US 20100076352A1

(19) United States

(12) Patent Application Publication

Kim et al.

(10) Pub. No.: US 2010/0076352 A1

(43) Pub. Date: Mar. 25, 2010

(54) APPARATUS USING FOCUSED ULTRASOUND WAVE BY CONTROLLING ELECTRONIC SIGNALS AND USING METHOD THEREOF

(75) Inventors: **Yong Tae Kim**, Yuseong-gu (KR); **Moon Jae Jho**, Yuseong-gu (KR); **Sung Soo Jung**, Seo-gu (KR); **Ho Chul Kim**, Yuseong-gu (KR); **Yong Hyeon Yun**, Yuseong-gu (KR)

Correspondence Address:
HISCOCK & BARCLAY, LLP
2000 HSBC PLAZA, 100 Chestnut Street
ROCHESTER, NY 14604-2404 (US)

(73) Assignee: **Korea Research Institute of Standards and Science**, Daejeon (KR)

(21) Appl. No.: **12/513,244**

(22) PCT Filed: **Dec. 4, 2006**

(86) PCT No.: **PCT/KR06/05178**

§ 371 (c)(1), (2), (4) Date: **May 1, 2009**

(30) **Foreign Application Priority Data**

Nov. 22, 2006 (KR) 10-2006-0116052

Publication Classification

(51) **Int. Cl.**
A61N 7/00 (2006.01)
A61B 8/00 (2006.01)

(52) **U.S. Cl.** **601/2**; 600/437

(57) **ABSTRACT**

The present invention relates to an extracorporeal High Intensity Focused Ultrasound (HIFU) necrosis apparatus through the control of an electronic signal, including oscillation elements for generating ultrasonic beams, an ultrasonic oscillator array having the oscillation elements fixed on a plane and oriented toward a life, delay circuits respectively connected to the oscillation elements for delaying ultrasonic oscillation by a delay time, and control means for controlling the delay time so that the ultrasonic beams are focused, and a method of employing the same. According to the present invention, waved surfaces with a variety of directions and curvatures can be formed using several oscillation elements and several delay circuits disposed on a plane, and a focus can be formed at any desired place. Accordingly, there are advantages in that installation is convenient, and a tissue, such as tumor, which is a target tissue, can be necrotized without damage to normal tissues necrosis. Further, there is no damage to normal tissues other than a target tissue. Accordingly, there are advantages in that a recovery speed of a patient can quicken, a symptom after recovery can be mitigated, and so on.

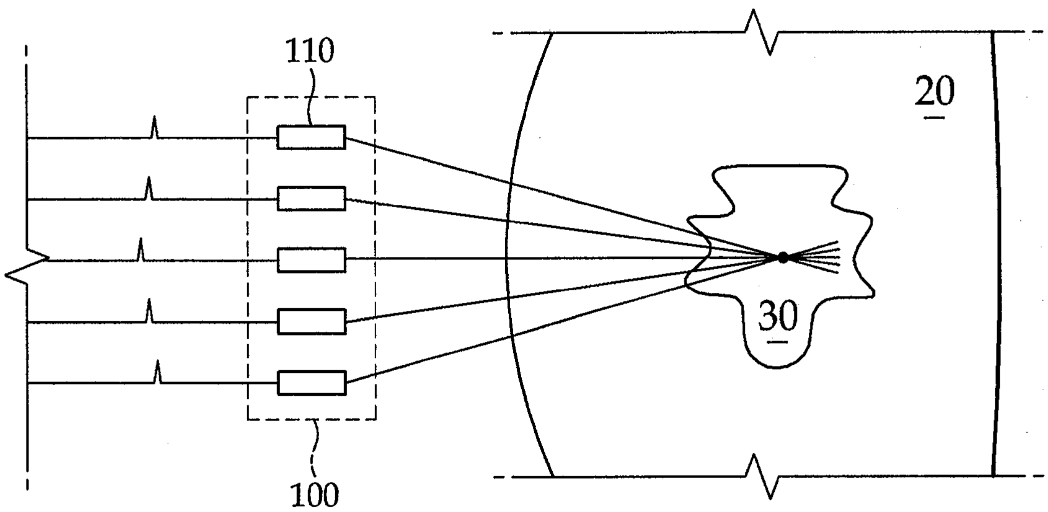


FIG.1

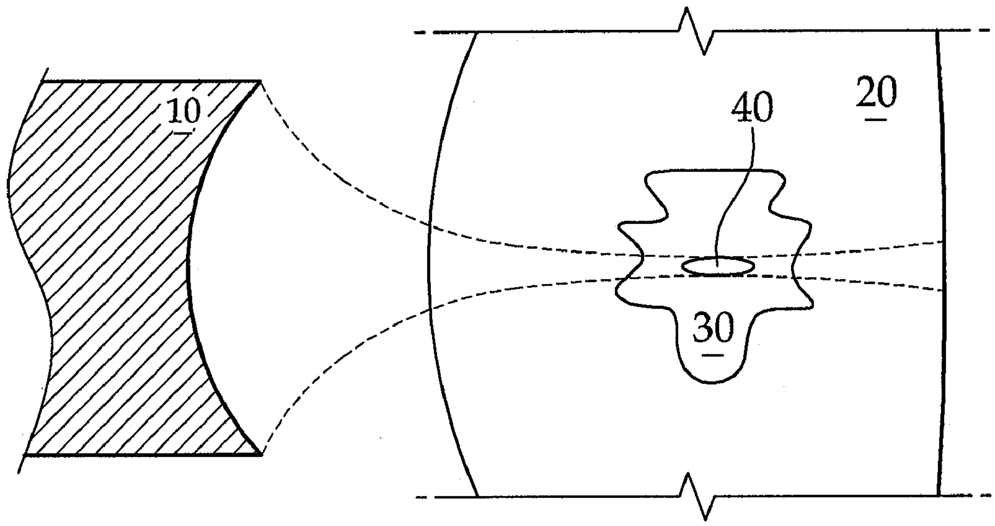


FIG.2

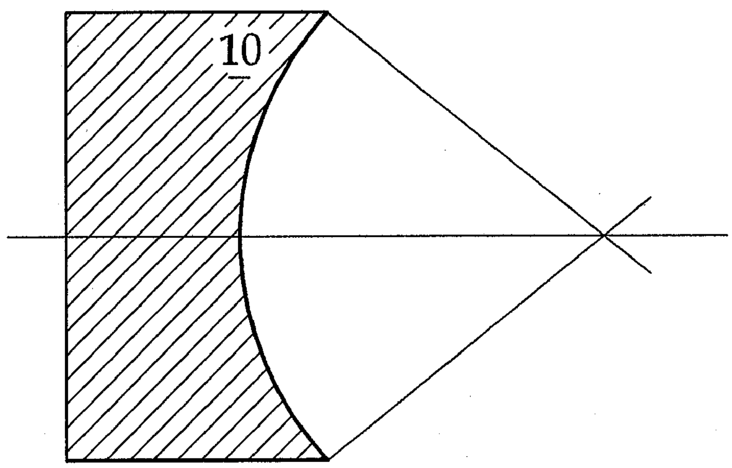


FIG.3

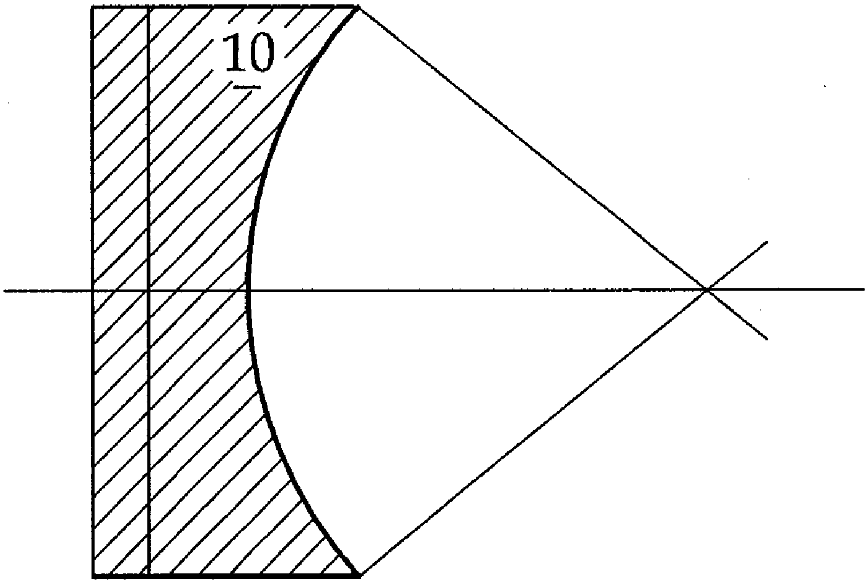


FIG.4

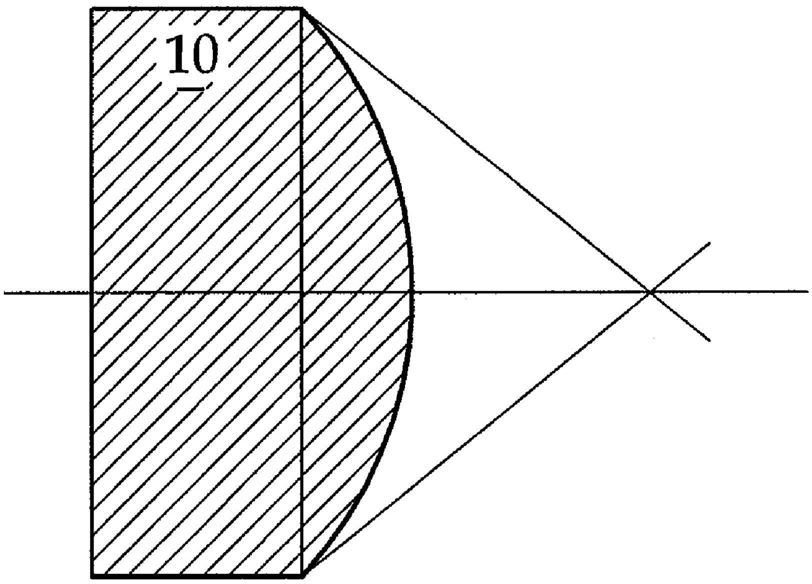


FIG.5

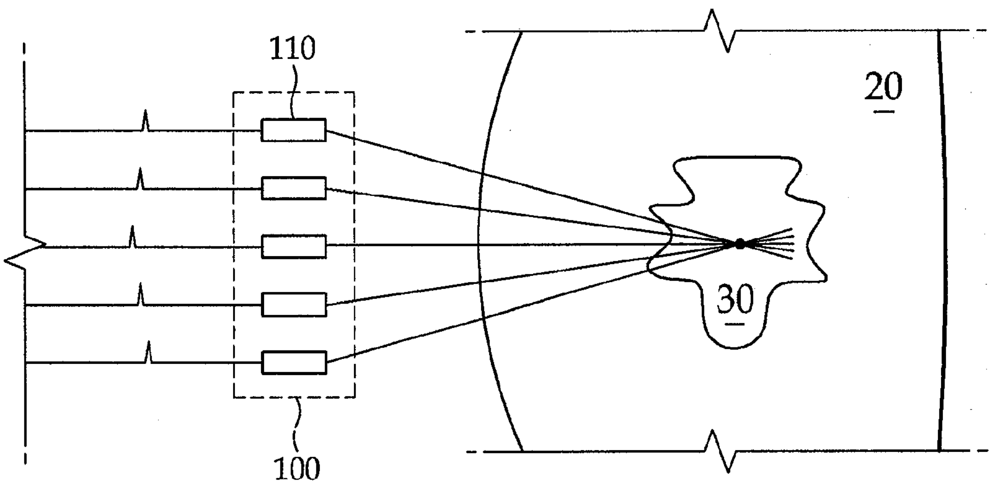


FIG.6

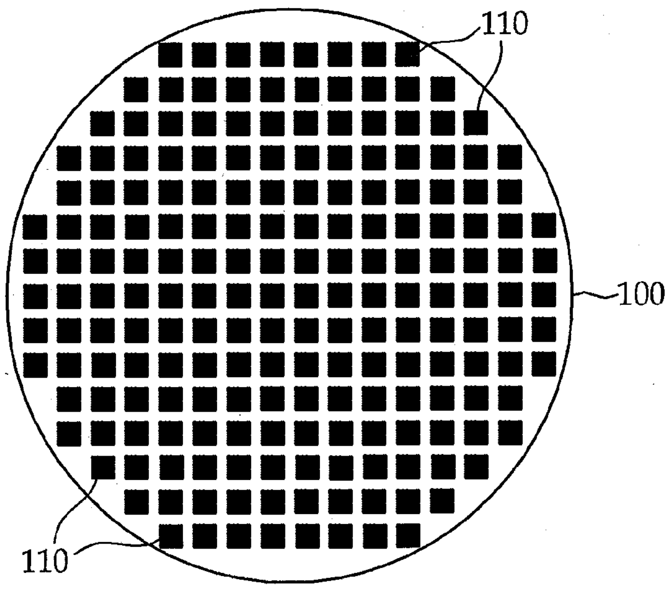


FIG.7

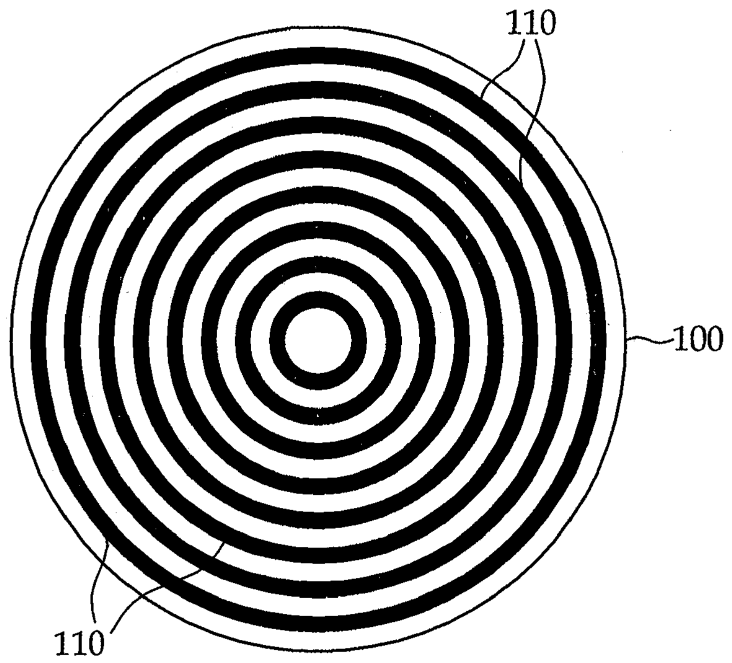


FIG.8

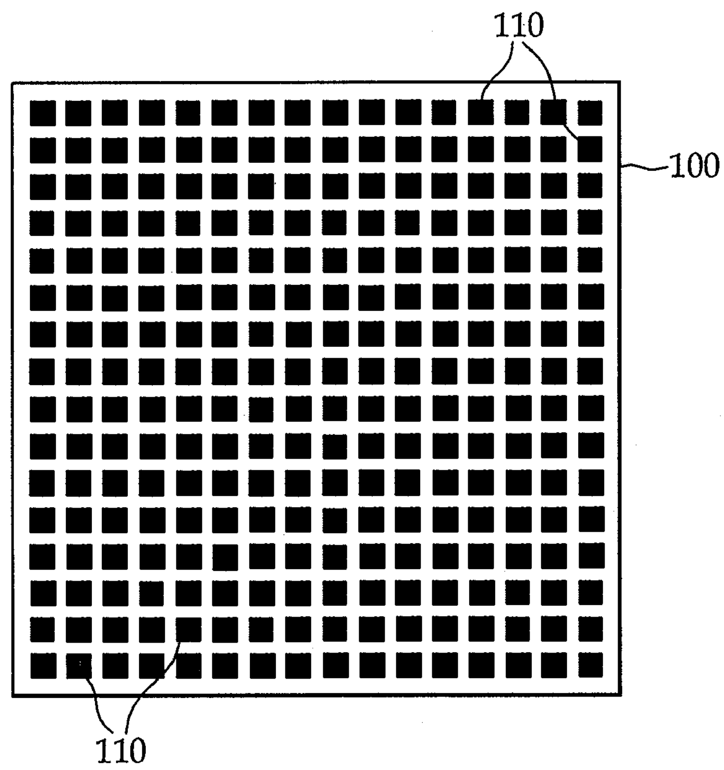
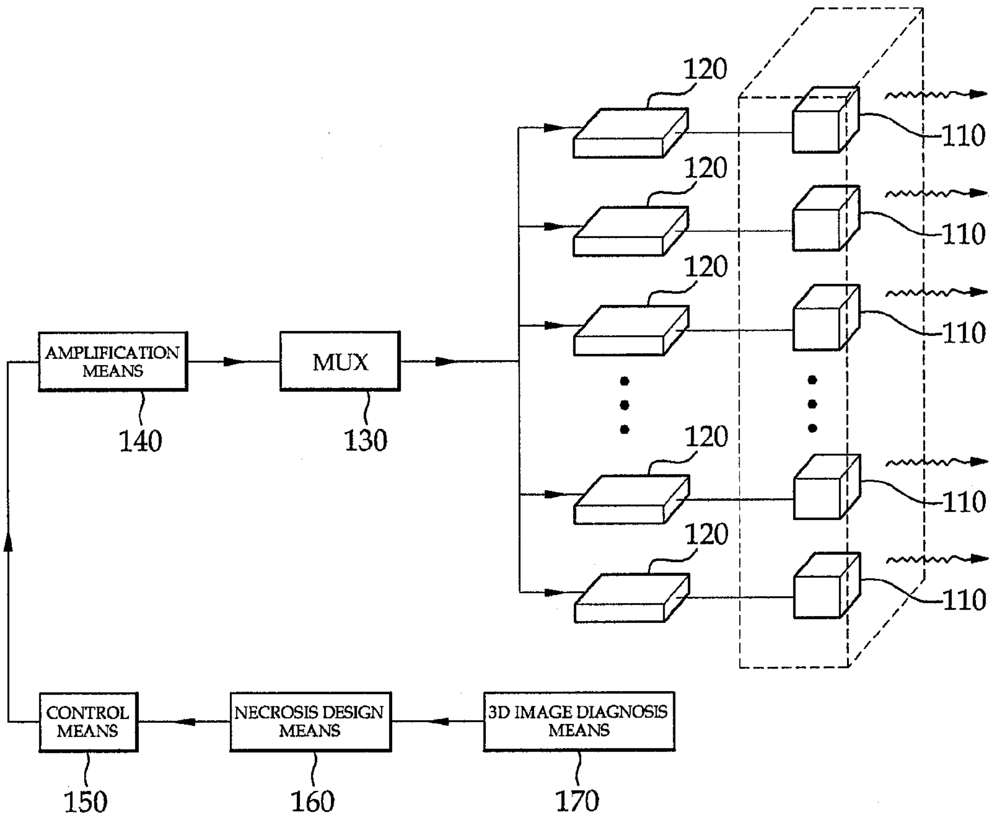
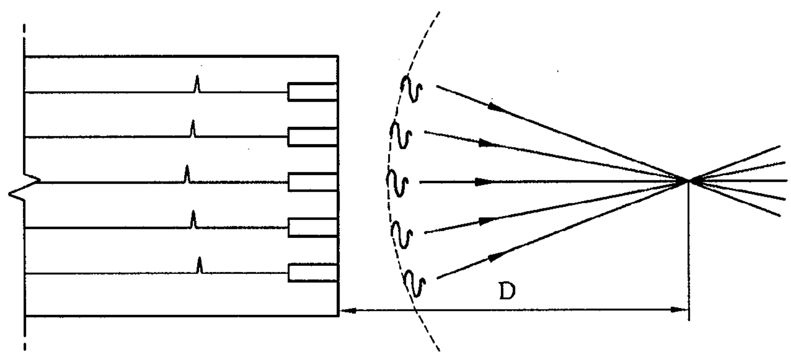


FIG.9



120
110
AMPLIFICATION MEANS
MUX
140
130
CONTROL MEANS
NECROSIS DESIGN MEANS
3D IMAGE DIAGNOSIS MEANS
150
160
170

FIG.10



D

FIG.11

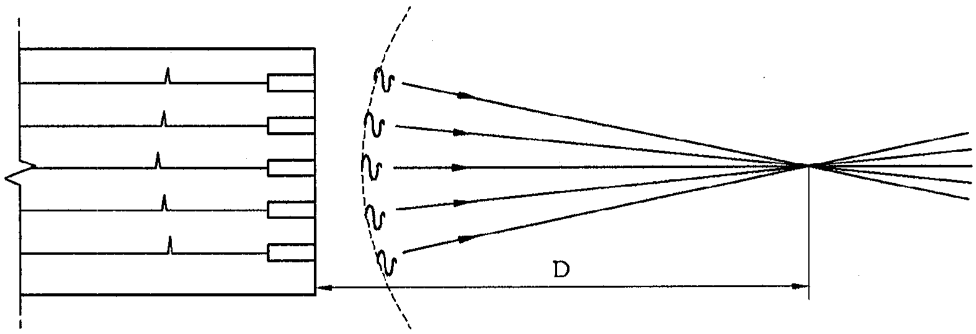


FIG.12

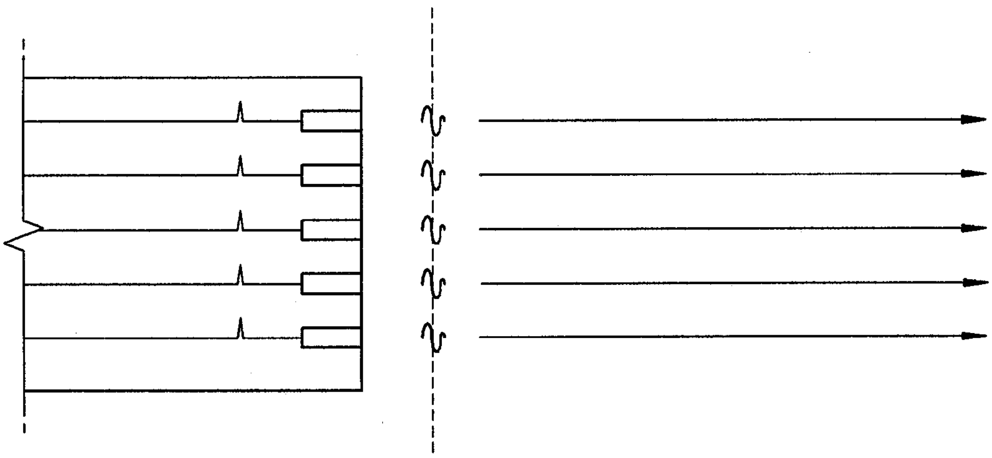


FIG.13

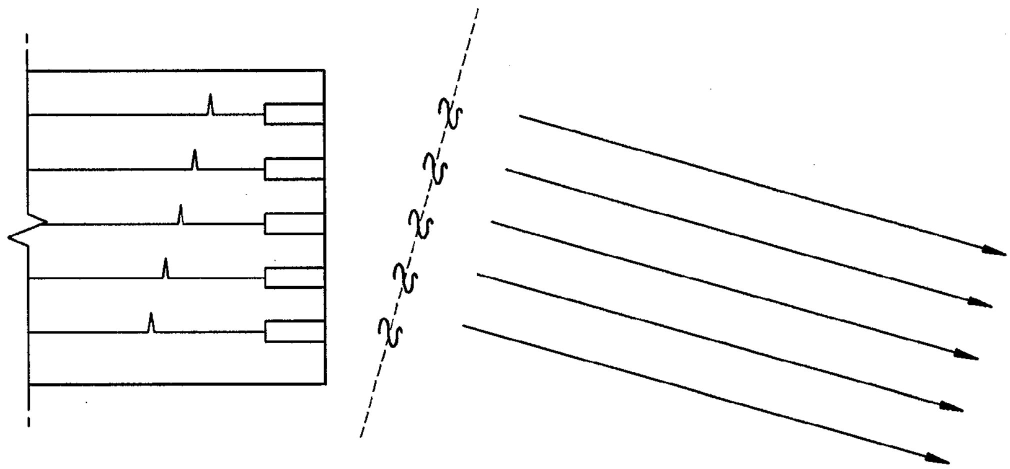


FIG.14

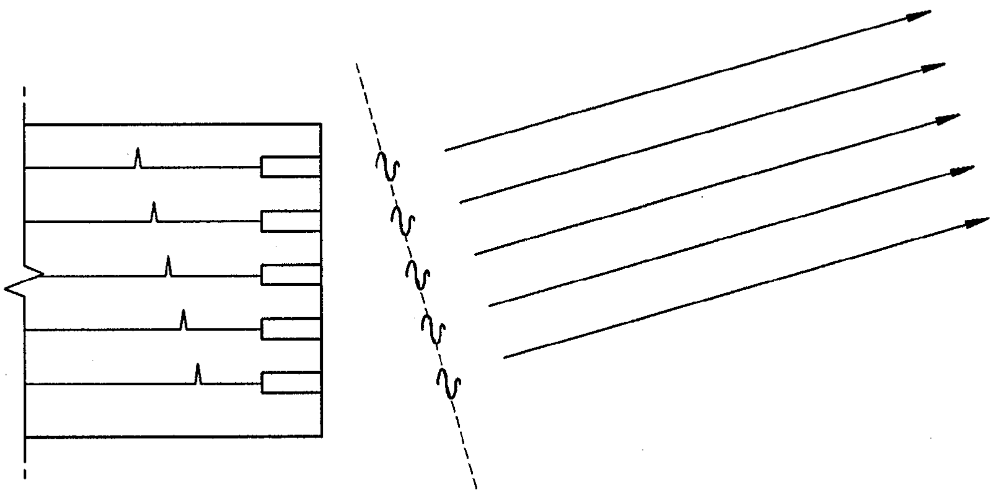


FIG.15

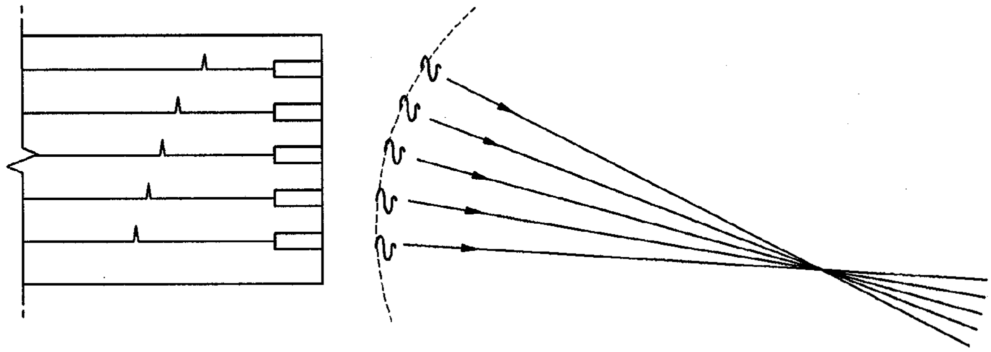
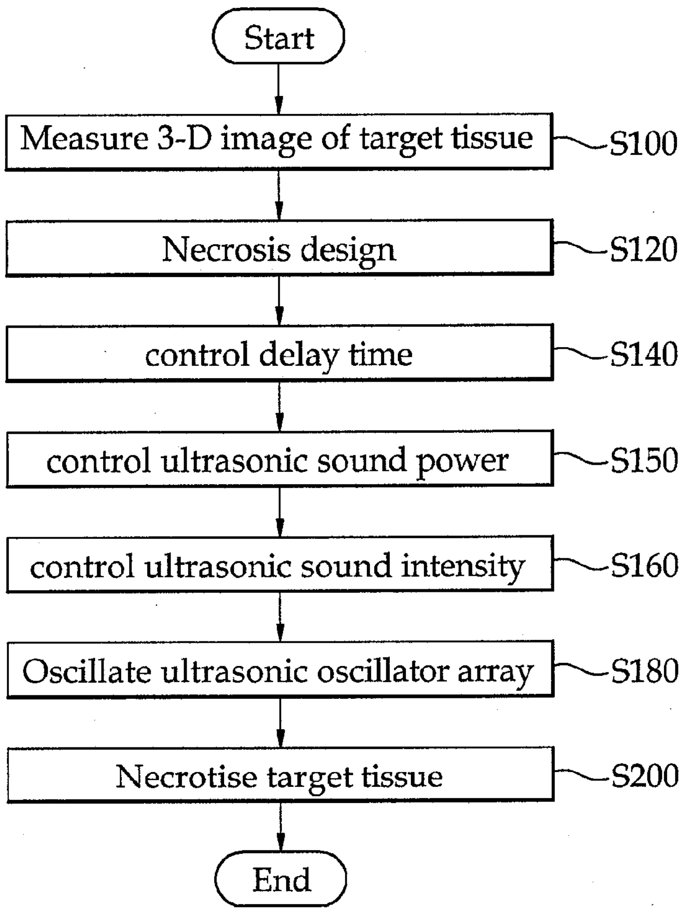


FIG.16


Start
Measure 3-D image of target tissue
S100
Necrosis design
S120
control delay time
S140
control ultrasonic sound power
S150
control ultrasonic sound intensity
S160
Oscillate ultrasonic oscillator array
S180
Necrotise target tissue
S200
End

APPARATUS USING FOCUSED ULTRASOUND WAVE BY CONTROLLING ELECTRONIC SIGNALS AND USING METHOD THEREOF

TECHNICAL FIELD

[0001] The present invention relates, in general, to an extracorporeal High Intensity Focused Ultrasound (HIFU) necrosis apparatus through the control of an electronic signal, and more particularly, to a method of forming a focus using an electronic signal in a planar type array of an ultrasonic oscillator that is an ultrasonic source.

BACKGROUND ART

[0002] In general, extracorporeal HIFU refers to ultrasonic wave that is obtained by focusing ultrasonic wave, generated outside a human body, on a target tissue (for example, tumor) within a life. Today, extracorporeal HIFU has been in the spotlight in the medical field because of its non-invasive characteristic.

[0003] A basic principle of HIFU, of selectively breaking tissues, such as tumor, by using a conventional ultrasonic wave is illustrated in FIG. **1**. Tumor, etc. existing within a life becomes a target tissue **30**, and an ultrasonic oscillator **10** is disposed outside a body so that the target tissue **30** is focused. Ultrasonic wave generated from the ultrasonic oscillator **10** is focused in the target tissue **30**. Temperature rises at a tissue **40** of a point where a focus is brought in. When the temperature reaches a constant critical temperature (for example, 60 degrees Celsius or more), the tissue **40** on which a focus is formed, of the target tissue **30**, is necrotized.

[0004] FIGS. **2** to **4** show states illustrating the ultrasonic oscillator **10**, which is an extracorporeal ultrasonic source according to the principle of the conventional HIFU. If ultrasonic wave generated from the ultrasonic oscillator **10** is to be focused on the target tissue **30**, the ultrasonic oscillator **10** that is geometrically concave, as shown in FIG. **2**, is required. A piano-concave or plano-convex ultrasonic oscillator **10** can also be used, as shown in FIGS. **3** and **4**.

[0005] The HIFU necrosis apparatus has been used to treat prostate tumor and hypertrophia in Korea since several years ago, and recently finds increasing application fields in various solid cancer treatments, including hepatoma. However, if a target tissue is eliminated using the conventional ultrasonic oscillator of the geometric form, there is a problem in that even normal tissues not having tumor are broken due to a limit accompanied by the geometric shape of the ultrasonic oscillator. A problem also arises in spatial limit for installation because the geometric curve of the ultrasonic oscillator is used.

DISCLOSURE OF INVENTION

Technical Problem

[0006] Accordingly, the present invention has been made keeping in mind the above problems occurring in the prior art, and an object of the present invention is to provide an extracorporeal HIFU necrosis apparatus through the control of an electronic signal and a method of using the same, in which an ultrasonic oscillator is constructed to have a planar shape not a geometric shape, so that convenience in installing the apparatus can be improved, an electrical signal can be controlled easily and precisely, and target tissues can be eliminated without damage to normal tissues.

Technical Solution

[0007] The above object of the present invention is accomplished by an extracorporeal HIFU necrosis apparatus through the control of an electronic signal, including oscillation elements for generating ultrasonic beams; an ultrasonic oscillator array having the oscillation elements fixed on a plane and oriented toward a life; delay circuits respectively connected to the oscillation elements for delaying ultrasonic oscillation by a delay time; and control means for controlling the delay time so that the ultrasonic beams are focused.

[0008] The shape of the ultrasonic oscillator array **100** in which the oscillation elements **110** are arranged may be circular or square.

[0009] A length of a diameter or one side of the ultrasonic oscillator array **100** may be in the range of 15 to 30 cm.

[0010] The ultrasonic oscillation elements **110** may be ring-shaped, and a plurality of the ring-shaped ultrasonic oscillation elements **110** having different sizes may be disposed on a concentric circle.

[0011] The oscillation elements **110** may include piezoelectric material, a magnetostrictive transducer or a Capacitive Micromachined Ultrasonic Transducer (CMUT).

[0012] Furthermore, the above object of the present invention is accomplished by an extracorporeal HIFU necrosis apparatus through the control of an electronic signal, including an ultrasonic oscillator array **100** having ultrasonic oscillation elements **110** fixed on a plane and oriented toward a life; delay circuits **120** respectively connected to the oscillation elements **110** for delaying ultrasonic oscillation by a delay time; an ultrasonic oscillator including control means **150** for controlling the delay time so that the ultrasonic beams are focused; and 3-D image diagnosis means **170** for measuring the shape of a target tissue **30** within the life and outputting the measured shape as a 3-D image, wherein the control means **150** controls the delay time of the delay circuits **120** based on a positional data of the 3-D image in order to focus the ultrasonic beams on the target tissue **30**.

[0013] The image diagnosis means **170** may include one of Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and ultrasonic image diagnosis means.

[0014] Meanwhile, the extracorporeal HIFU necrosis apparatus may further include amplification means **140** for amplifying a signal applied to the ultrasonic oscillator array **100**.

[0015] Furthermore, the extracorporeal HIFU necrosis apparatus may further include a multiplexer **130** for selectively applying a signal to the ultrasonic oscillator array **100**.

[0016] The extracorporeal HIFU necrosis apparatus may further include necrosis design means **160** for designating a necrosis sequence based on the 3-D image between the image diagnosis means **170** and the control means **150**. The control means **150** may control the delay time of the delay circuit **120** based on a necrosis sequence designated by the necrosis design means **160** in order to focus the ultrasonic waves on the target tissue **30**.

[0017] Furthermore, the above object of the present invention is accomplished by a method of employing an extracorporeal HIFU necrosis apparatus through the control of an electronic signal, including a step (S**100**) of allowing 3-D image diagnosis means **170** to measure a shape of a target tissue **30** within a life and output a measured shape as a 3-D image; a step (S**140**) of allowing control means **150** to control delay time of each of delay circuits **120** connected to an ultrasonic oscillator array **100** based on a positional data of the 3-D image; a step (S**180**) of allowing the control means **150** to oscillate the ultrasonic oscillator array **100**; and a step (S**200**) of making the target tissue **30** necrotized by focusing an oscillated ultrasonic wave on the target tissue **30** depending on a difference of the delay time.

[0018] Meanwhile, the method may further include a design step (S**120**) of specifying a necrosis sequence of the target tissue **30** and an intensity of an ultrasonic beam based on the 3-D image, after the step of outputting the 3-D image (S**100**).

[0019] Furthermore, the method may further include a step (S**150**) of amplifying a signal of the control means **150** and controlling ultrasonic sound power by controlling an amplification ratio, after the step (S**140**) of controlling the delay time.

[0020] Furthermore, the method may further include a step (S**160**) of selecting an oscillation element from which an ultrasonic beam is radiated and controlling a sound intensity I of an ultrasonic wave at a focus through the control of the amplification ratio, after the step (S**150**) of controlling the ultrasonic sound power.

[0021] The above object, and further objects and merits and characteristics of the present invention will become more apparent from the following detailed description and preferred embodiments taken in conjunction with the accompanying drawings.

Advantageous Effects

[0022] According to the present invention, a waved surface having a variety of directions and curvatures can be formed using several oscillation elements and delay circuits existing on a plane. In other words, if an ultrasonic oscillator array having a predetermined shape upon fabrication is used, an installation position of an apparatus has to be changed, posing a limit to a focus brought in a desired place. If an electronic signal is used, however, there is an advantage in that a focus can be brought in any desired place without changing an installation position.

[0023] Accordingly, there is an advantage in that a tissue, such as tumor, which is a target tissue, can be necrotized without damage to normal tissues. Furthermore, if an extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention is employed, there are advantages in that the recovery of a patient can quicken, a symptom after recovery can be mitigated, and so on because there is no damage to normal tissues other than target tissues.

DESCRIPTION OF THE DRAWINGS

[0024] FIG. **1** shows a state illustrating the basic principle of a HIFU using a conventional extracorporeal HIFU,

[0025] FIGS. **2** to **4** show states illustrating an ultrasonic oscillator, which is an extracorporeal ultrasonic source according to the principle of the conventional HIFU,

[0026] FIG. **5** shows a state illustrating a basic principle of HIFU using an extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention,

[0027] FIG. **6** is a front view illustrating a state where an oscillation element constituting a circular planar ultrasonic oscillator array, of the present invention, is disposed in matrix form,

[0028] FIG. **7** is a front view illustrating a state where a ring-shaped oscillation element constituting a circular planar ultrasonic oscillator array, of the present invention, is disposed on a concentric circle,

[0029] FIG. **8** is a front view of an oscillation element constituting a square planar ultrasonic oscillator array, of the present invention, is disposed,

[0030] FIG. **9** shows a system configuration of an extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention,

[0031] FIG. **10** illustrates a radiation state of an ultrasonic beam having a short focus distance by employing time delay of the present invention,

[0032] FIG. **11** illustrates a radiation state of an ultrasonic beam having a long focus distance by employing time delay of the present invention,

[0033] FIG. **12** illustrates a radiation state of an ultrasonic beam that is set to face the front by employing time delay of the present invention,

[0034] FIG. **13** illustrates a radiation state of an ultrasonic beam having a focus downward by employing time delay of the present invention,

[0035] FIG. **14** illustrates a radiation state of an ultrasonic beam having a focus upward by employing time delay of the present invention,

[0036] FIG. **15** illustrates a radiation state of an ultrasonic beam whose focus distance and direction are controlled, and

[0037] FIG. **16** is a flowchart illustrating a method of employing the extracorporeal HIFU necrosis apparatus of the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0038] The present invention will now be described in detail in connection with preferred embodiments with reference to the accompanying drawings.

[0039] FIG. **5** schematically illustrates the principle of HIFU using a planar ultrasonic oscillator array **100**, which is controlled in response to an electrical signal, according to the present invention.

[0040] The extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention has the same basic principle as that of the conventional geometrical ultrasonic oscillator array **10** in that an ultrasonic beam is focused on a target tissue **30** in order to induce a temperature rise of a critical temperature (for example, 60 degrees Celsius) or more, and the target tissue **30** is necrotized. However, the extracorporeal HIFU necrosis apparatus of the present invention differs from the conventional geometrical ultrasonic oscillator array **10** in that an ultrasonic oscillator array **100** is formed on a plane. The planar ultrasonic oscillator array **100** has several ultrasonic oscillation elements **110** mounted therein. Ultrasonic waves are radiated from the respective ultrasonic oscillation elements **110** with a time lag and are then focused on the target tissue **30**. As the ultrasonic waves are radiated with a time lag, a focus can be formed in the same manner as that a focus is formed by the geometric type ultrasonic oscillator.

[0041] The front shape of the planar ultrasonic oscillator array **100** in which the oscillation elements **110** are arranged may be preferably isotropic, circular or square, as shown in FIGS. **6**, **7** and **8**. This is because it is efficient that the ultrasonic oscillator array **100** is isotropic in order to obtain the temperature rise effect within a short time by allowing a greater amount of the ultrasonic beam to reach a portion of the target tissue **30** in which a focus will be brought.

[0042] Furthermore, when considering the size of the target tissue **30** (for example, tumor) to be eliminated, the size of a life, etc., the length of a diameter or one side of the planar ultrasonic oscillator array **100** may be preferably in the range of 15 to 30 cm. When the length of a diameter or one side of the planar ultrasonic oscillator array **100** is 15 cm or less, it is difficult to expect a sufficient temperature rise in the target tissue **30** during a predetermined time since the number of the ultrasonic oscillation elements **110** from which ultrasonic waves are generated is less. When the length of a diameter or one side of the planar ultrasonic oscillator array **100** is 30 cm or more, there is a problem in that efficiency is low, such as that the intensity of an ultrasonic beam is weak and time taken for temperature to rise is long, because a focus distance is lengthened.

[0043] The oscillation elements **110** forming the planar ultrasonic oscillator array **100** can be disposed in matrix form, as shown in FIGS. **6** and **8**.

[0044] In this case, the oscillation elements **110** forming a circular ultrasonic oscillator array **100** can be disposed in a ring shape and the oscillation elements **110** with different radii can be disposed on a concentric circle, as shown in FIG. **7**.

[0045] The shape of one of several ultrasonic oscillation elements **110** existing in the planar ultrasonic oscillator array **100** can be rectangular, circular, elliptical, fan-shaped, ring-shaped and so on as well as square shown in FIGS. **6**, **7** and **8**.

[0046] An oscillator that can be used as the ultrasonic oscillation element **110** can be formed from a piezoelectric material employing the piezoelectric effect, such as PZT-based material with a high electro-mechanical coupling coefficient, PMN-PT-based material with a good piezoelectric characteristic or LiNb-based material. A magnetostrictive transducer that varies according to a magnetization state can be used as the oscillator. A Capacitive Micromachined Ultrasonic Transducer (CMUT) can also be used as the oscillator. The CMUT is advantageous in that the same transducer can be fabricated and it can be directly applied to an electronic circuit because a semiconductor process is introduced.

[0047] As another embodiment of the extracorporeal HIFU necrosis apparatus through the control of an electronic signal, there is an extracorporeal HIFU necrosis apparatus through the control of an electronic signal, including the ultrasonic oscillator array **100** having the ultrasonic oscillation elements **110** fixed on a plane and oriented toward a life; the delay circuits **120** respectively connected to the oscillation elements **110** for delaying ultrasonic oscillation by a delay time; an ultrasonic oscillator including the control means **150** for controlling the delay time so that the ultrasonic beams are focused; and 3-dimensional (3-D) image diagnosis means **170** for measuring the shape of the target tissue **30** within the life and outputting the measured shape as a 3-D image. The control means **150** controls the delay time of the delay circuit **120** based on a positional data of the 3-D image in order to focus the ultrasonic beams on the target tissue **30**.

[0048] It is preferred that the image diagnosis means **170** generally employ Magnetic Resonance Imaging (MRI), Computed Tomography (CT), ultrasonic image diagnosis means or the like.

[0049] It is preferred that amplification means **140** for amplifying a signal applied to the ultrasonic oscillator array **100** be further included.

[0050] It is preferred that a multiplexer **130** for selectively applying a signal to the ultrasonic oscillator array **100** be further included.

[0051] Furthermore, it is preferred that necrosis design means **160** for designating a necrosis sequence based on the 3-D image acquired by the 3-D image diagnosis means be further included between the image diagnosis means **170** and the control means **150**.

[0052] The role and use method of each means, as a preferred embodiment of the extracorporeal HIFU necrosis apparatus through the control of an electronic signal, including the above means, is described below.

[0053] FIG. **9** shows a system configuration of the extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention.

[0054] A 3-D image of the target tissue **30**, which is acquired by the image diagnosis means **170**, is sent to the necrosis design means **160**.

[0055] The necrosis design means **160** establishes a plan for a sequence for breaking the target tissue **30**, the intensity of an ultrasonic beam, etc. based on the 3-D image. It is intended not to give much burden on a life in which the target tissue **30** exists when the size of the target tissue **30** is small and is not simple in structure.

[0056] The control means **150** controls a delay time given to each delay circuit **120** based on a positional data of the 3-D image and the designed plan. Ultrasonic beams are radiated according to the delay time and are focused on the target tissue **30**.

[0057] The amplification means **140** amplifies an electrical signal received from the control means **150**. The signal amplified in the amplification means **140** is related to the intensity of the ultrasonic beams radiated from the oscillation elements **110**. In other words, the output (that is, sound power P) of a desired ultrasonic beam can be controlled by controlling the amplification ratio (gain) of the amplification means **140**. In this case, a total sound power P is decided depending on voltage V_i applied to each of the oscillation elements **110** and radiation conductance G_i of each oscillation element, and can be expressed in the following [Equation 1].

$$p = \sum_{i=1}^{N} G_i \times V_i^2 \quad \text{[Equation 1]}$$

[0058] The multiplexer **130** selects one of several oscillation elements **110** at a location where the ultrasonic beam has to be radiated, and sends the amplified electrical signal to one of the delay circuits **120** connected to the selected oscillation element **110**. That is, it is not necessary to apply signals to the several delay circuits **120**, respectively, using the multiplexer **130**.

[0059] The plurality of delay circuits **120** are connected to the plurality of oscillation elements **110**, respectively. The delay circuits **120** delay the signal received from the multiplexer **130** by a specific time, and induce the radiation of the ultrasonic beam. The plurality of delay circuits **120** cause a variety of delay times so that the radiated ultrasonic beams have various waved surfaces.

[0060] That is, by using the delay circuit **120** and the planar ultrasonic oscillator array **100**, the same focus as that, which could be obtained in the conventional geometric ultrasonic oscillator array **10**, can be obtained. Furthermore, the geometric ultrasonic oscillator array **100** is problematic in accurate control since spatial movement is required in the ultrasonic oscillator when the location of the focus is to be changed. However, in the extracorporeal focus type necrosis apparatus through the control of an electronic signal, a focus location can be changed accurately and easily through the use of only a delay time without spatial movement.

[0061] A method of controlling a focus location by employing a time delay of several ultrasonic oscillation elements **110** and several delay circuits **120** disposed in the ultrasonic oscillator array **100** is described in detail below.

[0062] FIGS. **10** and **11** illustrate a method of controlling a focus distance of ultrasonic beams by employing a time delay.

[0063] FIG. **10** illustrates a method of forming a short focus distance. It is assumed that the illustrated oscillation elements **110** are sequentially assigned by S_1, S_2, S_3, S_4 and S_5 from the top to the bottom. In this state, in the case where ultrasonic waves are generated from the oscillation elements **110** having a symmetrical relationship around the oscillation elements (**110**) S_3, which is located at the center, that is, S_1 and S_5, and S_2 and S_4 at the same time, a waved surface of a curve can obtained. If a delay time distance between neighboring oscillation elements **110** (for example, S_1 and S_2) is set large, the curvature of the waved surface has a large value. Accordingly, a focus distance D is shortened.

[0064] FIG. **11** illustrates a method of forming a long focus distance. In the case where the delay time distance between neighboring oscillation elements **110** is set small compared with a case where the focus distance is short, a curvature has a small waved surface, and therefore the focus distance D is lengthened.

[0065] FIGS. **12** to **14** illustrate a method of controlling the direction of an ultrasonic beam by employing time delay.

[0066] Referring to FIG. **12**, if ultrasonic waves are generated from the respective oscillation elements **110** at the same time, a waved surface is formed parallel to the plane ultrasonic oscillation array **100**, and the beams orient toward the front.

[0067] Referring to FIG. **13**, if a beam is first generated from the oscillation element (**110**) S_1 and the beams S_2, S_3, S_4 and S_5 are then sequentially generated from the remaining oscillation elements **110** by a uniform time lag, waved surfaces are formed downward and the beams are oriented downward.

[0068] FIG. **14** illustrates a case where the oscillation sequence is reversed, and the waved surfaces are formed upward and the beams are oriented upward.

[0069] FIG. **15** is an example of a method of controlling both the focus distance and the direction of the ultrasonic beams described with reference to FIGS. **10** to **14**. In the case where ultrasonic beams are radiated from the ultrasonic oscillation elements **110**, which are symmetrical around the oscillation element **110** located at the center, and a delay time distance between S_1 and the remaining oscillation elements **110** is extended, a desired amount of a focus distance and direction can be obtained. That is, when a signal is applied with FIGS. **11** and **13** being coupled, a focus as shown in FIG. **15** can be obtained. By forming waved surfaces with various directions and curvatures by properly controlling a focus distance and the direction of a beam as described above, a variety of focuses can be formed. Therefore, a tissue of the target tissue **30** can be necrotized without damage to normal tissues.

[0070] Furthermore, by selecting an oscillation element through the multiplexer **130** and controlling the amplification ratio (gain) of the amplification means **140**, a sound intensity I at the focus can be controlled.

[0071] At this time, the sound intensity I can be expressed in the following [Equation 2].

$$I = \frac{1}{A} \cdot \sum_{i=1}^{N_s} G_i \times V_i^2 x e^{-2\alpha d_i} \quad \text{[Equation 2]}$$

[0072] where, d_i is a distance from each element to a focus distance, α is sound attenuation in a medium, A is a beam cross section in a focus, and V_i is voltage applied to each oscillation element. N_s is the number of oscillation elements, which are selected by the multiplexer **130**.

[0073] FIG. **16** illustrates a method of employing the extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to a preferred embodiment.

[0074] The method includes a step (S**100**) of allowing the 3-D image diagnosis means **170** to measure the shape of the target tissue **30** within a life and output a measured shape as a 3-D image, a step (S**140**) of allowing the control means **150** to control delay time of each of the delay circuits **120** connected to the ultrasonic oscillator array **100** based on a positional data of the 3-D image, a step (S**180**) of allowing the control means **150** to oscillate the ultrasonic oscillator array **100**, and a step (S**200**) of causing the target tissue **30** to be necrotized by focusing the oscillated ultrasonic wave on the target tissue **30** depending on a difference of the delay time.

[0075] It is preferred that after the 3-D image output step (S**100**), a design step (S**120**) of designating a necrosis sequence of the target tissue **30** and the intensity of an ultrasonic beam based on the 3-D image be further included. This is because a plan for the intensity of ultrasonic beams, a focus sequence, etc. for making a tissue necrotized when the target tissue **30** has a complicated structure or shape is required as mentioned earlier.

[0076] It is preferred that a step (S**150**) of amplifying signal of the control means **150** and controlling ultrasonic sound power by controlling an amplification ratio be further included, after the step (S**140**) of controlling the delay time. The ultrasonic sound power can be controlled by controlling the parameter values in [Equation 1], as mentioned earlier. This is because the ultrasonic sound power is concerned with the intensity of the ultrasonic beams radiated from the ultrasonic oscillation elements **110**. In the method of amplifying the signal, it would be economical to amplify the signal at the control means **150** before the signal reaches the delay circuit **120** in terms of the manufacturing cost. However, a method of amplifying the signal at the control means **150** after the signal reaches the delay circuit **120**, that is, when the signal reaches from the delay circuit **120** to the oscillation elements **110** may be used.

[0077] Furthermore, it is preferred that a step (S**160**) of selecting an oscillation element from which an ultrasonic beam is radiated and controlling the sound intensity I of an ultrasonic wave at a focus through the control of the amplification ratio be further includes, after the step (S**150**) of controlling the ultrasonic sound power. It is possible to predict the sound intensity at a point at which the focus of an ultrasonic beam is formed based on the above-mentioned [Equation 2] by controlling the sound power according to the step (S**140**) of controlling the ultrasonic sound power and selecting the oscillation element **110** from which the ultrasonic beam is radiated (in this case, the number of selected oscillation elements is indicated by N_s).

[0078] As described above, an optimal state for making the target tissue **30** necrotized within a life can be used safely for necrosis of the target tissue **30** without damage to normal tissues by predicting and controlling a focus location of an ultrasonic beam, the sound power P, and the sound intensity I at the focus.

INDUSTRIAL APPLICABILITY

[0079] As described above, according to the present invention, waved surfaces with a variety of directions and curvatures can be formed using several oscillation elements and several delay circuits disposed on a plane. It is therefore possible to form a focus at any desired place without change of an installation position of an ultrasonic oscillator array. Furthermore, a tissue, such as tumor, which is a target tissue, can be necrotized without damage to normal tissues necrosis.

[0080] Further, if an extracorporeal HIFU necrosis apparatus through the control of an electronic signal according to the present invention is used, there is no damage to normal tissues other than a target tissue. Accordingly, there are advantages in that a recovery speed of a patient can quicken, a symptom after recovery can be mitigated, and so on.

[0081] Although the specific embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

1. An extracorporeal High Intensity Focused Ultrasound (HIFU) necrosis apparatus through the control of an electronic signal, comprising:

Oscillation elements **110** for generating ultrasonic beams;

an ultrasonic oscillator array **100** having the oscillation elements **110** fixed on a plane and oriented toward a life;

delay circuits **120** respectively connected to the oscillation elements **110** for delaying ultrasonic oscillation by a delay time; and

control means **150** for controlling the delay time so that the ultrasonic beams are focused.

2. The extracorporeal HIFU necrosis apparatus of claim **1**, wherein the shape of the ultrasonic oscillator array **100** in which the oscillation elements **110** are arranged is circular or square.

3. The extracorporeal HIFU necrosis apparatus of claim **2**, wherein a length of a diameter or one side of the ultrasonic oscillator array **100** is in the range of 15 to 30 cm.

4. The extracorporeal HIFU necrosis apparatus of claim **1**, wherein:

the ultrasonic oscillation elements **110** are ring-shaped, and

a plurality of the ring-shaped ultrasonic oscillation elements **110** having different sizes are disposed on a concentric circle.

5. The extracorporeal HIFU necrosis apparatus of claim **1**, wherein the oscillation elements **110** include piezoelectric material, a magnetostrictive transducer or a Capacitive Micromachined Ultrasonic Transducer(CMUT).

6. An extracorporeal HIFU necrosis apparatus through the control of an electronic signal, comprising:

an ultrasonic oscillator array **100** having ultrasonic oscillation elements **110** fixed on a plane and oriented a life;

delay circuits **120** respectively connected to the oscillation elements **110** for delaying ultrasonic oscillation by a delay time;

an ultrasonic oscillator including control means **150** for controlling the delay time so that the ultrasonic beams are focused; and

3-D image diagnosis means **170** for measuring the shape of a target tissue **30** within the life and outputting the measured shape as a 3-D image,

wherein the control means **150** controls the delay time of the delay circuits **120** based on a positional data of the 3-D image in order to focus the ultrasonic beams on the target tissue **30**.

7. The extracorporeal HIFU necrosis apparatus of claim **6**, wherein the 3-D image diagnosis means **170** includes one of Magnetic Resonance Imaging (MRI), Computed Tomography (CT), and ultrasonic image diagnosis means.

8. The extracorporeal HIFU necrosis apparatus of claim **6**, further comprising amplification means **140** for amplifying a signal applied to the ultrasonic oscillator array **100**.

9. The extracorporeal HIFU necrosis apparatus of claim **6**, further comprising a multiplexer **130** for selectively applying a signal to the ultrasonic oscillator array **100**.

10. The extracorporeal HIFU necrosis apparatus of claim **6**, further comprising necrosis design means **160** for designating a necrosis sequence based on the 3-D image between the 3-D image diagnosis means **170** and the control means **150**,

wherein the control means **150** controls the delay time of the delay circuit **120** based on the necrosis sequence designated by the necrosis design means **160** in order to focus the ultrasonic beams on the target tissue **30**.

11. A method of employing an extracorporeal HIFU necrosis apparatus through the control of an electronic signal, the method comprising:

a step (S**100**) of allowing 3-D image diagnosis means **170** to measure a shape of a target tissue **30** within a life and output a measured shape as a 3-D image;

a step (S**140**) of allowing control means **150** to control delay time of each of delay circuits **120** connected to an ultrasonic oscillator array **100** based on a positional data of the 3-D image;

a step (S**180**) of allowing the control means **150** to oscillate the ultrasonic oscillator array **100**; and

a step (S**200**) of making the target tissue **30** necrotized by focusing an oscillated ultrasonic wave on the target tissue **30** depending on a difference of the delay time.

12. The method of claim **11**, further comprising a design step (S**120**) of specifying a necrosis sequence of the target tissue **30** and an intensity of an ultrasonic beam based on the 3-D image, after the step of outputting the 3-D image (S**100**).

13. The method of claim **11**, wherein the step (S**140**) of controlling the delay time further includes a step (S**150**) of amplifying a signal of the control means **150** and controlling ultrasonic sound power by controlling the amplification ratio.

14. The method of claim **13**, further comprising a step (S**160**) of selecting an oscillation element from which an ultrasonic beam is radiated and controlling a sound intensity I of an ultrasonic wave at a focus through the control of the amplification ratio, after the step (S**150**) of controlling the ultrasonic sound power.

* * * * *

专利名称(译)	通过控制电子信号使用聚焦超声波的装置及其使用方法		
公开(公告)号	US20100076352A1	公开(公告)日	2010-03-25
申请号	US12/513244	申请日	2006-12-04
[标]申请(专利权)人(译)	韩国标准科学研究院		
申请(专利权)人(译)	韩国研究院标准和科学		
当前申请(专利权)人(译)	韩国研究院标准和科学		
[标]发明人	KIM YONG TAE JHO MOON JAE JUNG SUNG SOO KIM HO CHUL YUN YONG HYEON		
发明人	KIM, YONG TAE JHO, MOON JAE JUNG, SUNG SOO KIM, HO CHUL YUN, YONG HYEON		
IPC分类号	A61N7/00 A61B8/00		
CPC分类号	A61B8/483 G10K11/346 A61N2007/0078 A61N7/02		
优先权	1020060116052 2006-11-22 KR		
外部链接	Espacenet USPTO		

摘要(译)

本发明涉及通过控制电子信号的体外高强度聚焦超声（HIFU）坏死装置，包括用于产生超声波束的振荡元件，具有固定在平面上并朝向生命的振荡元件的超声波振荡器阵列，分别连接到振荡元件的延迟电路用于延迟超声波振荡延迟时间，控制装置用于控制延迟时间以使超声波束聚焦，以及采用该延迟电路的方法。根据本发明，可以使用若干振荡元件和设置在平面上的若干延迟电路形成具有各种方向和曲率的波形表面，并且可以在任何期望的位置形成焦点。因此，优点在于安装方便，并且作为靶组织的组织（例如肿瘤）可被坏死，而不会损害正常组织坏死。此外，除了靶组织之外，对正常组织没有损伤。因此，优点在于可以加快患者的恢复速度，减轻恢复后的症状等。