US 20140323864A1

(19) **United States**

(12) **Patent Application Publication**

Barthe et al.

(10) **Pub. No.: US 2014/0323864 A1**

(43) **Pub. Date: Oct. 30, 2014**

(54) **MEDICAL SYSTEM HAVING AN ULTRASOUND SOURCE AND AN ACOUSTIC COUPLING MEDIUM**

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(21) Appl. No.: **14/327,881**

(22) Filed: **Jul. 10, 2014**

Related U.S. Application Data

(63) Continuation of application No. 12/818,261, filed on Jun. 18, 2010, which is a continuation of application No. 10/848,550, filed on May 18, 2004, now Pat. No. 7,883,468.

Publication Classification

(51) **Int. Cl.**

A61B 8/00	(2006.01)
A61N 7/00	(2006.01)
A61B 8/12	(2006.01)

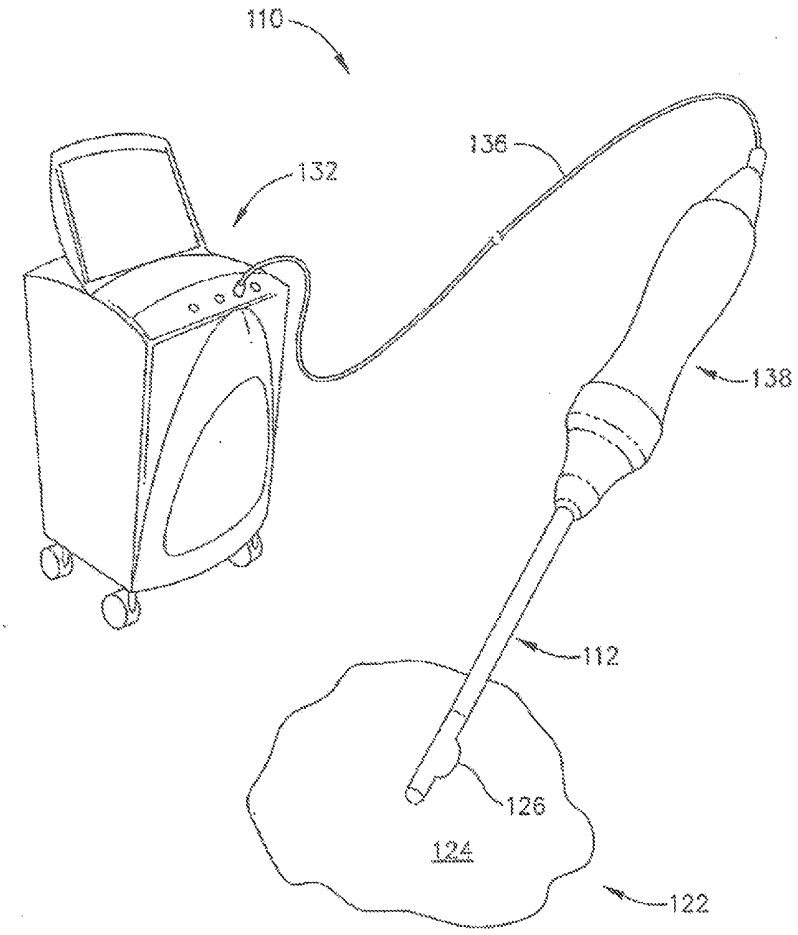
(52) **U.S. Cl.**

CPC ***A61B 8/4272*** (2013.01); ***A61B 8/4444*** (2013.01); ***A61B 8/12*** (2013.01); ***A61B 8/546*** (2013.01); ***A61N 7/00*** (2013.01); *A61N 2007/0052* (2013.01)

USPC **600/439**; 600/472; 601/2

(57) **ABSTRACT**

An ultrasound medical system has an end effector including a medical ultrasound transducer and an acoustic coupling medium. The acoustic coupling medium has a transducer-proximal surface and a transducer-distal surface. The medical ultrasound transducer is positioned to emit medical ultrasound through the acoustic coupling medium from the transducer-proximal surface to the transducer-distal surface. The end effector is adapted to change a property (such as the shape and/or the temperature) of the acoustic coupling medium during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during a medical procedure on a patient. In one example, such changes are used to change the focus and/or beam angle of the emitted ultrasound during the medical procedure.



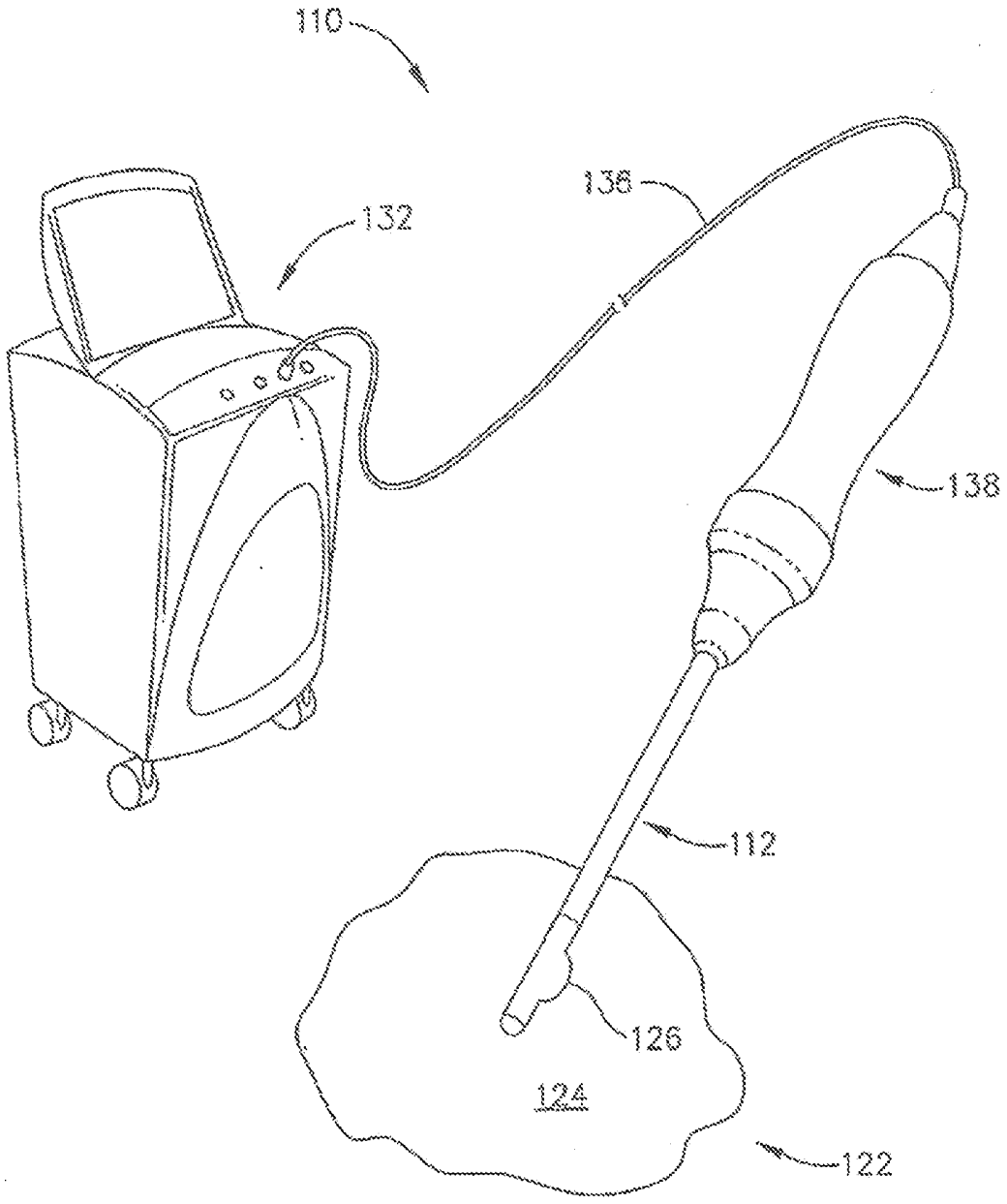
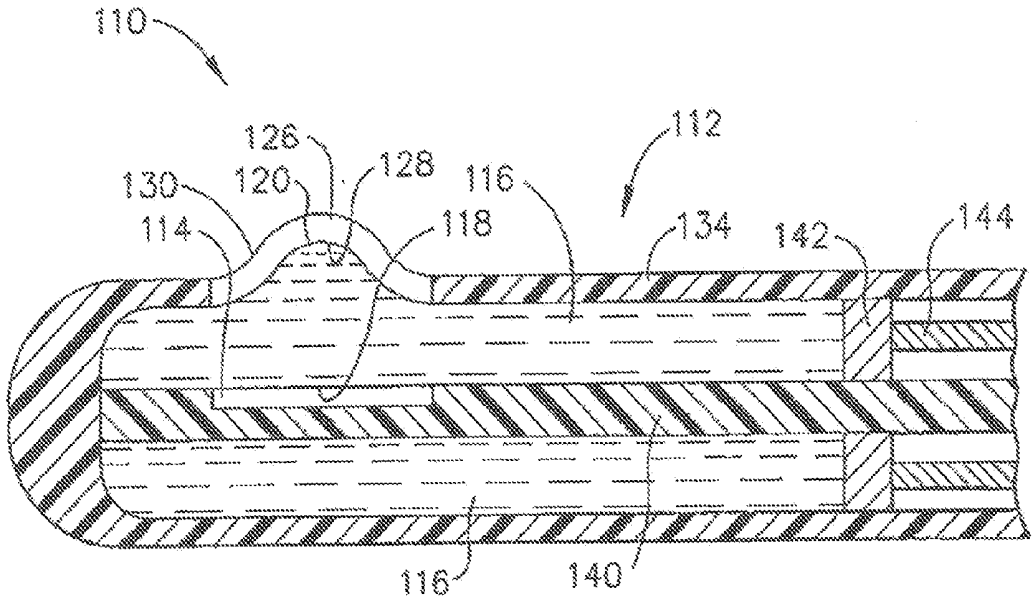


FIG. 1


110
126
128
112
130
120
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140

FIG. 2

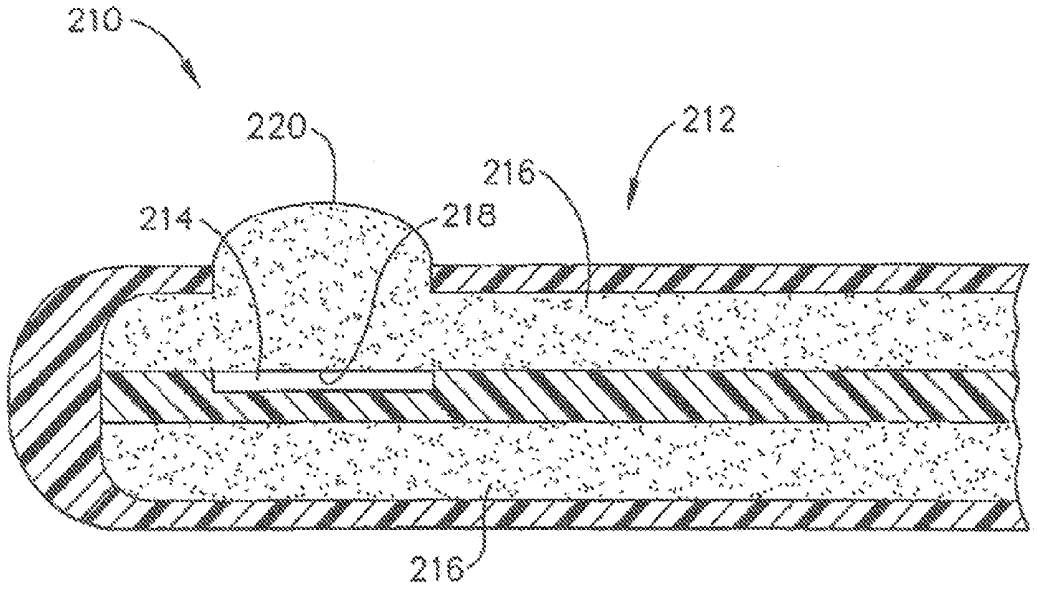
210
220
212
216
214
218
216

FIG. 3

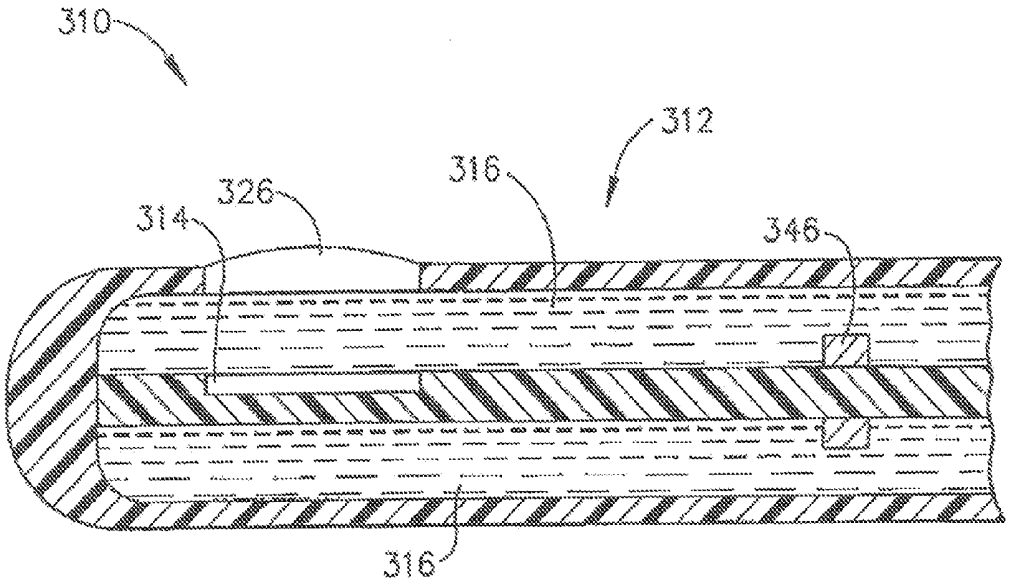

FIG. 4

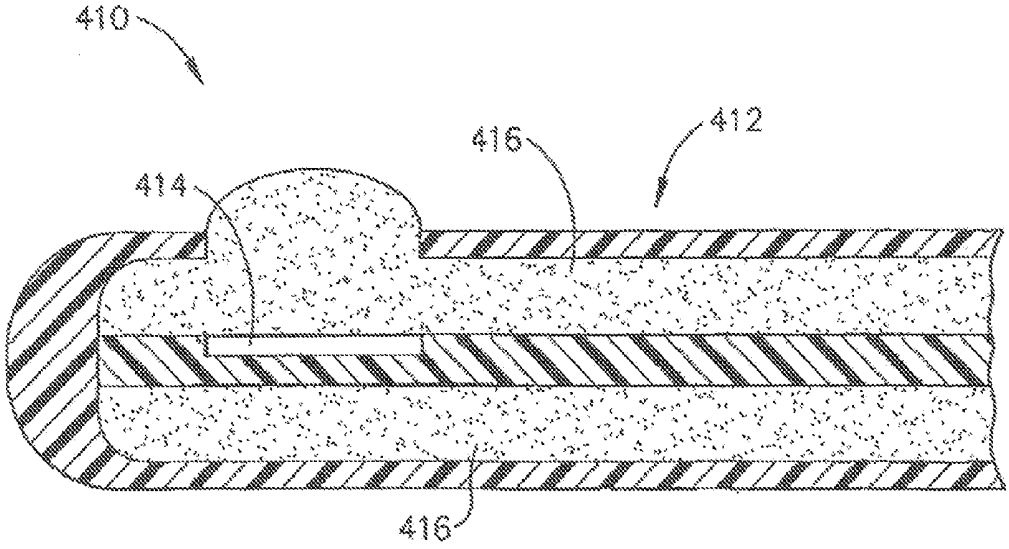

FIG. 5

MEDICAL SYSTEM HAVING AN ULTRASOUND SOURCE AND AN ACOUSTIC COUPLING MEDIUM

REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of U.S. patent application Ser. No. 12/818,261 entitled "MEDICAL SYSTEM HAVING AN ULTRASOUND SOURCE AND AN ACOUSTIC COUPLING MEDIUM", filed on Jun. 18, 2010, which is a continuation of claims the benefit of priority from U.S. patent application Ser. No. 10/848,550 entitled "MEDICAL SYSTEM HAVING AN ULTRASOUND SOURCE AND AN ACOUSTIC COUPLING MEDIUM", filed May 18, 2004, which issued as U.S. Pat. No. 7,883,468 on Feb. 8. 2011, all of which are incorporated in entirety by reference herein. The present application claims the benefit of and priority from U.S. patent application Ser. Nos. 12/818,261 and 10/848,550.

FIELD OF THE INVENTION

[0002] The present invention relates generally to ultrasound, and more particularly to an ultrasound medical system haying an ultrasound source and an acoustic coupling medium.

BACKGROUND OF THE INVENTION

[0003] Known ultrasound medical methods include using ultrasound imaging (at low power) of patients to identify patient tissue for medical treatment and include using ultrasound at high power), from the same or a different ultrasound transducer, to ablate identified patient tissue by heating the tissue.

[0004] Known ultrasound medical systems and methods include deploying an end effector having an ultrasound transducer outside the body to break up kidney stones inside the body, endoscopically inserting an end effector having an ultrasound transducer in the rectum to medically destroy prostate cancer, laparoscopically inserting an end effector haying an ultrasound transducer in the abdominal cavity to medically destroy a cancerous liver tumor, intravenously inserting a catheter end effector having an ultrasound transducer into a vein in the arm and moving the catheter to the heart to medically destroy diseased heart tissue, and interstitially inserting a needle end effector having an ultrasound transducer needle into the tongue to medically destroy tissue to reduce tongue volume to reduce snoring.

[0005] Conventional ultrasound medical systems include a system having an end effector including a medical ultrasound transducer, a sheath, and a water acoustic coupling medium. The end effector is inserted into a patient, and a balloon portion (which acts as an acoustic window) of the sheath is expanded by increasing water pressure until the balloon portion contacts patient tissue. Then, the medical ultrasound transducer emits medical ultrasound through the balloon. portion via the water to image and/or treat the patient tissue.

[0006] Still, scientists and engineers continue to seek improved ultrasound medical systems.

SUMMARY OF THE INVENTION

[0007] A first expression of an embodiment of the invention is an ultrasound medical system having an end effector including a medical ultrasound transducer and an acoustic coupling medium. The acoustic coupling medium has a transducer-proximal surface and a transducer distal surface. The medical ultrasound transducer is positioned to emit medical ultrasound through the acoustic coupling medium from the transducer-proximal surface to the transducer distal surface. The end effector is adapted to change at least one property of the acoustic coupling medium during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during a medical procedure on a patient.

[0008] A second expression of an embodiment of the invention is an ultrasound medical system having a controller and an end effector end effector includes a medical ultrasound transducer and an acoustic coupling medium. The acoustic coupling medium has a transducer proximal surface and a transducer-distal surface. The medical ultrasound transducer is positioned to emit medical ultrasound haying a focus and a beam angle through the acoustic coupling medium from the transducer-proximal Surface to the transducer-distal surface. The end effector is adapted to change at least one property of the acoustic coupling medium during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during a medical procedure on a patient. The controller controls the end effector to change the property to change the focus and/or the beam angle.

[0009] A third expression of an embodiment of the invention is an ultrasound medical system having a controller and an end effector. The end effector includes a medical ultrasound transducer, an acoustic coupling medium, and a sheath. The sheath includes an expandable acoustic window, wherein the acoustic coupling medium is placed in direct contact with the medical ultrasound transducer and the acoustic window. The medical ultrasound transducer is positioned to emit medical ultrasound through the acoustic window via the acoustic coupling medium. The controller controls the end effector to change the shape of the acoustic window, by changing the pressure exerted by the acoustic coupling medium against the acoustic window, during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during a medical procedure on a patient.

[0010] Several benefits and advantages are obtained from one or more of the expressions of an embodiment of the ultrasound medical system of the invention. The acoustic coupling medium also acts as an acoustic lens, wherein the end effector is adapted to change at least one property (such as the shape and/or the temperature) of the acoustic coupling medium which will change the focus and/or the beam angle of emitted ultrasound, with such changes occurring during emission, and/or between emissions, of ultrasound while performing a medical procedure on a patient.

[0011] The present invention has, without limitation, application in conventional endoscopic, laparoscopic, and open surgical instrumentation as well as application in robotic-assisted surgery.

BRIEF DESCRIPTION OF THE FIGURES

[0012] FIG. **1** is a perspective view of a first embodiment of an ultrasound medical system of the invention including a controller and an end effector wherein the end effector is seen inserted into a patient (only a portion of whom is shown) and has an acoustic window, and wherein the end effector is adapted to change the shape of be acoustic window during a medical procedure by increasing the pressure of an acoustic coupling medium located inside the end effector;

[0013] FIG. **2** is a schematic cross-sectional view of the end effector of the ultrasound medical system of FIG. **1**, Wherein the adaptation of the end effector is shown and includes a movable piston which exerts pressure on the acoustic coupling medium;

[0014] FIG. **3** is a schematic cross-sectional view of an end effector of a second embodiment of an ultrasound medical system of the invention, wherein the end effector has an acoustic coupling medium, and wherein the end effector is adapted to change the shape of the medium-patient interface during a medical procedure, such adaptation being omitted for clarity;

[0015] FIG. **4** is a schematic cross-sectional view of an end effector of a third embodiment of an ultrasound medical system of the invention, wherein the end effector has an acoustic window and has an acoustic coupling medium located inside the end effector, wherein the end effector is adapted to change the temperature of the acoustic coupling medium during a medical procedure, and wherein the adaptation of the end effector includes a heater; and

[0016] FIG. **5** is a schematic cross-sectional view of an end effector of a fourth embodiment of an ultrasound medical system of the invention, wherein the end effector has an acoustic coupling medium and is adapted to change the temperature of the acoustic coupling medium during a medical procedure, such adaptation being omitted for clarity.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Before explaining the present invention in detail, it should be noted that the invention is not limited in its application or use to the details of construction and arrangement of parts illustrated in the accompanying drawings and description. The illustrative embodiments of the invention may be implemented or incorporated in other embodiments, variations and modifications, and may be practiced or carried out in various ways. Furthermore, unless otherwise indicated, the terms and expressions employed herein have been chosen for the purpose of describing the illustrative embodiments of the present invention for the convenience of the reader and are not for the purpose of limiting the invention.

[0018] It is understood that any one or more of the following-described embodiments, examples, etc. can be combined with any one or more of the other following-described embodiments, examples, etc.

[0019] Referring now to the drawings, FIGS. **1-2** illustrate an embodiment of the present invention. A first expression of the embodiment of FIGS. **1-2** is an ultrasound medical system **110** comprising an end effector **112** including a medical ultrasound transducer **114** and an acoustic coupling medium **116**. The acoustic coupling medium **110** has a transducer-proximal surface **118** and a transducer-distal surface **120**. The medical ultrasound transducer **114** is disposed to emit medical ultrasound through the acoustic coupling medium **116** from the transducer-proximal surface **118** to the transducer-distal surface **120**. The end effector **112** is adapted to change at least one property of the acoustic coupling medium **116** during emission and/or between emissions, of medical ultrasound from the medical ultrasound transducer **114** during a medical procedure on a patient **122**. The terminology "ultrasound medical system" includes an ultrasound medical imaging system, an ultrasound medical treatment system, and an ultrasound medical imaging and ultrasound medical treatment system. The terminology "medical procedure" includes an imaging procedure, a treatment procedure, and an imaging and treatment procedure.

[0020] In an enablement of the first expression of the embodiment of FIGS. **1-2**, the at-least-one property includes shape, and the end effector **112** is adapted to change the shape (such as the curvature) of the transducer-distal surface **120** during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer **114** during the medical procedure.

[0021] In one variation of this enablement as shown in the embodiment of FIG. **3**, the transducer-distal surface **220** of the acoustic coupling medium **216** is disposable in direct contact with patient tissue. In one modification, the end effector **212** of the ultrasound medical system **210** changes the pressure exerted by the acoustic coupling medium **216** against the patient tissue when the transducer-distal surface **220** of the acoustic coupling medium **216** is disposed in direct contact with patient tissue during the medical procedure. In one construction, the medical ultrasound transducer **214** is disposed. In direct contact with the transducer-proximal surface **218** of the acoustic coupling medium **216**. In one application, ultrasound imaging from the medical ultrasound transducer **214** or another ultrasound transducer is used to determine the shape of the interface between the transducer-distal surface **220** of the acoustic coupling medium **216** and the patient tissue. It is noted that the interface acts as an acoustic lens surface, and that changing the shape of the interface during the medical procedure can be used to change the focus and/or the beam angle of the ultrasound emitted from the medical ultrasound transducer **214** during the medical procedure when such ultrasound non-perpendicularly passes through the interface. In one option, ultrasound strain imaging of patient tissue is performed by the ultrasound medical system **210**.

[0022] In a different variation of this enablement, as shown in the embodiment of FIGS. **1-2**, the end effector **112** also includes an expandable acoustic window **126** having an interior surface **128** in direct contact with the transducer-distal surface **120** of the acoustic coupling medium **116** and having an exterior surface **130** disposable in direct contact with patient tissue **124**. In one modification, the end effector **112** changes the pressure exerted by the acoustic coupling medium **116** against the acoustic window **126** when the exterior surface **130** of the acoustic window **126** is disposed in direct contact with patient tissue **124** during the medical procedure. In one construction, the medical ultrasound transducer **114** is disposed in direct contact with the transducer-proximal surface **118** of the acoustic coupling medium **116**. In one application, ultrasound imaging from the medical ultrasound transducer **114** or another ultrasound transducer is used to determine the shape of the interface between the transducer-distal surface **120** of the acoustic coupling medium **116** and the interior surface **128** of the acoustic window **126** and the shape of the interface between the exterior surface **130** of the acoustic window **126** and the patient tissue **124**. In one variation, the acoustic window **126** is a fully-circumferential acoustic window and in another variation it is not. In one option, ultrasound strain imaging of patient tissue **124** is performed by the ultrasound medical system.

[0023] It is noted that the interfaces act as acoustic lens surfaces, and that changing the shape of the interfaces during the medical procedure can be used to Change the focus and/or

the beam angle of the ultrasound milted from the medical ultrasound transducer **114** during the medical procedure when such ultrasound non-perpendicularly passes through the interfaces. In one application, the acoustic coupling medium **116** is circulating water, wherein changing the flow rate of the circulating water changes the pressure exerted by the acoustic coupling medium **116** against the acoustic window **126**. It is also noted that a change in shape (such as a change in curvature) of the acoustic window **126** typically is accompanied by a change in thickness of the acoustic window **12**$ and a change in the distance between the medical ultrasound transducer **114** and the acoustic window **126** which can also effect focus and/or beam angle as is understood by those skilled in the art. In one implementation, the acoustic window **126** is provided with a transducer-distal surface **120** which is rippled (not shown) for use in beam angle steering as is within the level of skill of the artisan.

[0024] In the same or a different enablement, as shown in the embodiment of FIG. **4**, the at-least-one property includes temperature, and the end effector **312** of the ultrasound medical system **310** is adapted to change the temperature of the acoustic coupling medium **316** during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer **314** during the medical procedure. Changing the temperature of the acoustic coupling medium **316** changes the speed of sound of the emitted ultrasound in the acoustic coupling medium **316** which can be used by those skilled in the art to change the focus and/or the beam angle of the emitted ultrasound when non-perpendicularly passing through a transmission medium interface. It is noted that the embodiment of FIG. **4** includes a rigid or expandable acoustic window **326**, and that the embodiment of the ultrasound medical system **410** of FIG. **5** is identical to that of FIG. **4** except that the end of **412** of FIG. **5** lacks an acoustic window.

[0025] In one example of any one or more or all of the embodiments of FIGS. **1-5** the medical ultrasound transducer **114**, **24**, **314** and/or **414** is chosen from the group consisting of a medical-imaging-only ultrasound transducer, a medical-treatment-only ultrasound transducer, and a medical-imaging-and-treatment ultrasound transducer. In one variation, the medical ultrasound transducer has a single transducer element having as planar or a curved ultrasound-emitting surface. In another variation, the medical ultrasound transducer has an array of transducer elements whose planar or curved. ultrasound-emitting surfaces are together disposed to define a curved array surface or whose planar ultrasound-emitting surfaces are together disposed to define a planar array surface. In one modification, the transducer element array is also electronically focused and/or steered as is within the routine capabilities of those skilled in the art. In one extension, the end effector has one or more additional medical ultrasound transducers.

[0026] In the same or a different example, the acoustic coupling, medium **116**, **216**, **316** and/or **416** is chosen from the group consisting of a liquid, a gel, and a colloid. In one variation, the acoustic coupling medium is a circulating acoustic coupling medium and in a different variation it is not circulating. Examples of liquids include, without limitation, water, a saline solution, glycerol, castor oil, and mineral oil. Other examples of liquids and examples of gels and colloids and other acoustic, coupling media are left to the artisan.

[0027] In one implementation any one or more or all of the embodiments of FIGS. **1-5**, the end effector **112**, **212**, **312** and/or **412** is disposable against an outside surface of the patient. In another implementation, the end effector is insertable into the patient.

[0028] A second expression of the embodiment of FIGS. **1-2** is an ultrasound medical system **110** comprising a controller **132** and an end effector **112**. The end effector **112** includes a medical ultrasound transducer **114** and an acoustic coupling medium **116**. The acoustic coupling medium **116** has a transducer-proximal surface **118** and a transducer-distal surface **120**. The medical ultrasound transducer **114** is disposed to emit medical ultrasound through the acoustic coupling medium **116** from the transducer-proximal surface **118** to the transducer-distal surface **120**. The end effector **112** is adapted to change at least one property of the acoustic coupling medium **116** doting emission, and/or between omissions, of medical ultrasound from the medical ultrasound transducer **114** during a medical procedure on a patient **122**. The controller **132** controls the end effector **112** to change the property change ultrasound focus and/or ultrasound beam angle. In one extension of the embodiments of FIGS. **3-5**, and in any one or more or all of the enablements, examples, etc. thereof, the ultrasound medical systems of FIGS. **1-5** also include: the controller of the second expression of the embodiment of FIGS. **1-2**.

[0029] A third expression of the embodiment of FIGS. **1-2** is an ultrasound medical system **110** comprising a controller **132** and an end effector **112**. The end effector **112** includes a medical ultrasound transducer **114**, an acoustic coupling medium **116**, and a rigid or flexible sheath **134**. The sheath **134** includes an expandable acoustic window **126**. The acoustic coupling medium **116** is disposed in direct contact with the medical ultrasound transducer **114** and the acoustic window **126**. The medical Ultrasound transducer **114** is disposed to emit medical ultrasound through the acoustic window **12.6** via the acoustic coupling medium **116**. The controller **132** controls the end effector **112** to change the shape of the acoustic window **126**, by changing (directly or indirectly) the pressure exerted by the acoustic, coupling medium **116** against the acoustic window **126**, during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer **114** during a medical procedure on a patient **122**.

[0030] In one example of the third expression of the embodiment of FIGS. **1-2**, a piston is used to directly change the pressure of an essentially static acoustic coupling medium. In another example, a valve is used to change the flow rate (and hence is used to indirectly change the pressure) of a flowing acoustic coupling medium. In one employment of the third expression of the embodiment of FIGS. **1-2**, the controller **132** controls the end effector **112** to change the thickness of the acoustic window **126**, by changing the pressure exerted by the acoustic coupling, medium **116** against the acoustic window **126**, during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer **114** during a medical procedure on a patient **122**.

[0031] in one arrangement of the embodiment of FIGS. **1-2**, the ultrasound medical system **110** also includes a cable **136**, a handpiece **138**, arid a rigid or flexible shaft **140**. In this arrangement, the cable **136** operatively connects the controller **132** to the handpiece **138**, the handpiece **138** is operatively connected to the end effector **112**, and the shaft **140** supports the medical ultrasound transducer **114** and is operatively connected to the handpiece **138**. The shaft **140** can be rotatable or

non-rotatable with respect to the handpiece **138**. Other arrangements are left to the artisan.

[0032] In one construction of the third expression of the embodiment of FIGS. **1-2**, a thinner part of the sheath acts as the acoustic window. In another construction, the acoustic window is made from a different material or materials than the material or materials of the non-acoustic window portion of the sheath. In an additional construction, the entire sheath acts as the acoustic window. Other constructions are left to the artisan.

[0033] Examples of acoustically-transmissive materials for acoustic windows include, without limitation, PET [polyethylene terephthalate] (such as 0.001-inch-thick PET for a fully-circumferential acoustic window). Nylon 6, 11 or 12, TPX [methylpentene copolymer] and flouropolymers such as PTFE [polytetrafluoroethylene], FEP [fluorinated ethylene propylene], PFA [perfluoroalkoxy], PVDA [polyvinylidene acetate], ETFE [ethylene tetrofluoroethylene], polyurethane and polyethylene (high and low density). Shaft and sheath materials, for flexible shafts and sheaths, include, without limitation, Nitinol, polyimide, reinforced polyimide, Nylon, Pebax, silicone, reinforced silicone, polyurethane, polyethylene, flouropolymers and coiled metals (e.g., coiled, stainless steel).

[0034] In one deployment of the ultrasound medical system **110** of FIGS. **1-2** the end effector **112** is adapted to change the shape of the transducer-distal surface **120** of the acoustic coupling medium **116** by having the end effector **112** include an angular piston **142**, movable by an attached annular piston rod **144**. The movable piston **142** is used to change the pressure of a non circulating acoustic coupling medium **116** to change the curvature of the transducer-distal surface **120** of the acoustic coupling medium **115** (which changes the curvature of the acoustic window **126**). In a different deployment, not shown, the end effector **112** is adapted by having the end effector **112** include a channel for the acoustic coupling medium **116** extending from the area of the acoustic window **126** to an orifice connectable to a variable-pressure-exerting device.

[0035] In one deployment of the ultrasound medical system **310** of FIG. **4**, the end effector **312** is adapted by having the end effector **312** include a heater **346** which is used to change the temperature of the acoustic coupling medium **316**. In a different deployment, not shown, the end effector **312** is adapted by haying the end effector **312** include a channel for the acoustic coupling medium **316** extending from the area of the acoustic window **326** to an orifice connectable to a heating device.

[0036] In a further deployment of the ultrasound medical systems of FIGS. **1-2** and FIG. **5**, a tube (not shown) surrounds the shaft, is radially spaced apart from the shaft and the sheath, and longitudinally extends proximate the acoustic window with, for example, circulating water as the acoustic coupling medium which enters the ultrasound transducer-acoustic window area from the channel between the shaft and the tube and which exits the ultrasound transducer-acoustic window area from the channel between the tube and the sheath. In one variation, a pump not shown) varies the flow rate of the water. In such adaptation of the end effector, an increasing flow rate increases the pressure of the circulating acoustic coupling medium which changes the shape of the transducer-distal surface of the acoustic coupling medium (in both the FIGS. **1-2** and FIG. **5** ultrasound medical systems) and hence the shape of the acoustic window (in the FIGS. **1-2** ultrasound medical system). Other deployments are left to the artisan.

[0037] Several benefits and advantages are obtained from one or more of the expressions of an embodiment of the ultrasound medical system of the invention. The acoustic coupling medium also acts as an acoustic lens, wherein the end effector is adapted to change at least one property (such as the shape and/or the temperature) of the acoustic coupling, medium which will change the focus and/or the beam angle of emitted ultrasound, with such changes occurring during emission, and/or between emissions, of ultrasound while performing a medical procedure on a. patient.

[0038] While the present invention has been illustrated by a description of several embodiments, it is not the intention of the applicants to restrict or limit the spirit and scope of the appended claims to such detail. Numerous other variations, changes, and substitutions will occur to those skilled in the art without departing from the scope of the invention. For instance, the ultrasound medical system of the invention has application in robotic assisted surgery taking into account the obvious modifications of such systems, components and methods to be compatible with such a robotic system. It will be understood that the foregoing description is provided by way of example, and that other modifications may occur to those ski fled in the art without departing from the scope and spirit of the appended Claims.

1. An ultrasound medical system comprising a controller and an end effector,

wherein, the end effector comprises a rigid housing comprising a closed, expandable acoustic window, a medical ultrasound transducer and an acoustic coupling medium,

wherein the medical ultrasound transducer is disposed within and spaced apart from the rigid housing and is proximate to the acoustic window,

wherein the acoustic coupling medium has a transducer-proximal surface disposed in direct physical contact with the medical ultrasound transducer and has a transducer-distal surface disposed in direct physical contact with the acoustic window,

wherein the medical ultrasound transducer is disposed to emit medical ultrasound through the acoustic coupling medium from the transducer-proximal Surface to the transducer-distal surface,

wherein the end effector is adapted to change at least one property of the acoustic coupling medium during emission, author between emissions, of medical ultrasound from the medical ultrasound transducer during a medical procedure on a patient,

wherein the controller controls the end effector to change the property to change ultrasound focus and/or ultrasound beam angle,

wherein the at-least-one property includes temperature, and

wherein the end effector comprises a heater spaced apart from any ultrasound transducer and adapted to directly change the temperature of the acoustic coupling medium during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during the medical procedure.

2. The ultrasound medical system of claim **1**, wherein the at-least-one property includes shape, and wherein the end effector is adapted to change the shape of the transducer-

distal surface during emission, and/or between emissions, of medical ultrasound from the medical ultrasound transducer during the medical procedure.

3. The ultrasound medical system of claim **1**, wherein the medical ultrasound transducer is chosen from the group consisting of a medical-imaging-only ultrasound transducer, a medical, treatment-only ultrasound transducer, and a medical-imaging-and-treatment ultrasound transducer.

4. The ultrasound medical system of claim **1**, wherein the acoustic coupling medium is chosen from the group consisting of a liquid, and a colloid.

5. The ultrasound medical system of claim **1**, wherein the end effector is disposable against an outside surface of the patient.

6. The ultrasound medical system of claim **1**, wherein the end effector is insertable into the patient.

7. An end effector comprising:
a rigid housing encompassing:
an acoustic medium,
an ultrasound transducer in contact with the acoustic medium and configured to emit ultrasound energy through the acoustic medium, and
a heater in thermal communication with the acoustic medium and configured to control a temperature of the acoustic medium; and
an acoustic window
positioned in the rigid, housing and configured to seal the acoustic medium in the rigid housing and configured to pass through at feast, a portion of the ultrasound energy,
the acoustic window comprising an interior surface configured to contact the acoustic medium and an exterior surface configured to contact tissue of a patient.

8. The end effector according to claim **7**, wherein the acoustic window is further configured to acoustically couple the ultrasound transducer to the tissue of the patient.

9. The end effector according to claim **7**, wherein the ultrasound transducer is configured to treat at least a portion of the tissue of the patient.

10. The end effector according to claim **7**, wherein the ultrasound transducer is con/huffed to image a portion of the tissue of the patient.

11. The end effector according to claim **7**, wherein the rigid housing is configured to be insertable in to the patient.

12. The end effector according to claim **7**, wherein the rigid housing is configured to be coupled to an outside surface of the patient.

13. The end effector according to claim **7**, wherein the acoustic window is expandable.

14. A system comprising:
the end elector according to claim **7**; and
a controller in communication with the end effector and configured to control the ultrasound transducer and to control the temperature of the acoustic medium.

15. An ultrasound system comprising:
probe comprising
an acoustic coupling medium,
an ultrasound transducer configured to emit ultrasound enemy through the
acoustic coupling medium, and
a heater in thermal, communication with the acoustic coupling medium and configured to change a temperature of the coupling acoustic medium;
an acoustic window positioned in a fixed surface of the probe and in-line with a path of the ultrasound enemy, the acoustic window configured to expand and shape a surface of the acoustic coupling medium above the fixed surface of the probe and to enable a change of a speed of sound of the ultrasound energy; and
a controller in communication with the probe and configured to control the ultrasound transducer and to control the temperature of the acoustic coupling medium.

16. The ultrasound system according to claim **15**, wherein the acoustic coupling medium is chosen from the group consisting of a liquid, a gel, and a colloid.

17. The ultrasound system according to claim **15**, wherein the ultrasound transducer is one of a imaging-only ultrasound transducer, a treatment-only ultrasound transducer, and a imaging-and-treatment ultrasound transducer.

18. The ultrasound system according, to claim **15**, wherein the controller is configured to control the heater to change the temperature of the acoustic coupling medium during at least one of an emission of the ultrasound energy and a period between at least two emissions of the ultrasound energy.

19. The ultrasound system according to claim **15**, wherein the acoustic coupling medium is configured to change a focus of the ultrasound energy having a non-perpendicular path through the acoustic window.

20. The ultrasound system according to claim **19**, wherein the focus of the ultrasound enemy is controlled by an expansion of the acoustic window and is shape of the surface of the acoustic coupling medium above the fixed surface of the probe.

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专利名称(译)	具有超声源和声学耦合介质的医疗系统		
公开(公告)号	US20140323864A1	公开(公告)日	2014-10-30
申请号	US14/327881	申请日	2014-07-10
申请(专利权)人(译)	引导治疗系统公司		
当前申请(专利权)人(译)	引导治疗系统公司		
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IPC分类号	A61B8/00 A61N7/00 A61B8/12 A61B17/22 A61H1/00 A61N7/02		
CPC分类号	A61B8/4272 A61B8/4444 A61N2007/0052 A61B8/546 A61N7/00 A61B8/12 A61B8/4281 A61B2017/2253 A61N7/022		
外部链接	Espacenet USPTO		

摘要(译)

超声医疗系统具有末端执行器，该末端执行器包括医学超声换能器和声耦合介质。声耦合介质具有换能器近侧表面和换能器远侧表面。医学超声换能器定位成通过声耦合介质从换能器近侧表面到换能器远侧表面发射医学超声。末端执行器适于在患者的医疗过程期间在医疗超声换能器的发射期间和/或发射之间改变声学耦合介质的性质（诸如形状和/或温度）。在一个示例中，这种改变用于在医疗过程期间改变发射的超声的焦点和/或光束角。