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(54) Title: INDUCTIVE LINK WITH FERRITE SHEETS

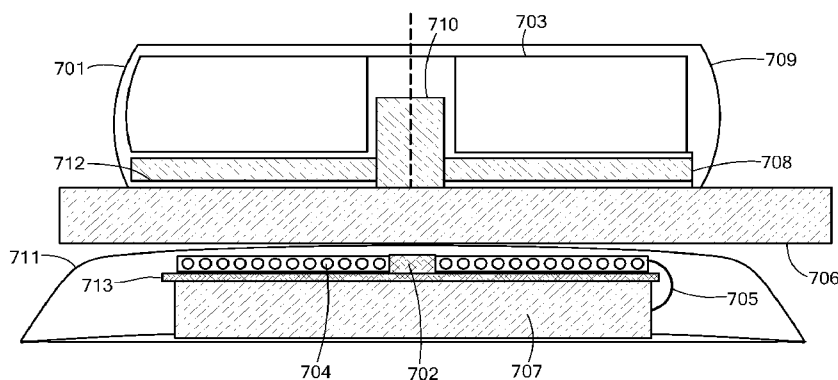


FIG. 7

(57) Abstract: An arrangement is described for a partially implantable medical system. A communications coil is adapted for placement parallel to a corresponding partner coil for communication of an implant communications signal having an associated magnetic field component. An implant electronics module is adjacent to the communications coil and electrically connected with it for coupling of the communications signal. And a planar coil shield lens is between the communications coil and the electronics module to promote coupling of the communications signal between the coils and to shield the electronics module from interaction with the magnetic field component.



TITLE

Inductive Link with Ferrite Sheets

[0001] This application claims priority from U.S. Provisional Patent Application 61/324,463, filed April 15, 2010, which is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to implantable medical devices such as cochlear implant systems, and specifically to energy transfer mechanisms in such devices.

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**. In response to received sounds transmitted by the middle ear **103**, the fluid filled cochlea **104** functions 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 **111** 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 by external transmitting coil **107** into an implanted processor **108**. Besides extracting the audio information, the implanted processor **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, the external transmitter coil **107** (coupled to the external signal processor **111**) is placed on the skin adjacent to the implanted processor **108**. Often, a magnet in the external transmitter coil **107** interacts with a corresponding magnet in the implanted processor **108**. This arrangement inductively couples a radio frequency (rf) implant communications signal to the implanted processor **108**, which is able to extract from the signal both the audio information and a power component.

[0006] In such systems, it is desirable to optimize the coupling of the implant communications signal across the skin. Thus, it is beneficial to increase inductance and coupling between the external and internal coils. But, strong radio frequency fields can also lead to eddy currents in metallic components of the system such as the housing, battery electrodes, etc. In an effort to control these requirements and issues, system designers attempt to optimize various specific design factors such as:

- coil properties (number of windings)
- disruptive patterns in electrode geometry, orientation of coil relative to metallic parts
- orientation of coil relative to metallic parts,
- use of non-conductive (ceramic) housing components in proximity to the coil

SUMMARY OF THE INVENTION

[0007] Embodiments of the present invention are directed to an arrangement for a partially implantable medical system. A communications coil is adapted for placement parallel to a corresponding partner coil for communication of an implant communications signal having an associated magnetic field component. An implant electronics module is adjacent to the communications coil and electrically connected with it for coupling of the communications signal. And a planar coil shield lens (e.g., made of a ferrite material) is between the communications coil and the electronics module to promote coupling of the communications signal between the coils and to shield the electronics module from interaction with the magnetic field component.

[0008] In specific embodiments, the communications coil may be an implantable receiver coil and the partner coil would be an external transmitter coil, or vice versa. The electronics module may include a module housing enclosing the electronics module and/or a battery arrangement providing electrical power, whereby the coil shield lens shields the module housing and/or battery arrangements to prevent eddy currents from arising due to the magnetic field component.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Figure 1 shows a human auditory system with a cochlear implant.

[0010] Figure 2 A-B shows the principle of a planar coil shield lens according to an embodiment of the present invention.

[0011] Figure 3 A-B shows photographs of a coil and a coil shield lens according an embodiment of the present invention.

[0012] Figure 4 shows an equivalent electronic circuit arrangement of one specific embodiment of the present invention.

[0013] Figure 5 shows coil and disk arrangement for three experimental measurements that were taken.

[0014] Figure 6 shows a graph of data obtained for the experimental measurements shown in Fig. 5.

[0015] Figure 7 shows various elements in a system having a planar coil shield lens according to one specific embodiment.

DETAILED DESCRIPTION OF SPECIFIC EMBODIMENTS

[0016] Various embodiments of the present invention are directed to a magnetic shield lens arrangement for use with the communications coils in medical implant systems such

as cochlear implant systems. A planar coil shield lens is positioned between one of the coils and an electronics module so as to promote coupling of a system communications signal between the coils and to shield the electronics module from interaction with the magnetic field component of the communications signal. Typically, a ferrite disk would serve as a specific example of a coil shield lens.

[0017] Figure 2A shows one example of such a coil and shield lens where a generally planar communications coil **202** may be either or both of a transmitting coil or receiving coil in a medical implant system such as a cochlear implant system. The communications coil **202** is backed by a coil shield lens **201** in the specific form of a sheet of ferrite material having a lens thickness **203**. Figure 2B shows a cross-sectional view of such an arrangement together with a corresponding partner coil **204** and the lines of the magnetic field component of the communications signal between them. As seen in Fig. 2B, the field lines of the magnetic field component are focused by the coil shield lens **201** on its near side adjacent to the communications coil **202** to promote coupling of the communications signal with the communications coil **202**. At the same time, the coil shield lens **201** bends the field of the magnetic field component on the far side of coil shield lens **201** to shield that area from the effects of the magnetic field component of the communications signal. For example, if an electronics module is positioned on the far side of the coil shield lens **201**, then the electronics module including its housing and any components therein such as a battery power arrangement will be shielded from the potentially adverse effects of the magnetic field component such as undesirable eddy currents in the metallic components.

[0018] Figure 3A shows a photograph of one specific example of a coil shield lens **301** for use in a cochlear implant system. In this case, the coil shield lens **301** is in the form of a disk of ferrite material 30 mm in diameter. Figure 3B shows a photograph of a corresponding communications coil **302** 29 mm in diameter. Once again, in specific embodiments, the communications may be either or both of a transmitting coil and/or a receiving coil.

[0019] Figure 4 shows an equivalent electronic circuit arrangement of one specific embodiment of the present invention. The depicted system is for inductive coupling of a

communications signal between coils L_1 and L_2 . The amount of signal coupling will be a function of the distance d between the coils and a coupling constant k . The coil shielding lens **401** acts to increase that coupling constant k to increase the coupling of the signal with respect to the physically adjacent coil L_2 .

[0020] Figure 5 shows various measurement arrangements for a series of experiments which compared the coupling effects of using a planar coil shield lens adjacent to a primary transmitting coil. In Measurement 1 of the experiments, a copper disk 3 mm thick and 27 mm in diameter was positioned in a plane 1 mm from a primary transmitting coil where it acted as a coil shield lens. Measurement 2 provided baseline data for an air coil primary without any coil shield lens. Measurement 3 used a combination of copper and ferrite disks as a coil shield lens: a copper disk as in Measurement 1 that was 0.3 mm thick, 27 mm in diameter, and 1 mm from the primary coil, and a ferrite disk 1 mm thick and 30 mm in diameter between the copper disk and the primary coil.

[0021] Figure 6 shows a graph of the coupling measurements that were taken which characterized the coupling from the primary coil to a corresponding secondary coil at different distances as shown. Measurement 1 with just a copper disk had significantly lower signal coupling than for Measurement 2 without any disk. So regardless of any shielding effects on the far side of the copper disk in Measurement 1, its significantly lower coupling characteristics are undesirable. But in Measurement 3, the copper disk is supplemented with a second ferrite disk that improves the signal coupling that was observed.

[0022] Fig. 7 shows elements of an embodiment in which an external processor housing **701** has a generally planar skin contacting surface **712**. An annular housing lumen **703** contains circuitry for an external transmitter processor for developing an implant communications signal. The implant communications signal is output to a transmitter coil **708** which couples the signal across the skin **706**. The housing lumen **703** also contains electrical power circuitry and a rechargeable battery arrangement which provides the power for developing and transmitting the implant communications signal. An external positioning magnet **710** is located radially inward of the housing lumen **703** and

magnetically interacts with a corresponding internal positioning magnet **702** to hold the external transmitter coil **708** in a fixed position on the skin **706** over a corresponding implant receiver coil **704** in an implant housing **711**. By this arrangement, the implant communications signal is coupled by the transmitter coil **708** across the skin **706** to the implant receiver coil **704**. The receiver coil **704** is connected by implant wires **705** to an implant processor **707** which develops a stimulation signal for the implanted electrode array to stimulate audio nerve tissue in the cochlea.

[0023] A planar coil shield lens **713** in the form of a disk of ferrite material lies under the receiver coil **704**. The coil shield lens **713** interacts with the magnetic field component of the communications signal as described above so as to increase the coupling of the communications signal to the receiver coil **704** while shielding the underlying implant processor **707** from the effects of the magnetic field component. This avoids the creation of undesirable eddy currents in the implant housing **711** and its enclosed components such as the implant processor **707** and/or any implanted battery power arrangements.

[0024] Implementing a coil shield lens as described above can significantly improve the efficiency of the RF transmission of the communications signals in medical implant systems such as cochlear implant systems. And the battery electrode plates can more readily be stacked in parallel to the coil plane without weakening of the RF transmission. In addition, since a coil shield lens prevents eddy currents from the RF signal, the materials used for the device housings can be made of metal or composite ceramic/metal structures.

[0025] 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.

CLAIMS

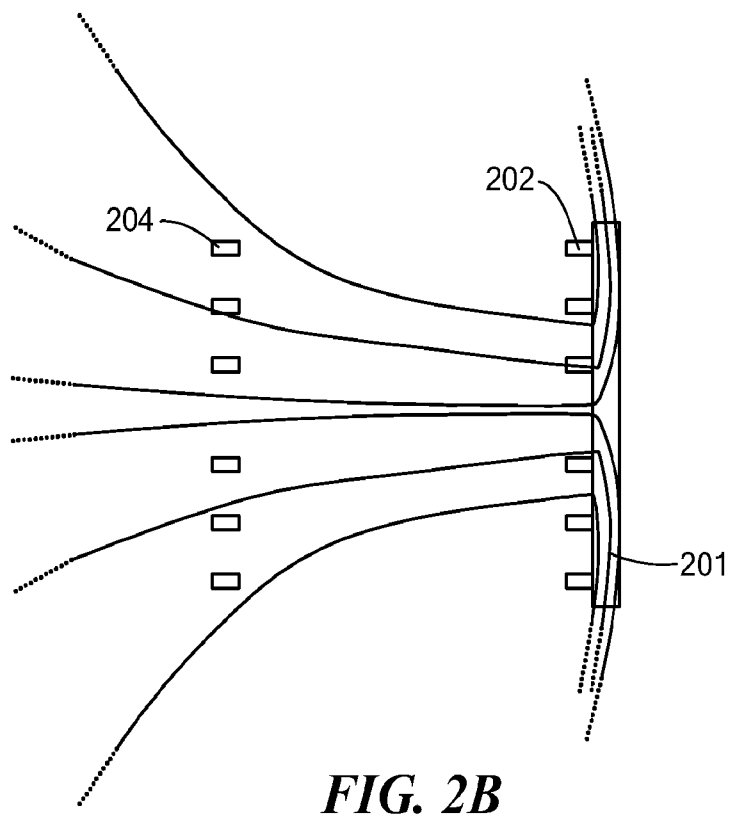
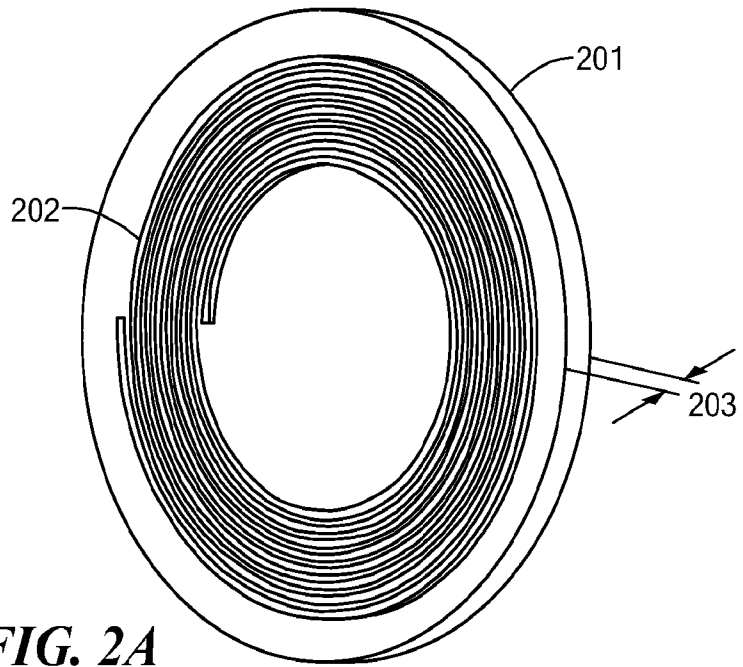
What is claimed is:

1. An arrangement for a partially implantable medical system, the arrangement comprising:
 - a communications coil adapted for placement parallel to a corresponding partner coil for communication of an implant communications signal having an associated magnetic field component;
 - an implant electronics module adjacent to the communications coil and electrically connected with the communications coil for coupling of the communications signal;
 - a planar coil shield lens between the communications coil and the electronics module to promote coupling of the communications signal between the communications coil and the partner coil and to shield the electronics module from interaction with the magnetic field component.
2. An arrangement according to claim 1, wherein the communications coil is an implantable receiver coil and the partner coil is an external transmitter coil.
3. An arrangement according to claim 1, wherein the communications coil is an external transmitter coil and the partner coil is an implantable receiver coil.
4. An arrangement according to claim 1, wherein the electronics module includes a module housing enclosing the electronics module, whereby the coil shield lens shields the module housing to prevent eddy currents from arising due to the magnetic field component.
5. An arrangement according to claim 1, wherein the electronics module includes a battery arrangement providing electrical power, whereby the coil shield lens shields the battery arrangement to prevent eddy currents from arising due to the magnetic field component.

6. An arrangement according to claim 1, wherein the coil shield lens includes a disk of ferrite material.

7. An arrangement according to claim 1, wherein the coil shield lens includes a disk of copper material.

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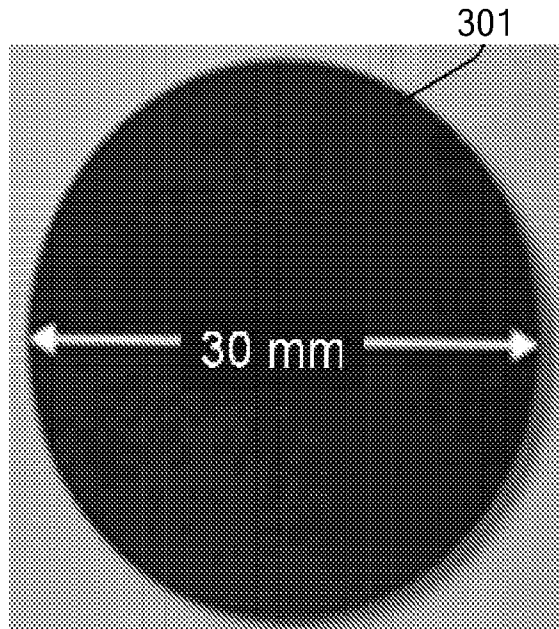


FIG. 3A

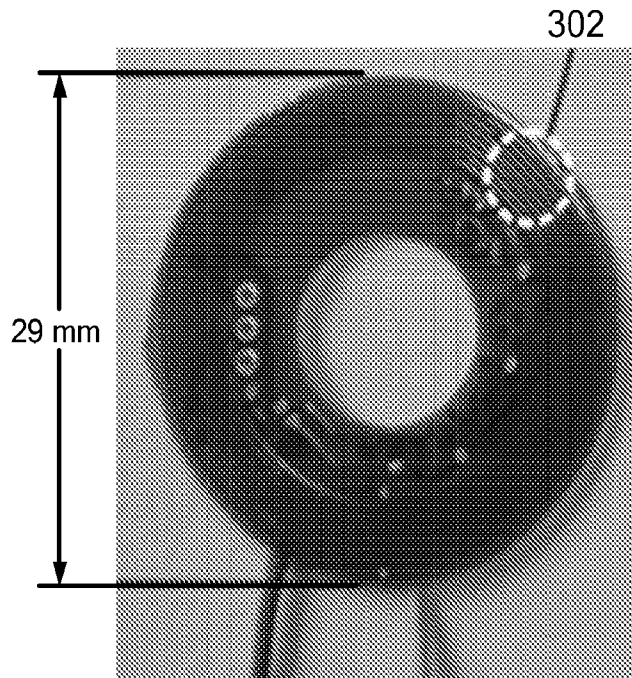


FIG. 3B

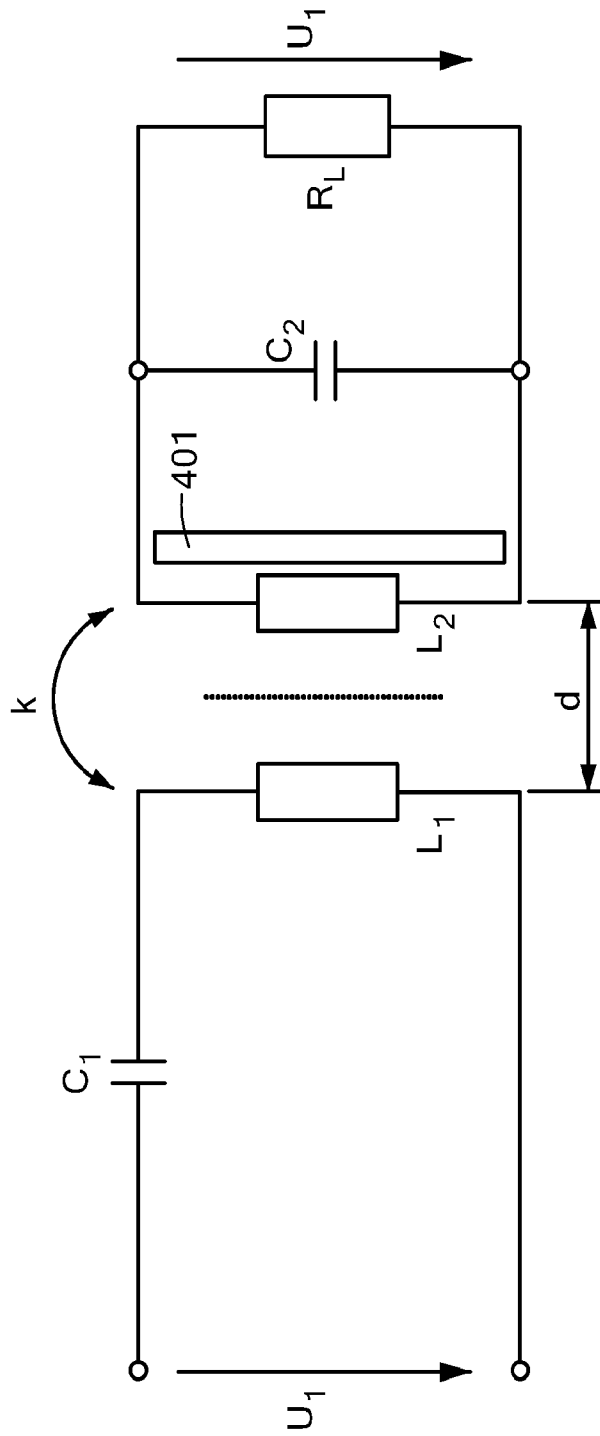


FIG. 4

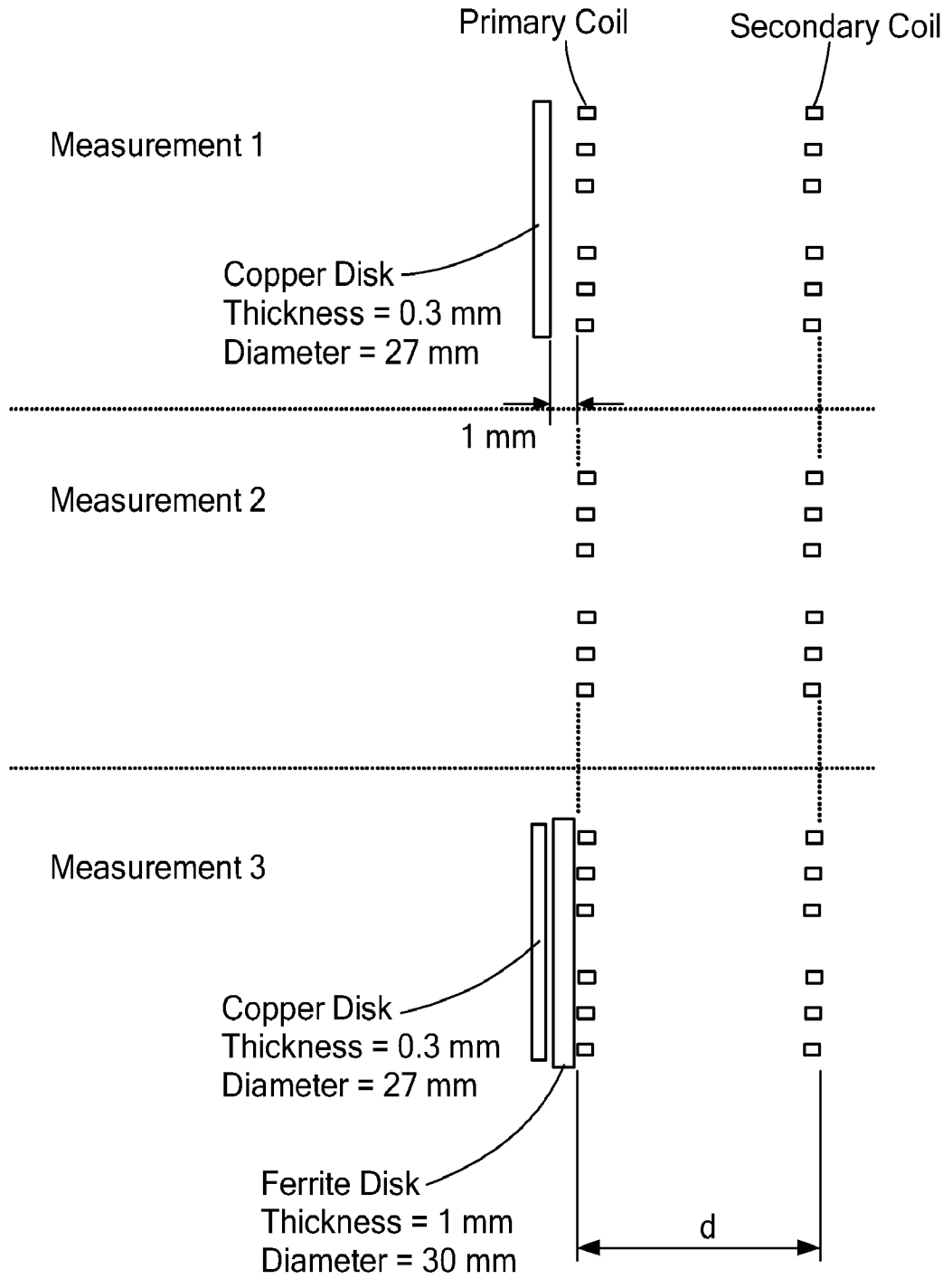


FIG. 5

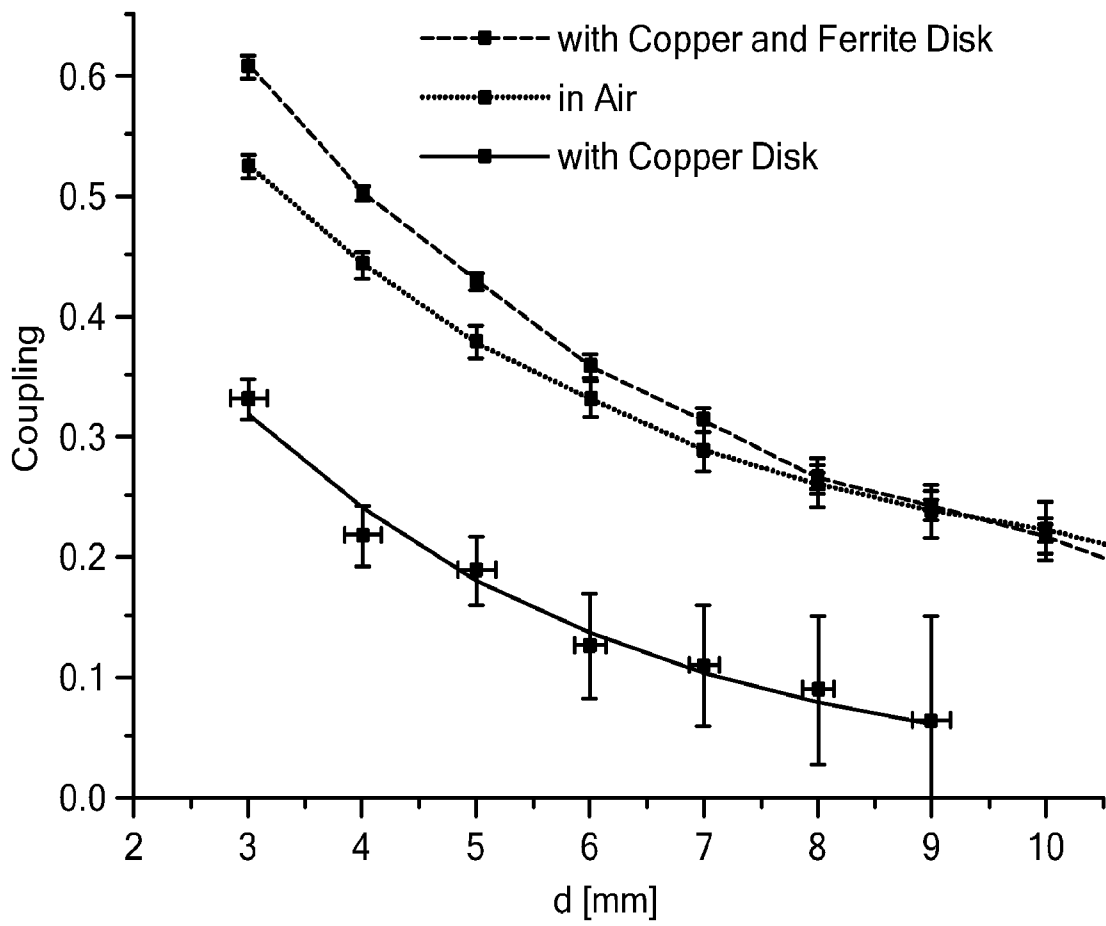


FIG. 6

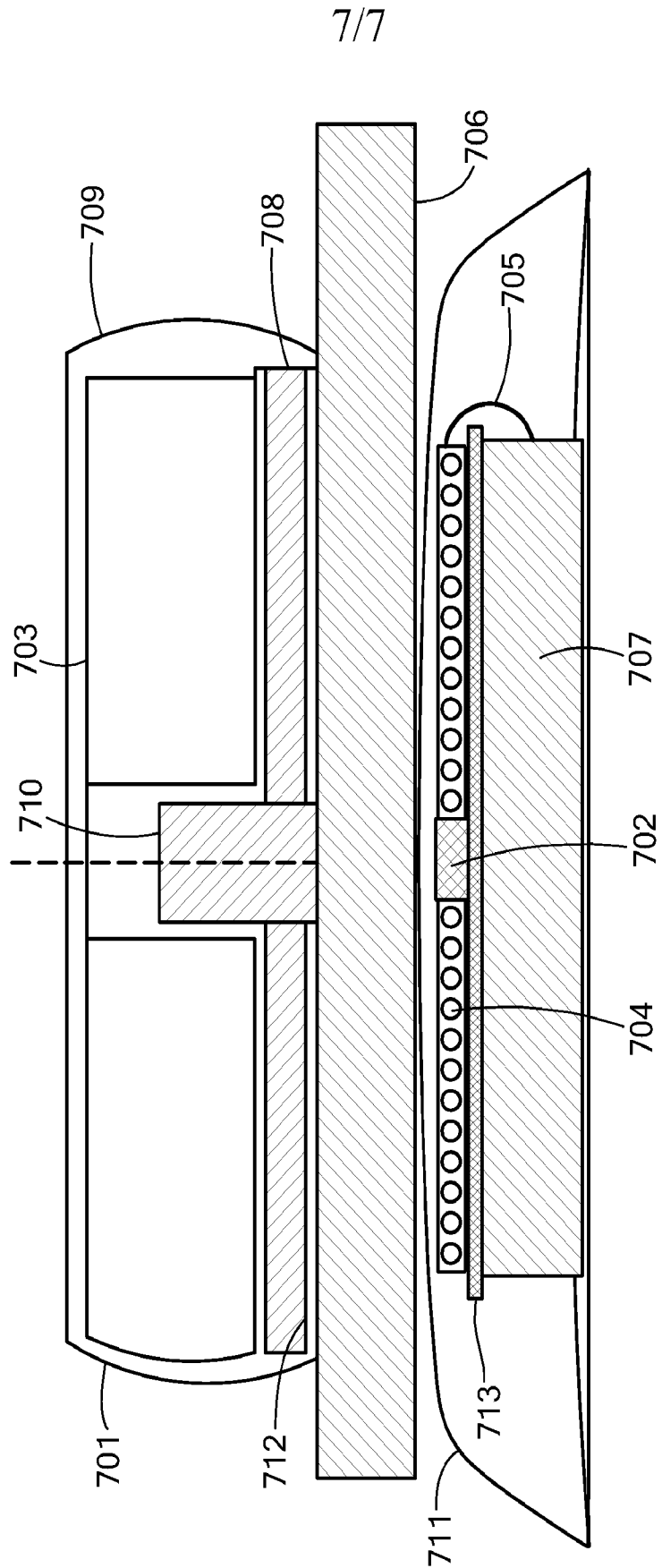


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2011/032629

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61N1/36 A61N1/372 A61N1/378
ADD.
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

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	EP 1 424 098 A1 (MANN ALFRED E FOUND SCIENT RES [US]; ADVANCED BIONICS CORP [US] MANN A) 2 June 2004 (2004-06-02) paragraphs [0040] - [0044], [0 80] - [0085]; figures 1C, 16, 17 -----	1-7
A	US 2006/155347 A1 (FORSELL PETER [CH]) 13 July 2006 (2006-07-13) the whole document -----	1-7
A	EP 1 491 235 A2 (MANN ALFRED E FOUND SCIENT RES [US]) 29 December 2004 (2004-12-29) the whole document -----	1-7

Further documents are listed in the continuation of Box C.

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"&" document member of the same patent family

Date of the actual completion of the international search 1 June 2011	Date of mailing of the international search report 17/06/2011
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Smit, Jos
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2011/032629

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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