Applicants' ultrasound emitting device comprises a parallelepiped, i.e. dimension **132** is substantially equal to dimension **134**.

[0044] Referring to FIG. **1**C, in certain embodiments Applicants' ultrasound emitting device **100** comprises housing **170** which includes top **110** and sides **130**, **140**, **150**, and **160**. In certain embodiments, housing **170** is integrally formed from one or more metallic materials. In certain embodiments, housing **170** is integrally molded from one or more polymeric materials. In certain embodiments, housing **170** is formed from one or more full density polymeric materials. In certain embodiments, those polymeric materials include polyethylene, polypropylene, polycarbonate, polystyrene, polyvinylchloride, combinations thereof, and the like.

[0045] In certain embodiments, those polymeric materials comprise one or more partial-density materials, i.e. one or more cellular materials. In certain embodiments, such cellular materials comprise one or more structural foam materials formed from the group which includes one or more polyurethanes, one or more polystyrenes, and combinations thereof, and the like.

[0046] Bottom **120** in combination with housing **170** comprises an enclosure. Bottom **120** includes interior surface **122** and exterior surface **124** (FIG. **1**B). In certain embodiments, bottom **120** is formed from metal, one or more polymeric materials, and combinations thereof. In certain embodiments, housing **170** is formed from one or more first polymeric materials and bottom **120** is formed from one or more second polymeric materials, where the one or more first polymeric materials differ from the one or more second polymeric materials.

[0047] In certain embodiments, bottom **120** is attached to housing **170** using adhesive bonding. In certain embodiments, bottom **120** is attached to housing **170** using conventional attachment means such as, for example, screws, nuts/bolts, rivets, and the like. In certain embodiments, bottom **120** can be releaseably affixed to housing **170**, such that housing **170** can be used with a variety of differing sound head matrix assemblies, as described below.

[0048] One or more piezoelectric transducers are disposed on, or through, the exterior surface of the bottom portion of Applicants' device. Each piezoelectric transducer, sometimes referred to as a "sound head," includes one or more piezoelectric materials. When an alternating current is applied to such a piezoelectric material, deformation occurs wherein the piezoelectric material expands and contracts. Such expansion and contraction crystal produces vibrations, i.e. acoustic waves.

[0049] In certain embodiments, Applicants' piezoelectric transducers comprise one or more ceramic materials having pronounced piezoelectric characteristics. In certain embodiments, Applicants' piezoelectric transducers comprise lead zirconate titanate ("PZT"). In other embodiments, Applicants' piezoelectric material comprises lead-magnesium-niobate lead titanate, hereafter referred to for brevity by the acronym PMN-PT. Such PMN-PT materials are described in U.S. Pat. No. 6,737,789.

[0050] In certain embodiments, Applicants' piezoelectric materials are formed from a thick-film ink, wherein one or more PZT and/or PMN-PT pastes are mixed with a powdered glass and an organic carrier, which is then printed onto the bottom portion of Applicants' device.

[0051] In certain embodiments, the one or more piezoelectric transducers disposed on the exterior of Applicants' device comprise therapeutic ultrasound transducers. By "therapeutic ultrasound transducer," Applicants mean a device that is capable of operating at between a 0.1 percent and a 100 percent duty cycle, and that emits therapeutic ultrasound energy. By "therapeutic ultrasound energy," Applicants mean sound waves having a frequency between about 150 kilohertz and about 10 megahertz or higher, and a power level between about 0.1 watt/cm^2 and about 30 watts/cm^2. In certain embodiments, when operated continuously, the output power for each of the plurality of therapeutic ultrasound transducers can as great as about 50 watts. In other embodiments, the output power for each of the plurality of therapeutic ultrasound transducers is between about 6 to about 10 watts.

[0052] The plurality of therapeutic ultrasound transducers disposed on Applicants' device comprise a sound head matrix. In certain embodiments, Applicants' sound head matrix comprises a plurality of therapeutic ultrasound transducers are arranged in columns and rows. In other embodiments, Applicants' sound head matrix comprises a plurality of therapeutic ultrasound transducers arranged in a pattern comprising concentric circles.

[0053] FIG. **4**A shows one embodiment of Applicants' sound head matrix. In the illustrated embodiment of FIG. **4**A, the sound head matrix comprises sixteen (16) therapeutic ultrasound transducers arranged in two columns of eight (8) transducers. Thus, sound head matrix of FIG. **4**A comprises an 8×2 sound head matrix.

[0054] Each transducer comprising the sound head matrix of FIG. **4**A is disposed on, or through, one of two planar members, either planar member **420** or planar member **430**. In certain embodiments, planar member **420** and/or planar member **430** comprises a circuit substrate, wherein one or more electrical circuit components are attached to and/or through that circuit substrate. In certain embodiments, such a circuit substrate comprises what is sometimes referred to as a printed circuit board ("PCB"). In certain embodiments, planar member **420** and/or planar member **430** comprises a single-sided PCB. In certain embodiments, planar member **420** and/or planar member **430** comprises a double-sided PCB. In certain embodiments, planar member **420** and/or planar member **430** comprises a multilayer PCB. In certain embodiments, planar member **420** and/or planar member **430** comprises a metal core, i.e. copper for example, encapsulated with a ceramic coating.

[0055] In certain embodiments, planar member **420** and/or planar member **430** comprise a ceramic material. In certain embodiments, planar member **420** and/or planar member **430** comprise aluminum oxide. In certain embodiments, planar member **420** and/or planar member **430** comprise beryllium oxide.

[0056] In embodiments wherein housing **170** comprises one or more metallic components, and wherein planar members **420** and/or **430** comprise a ceramic material and/or a ceramic material encapsulating a copper core, planar members **420** and/or **430** conduct heat generated by the plurality of ultrasound emitters from the core of Applicants' device to the metallic housing, i.e. the circuit substrates in combination with the housing, comprise, inter alia, an integrated heat sink assembly which continuously dissipates heat from Applicants' device to the environment.

[0057] Planar member **420** is continuously attached to planar member **430** along common edge, i.e. seam, **405**. Transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, and **448**, are disposed on, or through, surface **424** of planar member **420**. Transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, and **448**, in combination with planar member **420**, comprises planar assembly **460**. Transducers **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, are disposed on, or through, surface **434** of planar member **430**. Transducers **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, in combination with planar member **430**, comprises planar assembly **470**.

[0058] Planar assembly **460** in combination with planar assembly **470** comprises sound head matrix assembly **401**. In certain embodiments, sound head matrix assembly **401** comprises a flat structure. In other embodiments, sound head matrix assembly **401** is not flat, i.e. the dihedral angle formed by the intersection of assemblies **460** and **470** does not equal 180 degrees.

[0059] Referring to FIG. **2**A, device **200** includes housing **170** (FIG. **1**C) in combination with an "offset" embodiment of sound head matrix assembly **401**. As described above, sound head matrix assembly **401** includes planar assembly

460 in combination with planar assembly 470, where planar assembly 460 is continuously joined to planar assembly 470 along common edge 405. Planar assembly 460 lies in a first plane, and planar assembly 470 lies in a second plane. That first plane intersects the second plane along common edge 405 to form an interior dihedral angle, as defined herein, less than 180 degrees.

[0060] Referring now to FIGS. 2A, 2B, and 2C, planar assembly 460 includes edge 422. Planar assembly 470 includes edge 432. Edge 422 meets edge 432 at seam 405. Dotted line 250 represents the extension of edge 422 past seam 405. As shown in FIG. 2C, angle Φ represents the angle formed between edge 432 and extension line 250. For purposes of this Application, planar assembly 460 is "offset" from planar assembly 470 by angle Φ. As those skilled in the art will appreciate, the interior dihedral angle, in degrees, formed by the intersection of planar assembly 460 and planar assembly 470 is 180−Φ.

[0061] In certain embodiments, angle Φ is between about 5 degrees and about 25 degrees. In certain embodiments, angle Φ is between about 10 degrees and about 20 degrees. In certain embodiments, angle Φ is about 13 degrees.

[0062] As those skilled in the art will appreciate, the interior dihedral angle formed by planar assembly 460 and planar assembly 470 is inversely proportional to the offset angle Φ. Therefore, as Φ increases from 0 degrees, the dihedral angle decreases from 180 degrees. Thus, where planar assembly 460 is "offset" from planar assembly 470 by, for example, 15 degrees, then the interior dihedral angle formed by planar assembly 460 and planar assembly 470 is 165 degrees. In certain embodiments, the interior dihedral angle formed by planar assembly 460 and planar assembly 470 is between 155 degrees and 175 degrees.

[0063] FIG. 4B shows a side view of apparatus 200 which includes housing 170 in combination with an offset sound head matrix assembly 401. Transducer 441 (FIGS. 4A, 4B, 4C) comprises a first side 481 and an opposing second side 482. Transducer 451 (FIGS. 4A, 4B, 4C) includes a first side 491 and an opposing second side 492. In the illustrated embodiment of FIG. 4B, side 481 of transducer 441 is disposed on surface 424 of planar member 420, and side 491 of transducer 451 is disposed on surface 434 of planar member 430. As those skilled in the art will appreciate, transducers 441 may include one or more leads which extend through holes, i.e. vias, drilled through planar member 420. In other embodiments, transducer 441 comprises what is sometimes called a "surface mounted" device, wherein that surface mounted device is attached to a solder pad disposed on surface 424.

[0064] FIG. 4C shows a side view of apparatus 201 which includes housing 170 in combination with an offset sound head matrix assembly 402. Sound head matrix assembly 402 is identical to sound head matrix assembly 401 except that each of the plurality of therapeutic ultrasound transducers extends through a planar member rather than being disposed on that planar member. For example in the illustrated embodiment of FIG. 4C, transducer 441 is disposed through planar member 420 such that surface 482 of transducer 441 is flush with surface 424 of planar assembly 460. Similarly in this embodiment, transducer 451 is disposed through planar member 430 such that surface 492 of transducer 451 is flush with surface 434 of planar assembly 470.

[0065] FIG. 5A shows another embodiment of Applicants' sound head matrix. In the illustrated embodiment of FIG. 5A, the sound head matrix comprises sixteen (16) therapeutic ultrasound transducers arranged in four columns of four transducers. Thus, sound head matrix of FIG. 5A comprises an 4×4 sound head matrix.

[0066] Each transducer comprising the sound head matrix of FIG. SA is disposed on, or through, one of four planar members, namely planar member 510, or planar member 520, or planar member 530, or planar member 540. Planar member 510 is continuously attached to planar member 520 along common edge 511. Transducers 514, 515, 516, and 517, are disposed on, or through, surface 513 of planar member 510. Transducers 514, 515, 516, and 517, in combination with planar member 510, comprise planar assembly 550. Angle 518 comprises the interior dihedral angle formed by the intersection of planar member 510 with planar member 520.

[0067] In certain embodiments, angle 518 is about 180 degrees. In these embodiments, planar member 510 is not offset from planar member 520, i.e. planar member 510 in combination with planar member 520 comprises a flat assembly. In other embodiments, angle 518 is less than 180 degrees, i.e. planar member 510 is offset from planar member 520.

[0068] In certain embodiments, planar members 510 and 520 are integrally formed to include angle 518. In other embodiments, planar members 510 and 520 are individually formed, and subsequently attached using conventional attachment methods.

[0069] Planar member 520 is continuously attached to planar member 530 along common edge 521. Transducers 524, 525, 526, and 527, are disposed on, or through, surface 523 of planar member 520. Transducers 524, 525, 526, and 527, in combination with planar member 520, comprise planar assembly 560. Angle 528 comprises the interior dihedral angle formed by the intersection of planar member 520 with planar member 530.

[0070] In certain embodiments, angle 528 is about 180 degrees. In these embodiments, planar member 520 is not offset from planar member 530, i.e. planar member 520 in combination with planar member 530 comprises a flat assembly. In other embodiments, angle 528 is less than 180 degrees, i.e. planar member 520 is offset from planar member 530.

[0071] In certain embodiments, planar members 520 and 530 are integrally formed to include angle 528. In other embodiments, planar members 520 and 530 are individually formed, and subsequently attached using conventional attachment methods.

[0072] Planar member 530 is continuously attached to planar member 540 along common edge 531. Transducers 534, 535, 536, and 537, are disposed on, or through, surface 533 of planar member 530. Transducers 534, 535, 536, and 537, in combination with planar member 530, comprise planar assembly 570. Angle 538 comprises the interior dihedral angle formed by the intersection of planar member 530 with planar member 540.

[0073] In certain embodiments, angle 538 is about 180 degresss. In these embodiments, planar member 530 is not offset from planar member **540**, i.e. planar member **530** in combination with planar member **540** comprises a flat assembly. In other embodiments, angle **538** is less than 180 degresss, i.e. planar member **530** is offset from planar member **540**.

[0074] In certain embodiments, planar members **530** and **540** are integrally formed to include angle **538**. In other embodiments, planar members **530** and **540** are individually formed, and subsequently attached using conventional attachment methods.

[0075] Transducers **544**, **545**, **546**, and **547**, are disposed on, or through, surface **543** of planar member **530**. Transducers **544**, **545**, **546**, and **547**, in combination with planar member **540**, comprise planar assembly **580**.

[0076] Planar assemblies **550**, **560**, **570**, and **580**, in combination, comprise sound head matrix assembly **501**. In certain embodiments, sound head matrix assembly **501** comprises a flat structure. In other embodiments, sound head matrix assembly **501** is not flat.

[0077] Referring to FIGS. 3A and 3B, Applicants' ultrasonic emitting apparatus **300** includes housing **170** (FIG. 1C) in combination with sound head matrix assembly **501** (FIGS. 3A, 3B, 5A, 5B). Edge **512** of planar assembly **550** meets edge **522** of planar assembly **560** along seam **511**. Dotted line **355** represents the extension of edge **512** past seam **511**. As shown in FIG. 3B, angle **Φ1** represents the angle formed between edge **522** and extension line **335**. For purposes of this Application, planar assembly **550** is "offset" from planar assembly **560**, where the offset angle is angle **Φ1**. As those skilled in the art will appreciate, the interior dihedral angle, in degrees, formed by the intersection of planar assembly **550** and planar assembly **560** is 180−**Φ1**. By "interior dihedral angle," Applicants' mean the angle formed between surface **513** and surface **523**.

[0078] In certain embodiments, angle **Φ1** is between about 5 degrees and about 25 degrees. In certain embodiments, angle **Φ1** is between about 8 degrees and about 15 degrees. In certain embodiments, angle **Φ1** is about 13 degrees.

[0079] Edge **522** of planar assembly **560** meets edge **532** of planar assembly **570** along seam **521**. Dotted line **345** represents the extension of edge **522** past seam **521**. As shown in FIG. 3B, angle **Φ2** represents the angle formed between edge **532** and extension line **345**. For purposes of this Application, planar assembly **560** is "offset" from planar assembly **570**, where the offset angle is angle **Φ2**. As those skilled in the art will appreciate, the interior dihedral angle, in degrees, formed by the intersection of planar assembly **560** and planar assembly **570** is 180−**Φ1**. By "interior dihedral angle," Applicants' mean the angle formed between surface **523** and surface **533**.

[0080] In certain embodiments, angle **Φ2** is between about 5 degrees and about 25 degrees. In certain embodiments, angle **Φ2** is between about 8 degrees and about 15 degrees. In certain embodiments, angle **Φ2** is about 10 degrees.

[0081] Edge **532** of planar assembly **570** meets edge **542** of planar assembly **570** along seam **531**. Dotted line **335** represents the extension of edge **532** past seam **531**. As shown in FIG. 3B, angle **Φ3** represents the angle formed between edge **542** and extension line **335**. For purposes of this Application, planar assembly **570** is "offset" from planar assembly **580**, where the offset angle is angle **Φ3**. As those skilled in the art will appreciate, the interior dihedral angle, in degrees, formed by the intersection of planar assembly **570** and planar assembly **580** is 180−**Φ1**. By "interior dihedral angle," Applicants' mean the angle formed between surface **533** and surface **543**.

[0082] In certain embodiments, angle **Φ3** is between about 5 degrees and about 25 degrees. In certain embodiments, angle **Φ3** is between about 8 degrees and about 15 degrees. In certain embodiments, angle **Φ3** is about 13 degrees.

[0083] In certain embodiments, two or more of offset angles **Φ1**, **Φ2**, and/or **Φ3**, are substantially the same. By "substantially the same," Applicants means within about plus or minus ten percent or less. In other embodiments, two or more of offset angles **Φ1**, **Φ2**, and/or **Φ3**, differ.

[0084] FIG. 5B shows a side view of apparatus **300** which includes housing **170** in combination with a multiply offset sound head matrix assembly **501**. Transducers **514**, **524**, **534**, and **544**, each comprise a first side **591**, **593**, **595**, and **597**, respectively, and an opposing second side **592**, **594**, **596**, and **598**, respectively.

[0085] In the illustrated embodiment of FIG. 5B, side **591** of transducer **441**, and side **593** of transducer **524**, and side **595** of transducer **534**, and side **597** of transducer **544**, respectively, are disposed on surface **513** of planar assembly **550**, surface **523** of planar assembly **560**, surface **533** of planar assembly **570**, and surface **543** of planar assembly **580**, respectively. Transducers **515**, **516**, **517**, **525**, **526**, **527**, **535**, **536**, **537**, **545**, **546**, and **547**, are similarly attached to their respective planar assemblies.

[0086] As those skilled in the art will appreciate, the plurality of transducers comprising sound head matrix assembly **501** may include one or more leads which extend through holes, i.e. vias, drilled through one of the four planar assemblies. In other embodiments, the plurality of transducers comprising sound head matrix **501** each comprise what is sometimes called a "surface mounted" device, wherein that surface mounted device is attached to a solder pad disposed on surface **513**, or surface **523**, or surface **533**, or surface **443**.

[0087] FIG. 5C shows a side view of apparatus **301** which includes housing **170** in combination with an offset sound head matrix assembly **502**. Sound head matrix assembly **502** is identical to sound head matrix assembly **501** except that each of the plurality of therapeutic ultrasound transducers extends through a planar assembly rather than being disposed on the exterior surface of that planar assembly. For example in the illustrated embodiment of FIG. 5C, transducers **514**, **524**, **534**, and **544**, respectively, are disposed through planar assembly **550**, planar assembly **560**, planar assembly **570**, and planar assembly **580**, respectively, such that surface **592** of transducer **514** is flush with surface **513** of planar assembly **550**, and, such that surface **594** of transducer **524** is flush with surface **523** of planar assembly **560**, and such that surface **596** of transducer **534** is flush with surface **533** of planar assembly **570**, and such that surface **598** of transducer **544** is flush with surface **543** of planar assembly **580**.

[0088] FIG. **6** shows one embodiment of Applicants' therapeutic ultrasound apparatus **600**. Apparatus **600** includes ultrasonic emitting device **610**, external controller

620, and power source **650**. Power source **650** provides power to device **610** by power cable **660**. In certain embodiments, Applicants' system **600** includes power switch **665**. In the illustrated embodiment of FIG. **6** power switch **665** is disposed in power cable **660**. In other embodiments, switch **665** is disposed on power source **650**. In other embodiments, switch **665** is disposed on the outer surface of device **610**. Power switch **665** can comprise any suitable power switching device, and may take the form of, for example, a rocker switch, a toggle switch, a push to operate switch, and the like.

[0089] Device **610** includes housing **170** and sound head matrix assembly **605**. In the illustrated embodiment of FIG. **6**, Applicants' sound head matrix assembly **605** comprises a 4×2 sound head matrix. As a general matter, Applicants' sound head matrix assembly **605** comprises a Y×Z sound head matrix, wherein Y represents the number of transducers in a column, and wherein Z represents the number of columns, wherein Y is greater than or equal to 1, and less than or equal to about 10, and wherein Z is greater than or equal to 1 and less than or equal to about 6.

[0090] For example in certain embodiments, Applicants' ultrasonic device **610** comprises an 8×2 sound head matrix, such as the sound head matrix recited in FIG. **4**A. In certain embodiments, Applicants' ultrasonic device **610** comprises a 4×4 sound head matrix, such as the sound head matrix recited in FIG. **5**A.

[0091] In the illustrated embodiment of FIG. **6**, Applicants' sound head matrix assembly is substantially flat. In other embodiments, Applicants' sound head matrix assembly comprises (N) offset planar assemblies, wherein (N) is greater than or equal to 2 and less than or equal to about 6.

[0092] For example, in certain embodiments, Applicants' ultrasonic device **610** comprises offset sound head matrix assembly **401** (FIGS. **2**A, **3**A, **4**A, **4**B)), where that sound head matrix assembly comprises a Y×2 sound head matrix. In other embodiments, Applicants' ultrasonic device **610** comprises offset sound head matrix assembly **402** (FIG. **4**C), where that sound head matrix assembly comprises a Y×2 sound head matrix. In other embodiments, Applicants' ultrasonic device **610** comprises offset sound head matrix assembly **501** (FIGS. **5**A, **5**B), where that sound head matrix assembly comprises a Y×4 sound head matrix. In other embodiments, Applicants' ultrasonic device **610** comprises offset sound head matrix assembly **502** (FIG. **5**C), where that sound head matrix assembly comprises a Y×4 sound head matrix.

[0093] Controller **620** is interconnected with device **610** by communication link **628**. In certain embodiments, communication link **628** is selected from the group which includes a serial interconnection, such as RS-232 or RS-422, an ethernet interconnection, a SCSI interconnection, a Fibre Channel interconnection, an ESCON interconnection, a FICON interconnection, a Local Area Network (LAN), a private Wide Area Network (WAN), a public wide area network, Storage Area Network (SAN), Transmission Control Protocol/Internet Protocol (TCP/IP), the Internet, and combinations thereof.

[0094] In certain embodiments, controller **620** wirelessly communicates with device **610** using Bluetooth-compliant emissions at about 2.4 GHz. In certain embodiments, communication link **628** is compliant with one or more of the embodiments of IEEE Specification 802.11 (collectively the "IEEE Specification"). As those skilled in the art will appreciate, the IEEE Specification comprises a family of specifications developed by the IEEE for wireless LAN technology.

[0095] The IEEE Specification specifies an over-the-air interface between a wireless client, such as for example projector **100**, and a base station or between two wireless clients. The IEEE accepted the IEEE Specification in 1997. There are several specifications in the 802.11 family, including (i) specification 802.11 which applies to wireless LANs and provides 1 or 2 Mbps transmission in the 2.4 GHz band using either frequency hopping spread spectrum (FHSS) or direct sequence spread spectrum (DSSS); (ii) specification 802.11a which comprises an extension to 802.11 that applies to wireless LANs and provides up to 54 Mbps in the 5 GHz band using an orthogonal frequency division multiplexing encoding scheme rather than FHSS or DSSS; (iii) specification 802.11b, sometimes referred to as 802.11 High Rate or Wi-Fi, which comprises an extension to 802.11 that applies to wireless LANS and provides up to about 11 Mbps transmission in the 2.4 GHz band; and/or (iv) specification 802.11g which applies to wireless LANs and provides **20+** Mbps in the 2.4 GHz band.

[0096] Communication link **628** can be releaseably attached to coupling **630** disposed on housing **170**. Coupling **630** is interconnected with control bus **640**. Control bus **640** is interconnected to each transducer comprising Applicants' sound head matrix assembly **610**.

[0097] In certain embodiments, controller **620** provides control signals to device **610** wirelessly. In these wireless embodiments, communication link **628** comprises a first antenna coupled to controller **620** and coupling **630** comprises a second antenna coupled to communication bus **640**.

[0098] Controller **620** includes processor **622**, memory **624**, and device microcode **626**. In certain embodiments, memory **624** comprises one or more nonvolatile memory devices. In certain embodiments, such nonvolatile memory is selected from the group which includes one or more EEPROMs (Electrically Erasable Programmable Read Only Memory), one or more flash PROMs (Programmable Read Only Memory), battery backup RAM, hard disk drive, combinations thereof, and the like.

[0099] In certain embodiments, microcode **626** is stored in memory **624**. Device microcode **626** comprises instructions residing in memory, such as for example memory **624**, where those instructions are executed by processor **622** to implement the selected operational mode for the plurality of transducers comprising Applicants' sound head matrix assembly.

[0100] For example, where Applicants' ultrasound emitting device comprises (N) therapeutic ultrasound transducers processor **622** provides the (i)th signal to the (i)th therapeutic ultrasound transducer causing that (i)th therapeutic ultrasound transducer to emit the (i)th therapeutic ultrasound energy comprising the (i)th frequency and the (i)th phase, wherein (i) is greater than or equal to 1 and less than or equal to (N).

[0101] In certain embodiments, device microcode **626** comprises instructions residing in memory, such as for example memory **624**, where those instructions are executed by processor **622** to cause each of the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix assembly **605** to operate continuously. In other embodiments, device microcode **626** comprises instructions residing in memory, such as for example memory **624**, where those instructions are executed by processor **622** to cause each of the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix assembly **605** to operate discontinuously.

[0102] As a general matter, such discontinuous operation modes include embodiments wherein each of the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix assembly **605** operates on a duty cycle from about 0.1 percent to 100 percent. In certain embodiments, such discontinuous operation modes include embodiments wherein each of the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix assembly **605** operates on a duty cycle selected from the group comprising a 20 percent duty cycle, a 40 percent duty cycle, a 60 percent duty cycle, and an 80 percent duty cycle.

[0103] In certain of these discontinuous operational modes, each of the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix assembly **605** operates independently of any of the other transducer, i.e. each transducer is alternately turned on and off randomly. In other embodiments, an entire column of transducers operates at the same time, while transducers comprising other columns do not operate. In other embodiments, an entire row of transducers operates at the same time, while transducers comprising other rows do not operate.

[0104] In certain embodiments of Applicants' method using Applicants' ultrasound emitting apparatus, combinations of frequencies from differing transducers are employed to effectively treat complex structures. Various frequencies and combinations of frequencies may be desirable in particular circumstances to both avoid standing waves with excessively concentrated energy deposition in particular locations and to provide more uniform distribution of the energy at therapeutic levels. For example, lower frequency acoustic waves, such as 40 kHz, may be better dispersed by refraction of the beam when directed through a small opening in a bone structure. The lower frequency provides longer range and better coverage than higher frequencies. In relation to the skull in particular, lower frequencies also pass through bone more efficiently than higher frequencies.

[0105] In general, acoustic waves at higher frequencies penetrate less well, degrade faster, and are much shorter than lower frequency waves. As a result, use of higher frequency waves avoids a problem of low frequency waves that may match the scale of anatomical structures, and thereby, form detrimental large standing waves in such anatomical structures. Also, higher frequencies do not disperse to the same extent as lower frequencies and may therefore be more effective as a straight beam, either aimed at a target or swept through a range of vectors to cover a volume. In addition, higher frequencies, above 500 kHz and particularly between 500 kHz and 2 MHz, are helpful in avoiding unanticipated peaks in the energy deposition pattern and standing waves.

[0106] In addition, in certain embodiments the frequency and/or phase of the acoustic waves produced by the plurality of therapeutic ultrasound transducers comprising Applicants' sound head matrix is variable. In certain embodiments, each of the plurality of transducers emits acoustic waves having substantially the same frequency, but with differing phases. In other embodiments, each of the plurality of transducers emits a pattern of modulated acoustic waves wherein the frequency and/or phase of the acoustic waves emitted by each of those transducers is continuously changed from an initial, i.e. beginning, frequency and phase, through a final, i.e. ending frequency and phase. In certain embodiments, each of the transducers comprising Applicants' sound head matrix operates using a different frequency modulation pattern and/or a different phase modulation pattern.

[0107] In certain embodiments, the frequency of one or more of Applicants' therapeutic transducers initial emit acoustic waves comprising a low frequency, i.e. 250 KHz and sweep through intervening frequencies to an ending frequency of about 2 MHZ. In certain embodiments, each of the therapeutic transducers using this "low to high" frequency modulation pattern generates acoustic waves having a different phase than the waves emitted from the other "low to high" transducers. Other transducers comprising Applicants' sound head matrix initially emit acoustic waves comprising a high frequency, i.e. 2 MHZ, and sweep through intervening frequencies to an ending frequency of about 250 KHz. In certain embodiments, each of the therapeutic transducers using this "high to low" frequency modulation pattern generates acoustic waves having a different phase than the waves emitted from the other "high to low" transducers.

[0108] As those skilled in the art will appreciate, interference occurs when two or more ultrasound waves intersect. The waves may be produced directly from an ultrasound transducer or from a reflection from an anatomical structure, such as the surface of the head. Interference may be either constructive or destructive in nature depending upon the relative phase and amplitudes of the combining waves.

[0109] Such interference may be constructive or destructive. Constructive interference occurs when waves having about the same phase intersect with a resulting additive effect regarding the composite energy produced. Destructive interference results when waves having opposing phases intersect with a resulting canceling effect.

[0110] If the interference is destructive, i.e. canceling, then when microbubbles are used as the lysing agent, the microbubbles may not expand and contract sufficiently to produce the desired therapeutic effect. In certain embodiments, the ultrasound frequency and phase from one or more therapeutic ultrasound transducers comprising Applicants' sound head matrix is modulated by controller **620** with the result that any interference pattern(s) will be constantly shifting in position, thereby insuring uniform coverage of the targeted anatomical portion of the patients' cerebral anatomy. In addition, the interference pattern of nodes and anti-nodes created thereby is not static but travels through the targeted tissue. Moreover, the frequencies of the acoustic signals are selected to avoid standing waves from resonance of the anatomical portion into which the acoustics signals are delivered.

[0111] In certain embodiments, controller **620** comprises a computer, which in addition to memory **624** and microcode **624**, further includes one or more input devices, such as for example a keyboard, a mouse, a pointing device, and the like. In certain embodiments, that computer further includes one or more output devices, such as for example one or more monitors, one or more printers, and the like.

[0112] In certain embodiments of Applicants' apparatus, the external control circuitry of FIG. **6**, i.e. controller **620**, is disposed within Applicants' ultrasonic device. Referring to FIG. **7**A, device **710** includes the elements of device **610** in combination with controller **720**. For clarity of illustration, FIG. **7** does not include power source **650**, power cable **660**, or power bus **605**. Controller **720** comprises processor **622**, memory **624**, and microcode **626**.

[0113] Applicants' ultrasonic device **710** includes controller **720** which is interconnected to each of a plurality of therapeutic ultrasound transducers **712**, **713**, **714**, **715**, **716**, **717**, **718**, and **719**, via communication links **732**, **733**, **734**, **735**, **736**, **737**, **738**, and **739**, respectively.

[0114] For further clarity of illustration, the illustrated embodiment of FIG. **7**A includes 4×2 sound head matrix assembly **705**. As a general matter, sound head matrix assembly **705** comprises a Y×Z sound head matrix, where that Y×Z sound head matrix is described above, and where that Y×Z sound head matrix may comprise a substantially flat assembly, or that Y×Z sound head matrix assembly may comprise (N) offset planar assemblies. In certain embodiments, controller **720** comprises an application specific integrated circuit, i.e. an "ASIC," which integrates the functions of processor **622**, memory **624**, and microcode **626**.

[0115] Referring now to FIG. **7**B, Applicants' ultrasonic device **715** includes the elements of device **710** (FIG. **7**A) in combination with integrated information input/output ("I/O") device **750**. In the illustrated embodiment of FIG. **7**B, I/O device **750** includes a visual display device **760** and a plurality of input device/touch screens **771**, **773**, **775**, **777**, and **779**. In certain embodiments, visual display device **760** comprises an LCD device. I/O device **750** communicates with controller **720** via communication links **740** and **755**.

[0116] In certain embodiments, Applicants' ultrasound emitting device includes one or more diagnostic ultrasound emitters in combination with a plurality of therapeutic ultrasound emitters. In the illustrated embodiments of FIG. **8**A, ultrasound emitting device **800** includes diagnostic ultrasound transceiver **810**, and a 2×3 sound head matrix comprising 6 therapeutic ultrasound emitters. In other embodiments, Applicants' ultrasound emitting device comprises a plurality of diagnostic ultrasound transducers. In certain embodiments, one or more of the ultrasound transducers disposed in Applicants' ultrasound emitting device are capable of functioning as both a diagnostic ultrasound emitter and a therapeutic ultrasound emitter.

[0117] In the illustrated embodiment of FIG. **8**A, ultrasound emitting device **800** comprises ultrasound transceiver **810** comprising diagnostic ultrasound emitter **812** and receiving device **814**. By "diagnostic ultrasound emitter," Applicants' mean a device which is capable of emitting diagnostic ultrasound energy having a output power of between about 0.5 and about 1 milliwatt per cm^2 at a frequency of between about 7 and about 13 megahertz. Emitter **812** produces and emits ultrasound waves. Receiver **814** detects emissions reflected back to transceiver **810** by various underlying body tissues. Those reflected emissions are processed by the controller, such as for example controller **620** (FIG. **6**) and/or controller **720** (FIGS. **7**A, **7**B), and/or controller **805** (FIGS. **8**B, **8**C), and/or controller **910** (FIG. **9**), and that controller causes a visual display device, such as visual display device **750** or visual display device **1042** (FIG. **10**), to display an image of the tissue structure underlying the diagnostic ultrasound transceiver.

[0118] Any of the various types of diagnostic ultrasound imaging devices may be employed in the practice of the invention. Preferably, the transceiver **810** employs a resonant frequency (RF) spectral analyzer. Applicants' one or more diagnostic ultrasound transducers emit relatively low power level ultrasound waves. The various body tissues differentially reflect a portion of those sound waves. Applicants' diagnostic transceiver detects those reflected signals. An interconnected controller, external to or integral with the ultrasound emitting device, such as for example controller **620** (FIG. **6**), **805** (FIG. **8**B), **720** (FIGS. **7**A, **7**B), **910** (FIG. **9**), or computing device **1040** (FIG. **10**), processes those reflected signals and generates an image signal. That image signal is provided to a display device, external to or integral with the ultrasound emitting device, such as visual display device **760** (FIGS. **7**B, **8**C), or **1042** (FIG. **10**), which visually displays an image of the tissues and structures underlying the ultrasound emitting device.

[0119] In certain embodiments, Applicants' apparatus and method employ harmonic imaging and/or pulse inversion imaging. In harmonic imaging, the bandwidth of the transmitted and received imaging signals must be narrow enough to ensure that the received harmonic signal can be separated from the transmitted fundamental signal.

[0120] Pulse inversion imaging avoids these bandwidth limitations and overcomes the contrast detectability and imaging resolution trade-off by using broader transmit and receive bandwidths. In pulse inversion imaging, a sequence of two ultrasound imaging pulses is transmitted into tissue instead of only a single pulse. The first pulse is an in-phase pulse, the second is an identical copy of the first, but inverted. For any linear target, the response to the second pulse is an inverted copy of the response from the first pulse. These are then summed and all linear echoes cancel.

[0121] On the other hand, for a nonlinear target, such as for example gas bubbles, the responses to positive and negative pulses differ. The addition of the responses does not cancel completely. Rather, the fundamental components of the echo cancel whereas the harmonic components add, giving twice the harmonic level of a single pulse. The main advantage of pulse inversion over harmonic imaging and harmonic power Doppler imaging is that it can function over the entire bandwidth of the received echo signal and, therefore, achieves superior imaging resolution.

[0122] In certain embodiments, Applicants' imaging method employs pulse inversion imaging using a low mechanical index ("MI") thereby prolonging the lifetime of the contrast agent and obviating the need for intermittent imaging. In certain embodiments, Applicants' apparatus and method further employ a longer sequence of transmitted inverted pulses in order to remove tissue motion.

[0123] In still other embodiments, Applicants' imaging method utilize pulse inversion detection in combination with Doppler detection to exploit the advantages of both detection schemes. In these embodiments, more than two imaging pulses are transmitted and special Doppler filters are applied to remove tissue motion.

[0124] In yet other embodiments, Applicants' apparatus and method utilize power modulation for contrast agent detection based on nonlinear properties of gas micro bubbles. In these embodiments, Applicants' apparatus and method employ a multi-pulse technique wherein the acoustic amplitude of the transmitted imaging pulses is varied. For example, two transmit amplitudes are used, full and half amplitude. This transmit amplitude change induces changes in the response of the contrast agent. On receive, echoes from the half amplitude-transmitted pulse are adjusted in amplitude and subsequently subtracted from the full amplitude echoes. This procedure removes most of the linear responses at the fundamental frequency, and the remaining echoes contain mainly nonlinear signals from the micro bubbles.

[0125] In certain embodiments, Applicants' imaging method utilizes power modulation with a low-frequency wide band transducer. The low frequency transducer increases the depth of field and transmits the ultrasound energy more uniformly throughout the image. The combination of power modulation and wide band transducer allows ultraharmonic imaging, which results in a better elimination of tissue artifacts and therefore increased contrast to tissue ratio.

[0126] Referring once again to FIG. **8**A, therapeutic ultrasound emitters **842**, **844**, and **846**, are disposed on, or through, planar member **820**. Emitters **842**, **844**, and **846**, in combination with planar member **820**, comprise planar assembly **860**. Therapeutic ultrasound emitters **852**, **854**, **856**, are disposed on, or through, planar member **830**. Emitters **852**, **854**, and **856**, in combination with planar member **830**, comprise planar assembly **870**.

[0127] Planar assembly **860** is continuously attached to planar assembly **870** along seam **825**. In certain embodiments, the dihedral angle formed by the intersection of planar assembly **860** and planar assembly **870** is 180 degresss, i.e. the angle Φ shown in FIG. **8**A is zero. In other embodiments, planar assembly **860** is offset from planar assembly **870**, i.e. the angle Φ shown in FIG. **8**A is greater than zero. In certain embodiments, the dihedral angle formed by the intersection of planar assembly **860** and planar assembly **870** is between 155 degrees and 175 degrees. the dihedral angle formed by the intersection of planar assembly **860** and planar assembly **870** is 167 degrees.

[0128] The illustrated embodiment of FIG. **8**A comprises one embodiment of Applicants' ultrasound emitting device comprising both diagnostic and therapeutic ultrasound transducers. As a general matter, Applicants' ultrasound emitting device comprising both diagnostic and therapeutic transducers comprises a Y×Z sound head matrix, wherein Y represents the number of transducers in a column, and wherein Z represents the number of columns, wherein Y is greater than or equal to 1, and less than or equal to about 10, and wherein Z is greater than or equal to 1 and less than or equal to about 6. In certain embodiments, Applicants' diagnostic/therapeutic ultrasound emitting device comprises such a Y×Z therapeutic transducer sound head matrix in combination with one or more diagnostic transducers **812** and a receiver **814**. In other embodiments, Applicants' diagnostic/therapeutic ultrasound emitting device comprises such a Y×Z therapeutic transducer sound head matrix in combination with receiver **814**, wherein one or more of the therapeutic transducers is capable of emitting diagnostic ultrasound energy.

[0129] Referring now to FIG. **8**B, Applicants' ultrasound emitting device **800** comprises sound head matrix assembly **801** in combination with controller **805** and housing **170**. Controller **805** includes a processor such as processor **622**, memory such as memory **624**, and device microcode such as microcode **626**, wherein processor **622** utilizes microcode **626** to operate the plurality of therapeutic emitters **842**, **844**, **846**, **852**, **854**, and **856**, and to operate diagnostic transducer **812**, and to operate receiver **814**.

[0130] In certain embodiments, Applicants' ultrasound device **800** includes an integral information input/output device. Referring now to FIG. **8**C, ultrasound emitting device **802** comprises device **800** in combination with integrated I/O device **750**. Controller **805** communicates with I/O device **750** via communication links **804** and **755**. Diagnostic transceiver **810** is internally disposed within device **801** adjacent end **890**. In these embodiments, controller **805** includes a processor, such as processor **622**, memory, such as memory **624**, and device microcode, such as microcode **626**, to operate the plurality of therapeutic emitters **842**, **844**, **846**, **852**, **854**, and **856**, and to operate diagnostic transceiver **810**, and to operate visual display device **760**.

[0131] By monitoring display device **760**, the medical provider can determine when sufficient injected microbubbles have reached the occlusion site. At that time, the medical provider than causes the plurality of therapeutic ultrasound emitters to produce ultrasound energy having a higher power level than the diagnostic power levels emitted by transceiver **810**. Those higher power ultrasound energy causes the microbubbles to rupture. After the flow of the injected microbubbles ceases, the medical provider then discontinues emission of the therapeutic ultrasound energy.

[0132] In certain embodiments Applicants' ultrasound device includes an "auto-detect" feature, wherein that devices monitors the reflected diagnostic signals, and automatically detects the arrival of sufficient injected microbubbles at the occlusion site. When sufficient injected microbubbles are detected, Applicants' device automatically causes the plurality of therapeutic ultrasound devices to emit therapeutic ultrasound energy using a plurality of pre-determined therapeutic insonation regimes. When the flow of microbubbles ceases, Applicants' device automatically causes the plurality of therapeutic ultrasound devices to stop emitting therapeutic ultrasound energy.

[0133] In certain embodiments of Applicants' apparatus and method comprise "burst-mode" insonation embodiments, wherein in response to a detected event Applicants' ultrasound emitting device emits acoustic energy waves in bursts, using a plurality of pre-determined therapeutic insonation regimes, each such regime comprising a modulation pattern of duty cycles, frequencies, and phases. The period of insonation is followed by a period of no acoustic wave emissions. In certain embodiments, Applicants' burst mode insonation method comprises alternating a time period comprising bursts of acoustic energy followed by a time period of no acoustic energy emissions.

[0134] In certain embodiments, the detected event comprises a physiologic event. In other embodiments, the detected event comprises a non-physiologic event. Such a non-physiologic event comprises for example and without limitation a pre-determined time interval between the administration of one or more therapeutic agents and the initiation of acoustic energy emissions.

[0135] Such a detected physiologic event comprises for example and without limitation, a threshold heart rate, a threshold blood pressure, a threshold serum level of one or more compounds, and the like. In other embodiments, such an event comprises a non-detection event, for example the operation of Applicants' apparatus described herein is initiated upon imaging which shows the absence of a hemorrhagic stroke.

[0136] In certain embodiments, Applicants' controller/computing device **620**, **720**, **805/910**, **1040**, causes the plurality of therapeutic ultrasound transducers to emit acoustic waves, using a plurality of pre-determined therapeutic insonation regimes, in bursts, when a pre-determined concentration of microbubbles is detected. Each acoustic energy emission is followed by a period of no acoustic wave emissions. During the periods of no emissions, the concentration of microbubbles at the occlusion site is allowed to increase. When the pre-determined concentration of microbubbles is again detected, the controller again cause the plurality of ultrasound transducers to emit another burst of acoustic energy waves.

[0137] In certain embodiments, Applicants' ischemic stroke treatment protocol comprises selecting a sound head matrix comprising (N) therapeutic ultrasound transducers, establishing (N) therapeutic insonation regimes, wherein the (i)th therapeutic insonation regime is established for the (i)th therapeutic ultrasound transducer, wherein (N) is greater than or equal to 1, and wherein (i) is greater than or equal to 1 and less than or equal to (N). In certain embodiments, each (i)th therapeutic insonation regime comprises the (i)th duty cycle modulation pattern, the (i)th frequency modulation pattern, the (i)th power modulation pattern, and the (i)th phase modulation. In certain embodiments, selecting a sound head matrix and establishing the plurality of insonation regimes comprise selecting an ultrasound emitting device having a plurality of insonation regimes encoded to a processor disposed in the selected ultrasound emitting device.

[0138] In other embodiments, an insonation regime for each therapeutic ultrasound transducer disposed on the selected sound head matrix is created using a computing device external to the ultrasound emitting device comprising the selected sound head matrix. In certain of these embodiments, the external computing device remains interconnected to the ultrasound emitting device throughout Applicants' ischemic stroke treatment protocol, wherein the external computing device, using the pre-determined plurality of insonation regimes, controls the operation of each therapeutic transducer disposed on the selected sound head matrix. In other embodiments, the pre-determined plurality of insonation regimes is downloaded from the external computing device to a controller integral with the ultrasound emitting device comprising the selected sound head matrix.

[0139] In certain embodiments, Applicants' ischemic stroke treatment protocol further comprises establishing one or more imaging regimes. In certain embodiments, such imaging regimes utilize harmonic imaging. In certain embodiments, such imaging regimes utilize pulse inversion imaging. In certain embodiments, such imaging regimes utilize pulse inversion imaging using a low MI, In certain embodiments, such imaging regimes utilize pulse inversion imaging in combination with Doppler detection. In certain embodiments, such imaging regimes utilize power modulation. In certain embodiments, such imaging regimes utilize power modulation with a low-frequency wide band transducer.

[0140] In certain embodiments, establishing one or more imaging regimes comprise selecting an ultrasound emitting device having a one or more imaging regimes encoded in a processor disposed in the selected ultrasound emitting device. In other embodiments, an imaging regime is created using a computing device external to the ultrasound emitting device comprising the selected sound head matrix. In certain of these embodiments, the external computing device remains interconnected to the ultrasound emitting device throughout Applicants' ischemic stroke treatment protocol, wherein the external computing device, using the pre-determined imaging regimes, controls the operation of each diagnostic transducer disposed on the selected sound head matrix. In other embodiments, the pre-determined imaging regimes are downloaded from the external computing device to a controller integral with the ultrasound emitting device comprising the selected sound head matrix.

[0141] In the illustrated embodiment of FIG. **9**, ultrasound energy emitting device **900** comprises a sound head matrix comprising plurality of therapeutic ultrasound transducers **842**, **844**, **846**, **852**, **854**, **856**, in combination with ultrasound transceiver **810**, wherein controller **910** is in communication with each of the ultrasound transducers and with the ultrasound imaging transceiver **810**. In certain embodiments, controller **910** comprises controller **805** (FIGS. **8**B, **8**C). As a general matter, ultrasound emitting device **900** comprises a sound head matrix assembly comprising a Y×Z sound head matrix, wherein Y represents the number of therapeutic transducers in a column, and wherein Z represents the number of columns, wherein Y is greater than or equal to 1, and less than or equal to about 10, and wherein Z is greater than or equal to 1 and less than or equal to about 6. In certain embodiments, one or more of the therapeutic transducers also comprises a diagnostic transducer.

[0142] In the illustrated embodiment of FIG. **9**, controller **910** is interconnected with port **930** by communication link **920**. In certain embodiments, port **930** comprises a Universal Serial Bus ("USB") connection. In certain embodiments, port **930** comprises a USB 1.0 connection. In other embodiments, port **930** comprises a USB 2.0 connection. In certain embodiments, port **930** comprises an IEEE 1394 compliant connection, sometimes referred to as a "firewire" connection.

[0143] In the illustrated embodiment of FIG. **9**, controller **910** comprises processor element **912**, memory element **914**, and instructions/microcode **916** encoded to memory **914**. In certain embodiments, controller **910** comprises an ASIC. Processor **912** utilizes instructions **916** to implement Applicants' ischemic stroke treatment protocol, wherein instructions **916** comprise a plurality of pre-determined therapeutic insonation regimes, and one or more pre-determined imaging regimes.

[0144] Referring now to FIG. **10**, ultrasound emitting device **900** is interconnected with computing device **1040** via communication link **1030**. Computing device **1040** comprises processor **1044**, memory **1046**, and instructions **1048**. As a general matter, computing device **1040** comprises a computer system, such as a mainframe, personal computer, workstation, and combinations thereof, including an operating system such as Windows, AIX, Unix, MVS, LINUX, etc. (Windows is a registered trademark of Microsoft Corporation; AIX is a registered trademark and MVS is a trademark of IBM Corporation; UNIX is a registered trademark in the United States and other countries licensed exclusively through The Open Group; LINUX is a registered trademark owned by Linus Torvalds.)

[0145] Communication link **1030** is selected from the group comprising a wireless communication link, a serial interconnection, such as RS-232 or RS-422, an ethernet interconnection, a SCSI interconnection, an iSCSI interconnection, a Gigabit Ethernet interconnection, a Bluetooth interconnection, a Fibre Channel interconnection, an ESCON interconnection, a FICON interconnection, a Local Area Network (LAN), a private Wide Area Network (WAN), a public wide area network, Storage Area Network (SAN), Transmission Control Protocol/Internet Protocol (TCP/IP), the Internet, and combinations thereof.

[0146] In certain embodiments, a therapeutic insonation regime for each therapeutic transducer disposed on the selected sound head matrix is created using computing device **1040**, wherein that plurality of therapeutic insonation regimes is encoded in memory **1046** as a portion of instructions **1048**. In certain embodiments, one or more diagnostic imaging regimes for each diagnostic transducer disposed on the selected sound head matrix is created using computing device **1040**, wherein that plurality of therapeutic insonation regimes is encoded in memory **1046** as a portion of instructions **1048**.

[0147] In certain embodiments, computing device **1040** remains in communication with ultrasound emitting device **900** via communication link **1030** throughout all or a portion of Applicants' ischemic stroke treatment protocol. In other embodiments, instructions **1048** comprising a plurality of therapeutic insonation regimes, and optionally one or more imaging regimes, is downloaded to instructions **916** (FIG. **9**) via communication link **1030**, wherein communication link **1030** is disabled prior to initiating Applicants' ischemic stroke treatment protocol.

[0148] Referring now to FIGS. **11**A, **11**B, and **12**, in the illustrated embodiment of FIG. **11**A, apparatus **1100** comprises ultrasound emitting device **1120** in combination with head band elements **1110** and **1115**. In certain embodiments, head band portions **1110** and **1115** comprise an integral assembly which can be disposed circumferentially around a patient's head. In certain embodiments, head band portions **1110** and **1115** comprise an elastic material which can be stretched in order to place assembly **1100** around the head, and which then contracts to hold assembly **1100** in place around the head.

[0149] Applicants have found that insonation of the basal cerebral arteries and the circle of Willis is facilitated by placing Applicants' ultrasound emitting assembly **1100** around head such that the acoustic wave(s) emitted by ultrasound emitting device **1120** cross the thinnest portion of the squamous part of the temporal bone. The temporal window can be localized quite anteriorly (close to the vertical portion of the zygomatic bone) or, more frequently, posteriorly (close to the pinna of the ear).

[0150] In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **100** (FIGS. **1**A, **1**B). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **200** (FIGS. **2**A, **4**B). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **201** (FIG. **4**C). In certain embodiments, ultrasound emitting device **920** comprises Applicants' ultrasound emitting device **300** (FIGS. **3**A, **5**B). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **301** (FIG. **5**C). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **600** (FIG. **6**).

[0151] In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **710** (FIG. **7**A). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **715** (FIG. **7**B). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **800** (FIG. **8**B). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **802** (FIG. **8**C). In certain embodiments, ultrasound emitting device **1120** comprises Applicants' ultrasound emitting device **900** (FIGS. **9**, **10**).

[0152] Referring now to FIG. **11**B, apparatus **1105** comprises one or more ultrasound emitting devices **1120**, as described hereinabove, attached to head frame **1130**. In the illustrated embodiment of FIG. **12**, Applicants' ultrasound emitting assembly **1200** comprises ultrasound emitting device **1220** and ultrasound emitting device **1230**. Devices **1220** and **1230** are attached to opposing sides of head band portion **1110** (FIGS. **11**, **12**), or to opposing sides of head frame **1130**. In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **100** (FIGs. **1**A, **1**B). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **200** (FIGS. **2**A, **4**B). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **201** (FIG. **4**C). In certain embodiments, u one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **300** (FIGS. **3**A, **5**B). In certain embodiments, u one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **301** (FIG. **5**C). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **600** (FIG. **6**). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **710** (FIG. **7**A).

[0153] In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **715** (FIG. **7**B).). In certain embodiments, u one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device

800 (FIG. 8B). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **802** (FIG. 8C). In certain embodiments, one or more of ultrasound emitting devices **1220** and **1230** comprise Applicants' ultrasound emitting device **900** (FIGS. 9, 10).

[0154] The following examples are presented to further illustrate to persons skilled in the art how to make and use Applicants' invention, and to identify a presently preferred embodiment thereof. These examples are not intended as limitations, however, upon the scope of the invention which is defined by claims appended hereto.

EXAMPLE I

[0155] Referring now to FIGS. **2**A, **4**A, **4**B, **4**C, **11**A, **11**B, and **13**A, this Example I uses ultrasound emitting apparatus **200** (FIG. **4**A, **4**B) or ultrasound emitting apparatus **201** (FIG. **4**C), externally disposed over a patient's temporal window as shown in FIGS. **11**A and **11**B, wherein apparatus **200**/**201** comprises sound head matrix **401** (FIG. **4**A), wherein the interior dihedral angle, as defined hereinabove, is between **155** and **175** degrees.

[0156] FIG. **13**A shows the effective acoustic fields **1310** and **1320** produced by Applicants' ultrasound emitting apparatus **200**/**201**. The overlapping fields are shown by shading.

[0157] In certain embodiments, the frequency and/or the phase of the acoustic waves emitted by ultrasound transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, **448**, **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, are modulated such that, at any given time, none of those transducer are emitting acoustic waves having the same frequency and phase. In certain embodiments, transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, and **448**, employ the "low to high" frequency modulation described above, while transducers **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, employ the "high to low" frequency modulation described above.

[0158] In addition, in certain embodiments the duty cycles of ultrasound transducers are less than one hundred percent (100%). In these embodiments, in addition to modulating the frequency and/or the phase of transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, **448**, **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, the duty cycles are also modulated such that, at any given time, fewer than all of transducers **441**, **442**, **443**, **444**, **445**, **446**, **447**, **448**, **451**, **452**, **453**, **454**, **455**, **456**, **457**, and **458**, are emitting acoustic waves.

EXAMPLE II

[0159] Referring now to FIGS. **2**A, **4**A, **4**B, **4**C, **12**, and **13**B, this Example II uses a first ultrasound emitting apparatus **200** (FIG. **4**B) or **201**(FIG. **4**C) and a second ultrasound emitting apparatus **200**B or **201**B, wherein first apparatus **200**A/**201**A and second apparatus **200**B/**201**B are externally disposed bilaterally over a patient's temporal windows as shown in FIG. **12**, wherein apparatus **200**A or **201**A and apparatus **200**B or **201**B each comprise sound head matrix **401** (FIG. **4**A), wherein the interior dihedral angle for both apparatus **200**A/**201**B and **100**B, is between about 155 degrees and about 175 degrees.

[0160] FIG. **13**B shows the effective acoustic fields **1310** and **1320** produced by Applicants' ultrasound emitting apparatus **200**A or **201**A, in combination with acoustic fields **1330** and **1340** produced by Applicants' ultrasound emitting apparatus **200**B or **201**B. The overlapping fields are shown by shading.

[0161] In certain embodiments, the frequency and/or the phase of the acoustic waves emitted by ultrasound transducers **441**A, **442**A, **443**A, **444**A, **445**A, **446**A, **447**A, **448**A, **451**A, **452**A, **453**A, **454**A, **455**A, **456**A, **457**A, **458**A, **441**B, **442**A, **443**B, **444**B, **445**B, **446**B, **447**B, **448**B, **451**B, **452**B, **453**B, **454**B, **455**B, **456**B, **457**B, **458**B, are modulated such that, at any given time, none of those transducer are emitting acoustic waves having the same frequency and phase, wherein transducers designated with an "A", such as transducer **441**A, are disposed in apparatus **200**A/**201**A, and wherein transducers designated with a "B", such as transducer **441**B are disposed in apparatus **200**B/**201**B. In certain embodiments, transducers **441**A, **442**A, **443**A, **444**A, **445**A, **446**A, **447**A, **448**A, employ the "low to high" frequency modulation described above, while transducers **441**B, **442**A, **443**B, **444**B, **445**B, **446**B, **447**B, **448**B, **451**B, **452**B, **453**B, **454**B, **455**B, **456**B, **457**B, **458**B, employ the "high to low" frequency modulation described herein.

EXAMPLE III

[0162] Referring now to FIGS. **3**A, **5**A, **11**A, **11**B, and **14**A, this Example III uses ultrasound emitting apparatus **300** (FIG. **5**B) or ultrasound emitting apparatus **301** (FIG. **5**C), externally disposed over a patient's temporal window as shown in FIGS. **11**A and **11**B, wherein apparatus **300**/**301** comprises sound head matrix **501** (FIG. **5**A), wherein interior dihedral angles **518**, **528**, and **538** are between about 155 degrees and about 175 degrees.

[0163] FIG. **14**A shows the effective acoustic fields **1410**, **1420**, **1430**, and **1440**, produced by subassemblies **550** (FIG. **5**A), **560** (FIG. **5**A), **570** (FIG. **5**A), and **580** (FIG. **5**A). In certain embodiments, the frequency and/or the phase of the acoustic waves emitted by ultrasound transducers **514**, **515**, **516**, **517**, **524**, **525**, **526**, **527**, **534**, **535**, **536**, **537**, **544**, **545**, **546**, and **547**, are modulated such that, at any given time, none of those transducer are emitting acoustic waves having the same frequency and phase. In certain embodiments, transducers **514**, **515**, **516**, **517**, **534**, **535**, **536**, and **537**, employ the "low to high" frequency modulation described above, while transducers **524**, **525**, **526**, **527**, **544**, **545**, **546**, and **547**, employ the "high to low" frequency modulation described above.

[0164] In addition, in certain embodiments the duty cycles of ultrasound transducers **514**, **515**, **516**, **517**, **524**, **525**, **526**, **527**, **534**, **535**, **536**, **537**, **544**, **545**, **546**, and **547**, are less than one hundred percent (100%). In these embodiments, in addition to modulating the frequency and/or the phase of transducers **514**, **515**, **516**, **517**, **524**, **525**, **526**, **527**, **534**, **535**, **536**, **537**, **544**, **545**, **546**, and **547**, the duty cycles are also modulated such that, at any given time, fewer than all of transducers **514**, **515**, **516**, **517**, **524**, **525**, **526**, **527**, **534**, **535**, **536**, **537**, **544**, **545**, **546**, and **547**, are emitting acoustic waves.

EXAMPLE IV

[0165] Referring now to FIGS. **3**A, **5**A, **12**, and **14**B, this Example IV uses a first ultrasound emitting apparatus **300**A (FIG. **5**B) or **301**A (FIG. **5**C) and a second ultrasound emitting apparatus **300**B or **301**B, wherein first apparatus

300A/301A and second apparatus 300B/301B are externally disposed bilaterally over a patient's temporal windows as shown in FIG.12, wherein apparatus 300A or 301A and apparatus 300B or 301B each comprise sound head matrix 501 (FIG. 5A), wherein interior dihedral angles 518A, 528A, 538A, 518B, 528B, and 538B are between about 155 degrees and about 175 degrees.

[0166] FIG. 14B shows the acoustic fields 1410, 1420, 1430, and 1440, produced by subassemblies 550A (FIG. 5A), 560A (FIG. 5A), 570A (FIG. 5A), 580A (FIG. 5A), in combination with acoustic fields 1450, 1460, 1470, and 1480, produced by subassemblies 550B (FIG. 5A), 560B (FIG. 5A), 570B (FIG. 5A), 580B (FIG. 5A), wherein subassemblies designated with an "A", such as subassembly 550A, are disposed in apparatus 300A/301A, and wherein subassemblies designated with a "B", such as subassembly 550B, are disposed in apparatus 300B/301B.

[0167] In certain embodiments, the frequency and/or the phase of the acoustic waves emitted by ultrasound transducers 514A, 515A, 516A, 517A, 524A, 525A, 526A, 527A, 534A, 535A, 536A, 537A, 544A, 545A, 546A, 547A, 514B, 515B, 516B, 517B, 524B, 525B, 526B, 527B, 534B, 535B, 536B, 537B, 544B, 545B, 546B, and 547B, are modulated such that, at any given time, none of those transducer are emitting acoustic waves having the same frequency and phase, wherein transducers designated with an "A", such as transducer 514A, are disposed in apparatus 300A/301A, and wherein transducers designated with a "B", such as transducer 514B are disposed in apparatus 300B/301B. In certain embodiments, transducers 514A, 515A, 516A, 517A, 524A, 525A, 526A, 527A, 534A, 535A, 536A, 537A, 544A, 545A, 546A, and 547A, employ the "low to high" frequency modulation described above; while transducers 514B, 515B, 516B,517B, 524B, 525B, 526B, 527B,534B, 535B, 536B, 537B, 544B, 545B,546B, and 547B, employ the "high to low" frequency modulation described above.

[0168] In addition, in certain embodiments the duty cycles of ultrasound transducers 514, 515, 516, 517, 524, 525, 526, 527, 534, 535, 536, 537, 544, 545, 546, and 547, are less than one hundred percent (100%). In these embodiments, in addition to modulating the frequency and/or the phase of transducers 514A, 515A, 516A, 517A, 524A, 525A, 526A, 527A, 534A, 535A, 536A, 537A, 544A, 545A, 546A, 547A, 514B, 515B, 516B, 517B, 524B, 525B, 526B, 527B, 534B, 535B, 536B, 537B, 544B, 545B, 546B, and 547B, the duty cycles are also modulated such that, at any given time, fewer than all of transducers 514A, 515A, 516A, 517A, 524A, 525A, 526A, 527A, 534A, 535A, 536A, 537A, 544A, 545A, 546A, 547A, 514B, 515B, 516B, 517B, 524B, 525B, 526B, 527B, 534B, 535B, 536B, 537B, 544B, 545B, 546B, and 547B, are emitting acoustic waves.

[0169] In certain embodiments, Applicants' invention includes microcode, such as microcode 626, where that microcode is executed by a controller, such as controller 620 (FIG. 6)/720 (FIGS. 7A, 7B)/805 (FIGS. 8B, 8C), 895 (FIG. 8E), to operate Applicants' hand-held ultrasound emitting device.

[0170] In certain embodiments, Applicants' invention includes instructions, such as instructions 916, and/or instructions 1048, wherein those instructions are executed by a processor, such as processor 912 (FIG. 9), or 1044 (FIG. 10), respectively, to operate Applicants' hand-held ultrasound emitting device.

[0171] In other embodiments, Applicants' invention includes instructions residing in any other computer program product, where those instructions are executed by a computer external to, or internal to, Applicants' apparatus to operate Applicants' hand-held ultrasound emitting device. In either case, the microcode/instructions may be encoded in an information storage medium comprising, for example, a magnetic information storage medium, an optical information storage medium, an electronic information storage medium, and the like. By "electronic storage media," Applicants mean, for example, a device such as a PROM, EPROM, EEPROM, Flash PROM, compactflash, smartmedia, and the like.

[0172] While the preferred embodiments of the present invention have been illustrated in detail, it should be apparent that modifications and adaptations to those embodiments may occur to one skilled in the art without departing from the scope of the present invention.

We claim:

1. An ultrasound emitting device, comprising:

a sound head matrix comprising a first planar member, and a second planar member, wherein said first planar member is attached to said second planar member to form a V-shaped assembly comprising a first interior dihedral angle, wherein said first interior dihedral angle is between about 155 degrees and about 175 degrees;

a first plurality of ultrasound transducers disposed on said first planar member;

a second plurality of ultrasound transducers disposed on said second planar member;

a head frame, wherein said sound head matrix is disposed adjacent a patient's head when said head frame is removeably disposed around said patient's head.

2. The ultrasound emitting device of claim 1, wherein said interior dihedral angle is 167 degrees.

3. The ultrasound emitting device of claim 2, wherein said first plurality of ultrasound transducers comprises 8 ultrasound transducers, and wherein said second plurality of ultrasound transducers comprises 8 ultrasound transducers.

4. The ultrasound emitting device of claim 1, wherein said sound mead matrix further comprises:

a third planar member, wherein said third planar member is attached to said second planar member to define a second interior dihedral angle, wherein said second interior dihedral angle is between about 155 degrees and about 175 degrees;

a third plurality of ultrasound transducers disposed on said third planar member.

5. The ultrasound emitting device of claim 4, wherein said sound mead matrix further comprises:

a fourth planar member, wherein said fourth planar member is attached to said third planar member to define a third interior dihedral angle, wherein said third interior dihedral angle is between about 155 degrees and about 175 degrees;

a fourth plurality of ultrasound transducers disposed on said fourth planar member.

6. The ultrasound emitting device of claim 5, wherein said first interior dihedral angle, and said second interior dihedral angle, and said third interior dihedral angle, differ from one another.

7. The ultrasound emitting device of claim 5, wherein said first interior dihedral angle, and said second interior dihedral angle, and saidthird interior dihedral angle, are about 167 degrees

8. The ultrasound emitting device of claim 5, wherein:

said first plurality of ultrasound transducers comprises 4 ultrasound transducers;

said second plurality of ultrasound transducers comprises 4 ultrasound transducers;

said third plurality of ultrasound transducers comprises 4 ultrasound transducers; and

said fourth plurality of ultrasound transducers comprises 4 ultrasound transducers.

9. The ultrasound emitting device of claim 1, further comprising:

a processor, wherein said processor is interconnected with each of said first plurality of ultrasound transducers and with each of said second plurality of ultrasound transducer;

memory, wherein said processor is interconnected with said memory;

and instructions written to said memory, wherein said processor uses said microcode to operate said ultrasound emitting device.

10. The ultrasound emitting device of claim 9, wherein said instructions comprise computer readable code, wherein said processor can utilize said computer readable code to operate said ultrasound emitting device in an insonation burst mode.

11. The ultrasound emitting device of claim 9, further comprising:

a diagnostic ultrasound transceiver;

wherein said diagnostic ultrasound transceiver is interconnected with said processor.

12. The ultrasound emitting device of claim 11, wherein said instructions comprise computer readable code which can be used by said processor and said diagnostic ultrasound transducer to perform harmonic imaging.

13. The ultrasound emitting device of claim 11, wherein said instructions comprise computer readable code which can be used by said processor and said diagnostic ultrasound transducer to perform pulse inversion imaging.

14. The ultrasound emitting device of claim 13, wherein said instructions comprise computer readable code which can be used by said processor and said diagnostic ultrasound transducer to perform pulse inversion imaging with Doppler detection.

15. The ultrasound emitting device of claim 11, wherein said instructions comprise computer readable code which can be used by said processor and said diagnostic ultrasound transducer to perform power modulation imaging.

16. The ultrasound emitting device of claim 11, further comprising:

a visual display device, wherein said visual display device is interconnected with said processor.

17. An ultrasound emitting device comprising:

at least one diagnostic ultrasound transducer to emit first ultrasound energy comprising first power;

a sound head matrix comprising a first planar member, and a second planar member, wherein said first planar member is attached to said second planar member to form a V-shaped assembly comprising a first interior dihedral angle, wherein said first interior dihedral angle is between about 155 degrees and about 175 degrees;

a first plurality of therapeutic ultrasound transducers disposed on said first planar member;

a second plurality of therapeutic ultrasound transducers disposed on said second planar member, wherein said first plurality of therapeutic ultrasound transducers in combination with said second plurality of therapeutic ultrasound transducers comprise a total of (N) therapeutic ultrasound transducers, wherein each of said (N) therapeutic ultrasound transducers can emit second ultrasound energy comprising second power;

a computer readable medium having computer readable program code disposed therein to operate said ultrasound emitting device, wherein said second power is greater than said first power, the computer readable program code comprising a series of computer readable program steps to effect:

providing the (i)th signal to the (i)th therapeutic ultrasound transducer, wherein (i) is greater than or equal to 1 and less than or equal to (N);

emitting by said (i)th therapeutic ultrasound transducer second ultrasound energy comprising the (i)th frequency and the (i)th phase.

18. The ultrasound emitting device of claim 17, further comprising memory and (N) therapeutic insonation regimes encoded in said memory, wherein the (i)th therapeutic insonation regime comprises the (i)th frequency pattern and the (i)th phase pattern, and wherein, for each value of (i), the (i)th frequency pattern differs from the frequency pattern comprised by each of the remaining (N−1) therapeutic insonation regimes.

19. The article of manufacture of claim 18, wherein, for each value of (i), the (i)th phase pattern differs from the phase pattern comprised by each of the remaining (N−1) therapeutic insonation regimes.

20. The article of manufacture of claim 19, further comprising a receiver to detect reflected first ultrasound energy and a visual display device, said computer readable program code further comprising a series of computer readable program steps to effect:

emitting first ultrasound energy;

receiving reflected first ultrasound energy;

generating an image of the tissue structure underlying said diagnostic ultrasound transducer;

displaying on said visual display said device.

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摘要(译)

公开了一种超声发射装置。所述超声发射装置包括声头矩阵，所述声头矩阵包括第一平面构件和第二平面构件，其中所述第一平面构件附接到所述第二平面构件以形成包括第一内部二面角的V形组件，其中所述第一平面构件内部二面角在约155度和约175度之间。超声发射装置还包括设置在第一平面构件上的第一多个超声换能器，以及设置在第二平面构件上的第二多个超声换能器。