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(54) **ACOUSTIC SWITCH AND APPARATUS AND METHODS FOR USING ACOUSTIC SWITCHES WITHIN A BODY**

AKUSTISCHER SCHALTER, VERFAHREN UND VORRICHTUNG FÜR DAS VERWENDEN VON AKUSTISCHEN SCHALTERN IN EINEM KÖRPER

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(56) References cited:
WO-A-00/47109
US-A- 2 786 899
US-A- 3 672 352
US-A- 3 970 987
US-A- 4 041 954
US-A- 4 099 530
US-A- 4 651 740

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Description

INTRODUCTION

[0001] The present invention relates generally to devices for implantation within a patient's body, and more particularly to devices for activating, deactivating, and/or controlling implants located within a body that monitor physiological conditions and/or provide therapeutic functions.

BACKGROUND OF THE INVENTION

[0002] Devices are known that may be implanted within a patient's body to monitor one or more physiological conditions and/or to provide therapeutic functions. For example, sensors or transducers may be located deep within the body for monitoring a variety of properties, such as temperature, pressure, strain, fluid flow, chemical properties, electrical properties, magnetic properties, and the like. In addition, devices may be implanted that perform one or more therapeutic functions, such as drug delivery, defibrillation, electrical stimulation, and the like.

[0003] Often it is desirable to control by external command such devices once they are implanted within a patient, for example, to obtain data, and/or to activate or otherwise control the implant. An implant may include wire leads from the implant to an exterior surface of the patient, thereby allowing an external controller or other device to be directly coupled to the implant. Alternatively, the implant may be remotely controlled, for example, using an external induction device. For example, an external radio frequency (RF) transmitter may be used to communicate with the implant. RF energy, however, may only penetrate a few millimeters into a body, because of the body's dielectric nature, and therefore may not be able to communicate effectively with an implant that is located deep within the body. In addition, although an RF transmitter may be able to induce a current within an implant, the implant's receiving antenna, generally a low impedance coil, may generate a voltage that is too low to provide a reliable switching mechanism.

[0004] In a further alternative, electromagnetic energy may be used to switch or otherwise control an implant, since a body generally does not attenuate magnetic fields. The presence of external magnetic fields encountered by the patient during normal activity, however, may expose the patient to the risk of false positives, i.e., accidental activation or deactivation of the implant. Furthermore, external electromagnetic systems may be cumbersome and may not be able to effectively transfer coded information to an implant.

[0005] US-A-3 672 352 discloses an implant with an electrical circuit. It teaches the switching of an implant from a dormant mode to an active mode by using electromagnetic energy to physically move a switch form one position to another position. Further US-A-4 099 530 disclose a possibility for using an acoustic switch, but just when the implant is consuming an substantial amount of energy.

[0006] Accordingly, it is believed that a device that overcomes these problems and/or that may more effectively remotely activate or otherwise control an implant located within a patient's body may be considered useful.

SUMMARY OF THE INVENTION

[0007] The invention as defined by claim 1 is generally directed to implants that may be surgically or otherwise located within a mammalian body for monitoring one or more physiological parameters and/or for performing one or more therapeutic functions. For example, an implant in accordance with the present invention may be used for atrial defibrillation, pain relief stimulation, neuro-stimulation, drug release, activation of a light source for photodynamic therapy, monitoring of a radiation dose including ionizing, magnetic or acoustic radiation, monitoring of flow in a bypass graft, producing cell oxygenation and membrane electroportation, and measurement of various physiological parameters including heart chamber pressure, infraction temperature, intracranial pressure, electrical impedance, position, orthopedic implant strain or pH.

[0008] In a accordance with a first aspect of the present invention, an implant is provided that includes an electrical circuit configured for performing one or more commands when the implant is activated, an energy storage device, and a switch coupled to the electrical circuit and the energy storage device. An acoustic transducer is coupled to the switch that may be activated upon acoustic excitation by an external acoustic energy source for closing the switch to allow current flow from the energy storage device to the electrical circuit.

[0009] In one embodiment, the switch may be closed only when the acoustic transducer receives a first acoustic initiation signal followed by a second acoustic confirmation signal, the first and second acoustic signals being separated by a predetermined delay. The switch may remain closed for a predetermined time and then automatically open. Alternatively or in addition, the switch may be opened when an acoustic termination signal is received by the acoustic transducer for discontinuing current flow from the energy storage device to the electrical circuit.

[0010] According to the invention, the electrical circuit includes a sensor for measuring a physiological parameter within the body. A transmitter or the acoustic transducer itself may be coupled to the electrical circuit for receiving an electrical signal proportional to the physiological parameter measured by the sensor. The transmitter or acoustic transducer may transmit a signal including information regarding the physiological parameter to a receiver located outside the body. Preferably, the sensor is a biosensor configured for measuring at least one of blood pressure, heart chamber pressure, infraction temperature, intracranial pressure, electrical impedance, position, orthopedic implant strain, or pH, and the acoustic transducer enables communication of data from the sensor to a receiver located outside the body.

[0011] In another preferred embodiment, the electrical circuit includes an actuator for activating or controlling a therapeutic device within the body that is connected to or otherwise associated with the actuator. The electrical circuit may activate the therapeutic device for a predetermined time, or until the switch is opened. Alternatively, the electrical circuit may control the therapeutic device in response to a physiological parameter measured by a biosensor coupled to the electrical circuit.

[0012] During use, the acoustic transducer may receive a relatively low frequency acoustic signal that vibrates the piezoelectric layer at its resonant frequency. The acoustic signal closes the switch, activating the implant from its "sleep" mode to an "active" mode. In the sleep mode, the implant may wait substantially indefinitely with substantially no energy consumption. Once activated, i.e., when the switch is closed, the electrical circuit performs one or more commands, such as measuring a physiological parameter within the body, or controlling a therapeutic device within the body. A signal proportional to the physiological parameter may be transmitted from the implant to a receiver located outside the body. Alternatively, the therapeutic device may be controlled based upon the physiological parameter.

[0013] In a further alternative, a set of command signals may be sent from a source outside the body along with or after the acoustic activation signal. The command signals may be interpreted by the electrical circuit to provide a set of commands to control the therapeutic device, e.g., to provide a desired course of treatment. For example, the commands may instruct the therapeutic device to provide a desired dosage for a desired duration, and/or may modify dosage or duration based upon feedback from the biosensor.

[0014] Other objects and features of the present invention will become apparent from consideration of the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIGS. 1A-1C are block diagrams, showing exemplary embodiments of an implant, in accordance with the present invention.

FIG. 2 is a schematic diagram, showing a preferred embodiment of an electrical switch circuit, in accordance with the present invention.

FIG. 3A is a cross-sectional view of an acoustic transducer element, in accordance with the present invention.

FIG. 3B is a cross-sectional view of the transducer element of FIG. 3A, taken along line B-B.

FIG. 3C is a cross sectional view of the transducer element of FIG. 3A, taken along line C-C.

FIG. 3D is a cross sectional view of the transducer element of FIG. 3A, taken along line D-D.

FIG. 3E is a cross sectional view of the transducer element of FIG. 3A, taken along line E-E.

FIG. 3F is a cross sectional view of the transducer element of FIG. 3A, taken along line F-F.

FIG. 3G is a cross sectional view of the transducer element of FIG. 3A, taken along line G-G.

FIG. 4 is a top view of a preferred embodiment of an electrode shaped for maximizing the power response of a transducer, in accordance with the present invention.

FIG. 5 is a cross-sectional view of another preferred embodiment of a transducer element, in accordance with the present invention.

FIG. 6A-6F are schematic views of exemplary embodiments of an acoustic transmitter that may be used as a transmitter, in accordance with the present invention.

FIG. 7 is a cross-sectional view of another preferred embodiment of a transmitter element, in accordance with the present invention.

FIG. 8 is a cross-sectional view of still another preferred embodiment of a transmitter element, in accordance with the present invention.

DESCRIPTION OF THE PREFFERED EMBODIMENT

[0016] Turning to the drawings, FIGS. 1A-1C schematically show several exemplary embodiments of an implant 110, 210, 310, in accordance with the present invention. Generally, the implant 110, 210, 310 includes an electrical circuit 112, 212, 312 configured for performing one or more functions or commands when the implant 110, 210, 310 is activated, as described further below. In addition, the implant 110, 210, 310 includes an energy storage device 114 and an acoustic switch 116 coupled to the electrical circuit 112, 212, 312 and the energy storage device 114. The acoustic switch 116 is preferably activated upon acoustic excitation 100 by an external acoustic energy source (not shown) to allow current flow from the energy storage device 114 to the electrical circuit 112, 212, 312. In a preferred embodiment, the acoustic switch 116 includes an acoustic transducer 118, such as that disclosed in PCT Publication No. WO 99/34,453, published July 8, 1999, the disclosure of which is expressly incorporated herein by reference. In addition, the acoustic switch 116 also includes a switch 120, such as switch circuit 400 shown in FIG. 2 and described further below, although alternatively other switches, such as a miniature electromechanical switch and the like (not shown) may be provided.

[0017] The energy storage device 114 may be any of a variety of known devices, such as an energy exchanger, a battery and/or a capacitor (not shown). Preferably, the energy storage device 114 is capable of storing electrical energy substantially indefinitely for as long as the acoustic switch 116 remains open, i.e., when the implant 110, 210, 310 is in a "sleep" mode. In addition, the energy storage device 114 may be capable of being charged from an external source, e.g., inductively, as will be appreciated by those skilled in the art. In a preferred embodiment, the energy storage device 114 includes both a capacitor and a primary, non-rechargeable battery. Alternatively, the energy storage device 114 may include a secondary, rechargeable battery and/or capacitor that may be energized before activation or use of the implant 110, 210, 310.

[0018] The implant 110, 210, 310 may be surgically or minimally invasively inserted within a human body in order to carry out a variety of monitoring and/or therapeutic functions. For example, the electrical circuit 112, 212, 312 may include a control circuit 122, 222, 322, a biosensor 124, 224, an actuator 226, 326, and/or a transmitter 128, as explained in more detail below. The implant 210, 310 may be configured for providing one or more therapeutic functions, for example, to activate and/or control a therapeutic device implanted within a patient's body, such as an atrial defibrillator, a pain relief stimulator, a neuro-stimulator, a drug delivery device, and/or a light source used for photodynamic therapy. Alternatively, the implant may be used to monitor a radiation dose including ionizing, magnetic and/or acoustic radiation, to monitor flow in a bypass graft, to produce cell oxygenation and membrane electroportation, and the like. In addition or alternatively, the implant 110 may be used to measure one or more physiological parameters within the patient's body, such as pressure, temperature, electrical impedance, position, strain, pH, and the like.

[0019] An implant in accordance with the present invention operates in one of two modes, a "sleep" or "passive" mode when the implant remains dormant and not in use, i.e., when the acoustic switch 116 is open, and an "active" mode, when the acoustic switch 116 is closed, and electrical energy is delivered from the energy storage device 114 to the electrical circuit 112, 212, 312. Because the acoustic switch 116 is open in the sleep mode, there is substantially no energy consumption from the energy storage device 114, and consequently, the implant may remain in the sleep mode virtually indefinitely, i.e., until activated. Thus, an implant in accordance with the present invention may be more energy efficient and, therefore, may require a relatively small energy storage device than implants that continuously draw at least a small amount of current in their "passive" mode.

[0020] To activate the implant 110, 210, 310, one or more external acoustic energy waves or signals 100 are transmitted from an external source into the patient's body (not shown), e.g., generally towards the location of the implant 110, 210, 310 until the signal is received by the acoustic transducer 118. Upon excitation by the acoustic wave(s) 100, the acoustic transducer 1 18 produces an electrical output that is used to close, open, or otherwise activate the switch 120. Preferably, in order to achieve reliable switching, the acoustic transducer 118 is configured to generate a voltage of at least several tenths of a volt upon excitation that may be used as an activation signal to close the switch 120.

[0021] As a safety measure against false positives (either erroneous activations or deactivations), the acoustic switch 116 may be configured to close only upon receipt of an initiation signal followed by a confirmation signal. For example, the acoustic switch 116 may only acknowledge an activation signal that includes a first pulse followed by a second pulse separated by a predetermined delay. Use of a confirmation signal may be particularly important for certain applications, for example, to prevent unintentional release of drugs by a drug delivery implant.

[0022] In addition to an activation signal, the acoustic transducer 118 may be configured for generating a termination signal in response to a second acoustic excitation (which may the same or different than the acoustic wave(s) used to activate the acoustic switch 116) in order to return the implant 110, 210, 310 to its sleep mode. For example, once activated, the switch 120 may remain closed indefinitely, e.g., until the energy storage device 114 is depleted or until a termination signal is received by the acoustic transducer 118. Alternatively, the acoustic switch 116 may include a timer (not shown), such that the switch 120 remains closed only for a predetermined time, whereupon the switch 120 may automatically open, returning the implant 110, 210, 310 to its sleep mode.

[0023] Turning to FIG. 1A, a first preferred embodiment of an implant 110 is shown in which the electrical circuit 112 includes a controller 122, a biosensor 124 coupled to the controller 122, and a transmitter 128 coupled to the controller 122. The controller 122 may include circuitry for activating or controlling the biosensor 124, for receiving signals from the biosensor 124, and/or for processing the signals into data, for example, to be transmitted by the transmitter 128. Optionally, the electrical circuit 112 may include memory (not shown) for storing the data. The transmitter 128 may be any device capable of transmitting data from the controller 122 to a remote location outside the body, such as an acoustic transmitter, a radio frequency transmitter, and the like. In an alternative embodiment, the controller 122 may be coupled to the acoustic transducer 118 such that the acoustic transducer 118 may be used as a transmitter 128 instead of providing a separate transmitter.

[0024] The biosensor 124 may include one or more sensors capable of measuring physiological parameters, such as those described above. For example, U.S. Patent Nos. 4,793,825 issued in the name of Benjamin et al. and 5,833,603 issued in the name of Kovacs et al. disclose exemplary embodiments of biosensors that may be included in an implant, in accordance with the present invention. The disclosure of these references and others cited therein are expressly incorporated herein by reference. Thus, the biosensor 124 may generate a signal proportional to a physiological parameter that may be processed and/or relayed by the controller 122 to the transmitter 128, which may, in turn, generate a transmission signal to be received by a device outside the patient's body. Data regarding the physiological parameter(s) may be transmitted continuously or periodically until the acoustic switch 116 is deactivated, or for a fixed predetermined time, as will be appreciated by those skilled in the art.

[0025] Turning to FIG. 1B, a second preferred embodiment of an implant 210 is shown in which the electrical circuit 212 includes a controller 222 and an actuator 226. The actuator 226 may be coupled to a therapeutic device (not shown) provided in or otherwise coupled to the implant 210, such as a light source, a nerve stimulator, a defibrillator, or a valve communicating with an implanted drug reservoir (in the implant or otherwise implanted within the body in association with the implant). For example, the actuator 226 may be a light source for photo-dynamic therapy, such as that disclosed in U.S. Patent No. 5,800,478 issued in the name of Chen et al., the disclosure of which is expressly incorporated herein by reference.

[0026] When the switch 120 is closed, the controller 222 may activate the actuator 226 using a pre-programmed protocol, e.g., to complete a predetermined therapeutic procedure, whereupon the switch 120 may automatically open, or the controller 222 may follow a continuous or looped protocol until the switch 120 is deactivated. Alternatively, the acoustic transducer 118 may be coupled to the controller 222 for communicating a new or unique set of commands to the controller 222. For example, a particular course of treatment for a patient having the implant 210 may be determined, such as a flow rate and duration of drug delivery or an energy level and duration of electrical stimulation. Acoustic signals including commands specifying this course of treatment may be transmitted from an external device (not shown) to the acoustic switch 116, e.g., along with or subsequent to the activation signal 100. The controller 222 may interpret these commands and control the actuator 226 accordingly to complete the course of treatment.

[0027] Turning to FIG. 1C, yet another preferred embodiment of an implant 310 is shown in which the electrical circuit 312 includes a controller 322, a biosensor 324, and an actuator 326, all of which may be coupled to one another. This embodiment may operate similarly to the embodiments described above, e.g., to obtain data regarding one or more physiological parameters and/or to control a therapeutic device. In addition, once activated, the controller 322 may control the actuator 326 in response to data obtained from the biosensor 324 to automatically control or adjust a course of treatment being provided by a device connected to the actuator 326. For example, the actuator 326 may be coupled to an insulin pump (not shown), and the biosensor 324 may measure glucose levels within the patient's body. The controller 322 may control the actuator to open or close a valve on the insulin pump to adjust a rate of insulin delivery based upon glucose levels measured by the biosensor 324 in order to maintain the patient's glucose within a desired range.

[0028] Turning to FIG. 2, a preferred embodiment of a switch 400 is shown that may be incorporated into an implant in accordance with the present invention. The switch 400 includes a piezoelectric transducer, or other acoustic transducer (not shown, but generally connected to the switch 400 at locations piezo + and piezo -), a plurality of MOSFET transistors (Q1-Q4) and resistors (R1-R4), and switch S1. A "load" may be coupled to the switch 400, such as one of the electrical circuits described above. In the switch's "sleep" mode, all of the MOSFET transistors (Q1-Q4) are in an off state. To maintain the off state, the gates of the transistors are biased by pull-up and pull-down resistors. The gates of N-channel transistors (Q1, Q3 & Q4) are biased to ground and the gate of P-channel transistor Q2 is biased to +3V. During this quiescent stage, switch S1 is closed and no current flows through the circuit. Therefore, although an energy storage device (not shown, but coupled between the hot post, labeled with an exemplary voltage of + 3V, and ground) is connected to the switch 400, no current is being drawn therefrom since all of the transistors are quiescent.

[0029] When the piezoelectric transducer detects an external acoustic signal, e.g., having a particular Frequency such as the transducer's resonant frequency, the voltage on the transistor Q1 will exceed the transistor threshold voltage of about one half of a volt. Transistor Q1 is thereby switched on and current flows through transistor Q1 and pull-up resistor R2. As a result of the current flow through transistor Q1, the voltage on the drain of transistor Q1 and the gate of transistor Q2 drops from +3V substantially to zero (ground). This drop in voltage switches on the P-channel transistor Q2, which begins to conduct through transistor Q2 and pull-down resistor R3.

[0030] As a result of the current flowing through transistor Q2, the voltage on the drain of transistor Q2 and the gates of transistors Q3 and Q4 increases from substantially zero to +3V. The increase in voltage switches on transistors Q3 and Q4. As a result, transistor Q3 begins to conduct through resistor R4 and main switching transistor Q4 begins to conduct through the "load," thereby switching on the electrical circuit.

[0031] As a result of the current flowing through transistor Q3, the gate of transistor Q2 is connected to ground through transistor Q3, irrespective of whether or not transistor Q1 is conducting. At this stage, the transistors (Q2, Q3 & Q4) are latched to the conducting state, even if the piezoelectric voltage on transistor Q1 is subsequently reduced to zero and transistor Q1 ceases to conduct. Thus, main switching transistor Q4 will remain on until switch S1 is opened.

[0032] In order to deactivate or open the switch 400, switch S1 must be opened, for example, while there is no acoustic excitation of the piezoelectric transducer. If this occurs, the gate of transistor Q2 increases to +3V due to pull-up resistor R2. Transistor Q2 then switches off, thereby, in turn, switching off transistors Q3 and Q4. At this stage, the switch 400 returns to its sleep mode, even if switch S1 is again closed. The switch 400 will only return to its active mode upon receiving a new acoustic activation signal from the piezoelectric transducer.

[0033] It should be apparent to one of ordinary skill in the art that the above-mentioned electrical circuit is not the only possible implementation of a switch for use with the present invention. For example, the switching operation my be performed using a CMOS circuit, which may draw less current when switched on, an electromechanical switch, and the like.

[0034] Turning to FIGS. 3A-3G, a preferred embodiment of an acoustic transducer 1 is shown that includes a miniature flexural acoustic transducer capable of receiving external acoustic signals and producing an electrical output to "activate," i.e., deliver electrical current in or to an electrical circuit. Preferably, as explained above with respect to FIGS. 1A-1C, the electrical output from the acoustic transducer 118 is used to open and/or close the switch 120, allowing current flow in one or more the components of the electrical circuit 112, 212, 312. In addition, the electrical output from the acoustic transducer 118 may be transferred via a communications bus to other components of the implant 110, for example, to provide commands to a control circuit or internal processor.

[0035] In a preferred embodiment, the acoustic transducer 1 is configured for receiving relatively low frequency acoustic signals (up to several megahertz) for vibrating a piezoelectric layer 2 in the acoustic transducer 1 at its resonant frequency. Preferably, the acoustic transducer 1 may respond to acoustic excitation signal between about 20-60 kilohertz, and more preferably has a resonant frequency of about 40 kilohertz. Unlike high frequency waves (those greater than several megahertz), low frequency acoustic waves are generally only slightly attenuated by water-based tissues within the body. Consequently, low frequency acoustic waves may reach almost any point of the body, including deeply located organs, such as the heart, liver, or brain.

[0036] Returning to FIG. 3A, the transducer element 1 includes at least one cell member 3, including a cavity 4 etched into a substrate and covered by a substantially flexible piezoelectric layer 2. Preferably, the cavity 4 is etched into the substrate using conventional printed-circuit photolithography methods. Alternatively, the cavity 4 may be etched into the substrate using VLSI/micromachining technology or any other suitable technology.

[0037] The cavity 4 preferably includes a gas, such as air, providing a predetermined pressure within the cavity 4 that may be selected to provide a desired sensitivity and ruggedness of the transducer, as well as to at least partially define the resonant frequency of the piezoelectric layer 2. An upper electrode 8 and a lower electrode 6 are attached to the piezoelectric layer 2, the electrodes 6, 8 being coupled to the switch 400, for example, at points Piezo + and Piezo -, as described above with reference to FIG. 2. The substrate is preferably made of an electrical conducting layer 11 disposed on an electrically insulating layer 12, such that the cavity 4 is etched substantially through the thickness of electrically conducting layer 11.

[0038] The electrically conducting layer 11 is preferably made of copper and the insulating layer 12 is preferably made of a polymer such as polyamide. Conventional copper-plated polymer laminate such as Kapton™ sheets may be used for the production of the transducer element 1. Alternatively, commercially available laminates, such as Novaclad™, may be used. In a further alternative, the substrate may include a silicon layer, or any other suitable material, and/or the electrically conducting layer 11 may be made of a non-conductive material such as Pyralin™.

[0039] According to a preferred embodiment, the cavity 4 features a circular or hexagonal shape with radius of about 200μm. The electrically conducting layer 11 preferably has a thickness of about 15μm. The cell member 3 is preferably etched completely through the thickness of the electrically conducting layer 11. The electrically insulating layer 12 preferably features a thickness of about 50μm. The piezoelectric layer 2 may be made of PVDF or a copolymer thereof. Alternatively, piezoelectric layer 2 may be made of a substantially flexible piezoceramic. In a preferred embodiment, the piezoelectric layer 2 is a poled PVDF sheet having a thickness of about 9-28μm.

[0040] As best seen in FIG. 3D, an insulating chamber 18 is etched into the substrate, preferably through the thickness of the conducting layer 11, so as to insulate the transducer element from other portions of the substrate that may include other electrical components, such as other transducer elements etched into the substrate. According to a specific embodiment, the width of the insulating chamber 18 is about 100μm. As shown, the insulating chamber 18 is etched into the substrate so as to form a wall 10 of a predetermined thickness enclosing the cavity 4, and a conducting line 17 is integrally made with the wall 10 for connecting the transducer element to another electronic component preferably etched into the same substrate, or to an external electronic circuit (not shown). The upper electrode 8 and lower electrode 6 are preferably precisely shaped so as to cover a predetermined area of the piezoelectric layer 2. The electrodes 6, 8 may be deposited on the upper and lower surfaces of the piezoelectric membrane 2, respectively, by using various methods such as vacuum deposition, mask etching, painting, and the like.

[0041] As shown in FIG. 3B, the lower electrode 6 is preferably made as an integral part of a substantially thin electrically conducting layer 14 disposed on electrically conducting layer 11. Preferably, electrically conducting layer 14 is made of a Nickel-Copper alloy and is attached to the electrically conducting layer 11 by means of a sealing connection 16, which may be made of indium. According to a preferred embodiment, the sealing connection 16 may feature a thickness of about 10μm, such that the overall height of wall 10 of cavity 4 is about 20-25μm.

[0042] It will be appreciated that the precise dimensions of the various elements of a transducer element in accordance with the present invention may be specifically tailored according to the requirements of the specific application, and should not be limited to the exemplary dimensions provided herein. For example, the thickness and radius of the piezoelectric layer 2, as well as the pressure within cavity 4, may be specifically selected so as to provide a predetermined resonant frequency.

[0043] By using a substantially flexible piezoelectric layer 2, a miniature transducer element is provided that has a resonant frequency having an acoustic wavelength that is much larger than the extent of the transducer. This enables the transducer to be omnidirectional even at resonance, and further allows the use of relatively low frequency acoustic signals that do not suffer from significant attenuation in the surrounding medium. Thus, the transducer element may be suitable for application in confined or hidden locations where the orientation of the transducer element may not be ascertained in advance.

[0044] Returning to FIGS. 3A, 3B, and 3E, the electrically conducting layer 14 covers the various portions of the conducting layer 11, including wall 10 and conducting line 17. The portion of the conducting layer 14 covering the conducting line 17 may be used for connection to an electronic component, such as a neighboring cell.

[0045] According to a preferred embodiment, the electrodes 6, 8 are specifically shaped to include the most energy-productive region of the piezoelectric layer 2 so as to provide maximal response of the transducer while optimizing the electrode area, and therefore the cell capacitance, thereby maximizing a selected parameter such as voltage sensitivity, current sensitivity, or power sensitivity of the transducer element. Turning to FIG. 4, a preferred electrode shape for maximizing the power response of the transducer is shown in which the electrode includes two electrode portions 80a and 80b substantially covering the maximal charge density portions of layer 2, the electrode portions being interconnected by means of a connecting member 82 having a minimal area. Preferably, the electrode portions 80a and 80b cover the portions of piezoelectric layer 2 that yield at least a selected threshold (e.g. 30%) of the maximal charge density.

[0046] According to the present invention any other parameter may be optimized so as to determine the shape of electrodes 6 and 8. According to further features of the present invention, only one electrode (either the upper electrode 8 or lower electrode 6) may be shaped so as to provide maximal electrical response of the transducer, with the other electrode covering the entire area of the piezoelectric layer 2. Since the charge is collected only at the portions of the piezoelectric layer 2 received between the upper and lower electrodes 8, 6, this configuration may be operatively equivalent to a configuration including two shaped electrodes having identical shapes.

[0047] Turning to FIG. 5, another preferred embodiment of a acoustic transducer is shown, including a transducer element 1 over a chamber 4 that may contain gas at a substantially low pressure, thereby conferring a substantially concave shape to the piezoelectric membrane 2 at equilibrium. This configuration may enhance the electrical response of the transducer by increasing the total charge obtained for a given displacement of layer 2. For example, this embodiment may increase the charge output of the piezoelectric layer 2 for a given displacement, thereby increasing the voltage, current and power responses of the transducer without having to increase the acoustic pressure. Further, it may further facilitate miniaturization of the transducer since the same electrical response may be obtained for smaller acoustic deflections. This transducer may also be substantially more robust mechanically and therefore more durable than the first embodiment described above with respect to FIGS. 3A-3G. This further miniaturization may also allow higher resonance frequencies relative to the embodiment shown of FIGS. 3A-3G.

[0048] An acoustic transducer element according to the present invention may also be used as a transmitter, for example, for transmitting information from an implant to a remote receiver, e.g., by modulating the reflection of an external impinging acoustic wave arrived from a remote transmitter. The transducer element generally functions as a transmitter element due to the asymmetric fluctuations of the piezoelectric layer with respect to positive and negative transient acoustic pressures obtained as a result of the pressure differential between the interior and exterior of the underlying cavity.

[0049] The transmitter element preferably modulates the reflection of an external impinging acoustic wave by means of a switching element connected thereto, e.g., in the electrical circuit of an implant as described above. The switching element may encode the information that is to be transmitted, such as the output of a sensor, thereby frequency modulating a reflected acoustic wave. This may require very little expenditure of energy from the transmitting module itself, since the acoustic wave that is received is externally generated, such that the only energy required for transmission is the energy of modulation. Specifically, the reflected acoustic signal is modulated by switching the switching element according to the frequency of a message electric signal arriving from another electronic component such as a sensor, so as to controllably change the mechanical impedance of the piezoelectric layer according to the frequency of the message signal. Preferably, the invention uses a specific array of electrodes connected to a single cell member or alternatively to a plurality of cell members so as to control the mechanical impedance of the piezoelectric layer.

[0050] FIGS. 6A-6F show exemplary configurations of a transducer element including a piezoelectric layer 2 that may be controllably changed to provide a transmitter. Referring to FIG. 6A, the transmitter element may include a first and second pairs of electrodes, the first pair including an upper electrode 40a and a lower electrode 38a, and the second pair including an upper electrode 40b and a lower electrode 38b. Electrodes 38a, 38b, 40a and 40b are electrically connected to an electrical circuit (not shown) by means of conducting lines 36a, 36b, 34a and 34b, respectively, the electrical circuit including a switching element (also not shown) so as to alternately change the electrical connections of the conducting lines 36a, 36b, 34a and 34b.

[0051] Preferably, the switching element switches between a parallel connection and an anti-parallel connection of the electrodes. A parallel connection decreases the mechanical impedance of the piezoelectric layer 2, and an anti-parallel connection increases the mechanical impedance of the piezoelectric layer 2. An anti-parallel connection may be obtained by interconnecting line 34a to 36b and line 34b to 36a. A parallel connection may be obtained by connecting line 34a to 34b and line 36a to 36b. Preferably, the switching frequency equals the frequency of a message signal arriving from an electrical component such as a sensor.

[0052] According to another embodiment, shown in FIG. 6B, upper electrode 40a is connected to lower electrode 38b by means of a conducting line 28, and electrodes 38a and 40b are connected to an electrical circuit by means of conducting lines 27 and 29, respectively, the electrical circuit including a switching element. This embodiment provides an anti-parallel connection of the electrodes such that the switching element functions as an on/off switch, thereby alternately increasing the mechanical impedance of the piezoelectric layer 2.

[0053] In order to reduce the complexity of the electrical connections, the piezoelectric layer 2 may be depolarized and then repolarized at specific regions thereof. As shown in FIG. 6C, the polarity of the portion of the piezoelectric layer 2 received between the electrodes 40a and 38a is opposite to the polarity of the portion of the piezoelectric layer 2 received between the electrodes 40b and 38b. An anti-parallel connection is thus achieved by interconnecting the electrodes 38a and 38b by means of a conducting line 28, and providing conducting lines 27 and 29 connected to the electrodes 40a and 40b, respectively, the conducting lines for connection to an electrical circuit including a switching element.

[0054] Turning to 6D, another embodiment is shown in which the transmitting element includes a plurality of transducing cell members, such that the mechanical impedance of piezoelectric layer 2 is controllably changed by appropriately interconnecting the cell members. A first transducing cell member 3a includes a layer 2a and a cavity 4a, and a second transducing cell member 3b includes a layer 2b and a cavity 4b that are preferably contained within the same substrate. A first pair of electrodes including electrodes 6a and 8a is attached to the piezoelectric layer 2, and a second pair of electrode including electrodes 6b and 8b is attached to the piezoelectric layer 2b. The electrodes 6a, 8a, 6b and 8b are electrically connected to an electrical circuit (not shown) by means of conducting lines 37a, 35a, 37b and 35b, respectively, the electrical circuit including a switching element so as to alternately switch the electrical connections of the conducting lines 37a, 35a, 37b and 35b so as to alternately provide parallel and anti-parallel connections, substantially as described for FIG. 6A, thereby alternately decreasing and increasing the mechanical impedance of the piezoelectric layers 2a and 2b.

[0055] FIG. 8E shows another embodiment in which the first and second transducing cell members are interconnected by means of an anti-parallel connection. As shown, the polarity of piezoelectric layer 2a is opposite to the polarity of layer 2b so as to reduce the complexity of the electrical connections between cell members 3a and 3b. Thus, electrode 6a is connected to electrode 6b by means of a conducting line 21, and electrodes 8a and 8b are provided with conducting lines 20 and 22, respectively, for connection to an electrical circuit including a switching element (not shown), wherein the switching element preferably functions as an on/off switch that alternately increases the mechanical impedance of the piezoelectric layers 2a and 2b.

[0056] FIG.6F shows another embodiment in which the first and second transducing cell members are interconnected by means of a parallel connection. As shown, electrodes 6a and 6b are interconnected by means of conducting line 24, electrodes 8a and 8b are interconnected by means of conducting line 23, and electrodes 6b and 8b are provided with conducting lines 26 and 25, respectively, the conducting lines for connection to an electrical circuit including a switching element. The switching element preferably functions as an on/off switch for alternately decreasing and increasing the mechanical impedance of layers 2a and 2b.

[0057] FIG. 7 shows a possible configuration of two transducing cell members etched onto the same substrate and interconnected by means of an anti-parallel connection. As shown, the transducing cell members are covered by a common piezoelectric layer 2, wherein the polarity of the portion of the piezoelectric layer 2 received between electrodes 6a and 8a is opposite to the polarity of the portion of the piezoelectric layer 2 received between electrodes 6b and 8b. The electrodes 8a and 8b are bonded by means of a conducting line 9, and the electrodes 6a and 6b are provided with conducting lines 16 for connection to an electrical circuit (not shown).

[0058] Yet another embodiment of a transmitter element according to the present invention is shown in FIG. 8. The transmitter element includes a transducing cell member having a cavity 4 covered by a first and second piezoelectric layers 50a, 50b, preferably having opposite polarities. Preferably, the piezoelectric layers 50a, 50b are interconnected by means of an insulating layer 52. Upper and lower electrodes 44a, 42a are attached to the piezoelectric layer 50a, and upper and lower electrodes 44b and 42b are attached to the piezoelectric layer 50b. The electrodes 44a, 42a, 44b and 42b are provided with conducting lines 54, 55, 56 and 57, respectively, for connection to an electrical circuit.

[0059] It will be appreciated that the above descriptions are intended only to serve as examples, and that many other embodiments are possible.

Claims

1. An implant (110; 210; 310) for location within a body, comprising:

   an electrical circuit (112; 212; 312) configured for performing one or more commands when the implant is activated;
   an energy storage device (114);
   a switch (120) coupled to the electrical circuit and the energy storage device; and
   an acoustic transducer (118) coupled to the switch (120),-wherein said implant comprises a sensor (124; 224; 324) coupled to the electrical circuit (112; 212; 312), wherein the one or more commands comprises measuring a physiological parameter within the body using the sensor (124; 224; 324); said acoustic transducer (118) is coupled to the electrical circuit (112; 212; 312) and configured for transmitting a signal including information regarding said physiological parameter measured by said sensor to a remote receiver; and said acoustic transducer (118) is activatable upon acoustic excitation (100) by an external acoustic energy source for closing the switch (120) to allow current flow from the energy storage device (114) to the electrical circuit (112; 212; 312), thereby switching the implant (110; 210; 310) to an active mode wherein electrical energy is delivered from the energy storage device (114) to the electrical circuit from a passive mode wherein there is substantially no energy consumption from the energy storage device (114) for activating the implant (110; 210; 310).

2. The implant of claim 1, wherein the switch (120) is configured such that the switch (120) is closed only when the acoustic transducer (118) receives a first acoustic excitation signal (100) followed by a second acoustic excitation signal (100), the first and second acoustic excitation signals (100) being separated by a predetermined delay.

3. The implant of claim 1, wherein the acoustic transducer (118) is configured for receiving a first acoustic excitation signal (100) and a second acoustic excitation signal (100), the switch (120) being closed when the first acoustic excitation signal (100) is received by the acoustic transducer (118), and the switch (120) being opened when the second acoustic excitation signal (100) is received by the acoustic transducer (118) for discontinuing current flow from the energy storage device (114) to the electrical circuit (112; 212; 312).

4. The implant of claim 1, wherein the acoustic transducer (118) is configured for transmitting a signal proportional to the physiological parameter to a receiver external to the body.

5. The implant of claim 1, further comprising a therapeutic device coupled to the electrical circuit (112; 312), the electrical circuit (112; 312) being configured for controlling the therapeutic device in response to the physiological parameter measured by the sensor (124; 324).

6. The implant of claim 1, wherein the one or more commands comprises activating an actuator (226; 326) coupled to the electrical circuit (212; 312), the actuator (226; 326) being configured for controlling a therapeutic device coupled to the actuator (226; 326).

7. The implant of claim 1, wherein the acoustic transducer (118) comprises:

   a cell member (3) having a cavity (4);
   a substantially flexible piezoelectric layer (2) attached to the cell member(3), the piezoelectric layer (2) having an external surface and an internal surface, the piezoelectric layer (2) having predetermined dimensions for enabling fluctuations at its resonance frequency upon impinging of an external acoustic wave; and
   a first electrode attached to the external surface (8) and a second electrode attached to the internal surface (6).

8. The implant of claim 1, wherein the energy storage device (114) comprises a battery.

9. The implant of claim 1, wherein the energy storage device (114) comprises a rechargeable device, the rechargeable device being rechargeable by a device external to the body.

10. The implant of claim 1, wherein the acoustic transducer (118) is configured for receiving a first acoustic excitation signal (100) followed by a second acoustic excitation signal (100), the electrical circuit (112; 212; 312) configured for interpreting the second acoustic excitation signal (100) as one of a predetermined set of commands.

11. The implant of claim 1, further comprising a timer coupled to the switch (120), the timer configured for opening the switch (120) after a predetermined time

has passed after the switch (120) is initially closed.

12. A method for transmitting information to an implant (110; 210; 310) comprising an acoustic switch (120) coupled to an electrical circuit (112; 212; 312), a sensor coupled to the electrical circuit, and an energy storage device (114), the implant (110;210; 310) being located within a body, the method comprising:

transmitting an acoustic activation signal (100) from a source located outside of the body towards the implant (110; 210; 310), wherein said acoustic switch (120) in response to the acoustic activation signal (100) is closed, whereupon current flows from the energy storage device (114) to the electrical circuit (112; 212; 312), thereby switching the implant (110; 210; 310) to an active mode wherein electrical energy is delivered from the energy storage device (114) to the electrical circuit (112; 212; 312) from a passive mode wherein there is substantially no energy consumption from the energy storage device (114);

wherein the electrical circuit (112; 212; 312) performs one or more commands when the switch is closed, the one or more commands comprises measuring with said sensor a physiological parameter within the body; and wherein said acoustic switch (120) transmits a signal including information regarding the physiological parameter from the implant (110; 210; 310) to a remote receiver.

13. The method of claim 12, wherein said signal including information regarding the physiological parameter is a signal proportional to the physiological parameter.

14. The method of claim 12, wherein the one or more commands comprises controlling a therapeutic device within the body in response to the physiological parameter.

15. The method of claim 12, wherein the acoustic switch (120) remains closed until the energy storage device (114) is depleted.

16. The method of claim 12, wherein the acoustic switch (120) automatically opens after a predetermined time to discontinue current flow from the energy storage device (114) to the electrical circuit (112; 212; 312).

17. The method of claim 12, further comprising transmitting an acoustic termination signal (100) from a source located outside of the body towards the implant (110; 210; 310), the acoustic switch (120) opening in response to the acoustic termination signal (100) to discontinue current flow from the energy storage (114) device to the electrical circuit (112; 212; 312).

18. The method of claim 12, wherein the acoustic activation signal (100) comprises a first acoustic excitation signal (100) and a second acoustic excitation signal (100) separated by a predetermined delay.

19. The method of claim 12, further comprising transmitting an acoustic command signal from a source outside the body to the implant following the acoustic activation signal (100), the acoustic switch (120) sending an electrical command signal to the electrical circuit (112; 212; 312) in response to the acoustic command signal.

20. The method of claim 19, wherein the electrical circuit (112; 212; 312) interprets the electrical command signal to perform one or more pre-defined commands.

21. The method of claim 19, wherein the electrical circuit (112; 212; 312) performs one of a plurality of known commands in response to the electrical command signal.

22. The method of claim 12, further comprising charging the energy storage device (114) with an energy source located outside the body before transmitting the acoustic activation signal (100).

Patentansprüche

1. Implantat (110; 210; 310) zum Anordnen innerhalb eines Körpers, welches aufweist:

eine elektrische Schaltung (112; 212; 312), die ausgebildet ist zum Ausführen eines oder mehrerer Befehle, wenn das Implantat aktiviert ist;
eine Energiespeichervorrichtung (114);
einen Schalter (120), der mit der elektrischen Schaltung und der Energiespeichervorrichtung gekoppelt ist; und
einen akustischen Wandler (118), der mit dem Schalter (120) gekoppelt ist, wobei das Implantat einen Sensor (124; 224; 324) aufweist, der mit der elektrischen Schaltung (112; 212; 312) gekoppelt ist, wobei der eine oder die mehreren Befehle das Messen eines physiologischen Parameters innerhalb des Körpers unter Verwendung des Sensors (124; 224; 324) aufweisen;
der akustische Wandler (118) mit der elektrischen Schaltung (112; 212; 312) gekoppelt ist und ausgebildet ist zum Übertragen eines Signals, das Informationen betreffend den von

dem Sensor gemessenen physiologischen Parameter einschließt, zu einem entfernten Empfänger; und

der akustische Wandler (118) aktivierbar ist durch akustische Erregung (100) durch eine externe akustische Energiequelle zum Schließen des Schalters (120), um einem Strom zu ermöglichen, von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) zu fließen, wodurch das Implantat (110; 210; 310) in einen aktiven Betrieb geschaltet wird, in welchem elektrische Energie von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung geliefert wird, aus einem passiven Betrieb, in welchem im Wesentlichen kein Energieverbrauch von der Energiespeichervorrichtung (114) stattfindet, um das Implantat (110; 210; 310) zu aktivieren.

2. Implantat nach Anspruch 1, bei dem der Schalter (120) so ausgebildet ist, dass der Schalter (120) nur geschlossen ist, wenn der akustische Wandler (118) ein erstes akustisches Erregungssignal (100) gefolgt durch ein zweites akustisches Erregungssignal (100) empfängt, wobei das erste und das zweite akustische Erregungssignal (100) durch eine vorbestimmte Verzögerung getrennt sind.

3. Implantat nach Anspruch 1, bei dem der akustische Wandler (118) ausgebildet ist zum Empfangen eines ersten akustischen Erregungssignals (100) und eines zweiten akustischen Erregungssignals (100), der Schalter (120) geschlossen wird, wenn das erste akustische Erregungssignal (100) durch den akustischen Wandler (118) empfangen wird, und der Schalter (120) geöffnet wird, wenn das zweite akustische Erregungssignal (100) durch den akustischen Wandler (118) empfangen wird, um den Stromfluss von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) zu unterbrechen.

4. Implantat nach Anspruch 1, bei dem der akustische Wandler (118) ausgebildet ist zum Übertragen eines zu dem physiologischen Parameter proportionalen Signals zu einem Empfänger außerhalb des Körpers.

5. Implantat nach Anspruch 1, weiterhin aufweisend eine therapeutische Vorrichtung, die mit der elektrischen Schaltung (112; 312) gekoppelt ist, wobei die elektrische Schaltung (112; 312) ausgebildet ist zum Steuern der therapeutischen Vorrichtung in Abhängigkeit von dem durch den Sensor (124; 324) gemessenen physiologischen Parameter.

6. Implantat nach Anspruch 1, bei dem der eine oder die mehreren Befehle das Aktivieren eines Betätigungsteils (226; 326), das mit der elektrischen Schaltung (212; 312) gekoppelt ist, aufweisen, wobei das Betätigungsteil (226; 326) ausgebildet ist zum Steuern einer therapeutischen Vorrichtung, die mit dem Betätigungsteil (226; 326) gekoppelt ist.

7. Implantat nach Anspruch 1, bei dem der akustische Wandler (118) aufweist:

ein Zellenteil (3) mit einem Hohlraum (4);

eine im Wesentlichen flexible piezoelektrische Schicht (2), die an dem Zellenteil (3) angebracht ist, wobei die piezoelektrische Schicht (2) eine externe Oberfläche und eine interne Oberfläche hat, die piezoelektrische Schicht (2) vorbestimmte Abmessungen hat zum Ermöglichen von Schwankungen bei ihrer Resonanzfrequenz beim Auftreffen einer externen akustischen Welle; und

eine erste Elektrode, die an der externen Oberfläche (8) angebracht ist, und eine zweite Elektrode, die an der internen Oberfläche (6) angebracht ist.

8. Implantat nach Anspruch 1, bei dem die Energiespeichervorrichtung (114) eine Batterie aufweist.

9. Implantat nach Anspruch 1, bei dem die Energiespeichervorrichtung (114) eine wiederaufladbare Vorrichtung aufweist, welche wiederaufladbare Vorrichtung durch eine Vorrichtung außerhalb des Körpers wiederaufladbar ist.

10. Implantat nach Anspruch 1, bei dem der akustische Wandler (118) ausgebildet ist zum Empfangen eines ersten akustischen Erregungssignals (100) gefolgt durch ein zweites akustisches Erregungssignal (100), wobei die elektrische Schaltung (112; 212; 312) ausgebildet ist zum Interpretieren des zweiten akustischen Erregungssignals (100) als einen aus einem vorbestimmten Satz von Befehlen.

11. Implantat nach Anspruch 1, weiterhin aufweisend einen Zeitgeber, der mit dem Schalter (120) gekoppelt ist, wobei der Zeitgeber ausgebildet ist zum Öffnen des Schalters (120), nachdem eine vorbestimmte Zeit nach dem anfänglichen Schließen des Schalters (120) vergangen ist.

12. Verfahren zum Übertragen von Informationen zu einem Implantat (110; 210; 310), aufweisend einen akustischen Schalter (120), der mit einer elektrischen Schaltung (112; 212; 312) gekoppelt ist, einen Sensor, der mit der elektrischen Schaltung gekoppelt ist, und eine Energiespeichervorrichtung (114), wobei sich das Implantat (110; 210; 310) innerhalb eines Körpers befindet, welches Verfahren aufweist:

Übertragen eines akustischen Aktivierungssignals (100) von einer außerhalb des Körpers befindlichen Quelle zu dem Implantat (110; 210; 310), wobei

der akustische Schalter (120) als Antwort auf das akustische Aktivierungssignal (100) geschlossen wird, worauf Strom von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) fließt, wodurch das Implantat (110; 210; 310) in einen aktiven Betrieb geschaltet wird, in welchem elektrische Energie von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) geliefert wird, aus einem passiven Betrieb, in welchem im Wesentlichen kein Energieverbrauch von der Energiespeichervorrichtung (114) stattfindet;

wobei die elektrische Schaltung (112; 212; 312) einen oder mehrere Befehle ausführt, wenn der Schalter geschlossen ist, der eine oder die mehreren Befehle das Messen eines physiologischen Parameters innerhalb des Körpers mit einem Sensor aufweisen; und

wobei der akustische Schalter (120) ein Signal enthaltend Informationen betreffend den physiologischen Parameter von dem Implantat (110; 210; 310) zu einem entfernten Empfänger überträgt.

13. Verfahren nach Anspruch 12, bei dem das Signal enthaltend Informationen betreffend den physiologischen Parameter ein zu dem physiologischen Parameter proportionales Signal ist.

14. Verfahren nach Anspruch 12, bei dem der eine oder die mehreren Befehle das Steuern einer therapeutischen Vorrichtung innerhalb des Körpers in Abhängigkeit von dem physiologischen Parameter aufweisen.

15. Verfahren nach Anspruch 12, bei dem der akustische Schalter (120) geschlossen bleibt, bis die Energiespeichervorrichtung (114) erschöpft ist.

16. Verfahren nach Anspruch 12, bei dem der akustische Schalter (120) nach einer vorbestimmten Zeit automatisch öffnet, um den Stromfluss von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) zu unterbrechen.

17. Verfahren nach Anspruch 12, weiterhin aufweisend das Übertragen eines akustischen Beendigungssignals (100) von einer außerhalb des Körpers angeordneten Quelle zu dem Implantat (110; 210; 310), wobei der akustische Schalter (120) als Antwort auf das akustische Beendigungssignal (100) geöffnet wird, um den Stromfluss von der Energiespeichervorrichtung (114) zu der elektrischen Schaltung (112; 212; 312) zu unterbrechen.

18. Verfahren nach Anspruch 12, bei dem das akustische Aktivierungssignal (100) ein erstes akustisches Erregungssignal (100) und ein zweites akustisches Erregungssignal (100), die durch eine vorbestimmte Verzögerung getrennt sind, aufweist.

19. Verfahren nach Anspruch 12, weiterhin aufweisend das Übertragen eines akustischen Befehlssignals von einer Quelle außerhalb des Körpers zu dem Implantat, folgend dem akustischen Aktivierungssignal (100), wobei der akustische Schalter (120) ein elektrisches Befehlssignal zu der elektrischen Schaltung (112; 212; 312) als Antwort auf das akustische Befehlssignal sendet.

20. Verfahren nach Anspruch 19, bei dem die elektrische Schaltung (112; 212; 312) das elektrische Befehlssignal interpretiert, einen oder mehrere vorbestimmte Befehle auszuführen.

21. Verfahren nach Anspruch 19, bei dem die elektrische Schaltung (112; 212; 312) einen oder mehrere bekannte Befehle als Antwort auf das elektrische Befehlssignal ausführt.

22. Verfahren nach Anspruch 12, weiterhin aufweisend das Laden der Energiespeichervorrichtung (114) mit einer Energiequelle, die sich außerhalb des Körpers befindet, bevor das akustische Aktivierungssignal (100) übertragen wird.

Revendications

1. Implant (110 ; 210 ; 310) pour un placement à l'intérieur d'un corps, comprenant :

un circuit électrique (112 ; 212 ; 312) configuré pour réaliser une ou plusieurs commandes lorsque l'implant est activé ;

un dispositif de stockage d'énergie (114) ;

un commutateur (120) couplé au circuit électrique et au dispositif de stockage d'énergie ; et

un transducteur acoustique (118) couplé au commutateur (120), dans lequel ledit implant comprend un capteur (124 ; 224 ; 324) couplé au circuit électrique (112 ; 212 ; 312), dans lequel les une ou plusieurs commandes comprennent la mesure d'un paramètre physiologique à l'intérieur du corps en utilisant le capteur (124 ; 224 ; 324) ;

ledit transducteur acoustique (118) est couplé au circuit électrique (112 ; 212 ; 312) et est configuré pour transmettre un signal incluant une information concernant ledit paramètre physiologique mesuré par ledit capteur à un récepteur

à distance ; et
ledit transducteur acoustique (118) peut être activé suite à une excitation acoustique (100) par une source d'énergie acoustique externe pour fermer le commutateur (120) afin de permettre une circulation de courant depuis le dispositif de stockage d'énergie (114) jusqu'au circuit électrique (112 ; 212 ; 312), d'où ainsi la commutation de l'implant (110 ; 210 ; 310) dans un mode actif dans lequel de l'énergie électrique est délivrée depuis le dispositif de stockage d'énergie (114) sur le circuit électrique depuis un mode passif dans lequel il n'y a sensiblement pas de consommation d'énergie depuis le dispositif de stockage d'énergie (114) pour activer l'implant (110 ; 210 ; 310).

2. Implant selon la revendication 1, dans lequel le commutateur (120) est configuré de telle sorte que le commutateur (120) soit fermé seulement lorsque le transducteur acoustique (118) reçoit un premier signal d'excitation acoustique (100) suivi par un second signal d'excitation acoustique (100), les premier et second signaux d'excitation acoustique (100) étant séparés par un retard prédéterminé.

3. Implant selon la revendication 1, dans lequel le transducteur acoustique (118) est configuré pour recevoir un premier signal d'excitation acoustique (100) et un second signal d'excitation acoustique (100), le commutateur (120) étant fermé lorsque le premier signal d'excitation acoustique (100) est reçu par le transducteur acoustique (118), et le commutateur (120) étant ouvert lorsque le second signal d'excitation acoustique (100) est reçu par le transducteur acoustique (118) pour interrompre une circulation de courant depuis le dispositif de stockage d'énergie (114) sur le circuit électrique (112 ; 212 ; 312).

4. Implant selon la revendication 1, dans lequel le transducteur acoustique (118) est configuré pour transmettre un signal proportionnel au paramètre physiologique à un récepteur externe au corps.

5. Implant selon la revendication 1, comprenant en outre un dispositif thérapeutique couplé au circuit électrique (112 ; 312), le circuit électrique (112 ; 312) étant configuré pour commander le dispositif thérapeutique en réponse au paramètre physiologique mesuré par le capteur (124 ; 324).

6. Implant selon la revendication 1, dans lequel les une ou plusieurs commandes comprennent un actionneur (226 ; 326) couplé au circuit électrique (212 ; 312), l'actionneur (226 ; 326) étant configuré pour commander un dispositif thérapeutique couplé à l'actionneur (226 ; 326).

7. Implant selon la revendication 1, dans lequel le transducteur acoustique (118) comprend :

un élément de cellule (3) comportant une cavité (4) ;
une couche piézoélectrique sensiblement flexible (2) fixée à l'élément de cellule (3), la couche piézoélectrique (2) comportant une surface externe et une surface interne, la couche piézoélectrique (2) présentant des dimensions prédéterminées pour permettre des fluctuations à sa fréquence de résonance suite à l'arrivée en incidence d'une onde acoustique externe ; et
une première électrode fixée à la surface externe (8) et une seconde électrode fixée à la surface interne (6).

8. Implant selon la revendication 1, dans lequel le dispositif de stockage d'énergie (114) comprend un accumulateur.

9. Implant selon la revendication 1, dans lequel le dispositif de stockage d'énergie (114) comprend un dispositif rechargeable, le dispositif rechargeable pouvant être rechargé par un dispositif externe au corps.

10. Implant selon la revendication 1, dans lequel le transducteur acoustique (118) est configuré pour recevoir un premier signal d'excitation acoustique (100) suivi par un second signal d'excitation acoustique (100), le circuit électrique (112 ; 212 ; 312) étant configuré pour interpréter le second signal d'excitation acoustique (100) en tant que l'une d'un jeu prédéterminé de commandes.

11. Implant selon la revendication 1, comprenant en outre une minuterie couplée au commutateur (120), la minuterie étant configurée pour ouvrir le commutateur (120) après qu'un temps prédéterminé s'est écoulé après que le commutateur (120) est initialement fermé.

12. Procédé pour transmettre une information à un implant (110 ; 210 ; 310) comprenant un commutateur acoustique (120) couplé à un circuit électrique (112 ; 212 ; 312), un capteur couplé au circuit électrique et un dispositif de stockage d'énergie (114), l'implant (110 ; 210 ; 310) étant placé à l'intérieur d'un corps, le procédé comprenant :

la transmission d'un signal d'activation acoustique (100) depuis une source localisée à l'extérieur du corps en direction de l'implant (110 ; 210 ; 310), dans lequel :

ledit commutateur acoustique (120) est fermé en réponse au signal d'activation acoustique, suite à quoi un courant circule depuis

le dispositif de stockage d'énergie (114) jusqu'au circuit électrique (112 ; 212 ; 312), d'où ainsi la commutation de l'implant (110 ; 210 ; 310) dans un mode actif dans lequel de l'énergie électrique est délivrée depuis le dispositif de stockage d'énergie (114) sur le circuit électrique (112 ; 212 ; 312) depuis un mode passif dans lequel il n'y a sensiblement pas de consommation d'énergie depuis le dispositif de stockage d'énergie (114),
dans lequel le circuit électrique (112 ; 212 ; 312) réalise une ou plusieurs commandes lorsque le commutateur est fermé, les une ou plusieurs commandes comprenant la mesure d'un paramètre physiologique à l'intérieur du corps à l'aide dudit capteur ; et
dans lequel ledit commutateur acoustique (120) transmet un signal incluant une information concernant le paramètre physiologique depuis l'implant (110 ; 210 ; 310) jusqu'à un récepteur à distance.

13. Procédé selon la revendication 12, dans lequel ledit signal incluant une information concernant le paramètre physiologique est un signal proportionnel au paramètre physiologique.

14. Procédé selon la revendication 12, dans lequel les une ou plusieurs commandes comprennent la commande d'un dispositif thérapeutique à l'intérieur du corps en réponse au paramètre physiologique.

15. Procédé selon la revendication 12, dans lequel le commutateur acoustique (120) reste fermé jusqu'à ce que le dispositif de stockage d'énergie (114) soit appauvri.

16. Procédé selon la revendication 12, dans lequel le commutateur acoustique (120) s'ouvre automatiquement après un temps prédéterminé pour interrompre une circulation de courant depuis le dispositif de stockage d'énergie (114) jusqu'au circuit électrique (112 ; 212 ; 312).

17. Procédé selon la revendication 12, comprenant en outre la transmission d'un signal de terminaison acoustique (100) depuis une source localisée à l'extérieur du corps en direction de l'implant (110 ; 210 ; 310), le commutateur acoustique (120) s'ouvrant en réponse au signal de terminaison acoustique (100) pour interrompre une circulation de courant depuis le dispositif de stockage d'énergie (114) jusqu'au circuit électrique (112 ; 212 ; 312).

18. Procédé selon la revendication 12, dans lequel le signal d'activation acoustique (100) comprend un premier signal d'excitation acoustique (100) et un second signal d'excitation acoustique (100) séparés par un retard prédéterminé.

19. Procédé selon la revendication 12, comprenant en outre la transmission d'un signal de commande acoustique depuis une source à l'extérieur du corps jusqu'à l'implant suite au signal d'activation acoustique (100), le commutateur acoustique (120) envoyant un signal de commande électrique au circuit électrique (112 ; 212 ; 312) en réponse au signal de commande acoustique.

20. Procédé selon la revendication 19, dans lequel le circuit électrique (112 ; 212 ; 312) interprète le signal de commande électrique pour réaliser une ou plusieurs commandes prédéfinies.

21. Procédé selon la revendication 19, dans lequel le circuit électrique (112 ; 212 ; 312) réalise l'une d'une pluralité de commandes connues en réponse au signal de commande électrique.

22. Procédé selon la revendication 12, comprenant en outre la charge du dispositif de stockage d'énergie (114) à l'aide d'une source d'énergie localisée à l'extérieur du corps avant transmission du signal d'activation acoustique (100).

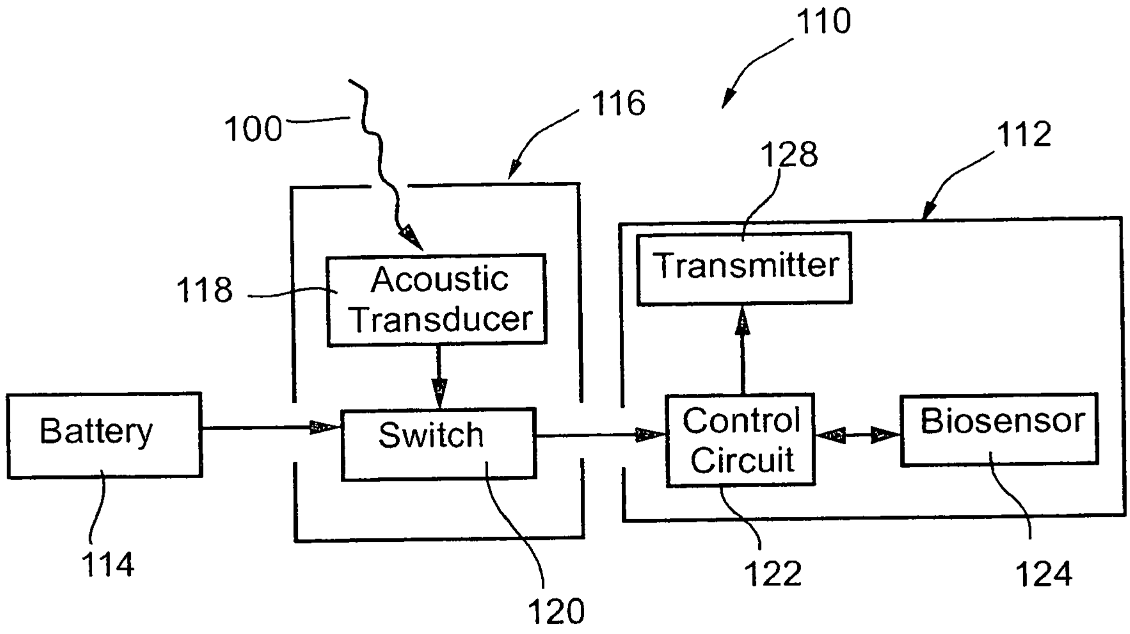

110
100
116
128
112
Acoustic Transducer
118
Transmitter
Battery
Switch
Control Circuit
Biosensor
114
120
122
124

Fig. 1A

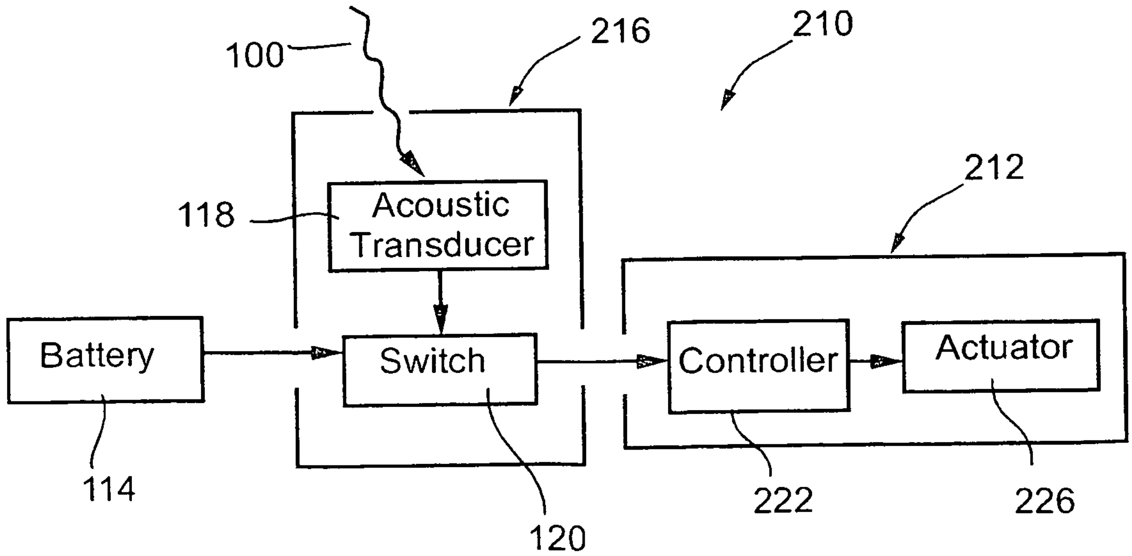

100
216
210
212
118
Acoustic Transducer
Battery
Switch
Controller
Actuator
114
120
222
226

Fig. 1B

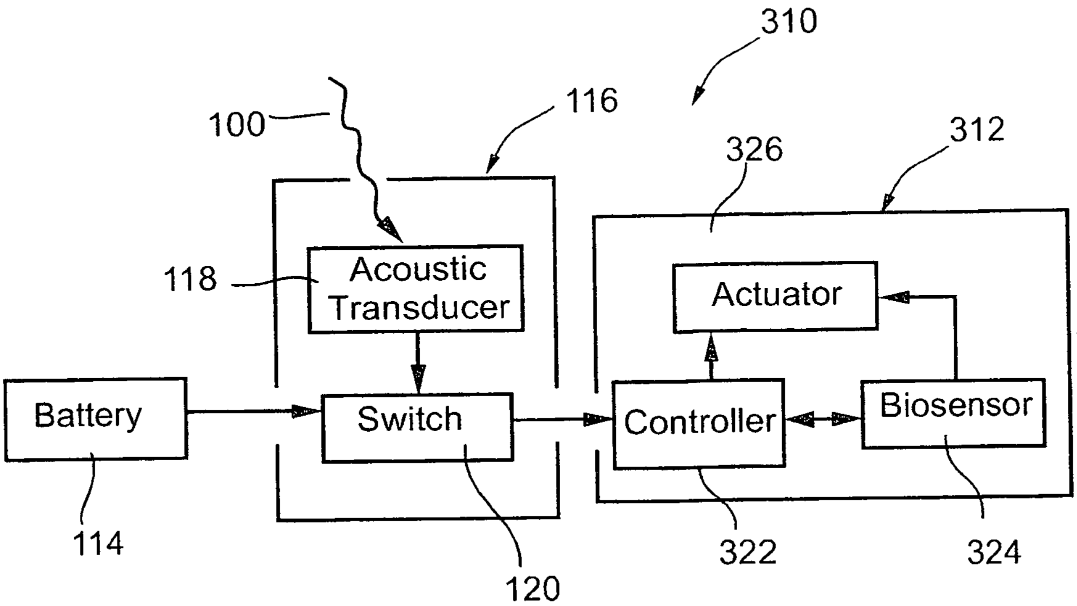

310
116
100
326
312
118
Acoustic Transducer
Actuator
Battery
Switch
Controller
Biosensor
114
120
322
324

Fig. 1C

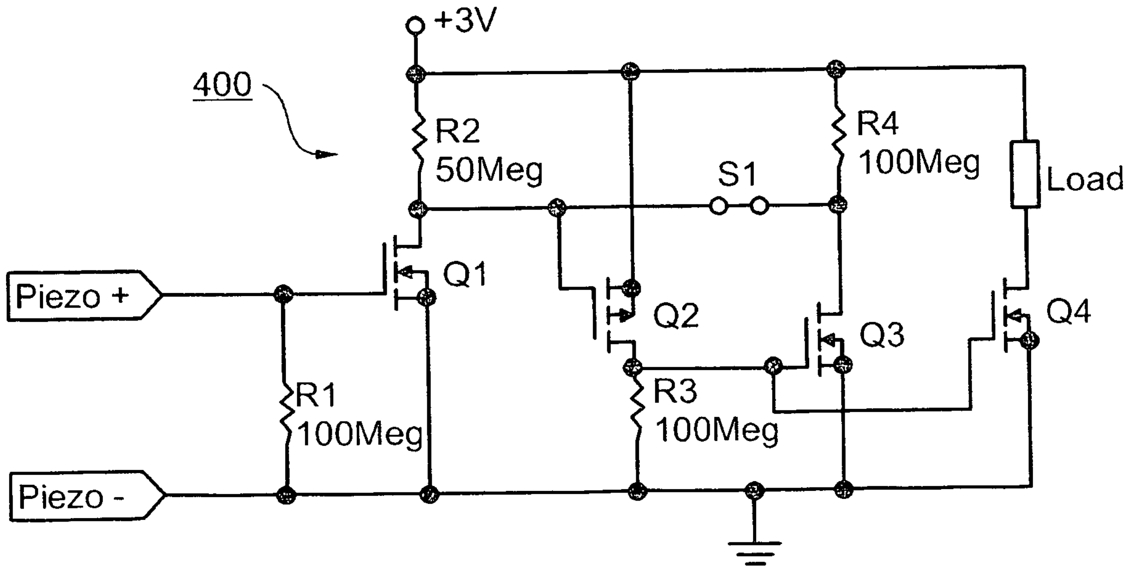

+3V
400
R2
50Meg
R4
100Meg
S1
Load
Piezo +
Q1
Q2
Q3
Q4
R1
100Meg
R3
100Meg
Piezo -

Fig. 2

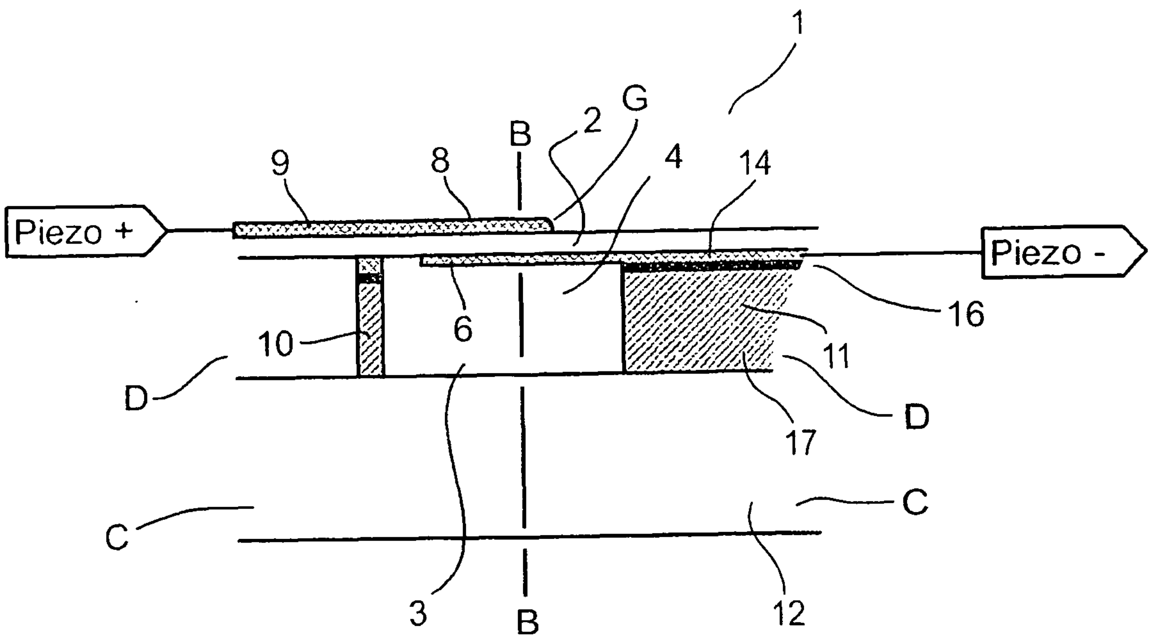

1
G
2
B
9
8
4
14
Piezo +
Piezo -
16
6
11
10
D
D
17
C
C
3
B
12

Fig. 3A

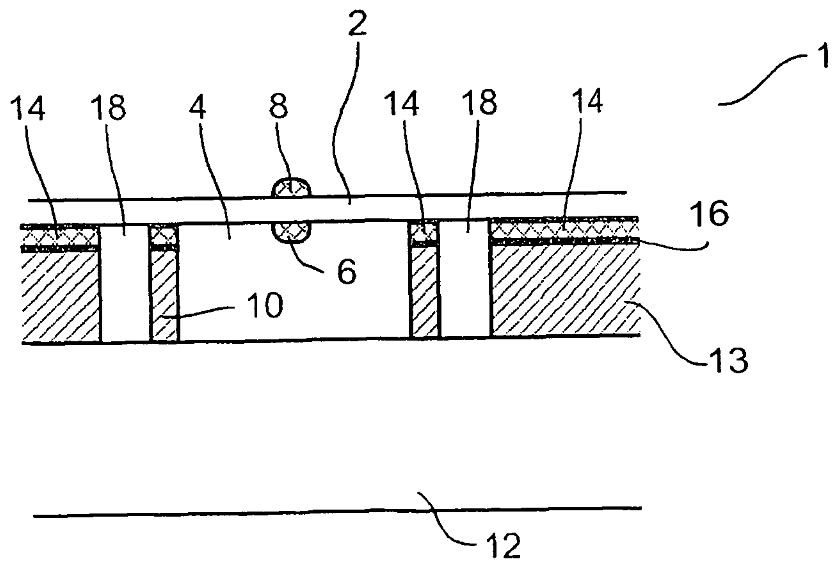

2
1
14
18
4
8
14
18
14
16
6
10
13
12

Fig. 3B

Fig. 3C

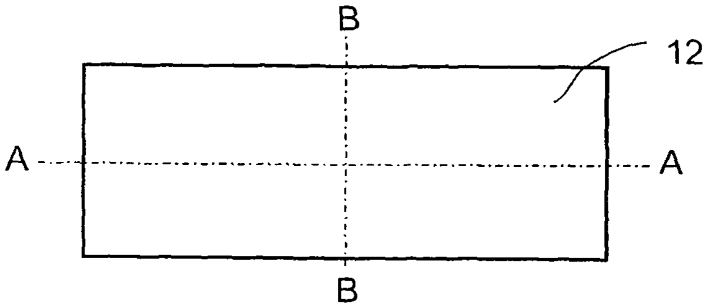


Fig. 3D

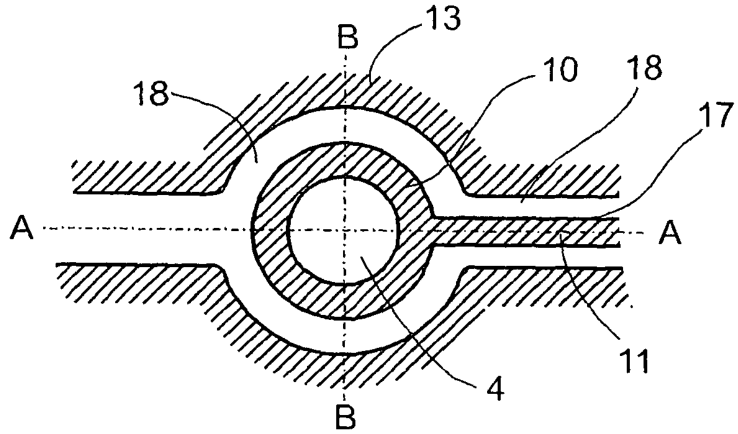


Fig. 3E

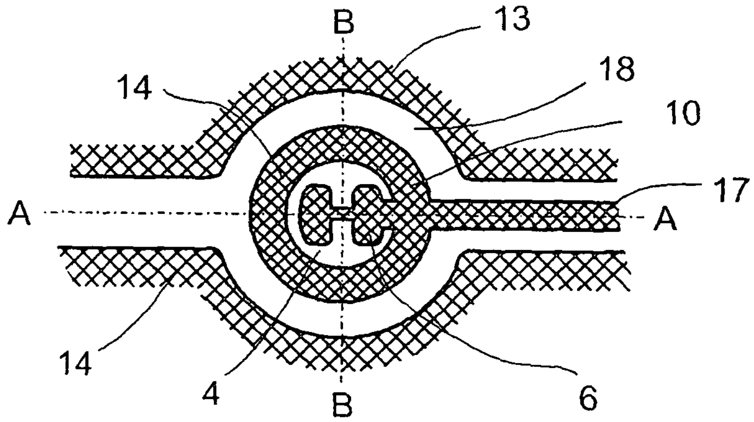


Fig. 3F

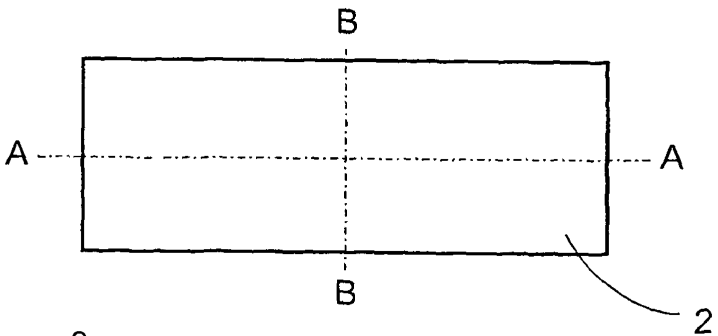
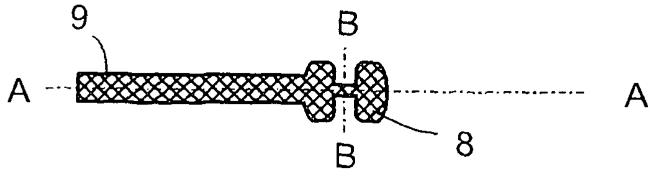


Fig. 3G



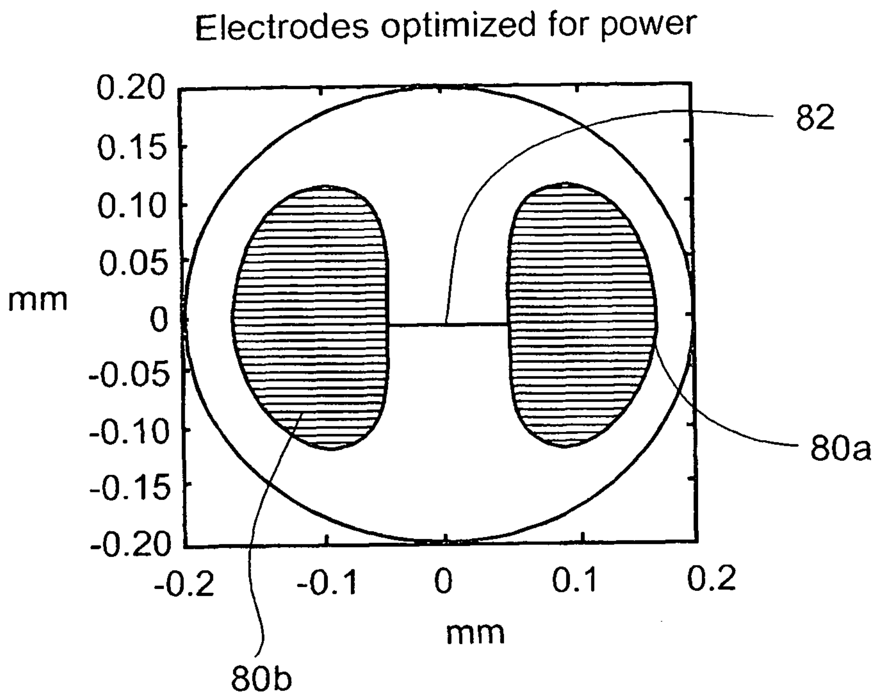

Electrodes optimized for power
0.20
0.15
0.10
0.05
0
-0.05
-0.10
-0.15
-0.20
mm
-0.2
-0.1
0
0.1
0.2
mm
82
80a
80b

Fig. 4

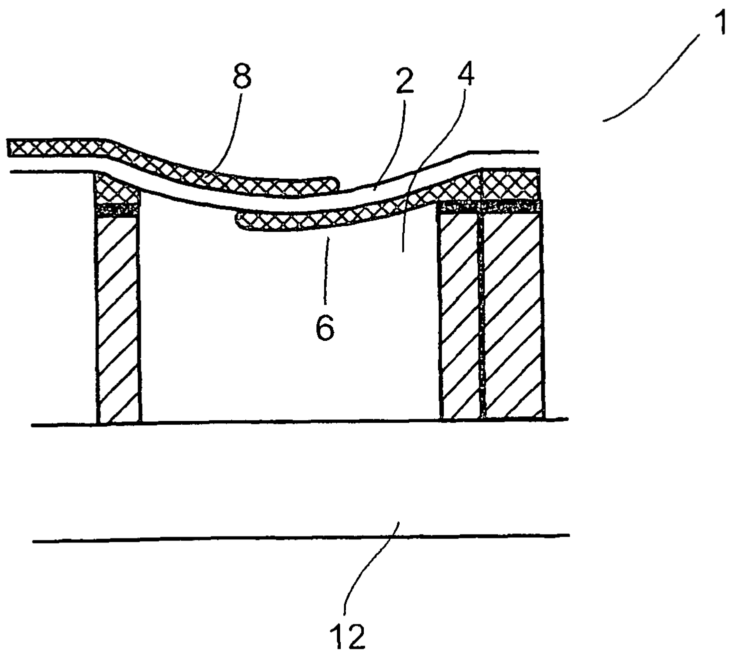

1
8
2
4
6
12

Fig. 5

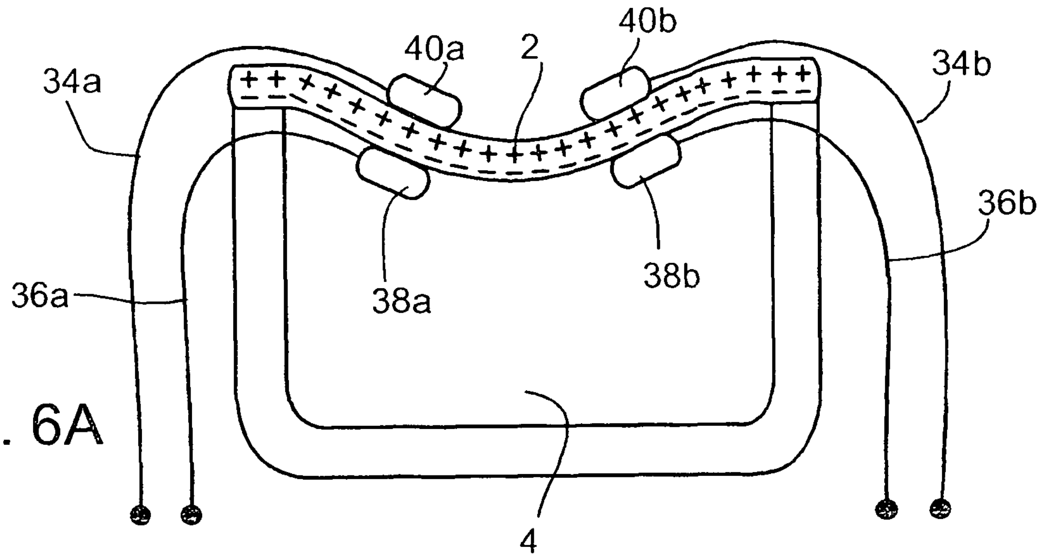


Fig. 6A

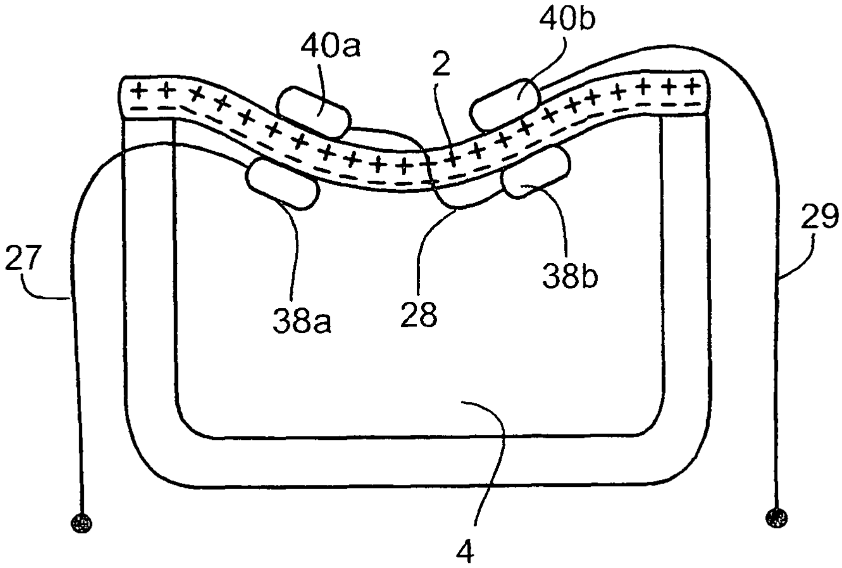


Fig. 6B

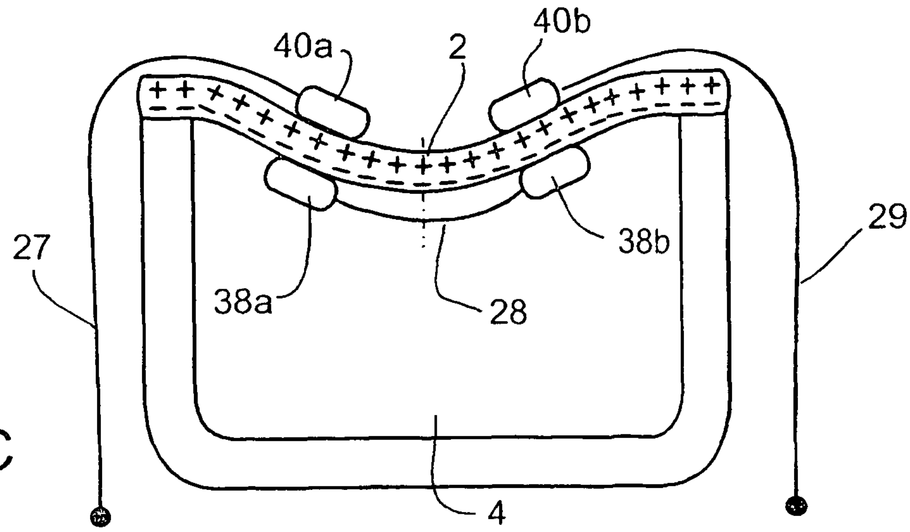


Fig. 6C

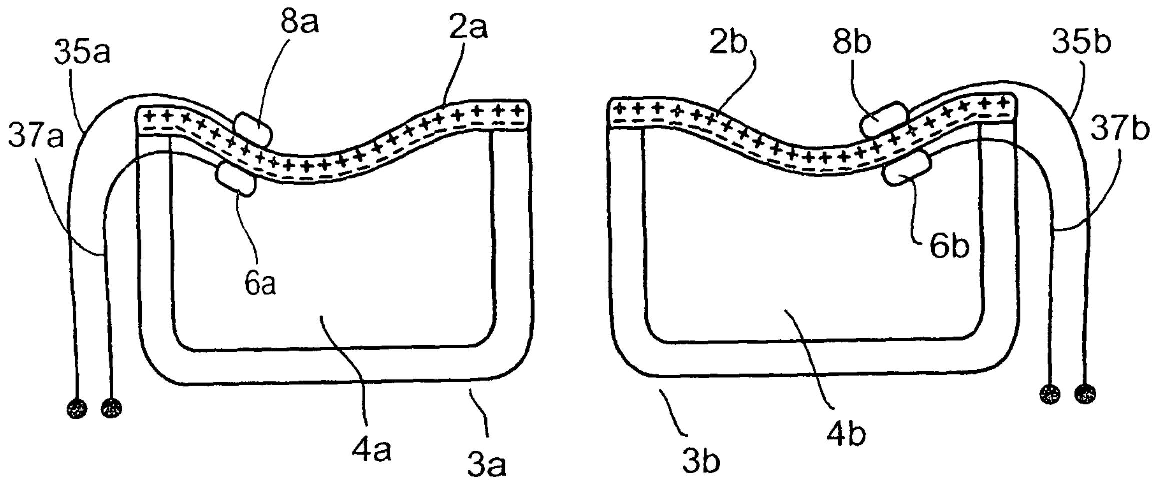


Fig. 6D

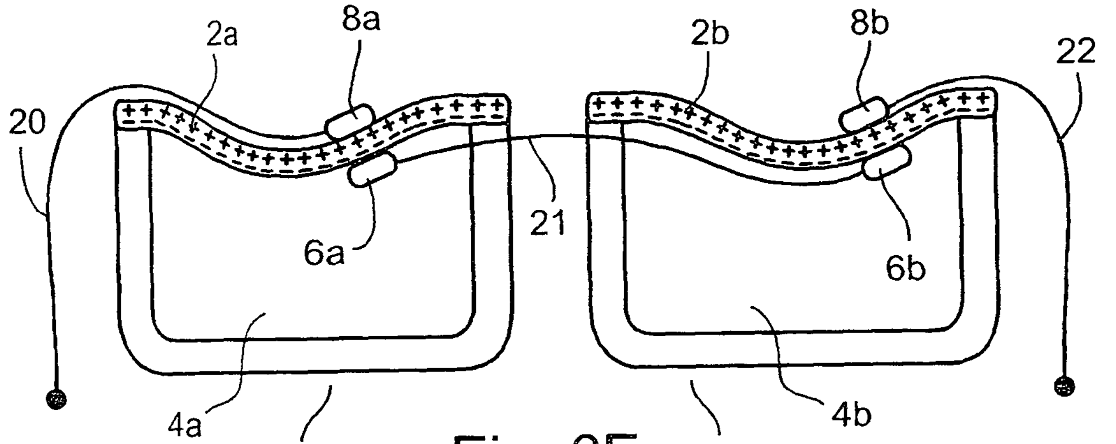


Fig. 6E

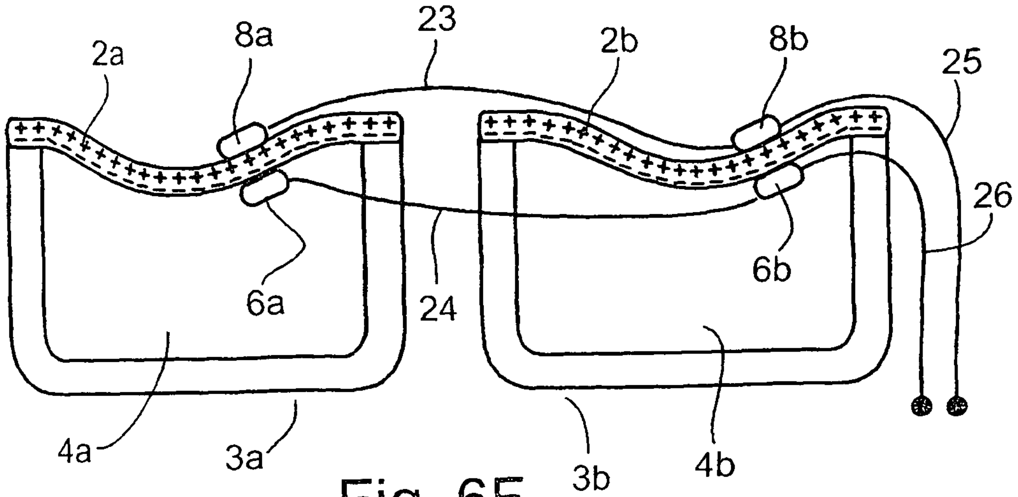


Fig. 6F

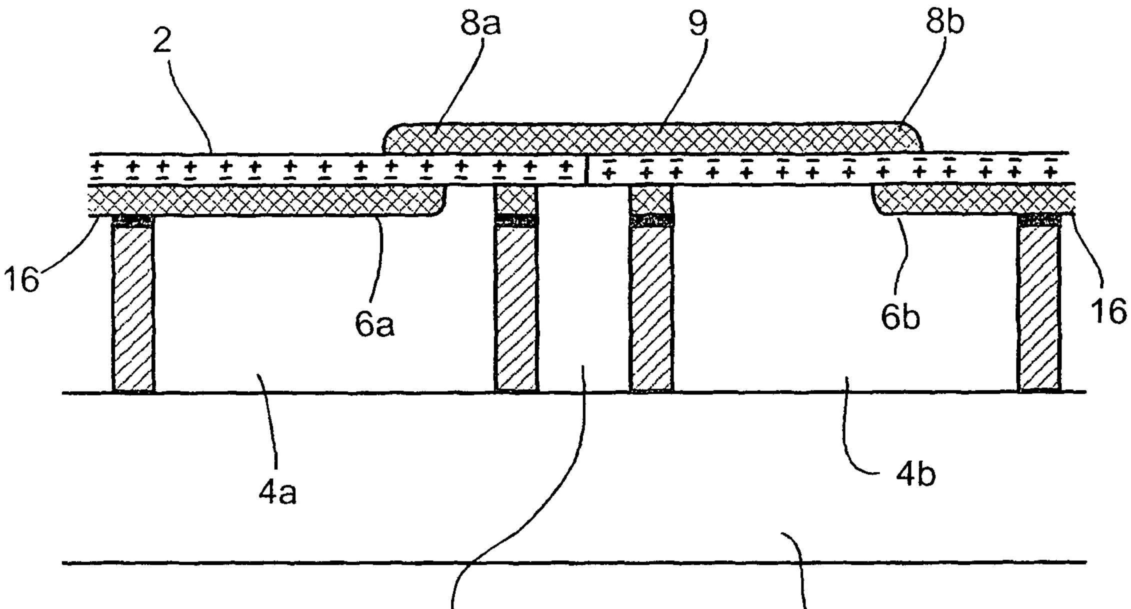

2
8a
9
8b
16
6a
6b
16
4a
4b
18
12

Fig. 7

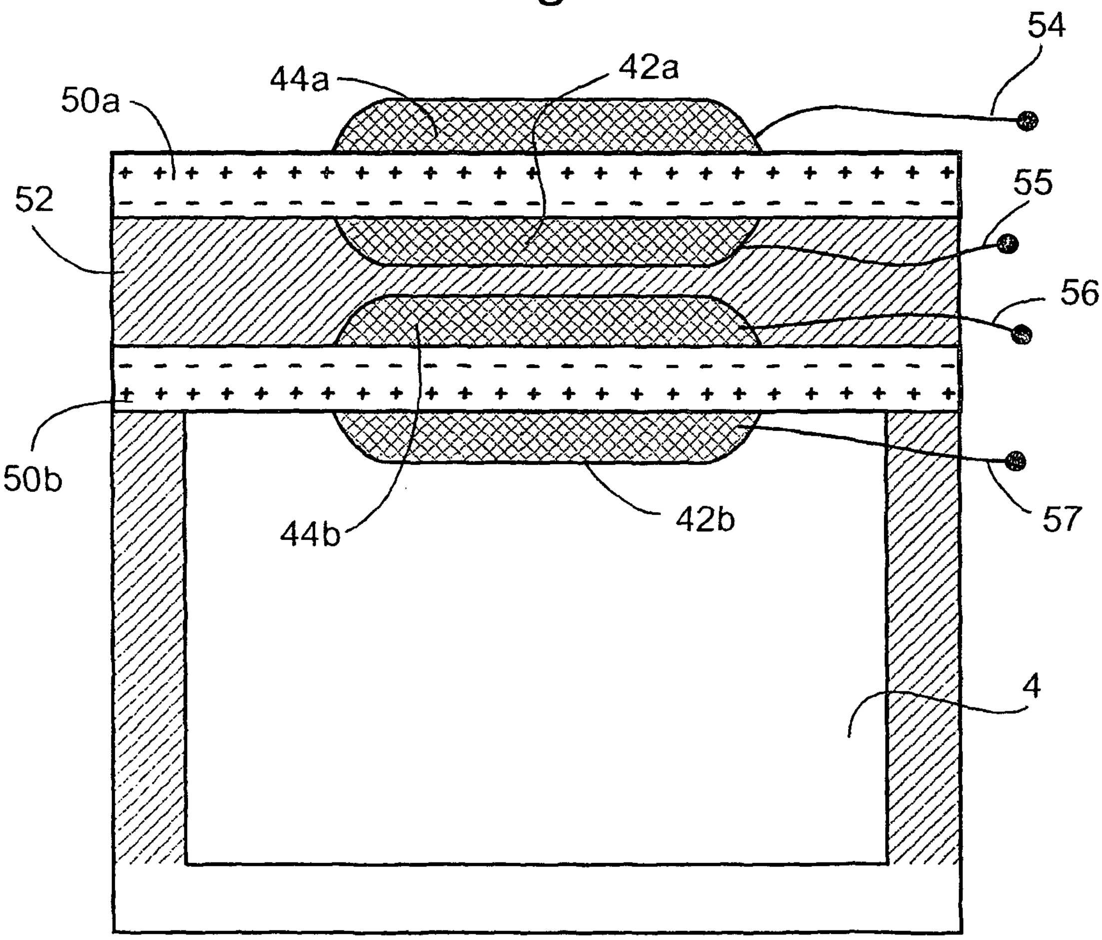

54
44a
42a
50a
52
55
56
50b
44b
42b
57
4

Fig. 8

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 3672352 A **[0005]**
- US 4099530 A **[0005]**
- WO 9934453 A **[0016]**
- US 4793825 A, Benjamin **[0024]**
- US 5833603 A, Kovacs **[0024]**
- US 5800478 A, Chen **[0025]**

patsnap

专利名称(译)	声学开关以及在体内使用声学开关的装置和方法
公开(公告)号	EP1331969B1
公开(公告)日	2012-11-21
申请号	EP2001980853
申请日	2001-10-15
[标]申请(专利权)人(译)	REMON医疗TECH
申请(专利权)人(译)	REMON MEDICAL TECHNOLOGIES LTD.
当前申请(专利权)人(译)	REMON MEDICAL TECHNOLOGIES LTD.
[标]发明人	PENNER AVRAHAM DORON EYAL
发明人	PENNER, AVRAHAM DORON, EYAL
IPC分类号	A61N1/372 A61B5/00 A61B5/103 A61M37/00 A61N1/34 A61N1/36 A61N1/378
CPC分类号	A61N1/3787 A61B5/0028 A61B5/0031 A61B5/01 A61B5/0215 A61B5/031 A61B5/053 A61B5/076 A61B5/14539 A61B2560/0219 A61B2562/0247 A61B2562/028 A61N1/37217 A61N5/0601 A61N5/062 A61N2005/0651
优先权	09/690615 2000-10-16 US
其他公开文献	EP1331969A1
外部链接	Espacenet

摘要(译)

用于在体内插入或植入的植入物包括用于在植入物被激活时执行一个或多个命令的电路，能量存储装置，以及耦合到电路和能量存储装置的开关。声换能器耦合到开关，声换能器在外部声能源的声激励下可激活，用于闭合开关以允许电流从能量存储装置流到电路。所述一个或多个命令包括利用耦合到电路的生物传感器测量生理参数，或者控制耦合到电路的治疗设备。治疗装置或生物传感器可被激活预定时间或直到开关响应于声换能器的另一声激励而打开。

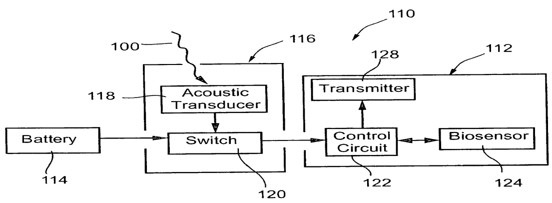

Fig. 1A

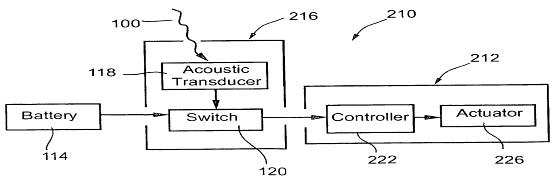

Fig. 1B