the contours of the outer surface of the ear plug are individually matched to at least part of the ear canal and the concha of the user, and wherein the ear plug is made of a dimensionally stable material for identical positioning in the ear canal each time it is inserted.

Thereby an ear plug is provided with which an improved contact between the user's ear canal and the electrodes and a very high degree of repeatability in the placement of the electrodes between individual measurement sessions is obtained in that the ear plug due to being individually matched will be positioned identically in the ear canal each time it is inserted. Thereby measurement uncertainties related to quantitative and qualitative variations due to changed electrode positions or insufficient contact may substantially be avoided.

As the ear plug according to the invention is individually matched it comprises surface convexities matching the concavities of the specific ear canal of the specific user to whom the plug is individually matched. This has several advantages. Firstly, there is one correct position of the ear plug in the user's ear canal only, and thus the ear plug is easy to insert and it is easy to determine when it is in its correct position. Secondly, the right and left ear plugs cannot be confused as each ear plug matches one specific ear canal. Furthermore, the ear plug according to the invention is firmly secured in the ear canal of the user substantially by friction alone, and produces no static pressure against the skin of the ear canal. Consequently, the ear plug according to the invention is very well suited for long term use, e.g. for use during the night, as the long term inconveniences caused by the static pressure against the skin of the ear canal in conventional ear plugs are eliminated. Also, the ear plug according to the invention is very well suited for use by children and other persons who cannot insert the plug into their ear canal themselves as the plug is very easy to insert and as it is easy for an assisting person to determine when the plug is in proper place. Also, the ear plug according to the invention will not fall out of the ear canal during physical activity.

Individually matched ear plugs are widely known and used within the hearing aid industry as completely-in-canal (CIC), in-the-ear (ITE) or as the ear plug of a behind the ear (BTE) hearing aid. For instance WO-A1-92/11737 describes a technology for preparing such ear

electrode size and obtaining sufficient separation between the individual electrodes. Sufficient separation between electrodes is of great importance to ensure that the signals obtained by two neighbouring electrodes are not mutually affected; either through the electrodes or through the tissue area on which the electrodes are placed.

The at least two electrodes are provided to the shell of the ear plug by means of a technique chosen from the group consisting of Physical Vapour Deposition (PVD), sputtering, a printing technique such as pad-printing and an inkjet technique using conductive ink. These methods are preferred, as they are methods proven to be particularly useful and efficient for placing a metallic material on a surface, here being the shell of an ear plug.

An alternative method for providing a surface with a metallic layer is known from EP-B1-1587343 describing how to provide a behind-the-ear component of a hearing aid with a high frequency antenna or a coil for transmitting electromagnetic energy or data.

Another alternative method is described in EP-B1-1351551 and is known as MID (Moulded Interconnect Device) moulding. In MID moulding the moulding material, such as a plastic, is provided with metallic beads, such as Silver-Palladium (Ag-Pa). When a structure has been moulded, the Ag-Pa beads may be activated, e.g. by laser. When subsequently providing a metallic layer to the surface of the structure, the metallic layer will be confined to the activated areas, and the activated areas may furthermore be used as conductors for transmitting an electrical signal from the metallic layer.

According to a second aspect of the invention, a system comprising an ear plug and at least one electrode, the ear plug and the electrode being individually matched to at least part of the ear canal and the concha of the user and made of a dimensionally stable material, ~~the ear plug having at least one electrode for measuring brain wave signals~~ and a behind-the-ear (BTE) component, where the BTE component accommodatinges ~~said~~ means for processing the brain wave signals, is provided.

According to a preferred embodiment, the BTE component comprises at least one electrode for measuring brain wave signals.

Preferably, the ear plug of the system is an ear plug according

to any one embodiment of the first aspect of the invention.

According to a third aspect of the invention, there is provided a method of producing an ear plug with surface electrodes for measuring brain wave signals comprising the steps of, tracing the shape of a part of the user's ear canal and concha, converting the traced shape into a digital form such as a three dimensional computer model and building the ear plug based on the computer model by means of a computer controlled production process, wherein at least one electrode is placed individually according to the shape of the user's outer ear.

According to a further preferred embodiment the at least one electrode is placed individually according to the shape of the user's outer ear.

Also disclosed is ~~further aspect of~~ a method of~~according to the invention includes~~ producing an ear plug as described above, preferably using Stereolithography (SLA), Selective Laser Sintering (SLS), Fused Deposition Modelling (FDM) or similar printing techniques, the method comprising the steps of providing a shell provided with a surface having contours being individually matched to the contours of the ear canal of a user, the shell being comprised of a dimensionally stable material, and comprising the further step of providing on and/or in a surface of said shell at least two electrodes adapted for detecting electrical signals such as brain waves.

The ~~Another further aspect of a~~ method may~~according to the invention~~ include~~s~~ one or more of the further steps of:

- providing connecting means connecting the at least two electrodes with means for processing electrical signals;
- providing each of the at least two electrodes with a shape following the local contours of the shell at the electrode; and
- providing the ear plug with means for processing electrical signals and/or means for taking an action in response to an output of said means for processing electrical signals.

The~~Another further aspect of a~~ method may~~according to the invention~~ include~~s~~ that the step of providing said connecting means comprises

providing conductive wiring drawn in and/or through said shell of said ear plug and/or comprises providing a pin or a rivet extending through at least a part of said shell of said ear plug in such a way that a part, such as a head, of said pin or rivet is arranged flush with or on said surface of said shell.

TheYet another further aspect of a method mayaccording to the invention includes that the step of providing said at least two electrodes is performed by means of a technique chosen form the group consisting of Physical Vapour Deposition (PVD), sputtering, a printing technique such as pad-printing and an inkjet technique using conductive ink.

The invention will now be described in further detail based on a non-limiting exemplary embodiment, and with reference to the drawings. In the drawings,

fig. 1 shows the system of an ear plug together with a BTE component

fig. 2 shows an ear plug according to the invention,

fig. 3 shows a cross section of the outer ear of the human ear,

figs. 4A, 4B, 5A and 5B show cross sectional views of four different embodiments of an electrode and connecting means of an ear plug according to the invention,

fig. 6 is a diagram showing an embodiment of the electronics of an ear plug according to the invention, and

fig 7 shows an embodiment of the ear plug in a monitoring device.

Fig. 1 shows an example of a use of an ear plug according to the invention in a system with a behind-the-ear (BTE) component. The system comprises a BTE-component 101, an ear plug 103 according to the invention for insertion in the ear canal of a user, the ear plug 103 thus constituting an in-the-ear (ITE) component, and a connection means 102 for connecting the BTE-component 101 and the ear plug 103. The ear plug 103 comprises a surface and a connection opening 104. In one embodiment of the invention, the shown system could be a hearing aid.

The opening 104 is in one embodiment of the system an opening for a receiver of a hearing aid. The receiver is placed in an ear plug

P A T E N T C L A I M S

1. An ear plug comprising a shell with at least two electrodes adapted for measuring brain wave signals, said electrodes being connected with means for processing the measured signals, c h a r a c t e r i z e d in that the contours of the outer surface of the ear plug and the electrodes are individually matched to at least part of the ear canal and the concha of the user, wherein the ear plug is made of a dimensionally stable material capable of maintaining a particular shape for identical positioning in the ear canal each time it is inserted.

2. An ear plug according to claim 1 or 2, wherein the means for processing said measured signals is adapted for delivering a signal to the user.

3. An ear plug according to any one of claims 1 to 3, wherein the means for processing is located external to the ear plug.

4. An ear plug according to any one of claims 1 to 3, wherein the means for processing is located inside the ear plug.

5. An ear plug according to any one of the preceding claims wherein the connecting means comprise a wiring drawn in or through said shell of the ear plug.

6. An ear plug according to claim 6, wherein the conductive wiring is arranged to form at least part of one of the electrodes.

7. An ear plug according to any one of the preceding claims, wherein the ear plug further comprises a pin or a rivet extending between said electrode and said connecting means through at least a part of said shell of said ear plug in such a way that a part, such as a head, of said pin or rivet is arranged flush with or on said surface of said shell.

8. An ear plug according to claim 8, wherein said part, e.g. the head, of said pin or rivet, being arranged flush with or on said surface of said shell is adapted to form or accommodate said at least one electrode.

9. An ear plug according to anyone of claims 1 to 7, wherein the ear plug comprises at least one recess in which the at least one electro-

de is mounted, the bottom surface of the recess following the contours of the outer surface of the ear plug.

10. An ear plug according to claim 10, wherein the electrode is held in the recess by the electrode comprising at least one of a close fit to the recess, at least one convexity corresponding to at least one concavity provided in the recess and an adhesive.

11. An ear plug according to claim 10 or 11, wherein the electrode is made of an electrically conductive flexible material, preferably an electrically conductive silicone.

12. An ear plug according to anyone of claims 1 to 11, wherein the electrodes are polarizable electrodes, preferably made of an alloy, such as stainless steel or platinum-iridium, or of a noble metal such as silver, titanium, platinum or tungsten.

13. An ear plug according to anyone of claims 1 to 11, wherein the electrodes are non-polarizable electrodes, preferably Ag/AgCl electrodes.

14. An ear plug according to anyone of the preceding claims, wherein each of the electrodes covers an area of at least 1 mm^2, preferably between 1 mm^2 and 30 mm^2.

15. An ear plug according to any one of the preceding claims, wherein said ear plug is a part of a hearing aid.

16. An ear plug according to any one of the preceding claims, wherein the processing of said brain wave signals provides information for detecting a medical condition of the user.

17. A system comprising an ear plug and at least one electrode, the ear plug being individually matched to at least part of the ear canal and the concha of the user and made of a dimensionally stable material capable of maintaining a particular shape, the electrode being adapted for measuring brain wave signals and individually matched to at least part of the ear canal and the concha of the user , and a behind-the-ear (BTE) component, where the BTE component accommodates said means for processing the brain wave signals.

18. A system according to claim 18, wherein the BTE component comprises at least one electrode for measuring brain wave signals.

19. A method of producing an ear plug with surface electrodes for measuring brain wave signals comprising the steps of, tracing the shape of a part of the user's ear canal and concha, converting the traced shape into a digital form such as a three dimensional computer model and building the ear plug based on the computer model by means of a computer controlled production process, wherein at least one electrode is individually matched to at least part of the ear canal and the concha of the user.

P A T E N T C L A I M S

1. An ear plug comprising a shell with at least two electrodes adapted for measuring brain wave signals, said electrodes being connected with means for processing the measured signals, wherein the contours of the outer surface of the ear plug are individually matched to at least part of the ear canal and the concha of the user, and wherein the ear plug is made of a dimensionally stable material for identical positioning in the ear canal each time it is inserted.

2. The ear plug according to claim 1, wherein the means for processing said measured signals is adapted for delivering a signal to the user.

3. The ear plug according to claim 1 or claim 2, wherein the means for processing is located external to the ear plug.

4. The ear plug according to any one of claims 1 to 3, wherein the means for processing is located inside the ear plug.

5. An ear plug according to any one of claims 1 to 4, wherein the connecting means comprises a wiring drawn in or through said shell of the ear plug.

6. The ear plug according to claim 5, wherein the wiring is arranged to form at least part of one of the electrodes.

7. The ear plug according to any one of claims 1 to 6, comprising a rivet extending between said electrode and said connecting means through at least a part of said shell of said ear plug in such a way that a part, such as a head, of said pin or rivet is arranged flush with or on said surface of said shell.

8. The ear plug according to claim 7, wherein said part of said pin or rivet is adapted to form or accommodate said at least one electrode.

9. The ear plug according to any one of claims 1 to 6, comprising at least one recess in which the at least one electrode is mounted, the bottom surface of the recess following the contours of the outer surface of the ear plug.

10. The ear plug according to claim 9, wherein the electrode is held in the recess by the electrode comprising at least one of a close fit to the recess, at least one convexity corresponding to at least one concavity provided in the recess, and an adhesive.

11. The ear plug according to claim 9 or 10, wherein the electrode is made of an electrically conductive flexible material, preferably an electrically conductive silicone.

12. The ear plug according to any one of claims 1 to 11, wherein the electrodes are polarizable electrodes made of a material comprising at least one of stainless steel, platinum-iridium, silver, titanium, platinum and tungsten.

13. The ear plug according to any one of claims 1 to 12, wherein the electrodes

are non-polarizable electrodes, preferably Ag/AgCl electrodes.

14. The ear plug according to any one of claims 1 to 13, wherein each of the electrodes covers an area of at least 1 mm^2, and no more than 30 mm^2.

15. The ear plug according to any one of claims 1 to 14, wherein said ear plug is a part of a hearing aid.

16. The ear plug according to any one of claims 1 to 15, wherein the processing of said brain wave signals provides information for detecting a medical condition of the user.

17. A system comprising an ear plug and at least one electrode , the ear plug and the electrode being individually matched to at least part of the ear canal and the concha of the user and made of a dimensionally stable material, and a behind-the-ear (BTE) component, where the BTE component accommodating means for processing brain wave signals.

18. The system according to claim 17, wherein the BTE component comprises at least one electrode for measuring brain wave signals.

19. A method of producing an ear plug with surface electrodes for measuring brain wave signals comprising the steps of, tracing the shape of a part of the user's ear canal and concha, converting the traced shape into a digital form such as a three dimensional computer model, and building the ear plug based on the computer model by means of a computer controlled production process, wherein at least one electrode is placed individually according to the shape of the user's outer ear.