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DESCRIPTION

[0001] The present invention relates to the ear stimulation prostheses for rehabilitation of patients with disorders of the inner ear.

5 [0002] The inner ear is a sensory organ whose function is to transcribe vibration waves between 0 and 20 kHz coming from the environment into a sensory inflow. It includes two physically distinct portions having two different respective functions, namely the balance portion and the hearing portion.

10 The balance portion, called the vestibule, has the function of encoding vibration waves between 0 and 800 Hz. It also makes it possible to situate the direction of the head with respect to its environment, by acceleration measurement systems in the semicircular canals. The hearing portion, called the cochlea, encodes the vibration waves between 20 Hz and 20 kHz.

[0003] The pathologies that may affect the inner ear can primarily be classified into three categories, namely loss of auditory acuity, balance disorders and tinnitus.

15 The main cause of these pathologies is associated with the natural aging of the sensory cells, and has for consequence hearing disorders (presbycusis, age-related deafness) and balance disorders (vestibulopathy, age-related hypoflexia).

Some diseases, such as Ménière's disease, can trigger all three categories of pathologies (deafness, tinnitus and vertigo).

20 [0004] There are a number of possibilities for treatment of these pathologies. For some cases of deafness associated with transmission and vestibular disorders, there are surgical treatments, such as the opening of endolymphatic sacs or the vestibular nerve section or middle ear surgeries. These treatments have the drawback of being irreversible.

25 [0005] Some drugs or rehabilitation treatments can attenuate vertigo, tinnitus and sudden or fluctuating deafness. These treatments do not cure the disease, but simply enable the

affects thereof to be reduced. These pathologies can also be treated with an apparatus. However, there is currently no apparatus enabling all of these pathologies to be treated.

For deafness, hearing aid apparatuses have for object to amplify the acoustic waves. They are commonly used to treat all levels of deafness, from slight to profound. There are also systems implanted into the middle ear, which are designed to mechanically amplify the movements of the ossicular chain (Patents US 5 913 815, US 6 293 903). There are systems for bone conduction, by means of a vibrator integrated in a pair of spectacles, for example, which are designed to cause the skull to vibrate so as to transmit the vibration wave to the inner ear. These latter systems are limited to the treatment of deafness associated with a transmission problem, because the pressure exerted on the skin to transmit the vibration to the skull must be limited. There are also implanted bone conduction systems in which the vibrator is either implanted or can be connected through an opening in the skin to an implant attached to the skull (Patents US 4 498 461, WO 02/09622). Electric stimulators (intra- or extra-cochlear implants), directly stimulating the auditory nerve, are used in cases of significant deafness, i.e. when the acoustic waves are insufficient for stimulating the auditory nerve.

[0006] There is no apparatus for vertigo. For tinnitus, a masking system has been proposed, which sends a noise to the inner ear to mask the tinnitus (Patent US 5 325 872). In addition, external hearing aids make it possible to correct tinnitus associated with deafness: the correction of the deafness leads to a reduction in the tinnitus. Electric stimulators of the inner ear are also used to reduce tinnitus, when the deafness is too severe to be treated acoustically.

[0007] Hearing aids and masks have the advantages of not requiring surgery and of being reversible and compatible with MRI imaging. On the other hand, they are generally relatively visible, and therefore unaesthetic. Furthermore, they sometimes have contraindications (aplasia of the outer ear, external otitis, eczema, ...). They often cause acoustic feedback due to their structure and in particular to the proximity of the microphone and of the earphone. Some of these apparatuses require plugging the auditory canal, which raises the problem of amplification of low-frequency sounds, and is often

disturbing for the patient who then hears more body sounds (chewing, blood circulation). Moreover, these apparatuses operate only on the frequency band 125 - 6000 Hz due to the use of an earphone.

5 [0008] Systems implanted in the middle ear, on the contrary, are discreet and do not require blocking of the auditory canal. They cause little acoustic feedback, thereby allowing a higher gain in the high-frequency sounds than with hearing aids. They cause less distortion and operate in a wider frequency band (up to 10 kHz) because they do not use an earphone. On the other hand, they require surgery of the middle ear and general anesthesia, with all of the risks of these operations (facial nerve, ossicular chain), which
10 makes them relatively irreversible and incompatible with MRI imaging and radiotherapy, and raises problems in case of breakdown or failure of the apparatus. By comparison with hearing aids, these apparatuses are also relatively expensive, and if the deafness changes, their capacity of adaptation is limited due to the use of an electromagnetic transducer. Moreover, their bandwidth does not cover the entire spectrum to which the inner ear is
15 normally sensitive (limited to frequencies between 125 Hz and 10 kHz).

[0009] Non-implanted or semi-implanted bone conduction systems have the advantage of providing a quality sound. They do not require the auditory canal to be plugged either, and do not generate acoustic feedback. On the other hand, they are highly visible and therefore unaesthetic, and require a lot of power. Moreover, they provide little or no left/right
20 selectivity due to the mode of transmission used (through a skull bone). Non-implanted systems must clamp the skin (conduction of vibrations through the skin), which is uncomfortable for the patient, and even painful, and can cause necrosis of the skin. Semi-implanted systems, requiring a permanent opening in the skin barrier, lead to risks of infection.

25 [0010] Cochlear implants require a complex surgery, therefore with risks, which is irreversible, presenting a problem in case of failure of the treatment and in case of breakdown of the apparatus. They are incompatible with imaging systems, expensive, and their bandwidth is limited to frequencies between 125 and 6000 Hz.

[0011] This invention is intended to overcome these drawbacks. This objective is achieved by providing an inner ear stimulation prosthesis including excitation means adapted to generate vibrations able to excite a patient's ear.

5 [0012] According to the invention, this prosthesis includes an implantable portion, comprising a rod able to transmit vibrations and which is shaped to be able to transmit the vibrations generated by the excitation means directly to the patient's inner ear.

[0013] Advantageously, the rod is adapted to be put in contact with a semicircular canal of the patient's inner ear, preferably the external semicircular canal of the patient's inner ear.

10 [0014] According to a special feature of the invention, the rod is made of a hard and rigid biocompatible material chosen from metals, plastic materials, and ceramic materials.

[0015] Advantageously, the rod has a cross-section with a flattened shape.

[0016] According to a special feature of the invention, the rod comprises at least one bend so as to be able to connect an external portion of the patient's skull to the inner ear without requiring a complex surgery involving total anesthesia of the patient.

15 [0017] Preferably, the rod has a length between the bend and its end in contact with a portion of the patient's inner ear comprised between 20 and 30 mm and has a bend angle between its two end portions comprised between 70° and 130°.

[0018] Also preferably, the surface of the implantable portion is treated so as to prevent any osseointegration.

20 [0019] Advantageously, the rod is pivotably mounted on a support.

[0020] According to a special feature of the invention, the excitation means are placed in an external housing and are adapted to generate vibrations intended to be transmitted through the patient's skin to a plate integral with the rod.

[0021] Preferably, the plate has a substantially rectangular shape with rounded edges of which the length is between 6 mm and 20 mm and the width is between 3 mm and 10 mm.

5 [0022] According to a special feature of the invention, the external housing is integrated in an object adapted to be worn on the patient's head so that the excitation means are placed facing the plate of the implantable portion.

[0023] Preferably, the object adapted to be worn on the patient's head is chosen from a pair of spectacles or a housing that fits around the ear.

10 [0024] According to a preferred embodiment of the invention, the external housing includes at least one magnetic part intended to cooperate with at least one magnetic part provided in the implantable portion so as to hold the excitation means facing the plate.

[0025] According to a preferred embodiment of the invention, the excitation means are integrated in the implantable portion and coupled directly to the rod.

[0026] According to a preferred embodiment of the invention, the rod is integral with attachment means for attaching the rod to the patient's skull bone.

15 [0027] Preferably, the excitation means are housed inside an external housing provided with coupling means, so as to be removably attached through the patient's skin to attachment means intended to be attached to the patient's skull bone.

20 [0028] According to a preferred embodiment of the invention, the external housing containing a microphone is intended to be attached on the same side as an ear of the patient that is wholly defective, whereas the rod is intended to be attached as to excite the patient's other ear that is not defective, the vibrations generated by the excitation means being transmitted to the rod by bone conduction of the patient's skull bone.

25 [0029] The invention also relates to a hearing prosthesis, and/or a neurostimulating prosthesis for treating tinnitus and/or balance disorders, having at least one of the characteristics disclosed hereinabove.

[0030] The invention further relates to an implantable prosthesis portion, in accordance with one of the characteristics disclosed hereinabove.

[0031] Because there is no intervention on the ossicular chain or in the middle ear, the prosthesis according to the invention can be implanted by a simple surgical procedure requiring only local anesthesia. Such surgery has therefore few risks of surgical complications, while being reversible.

Because a vibration is transmitted directly to the inner ear, the prosthesis according to the invention makes it possible to transmit the entire frequency band (0 to 20 kHz) to which the inner ear is normally sensitive. The prosthesis according to the invention can therefore be used as an auditory prosthesis, and/or as a neurostimulation prosthesis for fighting against tinnitus and/or balance disorders.

[0032] In the case of hearing correction, it provides the possibility of significant amplification without the risk of generating acoustic feedback. It therefore makes it possible to correct all disorders of the ear (deafness, tinnitus, balance). Because the inner ear is directly stimulated, the left/right selectivity is very good, which allows for selective and appropriate correction of the two ears independently of one another. Moreover, the prosthesis according to the invention does not require plugging, even partially, the external auditory canal.

[0033] A preferred embodiment of the invention will be described below, by way of a non-limiting example, in reference to the appended drawings, in which:

Figure 1 diagrammatically shows an implantable prosthesis according to the invention, installed on the patient's head;

Figures 2 and 3 show in greater detail, in perspective and in a side view, respectively, the implantable portion of the prosthesis shown in Figure 1;

Figure 4 shows in greater detail, in a front view, the external portion of the prosthesis shown in Figure 1;

Figure 5 shows, in a front view, a variant of the external portion of the prosthesis shown in Figure 1;

Figure 6 illustrates the way in which the external portion of the prosthesis shown in Figure 5 is worn by a patient;

5 Figures 7a and 7b show, in a partial profile view and a front view, respectively, a variant of the implantable portion of the prosthesis according to the invention;

Figures 8 and 9 show, in a front view, variants of the external prosthesis portion shown in Figures 7a and 7b;

10 Figure 10 illustrates the way in which the implantable portion of the prosthesis shown in Figures 7a, 7b and 9 is attached to a patient's head;

Figures 11 and 12 show, in a front view and a profile view, respectively, the external prosthesis portion corresponding to the implantable portion shown in Figures 7a, 7b and 9;

Figures 13 and 14 show two other variants of the implantable portion of the prosthesis according to the invention;

15 Figure 15 shows another entirely implantable variant of the prosthesis according to the invention;

Figure 16 illustrates the way in which the implantable portion of the prosthesis shown in Figure 15 or 16 is attached to a patient's head;

20 Figures 17 and 18 show, in a front view and a profile view, respectively, the external portion of the prosthesis corresponding to the implantable portion shown in Figure 13 or 14;

Figure 19 shows another variant of the implantable portion of the prosthesis according to the invention;

Figure 20 illustrates the way in which the implantable portion of the prosthesis shown in Figure 19 is attached to a patient's head;

Figures 21 and 22 show two variants of the external prosthesis portion corresponding to the implantable portion shown in Figure 19;

5 Figure 23 shows the implantable portion of a variant of the prosthesis shown in Figures 19 and 20;

Figure 24 shows another implantable portion intended to be associated with the implantable portion shown in Figure 22.

10 **[0034]** Figure 1 shows an implantable prosthesis according to the invention. In this figure, the prosthesis includes an entirely passive implantable portion 1 adapted to transmit vibrations to the inner ear, preferably at the semicircular canals, and an external portion 10 integrating excitation means 11, such as a vibrator, intended to cooperate with the implantable portion 1. The external portion can also include signal processing means, one or several microphones, and/or other electronic and/or power elements.

15 **[0035]** In Figures 2 and 3, the implantable portion 1 includes a plate 3, preferably in the form of a reverse cup, connected to a rod 2. The plate is intended to be implanted under the skin in contact with the patient's skull, preferably behind the ear (Figure 1), so as to receive, through the skin, the excitation produced by the external portion 10. The implantable rod 1 advantageously forms at least one bend 4 so that the angle between the
20 plate 3 and the end of the rod 2 is comprised between 70° and 130°, so as to reach the inner ear through the antrotomy cavity from the external surface of the skull. Thanks to its bend 4, the implantable rod provides for an acoustic piston-type transmission. The presence of band also makes it possible to prevent a shock on the plate 3 from causing trauma through driving in of the rod in the structures of the inner ear.

25 **[0036]** The implantable portion 1 consisted of the plate 3 and of the rod is advantageously made in a single piece with blunt edges, of a hard and rigid biocompatible material such as a biocompatible metal (for example, titanium, etc.), or a biocompatible hard plastic or

ceramic material, which is selected so as to be a very good vibration transmitter, and preferably compatible with MRI imaging and radiotherapy.

5 [0037] The rod 2 advantageously has a cross-section with a flattened shape, for example, rectangular with blunt edges, about 3 mm wide and 1.5 mm thick. These dimensions make it possible to ensure a good transmission of the vibrations between the plate and the inner ear, while reducing the risks of trauma to the skin. The length of the rod between the bend 4 and its distal end intended to come into contact with the inner ear is advantageously comprised between 20 and 30 mm, and preferably between 24 and 26 mm.

10 [0038] The distal portion of the rod 2 can have a non-flattened section so as to fit the body and concentrate the vibrations to the zone to be stimulated. The distal end of the rod 2 can advantageously include a shoe for facilitating its positioning and reducing the risk of trauma in case of shock.

15 [0039] The plate 3 advantageously has a rectangular shape of which the length is between 6 and 20 mm and the width is between 3 and 10 mm, so as to prevent risks of trauma and even tearing of the skin, which may occur if the plate has too small or too large dimensions. These dimensions also allow a good transmission of the vibrations generated by the vibrator 11 through the skin, which limits the pressure to be exerted on the skin between the vibrator and the plate 3.

20 [0040] The end of the rod 2 is advantageously implanted so as to come into contact with the semicircular canals of the inner ear, which have the advantage of being very sensitive, preferably with the external semicircular canal, which is easily accessible by minor surgery requiring only local anesthesia.

25 [0041] More precisely, the rod is implanted using a technique of retroauricular tympanoplasty followed by an antrotomy and an identification of the contact zone of the distal end of the rod 2. The rod 2 is then applied so that its distal end comes into contact with the shell of a semicircular canal, preferably the external semicircular canal, which is easier to reach. When the rod is in place, its bend 4 arrives at the height of the mastoid cortical bone, and the plate 3 is arranged in the retroauricular region away from the auricle

so as to prevent acoustic feedback phenomena.

5 [0042] To adapt the rod to the patient's body, it is possible to provide the surgeon with a measuring tool such as a graduated rod or a malleable gauge for determining the length of the rod between the bend and its distal end and the angle of the bend. Next, it is possible to provide the surgeon with a set of rods having different lengths and possibly different bend angles so that he/she can choose the appropriate rod for the patient's anatomy. Alternatively, or in combination, it is possible to provide tools for adapting the rod to the patient's anatomy, for adjusting the angle of the bend and/or the length of the rod between its bend and its distal end.

10 [0043] Preferably, the implantable portion 1 has a surface treated so as to prevent any osseointegration. The implantable portion 1 can also be covered with a coating made of a material that is a little or not at all osseointegratable, for example, silicone, PTFE or parylene.

15 [0044] In Figure 4, the external portion includes excitation means 11 intended to be applied against the skin, opposite the plate 3, as shown in Figure 1. The external portion can also include a signal processor 13 powered by a cell or a battery 12, and connected to the excitation means and possibly to a microphone 14, and, if necessary, to one or several optional microphones 15 intended, for example, to be arranged near the other ear in case of full deafness.

20 [0045] In Figures 1 and 4, the external portion is advantageously integrated in a sidearm of a pair of spectacles, the vibrator 11 being arranged in the end region of the spectacle sidearm intended to be applied behind the patient's ear, so as to come opposite the plate 3 of the implantable portion 1. By thus equipping the two sidearms of a pair of spectacles, it is possible to correct both ears of the patient, with the implantation of an implantable rod 1 in each ear. This arrangement makes it possible to correct the problems of deafness and/or tinnitus and/or a balance loss.

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[0046] The external portion 10 can also be integrated in any other object intended to be installed on the head, such as a headband or a diadem, a hair slide. It can also be attached

to the skull by transcutaneous anchoring.

[0047] The prosthesis described in reference to Figures 1 to 4 has further the advantages of being very discreet and of preserving the skin barrier. Owing to the use of a rod conducting the vibrations directly to the inner ear, the transmission of the vibrations through the skin does not require the skin to be clamped in a manner that is uncomfortable for the patient. Moreover, as the implantable portion is entirely passive, it does not present any risk of breakdown (by comparison with active implantable systems).

[0048] Figures 5 and 6 show a variant of the external portion. In this figure, the external portion 10' includes the vibrator 11, and possibly the processor 13, the microphone 14 and the cell or battery 12, the external portion being housed in a housing integral with the attachment means 15 that fit around the ear, enabling the vibrator 11 to be held opposite the plate 3 of the implantable portion 1.

[0049] Figures 7a, 7b and 8 show variants of the implantable portion including a rod 2a integral with a plate 3, preferably pivotably mounted on a plate 7, 7' including for that purpose supports 6 extending perpendicular to the plate 7, 7' and supporting swivels 9 engaging into cavities provided in the lateral sides of the plate 3 and forming a pivot axis. In Figures 7a and 7b, the plate 7 further supports two magnetic parts 8 such as magnets, provided for the attachment of an external housing.

[0050] In Figure 8, a magnetic part 8 such as a magnet is attached to the plate 3, whereas no magnetic part is attached to plate 7', so that the latter can be smaller than the one shown in Figures 7 and 8.

[0051] It is also possible to consider mounting the magnetic parts 8 directly onto the plate 3 or onto a positioning part 7'', for example in an arc of circle associated with the plate 3, as shown in Figure 9. Then, the plate 3 is not associated with a plate 7, 7' on which it is pivotably mounted.

[0052] In Figure 10, the implantable portion 1a, 1b is implanted under the patient's skin, in the temporo-occipital zone, or substantially in the mastoid region, so that the rod 2a has a

length between the plate 3 and the bend 4 that is greater than that shown in Figures 1 to 4.

[0053] In Figures 11 and 12, the external portion 10a of the prosthesis, corresponding to the implantable portion 1a shown in Figures 7 and 8 comprises a support plate 20 supporting two magnetic parts 18 intended to cooperate with the magnetic parts 8 of the implantable portion 1a, and a housing 19 containing the vibrator 11, and possibly the processor 13, the cell or battery 12, and, as the case may be, one or several microphones 14.

[0054] The external portion corresponding to the implantable portion 1b shown in Figure 9 is substantially identical to that shown in Figures 11 and 12, except that it includes only one magnetic part associated with the vibrator 11 that cooperates with the magnetic part 8 so as to cause the implantable portion 1b to vibrate.

[0055] Figures 13 to 16 show non-passive variants 1c, 1d of the implantable portion. In this variant, the implantable portion is active and comprises for that purpose a vibrator 11 coupled directly to a rod 2c to transmit vibrations generated by the vibrator to the inner ear, preferably to the external semicircular canal. The vibrator 11 is associated with attachment means 32 enabling it to be attached to the skull and is connected by the electrical wires to an electronic processing unit 33, 33', which is itself connected by electrical wires to a circular antenna 34, integral with one or two magnetic parts 35. In the variant shown in Figure 13, the electronic processing unit 33 is separate from the circular antenna 34. The processing unit 33 can also be mounted directly on the vibrator 11. Similarly, the assembly of the antenna 34 and the magnetic parts 35 and the electronic unit 33' can be mounted on the vibrator 11. In this latter case, the rod 2c is preferably bent so as to prevent the risk of trauma in case of shock.

[0056] In the variant illustrated in Figure 14, the electronic unit 33' is encapsulated with the antenna 34. In the variant illustrated in Figure 15, the implantable portion 1e includes its own cell or battery power supply 36. The antenna 34 makes it possible to ensure the transmission of signals and/or power transmitted by an external housing. This external housing can comprise a signal-processing unit, a cell or battery, and possibly one or

several microphones 14. Indeed, in the devices that must comprise at least one microphone, the latter can either be placed in the external housing or connected thereto, or be implanted.

5 [0057] In Figure 16, the antenna portion 34 of the implantable portion 1c, 1d, 1e is attached to the skull away from the portion including the vibrator 11 and the rod 2c. It should be noted that in these embodiments, the rod 2c does not need to be bent because the vibrator 11 is also implanted, and, therefore, it is not necessary to provide a plate 3 implanted just under the skin, liable to receive shocks.

10 [0058] In Figures 17 and 18, the external portion 10c corresponding to the internal portion shown in Figure 13, 14 or 15 comprises a housing 19' containing a signal processor 13 connected to an antenna 21 and to a power supply 12, and possibly to a microphone 14. It also comprises one or two magnetic parts 18 in correspondence with the magnetic parts 35 provided in the implantable portion to allow attachment of the external housing opposite the antenna 34. In the case of two magnetic parts, these latter are attached to a support
15 plate 20' with the housing'.

[0059] Figures 19 to 24 show variants of the invention including a passive (percutaneous) semi-implantable portion.

In Figures 19 and 20, the implantable portion 1f comprises a bent rod 2f having a bend angle and a length between the bend and its distal end intended to come into direct contact
20 with the inner ear, identical to that described in reference to Figures 1 and 2. The other end of the rod 2 is integral with an attachment means 41 such as a screw, intended to be attached to the patient's skull. The head of the screw 41 comprises an attachment profile 43 adapted to cooperate with a matching profile provided on an external housing 50, 50' shown in Figure 21 or 22. This housing contains a vibrator 11, and possibly a signal
25 processor 13 connected to the vibrator, and, as the case may be, to at least one microphone 14, as well as to a power supply 12 (Figure 22). In the example shown in Figure 21, the power supply 12 and the processor 13 are arranged in another housing 55 connected by an electrical connection to the housing 50.

[0060] The variant of the invention illustrated in Figures 23 and 24 makes it possible to treat patients who are entirely deaf in one ear. Near the entirely deaf ear, a screw 41 (Figure 24) is attached to the skull, making it possible to attach the housing 50' containing in particular the microphone, which enables vibrations to be generated, which are transmitted in the skull by bone conduction. Near the other ear, is attached the implantable portion 1g shown in Figure 23, which includes a rod 2f as described above, not integral with a screw as shown in Figure 19, but with means 45 for attaching the rod to the patient's skull, such as a wafer provided to receive a screw 46 intended to be screwed into the skull, with the end of the rod 2f being placed in contact with the non-defective inner ear, as shown in Figure 20. In this way, the sounds capable of being perceived by the defective ear are transmitted by the skull in the form of vibrations by bone conduction, then by means of the rod 2f directly into the non-defective inner ear.

Patentkrav

1. Protese til at stimulere det indre øre, hvor protesen omfatter excitationsmidler (11), der er indrettet til at frembringe vibrationer, der er i stand til at excitere en patients øre,
5 kendetegnet ved, at den indbefatter en implanterbar del (1, 1a to 1g), der omfatter en stang (2, 2a, 2c, 2f), der er i stand til at overføre vibrationer, hvilken stang er forsynet med en bøjning (4), og som er udformet til at være i stand til at overføre vibrationerne, der er frembragt af excitationsmidlerne (11), direkte til patientens indre øre, og ved at stangen (2, 2a, 2f) har en
10 længde mellem bøjningen (4) og dens ende, der er i kontakt med en del af patientens indre øre, der ligger indenfor et område fra 20 til 30 mm, og har en bøjningsvinkel mellem dens to endedele, der ligger indenfor et område fra 70° til 130°.
2. Protese ifølge krav 1,
15 kendetegnet ved, at stangen (2, 2a, 2c, 2f) er indrettet til at blive sat i kontakt med en halvrund kanal af patientens indre øre.
3. Protese ifølge krav 1 eller 2,
 kendetegnet ved, at stangen (2, 2a, 2c, 2f) er indrettet til at blive sat i kontakt med den udvendige halvrunde kanal af patientens indre øre.
- 20 4. Protese ifølge krav 2 eller 3,
 kendetegnet ved, at stangen (2, 2a, 2c, 2f) er fremstillet af et hårdt stift biokompatibelt materiale, der er valgt fra metal, plast og keramik.
5. Protese ifølge et hvilket som helst af kravene 1 til 4,
 kendetegnet ved, at stangen (2, 2a, 2f) har et tværsnit med en flad form.
- 25 6. Protese ifølge et hvilket som helst af kravene 1 til 5,
 kendetegnet ved, at overfladen af den implanterbare del (1) er behandlet for at forhindre osteointegration.
7. Protese ifølge et hvilket som helst af kravene 1 til 6,
 kendetegnet ved, at stangen (2a) er drejeligt monteret på en ramme (7, 7').
- 30 8. Protese ifølge et hvilket som helst af kravene 1 til 7,
 kendetegnet ved, at excitationsmidlerne (11) er anbragt i et udvendigt hus (10, 10', 10a) og er indrettet til at frembringe vibrationer, der er beregnet til at blive overført gennem patientens hud til en plade (3), der er forbundet til stangen (2, 2a).
- 35 9. Protese ifølge krav 8,

kendetegnet ved, at pladen (3) har en i det væsentlige rektangulær form med afrundede kanter med en længde, der ligger indenfor et område af 6 mm til 20 mm, og en bredde, der ligger indenfor et område fra 3 mm til 10 mm.

10. Protese ifølge krav 8 eller 9,

5 kendetegnet ved, at det udvendige hus (10, 10', 10a) er integreret i et objekt, der er indrettet til at blive båret på patientens hoved, således at excitationsmidlerne (11) er anbragt vendende mod pladen (3) af den implanterbare del (1).

11. Protese ifølge krav 10,

10 kendetegnet ved, at objektet, der er indrettet til at blive båret på patientens hoved, er udvalgt fra et par briller og et hus, der passer rundt om øret.

12. Protese ifølge et hvilket som helst af kravene 8 til 10,

15 kendetegnet ved, at det udvendige hus (10a) indbefatter i det mindste en magnetisk del (18), der er beregnet til at samvirke med i det mindste en magnetisk del (8), der er tilvejebragt i den implanterbare del (1a, 1b) for at holde excitationsmidlerne vendende mod pladen (3).

13. Protese ifølge et hvilket som helst af kravene 1 til 6,

kendetegnet ved, at excitationsmidlerne (11) er integreret i den implanterbare del (1c, 1d, 1e) og forbundet direkte til stangen (2c).

20 14. Protese ifølge et hvilket som helst af kravene 1 til 6,

kendetegnet ved, at stangen (2f) er forbundet til fastgørelsesmidler (41, 45, 46) til fastgørelse af stangen til patientens kranie.

15. Protese ifølge krav 14,

25 kendetegnet ved, at excitationsmidlerne (11) er anbragt inden i et udvendigt hus (50, 50'), der er forsynet med koblingsmidler (51), for at være aftageligt fastgjort gennem patientens hud til fastgørelsesmidler (41, 41'), der er beregnet til at blive fastgjort i patientens kranie.

16. Protese ifølge krav 15,

30 kendetegnet ved, at det udvendige hus (50, 50'), der indeholder en mikrofon (14), er beregnet til at blive fastgjort på den samme side en patients øre, der er helt defekt, hvorimod stangen (2f) er beregnet til at blive fastgjort for at excitere patientens andet øre, som ikke er defekt, hvor vibrationerne, der er frembragt af excitationsmidlerne, overføres til stangen ved knogleledning af patientens kranie.

35 17. Høreprotese,

kendetegnet ved, at den er i overensstemmelse med et hvilket som helst af kravene 1 til 16.

18. Protese til neurostimulation til behandling af tinnitus,
kendetegnet ved, at den er i overensstemmelse med et hvilket som helst af
kravene 1 til 17.

5 19. Protese til neurostimulation til behandling af balanceproblemer,
kendetegnet ved, at den er i overensstemmelse med et hvilket som helst af
kravene 1 til 18.

Fig. 1

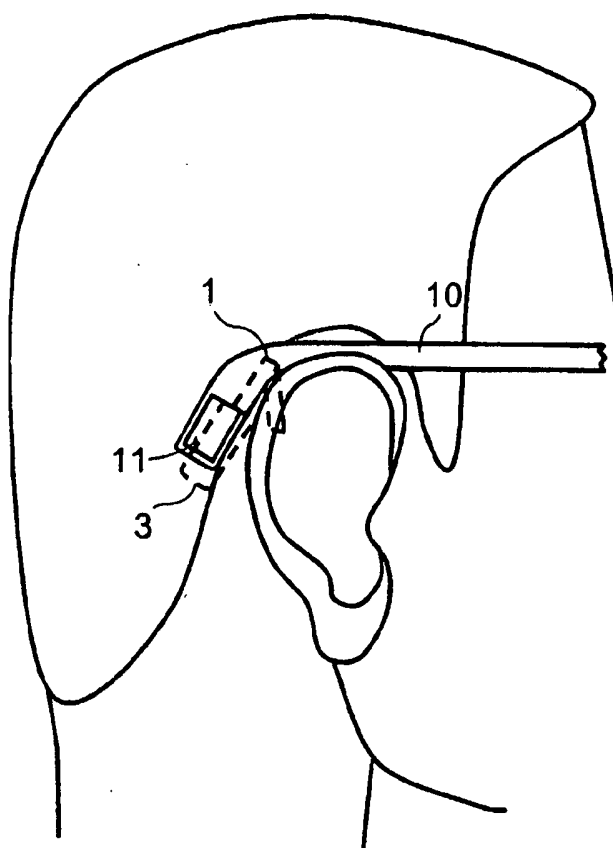


Fig. 2

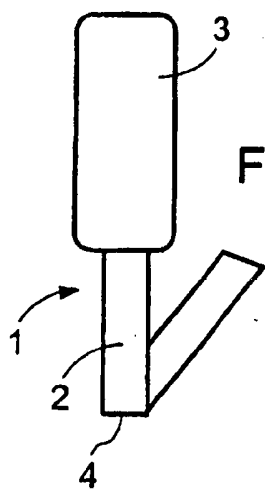


Fig. 3

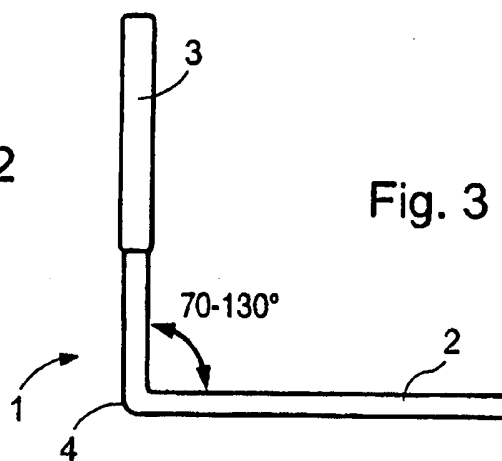
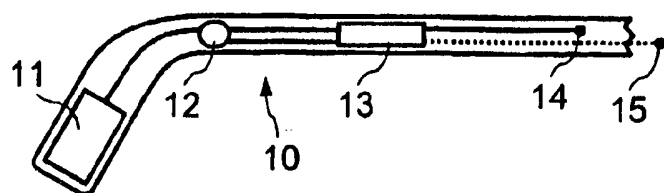


Fig. 4



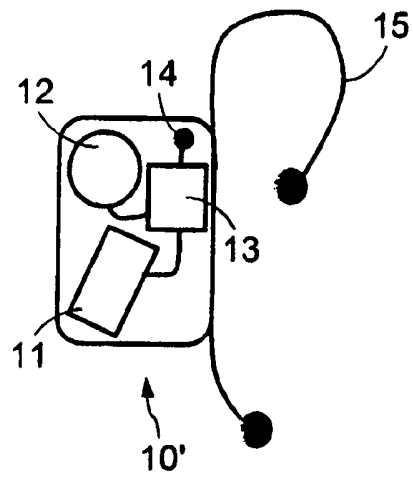


Fig. 5

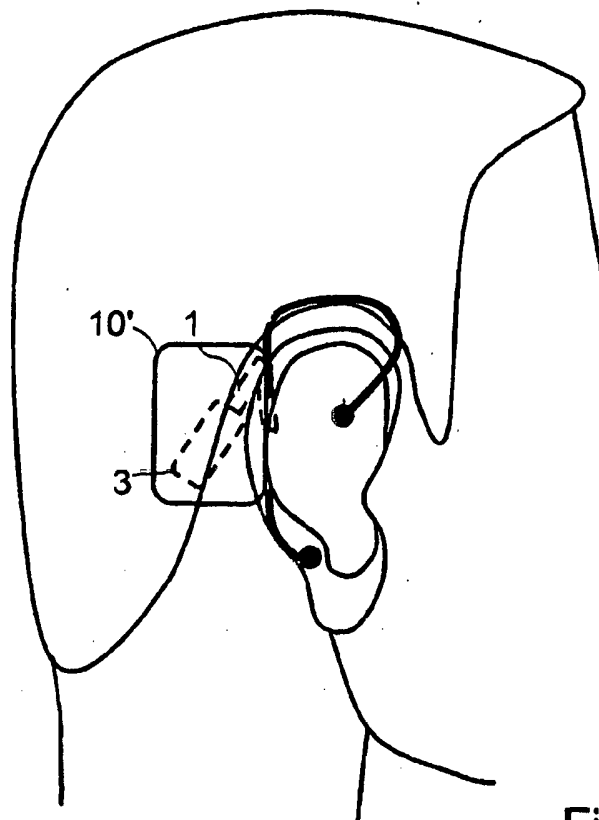
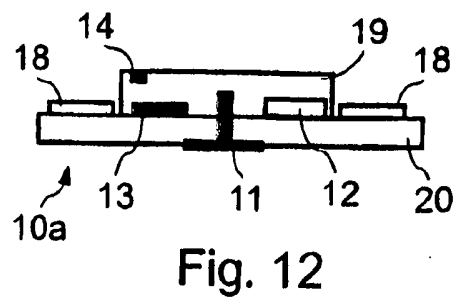
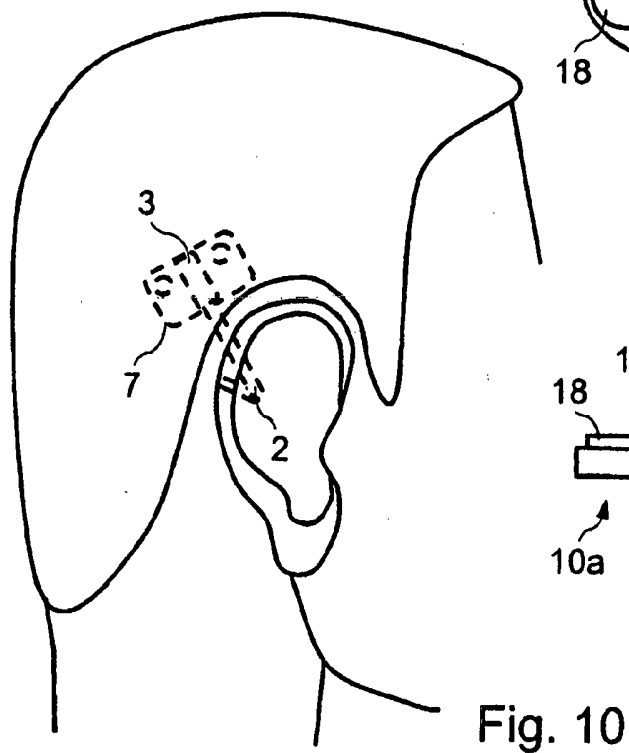
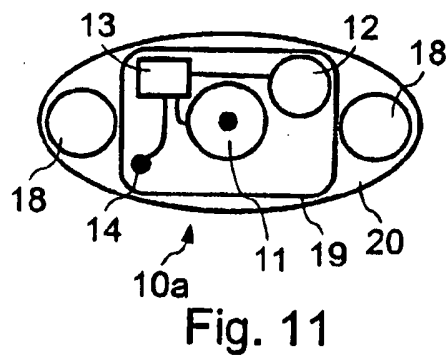
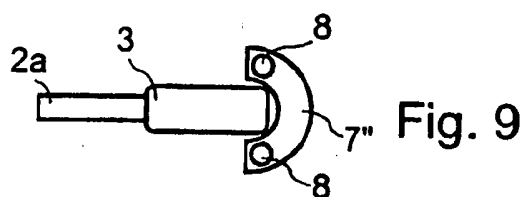
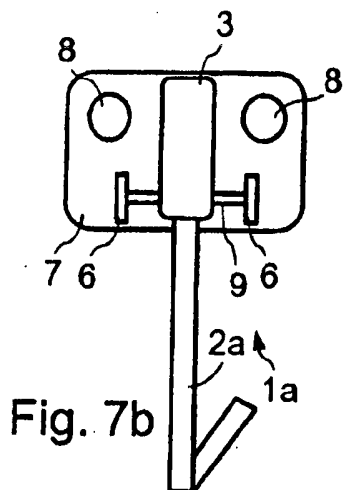
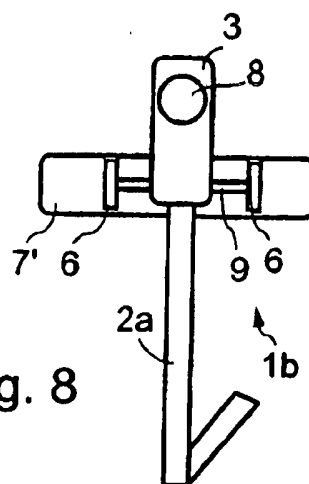
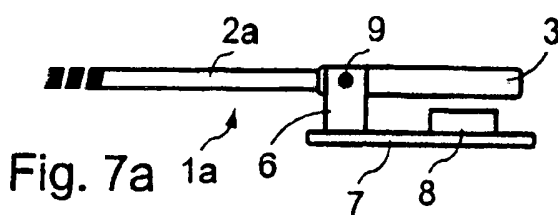


Fig. 6



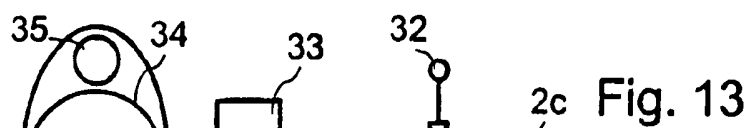


Fig. 13

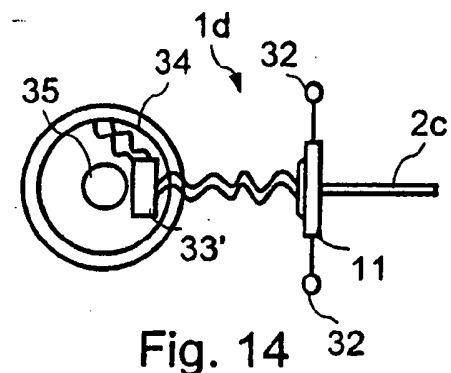


Fig. 14

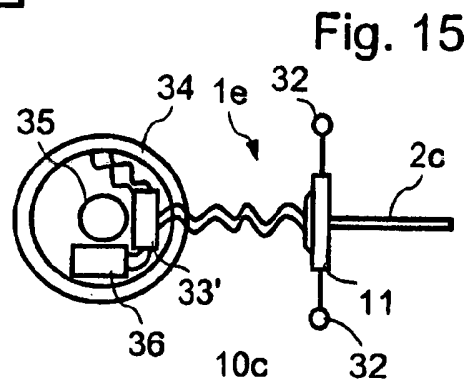


Fig. 15

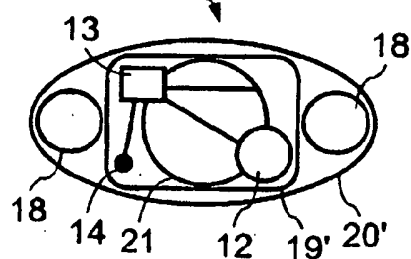


Fig. 17

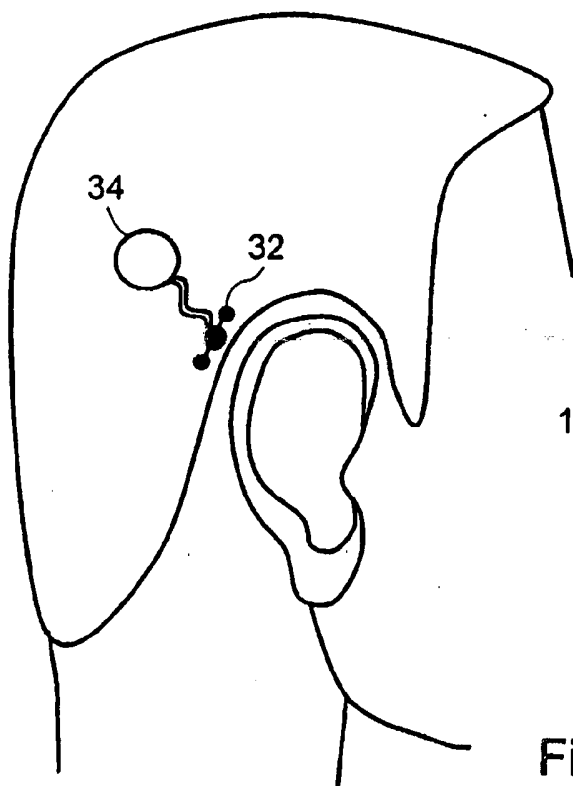


Fig. 16

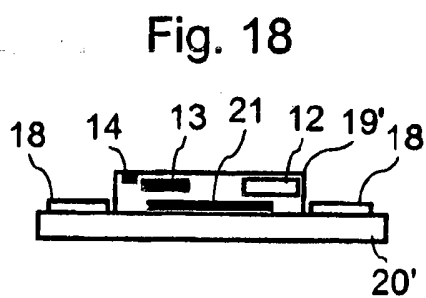


Fig. 18

