

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
21 December 2007 (21.12.2007)

PCT

(10) International Publication Number
WO 2007/146773 A1

- (51) International Patent Classification:
A61N 1/36 (2006.01)
- (21) International Application Number:
PCT/US2007/070711
- (22) International Filing Date: 8 June 2007 (08.06.2007)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
60/812,431 9 June 2006 (09.06.2006) US
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- (81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

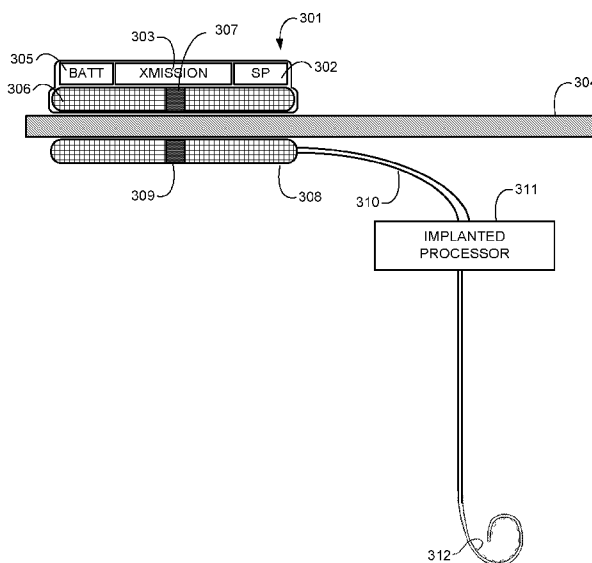
AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— with international search report
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: **BUTTON PROCESSOR FOR COCHLEAR IMPLANTS**



(57) Abstract: A cochlear implant system has an external housing (301) adapted for placement at a specific location on the external skin of a user. The external housing includes (i) a signal processing module (302) for converting an incoming acoustic signal into a representative electrical information signal, and (ii) a signal transmission module (303) for transmitting across the skin (304) of the user an electrical power signal representative of the electrical information signal. An implanted portion receives the electrical power signal and produces for the auditory system of the user an electrical stimulation signal representative of the acoustic signal. The external housing and the implanted portion magnetically cooperate so as to hold the external housing in place at the specific location without structural interaction with the outer ear of the user.

WO 2007/146773 A1

Attorney Docket: 1941/A25WO

Button Processor For Cochlear Implants

[0001] This application claims priority from U.S. Provisional Patent Application 60/812,431, filed June 9, 2006, the contents of which are incorporated herein by reference.

Field of the Invention

[0002] The invention generally relates to cochlear implant systems, and specifically to the external structures of such systems.

Background Art

[0003] A normal ear transmits sounds as shown in Fig. 1 through the outer ear **101** to the eardrum **102**, which moves the bones of the middle ear **103**, which in turn excites the cochlea **104**. The cochlea **104** includes an upper channel known as the scala vestibuli **105** and a lower channel known as the scala tympani **106**, which are connected by the cochlear duct **107**. In response to received sounds transmitted by the middle ear **103**, the fluid filled scala vestibuli **105** and scala tympani **106** function as a transducer to transmit waves to generate electric pulses that are transmitted to the cochlear nerve **113**, and ultimately to the brain.

[0004] Some persons have partial or full loss of normal sensorineural hearing. Cochlear implant systems have been developed to overcome this by directly stimulating the user's cochlea **104**. A typical system may include an external microphone that provides an audio signal input to an external signal processing stage (not shown in Fig. 1) where various signal processing schemes can be implemented. The processed signal is then converted into a digital data format, such as a sequence of data frames, for transmission into receiver **108**. Besides extracting the audio information, the receiver **108** also performs additional signal processing such as error correction, pulse formation, etc., and produces a stimulation pattern (based on the extracted audio information) that is sent through connected wires **109** to an implanted electrode carrier **110**. Typically, this electrode carrier **110** includes multiple electrodes on its surface that provide selective stimulation of the cochlea **104**.

[0005] Existing cochlear implant systems need to deliver electrical power from outside the body through the skin to satisfy the power requirements of the implanted portion of the system. Fig. 1 shows a typical arrangement based on inductive coupling through the skin to transfer both the required electrical power and the processed audio information. As shown in Fig. 1, an external primary coil **111** (coupled to the external signal processor) is placed on the skin adjacent to a subcutaneous secondary coil **112** (connected to the receiver **108**). Often, a magnet in the external coil structure interacts a corresponding magnet in the subcutaneous secondary coil structure. This arrangement inductively couples a radio frequency (rf) electrical signal to the receiver **108**. The receiver **108** is able to extract from the rf signal both the audio information for the implanted portion of the system and a power component to power the implanted system.

[0006] In prior systems, the external components generally have been held in separate housings so that the external primary coil **111** would not be in the same physical housing as the power source or the external signal processor. The various different physical components would generally be connected by hard wire, although some systems used wireless links between separate external components. A few systems have proposed that all of the external components could be placed within a single housing, but the weight of the various required components was relatively significant and such systems had to rely on anchoring such a single external housing on the stiff cartilaginous outer ear in order to provide enough support to hold the housing securely in a usable operating position.

Summary of the Invention

[0007] A representative embodiment of the present invention includes a cochlear implant system having an external housing adapted for placement at a specific location on the external skin of a user. The external housing includes (i) a signal processing module for converting an incoming acoustic signal into a representative electrical information signal, and (ii) a signal transmission module for transmitting across the skin of the user an electrical power signal representative of the electrical information signal. An implanted portion receives the electrical power signal and produces for the auditory system of the user an electrical stimulation signal representative of the acoustic signal. The external

housing and the implanted portion magnetically cooperate so as to hold the external housing in place at the specific location without structural interaction with the outer ear of the user.

[0008] In specific embodiments, the signal transmission module may include a transcutaneous transdermal transmission coil for transcutaneously transmitting the electrical power signal. Similarly, the implanted portion may include a reception coil for receiving the electrical power signal. The electrical power signal may be less than 20 mW and/or the external housing may weigh less than 10 g. The external housing may further include at least one battery, such as a Li-polymer battery or a zinc air battery.

[0009] Embodiments also include a method of operating a cochlear implant system. An external housing adapted for placement at a specific location on the external skin of a user is provided. The external housing includes (i) a signal processing module for converting an incoming acoustic signal into a representative electrical information signal, and (ii) a signal transmission module for transmitting across the skin of the user an electrical power signal representative of the electrical information signal. The electrical power signal is received with an implanted portion. And an electrical stimulation signal representative of the acoustic signal is produced for the auditory system of the user. The external housing and the implanted portion magnetically cooperate so as to hold the external housing in place at the specific location without structural interaction with the outer ear of the user.

[0010] In further specific embodiments, transmitting the electrical power signal may use a transmitting coil arrangement within the external housing. Similarly, receiving the electrical power signal may use a receiving coil arrangement associated with the implanted portion. The electrical power signal may be less than 20 mW and/or the external housing may weigh less than 10 g. The source of the electrical power signal may be at least one battery within the external housing such as a Li-polymer battery or a zinc air battery.

Brief Description of the Drawings

[0011] Figure 1 shows the ear structure of a human ear and a typical cochlear implant system.

[0012] Figure 2 shows the outlines of a single external housing in place behind the ear of a user according to an embodiment of the present invention.

[0013] Figure 3 shows a cross-sectional function view of one specific embodiment of the present invention.

Detailed Description of Specific Embodiments

[0014] Embodiments of the present invention are directed to a cochlear implant system having an external component in a single housing. The external housing is held in place at a specific location for proper electrical interaction with the implanted components. Unlike prior art systems which combined all external components into a single housing, embodiments of the present invention are designed to be light enough to be held in place without structural interaction with the outer ear of the user, solely by use of transdermal magnetics.

[0015] Figure 2 shows the outlines of such a single external housing **201** held in place on the skin of the user behind the ear without relying on a mechanical connection to the ear to provide support and anchoring for the housing. By controlling the power consumption requirements of the implanted portion of the system, efficiently generating the transdermal power and information signal into the implanted portion, utilizing light weight efficient batteries and structural materials, the entire external housing is overall light enough that magnetic coupling alone is capable of supporting the structure and maintaining it in place. For example, in specific embodiments the external housing may weigh 10 grams or less.

[0016] In contrast with ear-supported single housing systems, embodiments of the present invention are more comfortable for the user because they do not tug on the outer ear. Embodiments may also be more easily concealed beneath the hair of the wearer so that user may feel less self-conscious about using a cochlear implant.

[0017] Figure 3 shows a cross-sectional function view of one specific embodiment of the present invention. An external housing **301** includes a signal processing module **302** for

converting an incoming acoustic signal into a representative electrical information signal. The signal processing module **302** may include a microphone and related input signal processing circuitry and also various signal conditioning and power conditioning signal circuitry. The external housing **301** also includes a signal transmission module **303** powered by one or more batteries **305** for transmitting across the skin **304** of the user an electrical power signal representative of the electrical information signal. The one or more batteries **305** may typically be any modern lightweight efficient battery such as a Li-polymer battery or a zinc air battery.

[0018] The portion of the external housing **301** next to the skin **304** includes a primary transmission coil **306** and external positioning magnet **307**. Directly beneath these and under the skin **304** are a corresponding secondary receiving coil **308** and internal positioning magnet **309**. The magnetic coupling between the external positioning magnet **307** and the internal positioning magnet **309** is strong enough to hold in the external housing **301** in proper position on the skin **304** of the user directly over the secondary receiving coil **308**. An electrical power signal including the electrical information representative of the input acoustic signal is developed by the primary transmission coil **306** and coupled across the skin **304** to the secondary receiving coil **308**.

[0019] The electrical power signal received by the secondary receiving coil **308** is, e.g., coupled by implanted wires **310** to an implanted signal processor **311** which produces an electrical stimulation signal representative of the acoustic signal for an implanted stimulation electrode **312** to stimulate the auditory nerves of the cochlea. In another embodiment, the receiving coil **308** may be integrated within the case of the implanted signal processor **311**.

[0020] By efficient internal processing and stimulation, the power requirements of the implanted portion may be minimized. This allows a relatively low power electrical power signal to be used, for example, the electrical power signal may be less than 20 milliwatts. Such low power requirements contribute to allowing the external housing **301** to be as light and efficient as possible, enough so as to enable the external housing **301** to be maintained in proper position solely by the positioning magnetics without relying on

physical support from the outer ear.

[0021] Although various exemplary embodiments of the invention have been disclosed, it should be apparent to those skilled in the art that various changes and modifications can be made which will achieve some of the advantages of the invention without departing from the true scope of the invention.

What is claimed is:

1. A cochlear implant system comprising:
an external housing adapted for placement at a specific location on the external skin of a user, the external housing including:
 - i. a signal processing module for converting an incoming acoustic signal into a representative electrical information signal, and
 - ii. a signal transmission module for transmitting across the skin of the user an electrical power signal representative of the electrical information signal; andan implanted portion that receives the electrical power signal and produces for the auditory system of the user an electrical stimulation signal representative of the acoustic signal,
wherein the external housing and the implanted portion magnetically cooperate so as to hold the external housing in place at the specific location without structural interaction with the outer ear of the user.
2. A system according to claim 1, wherein the signal transmission module includes a transdermal transmission coil for transmitting the electrical power signal.
3. A system according to claim 1, wherein the implanted portion includes a reception coil for receiving the electrical power signal.
4. A system according to claim 1, wherein the electrical power signal is less than 20 mW.
5. A system according to claim 1, wherein the external housing weighs less than 10 g.
6. A system according to claim 1, wherein the external housing further includes at least one battery.
7. A system according to claim 6, wherein the at least one battery is a Li-polymer battery.
8. A system according to claim 6, wherein the at least one battery is a zinc air battery.

9. A method of operating a cochlear implant system, the method comprising:
providing an external housing adapted for placement at a specific location on the external skin of a user, the external housing including:
i. a signal processing module for converting an incoming acoustic signal into a representative electrical information signal, and
ii. a signal transmission module for transmitting across the skin of the user an electrical power signal representative of the electrical information signal; and
receiving the electrical power signal with an implanted portion, and
producing for the auditory system of the user an electrical stimulation signal representative of the acoustic signal,
wherein the external housing and the implanted portion magnetically cooperate so as to hold the external housing in place at the specific location without structural interaction with the outer ear of the user.
10. A method according to claim 9, wherein transmitting the electrical power signal uses a transmitting coil arrangement within the external housing.
11. A method according to claim 9, wherein receiving the electrical power signal uses a receiving coil arrangement associated with the implanted portion.
12. A method according to claim 9, wherein the electrical power signal is less than 20 mW.
13. A method according to claim 9, wherein the external housing weighs less than 10 g.
14. A method according to claim 9, wherein the source of the electrical power signal is at least one battery within the external housing.
15. A method according to claim 14, wherein the at least one battery is a Li-polymer battery.
16. A method according to claim 14, wherein the at least one battery is a zinc air battery.

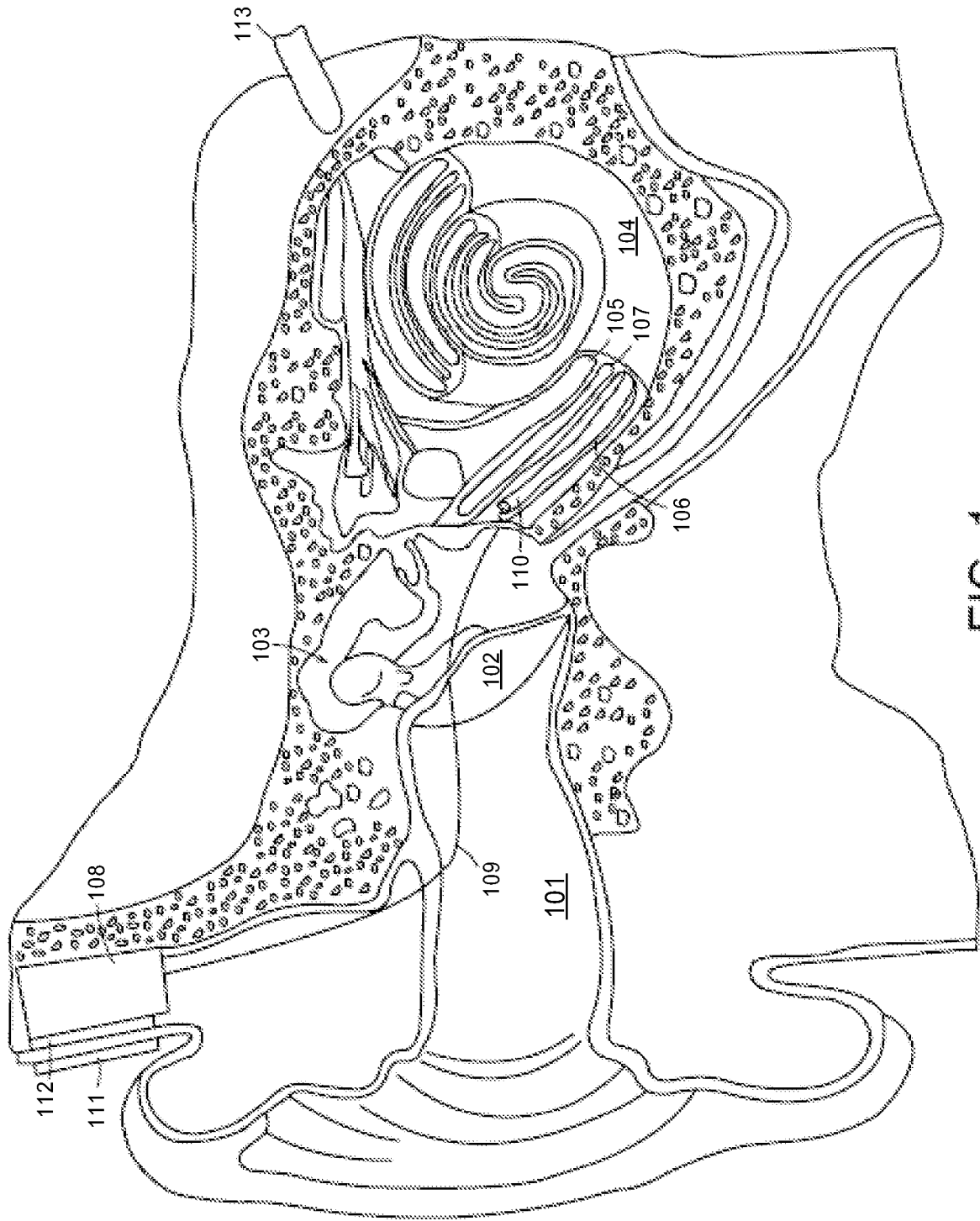


FIG. 1

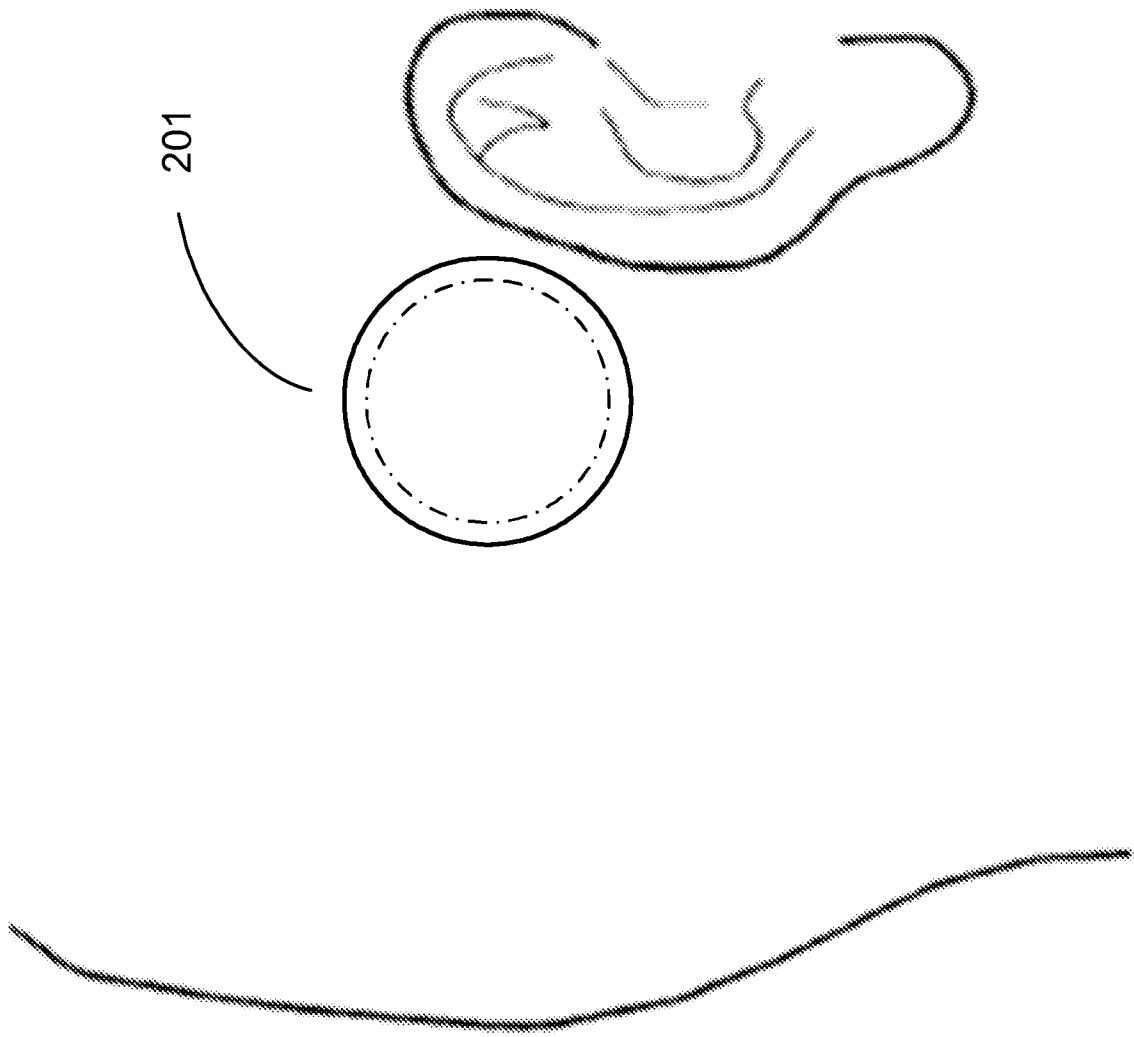


FIG. 2

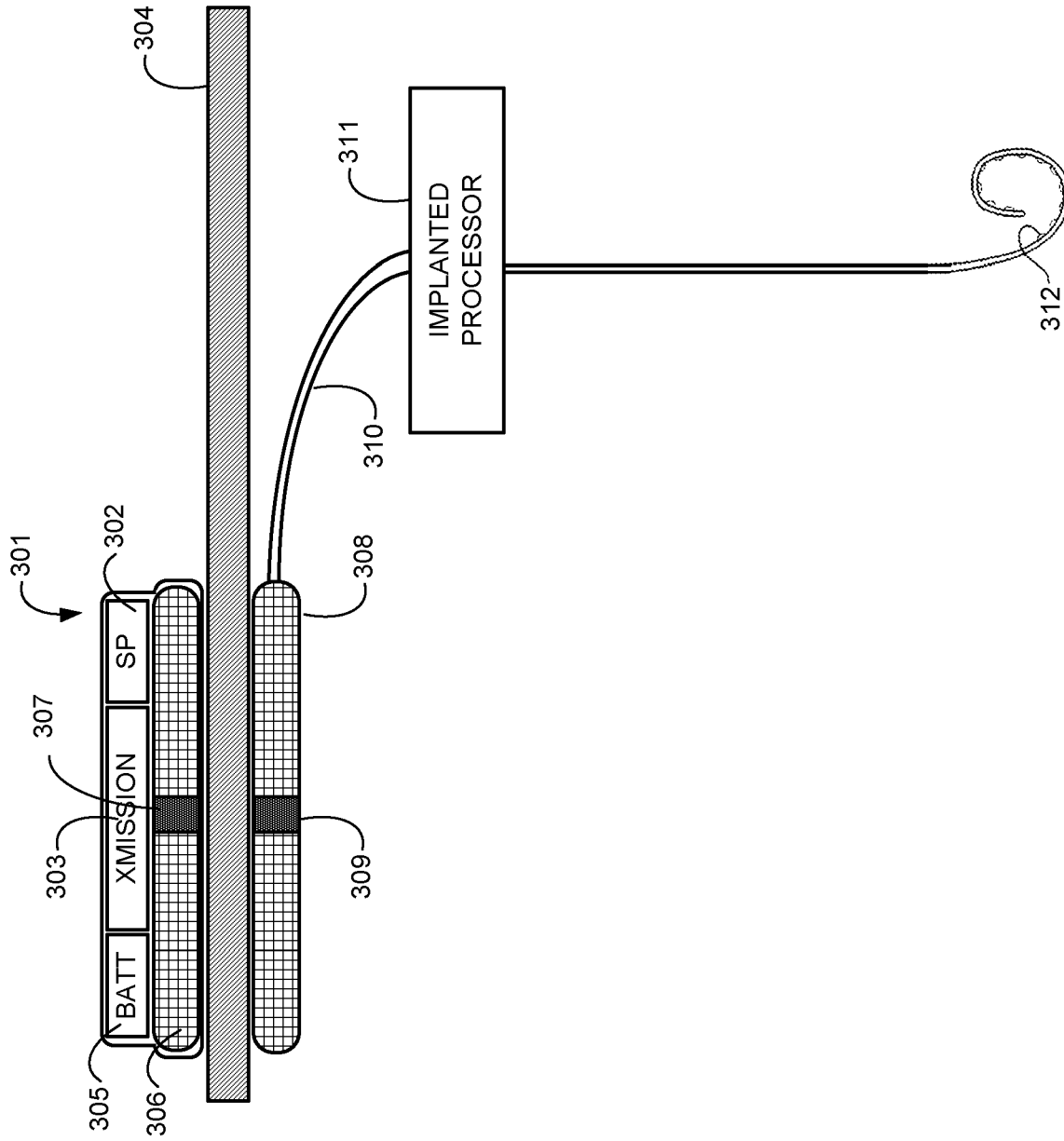


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2007/070711

A. CLASSIFICATION OF SUBJECT MATTER INV. A61N1/36		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) A61N H04R A61F		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 352 960 A (DORMER KENNETH J ET AL) 5 October 1982 (1982-10-05) column 1, line 7 - column 7, line 60; figures 1-4	1-16
X	WO 01/50816 A (HOUSE DAVID WILLIAM [US]) 12 July 2001 (2001-07-12) page 1, line 6 - page 9, line 15; figures 1-10	1-16
A	WO 01/39830 A (EPIC BIOSONICS INC [CA]; BERRANG PETER G [CA]; BLUGER HENRY V [CA]; JA) 7 June 2001 (2001-06-07) page 1, line 10 - page 33, line 22; figures 1-18	1-16
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
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Date of the actual completion of the international search 25 October 2007		Date of mailing of the international search report 06/11/2007
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Skorovs, Peteris

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No PCT/US2007/070711
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