

Behind-the-ear hearing aid

The present invention relates to a behind-the-ear hearing aid according to the preamble of claim 1.

The primary object of the invention is to optimally exploit the space available in such a hearing aid and thereby at the same time to improve its acoustic properties. This is achieved in the design of the hearing aid according to the characterizing clause of claim 1. Accordingly, the electric/acoustic transducer unit includes at least one loudspeaker with a membrane built into a loudspeaker housing. The loudspeaker housing is spring-mounted in a capsule, the latter defining an intermediate space with the loudspeaker housing. The first space defined by the membrane in the loudspeaker housing is coupled to the acoustic output of the hearing aid, and the second space defined by the membrane in said housing is coupled to said intermediate space via at least one opening in the housing.

In this way, the intermediate space to be provided anyway between hearing-aid housing and loudspeaker housing is used practically completely as a space for improving the acoustic behavior of the hearing aid. It was found that providing said intermediate space

increases the bass range by several dB. By means of the intermediate space created, the acoustically effective space to the rear side of the membrane is increased by a multiple.

In a preferred embodiment, the capsule is used as a magnetic shield and for this purpose is preferably made of μ -metal.

Extremely simple assembly and disassembly, in particular of the loudspeaker housing with loudspeaker, is achieved by the fact that the capsule includes a cup, preferably a metal one, which on one side, namely the open side of the cup, is fixed on the hearing-aid housing, for example snapped on.

By virtue of the fact that the loudspeaker housing is also substantially cube-shaped and is tensioned along four of its parallel edges by means of elastic mounting blocks in relation to the capsule, an extremely simple and substantially floating bearing is obtained for the loudspeaker housing.

The transducer unit is also preferably introduced into the hearing-aid housing with a form fit and makes electrical contact without solder points. As has been mentioned, the capsule is in this case fitted

releasably on the housing. In a preferred embodiment, the capsule and the loudspeaker housing form a resonance space which substantially encloses the latter on all sides.

The invention, or the behind-the-ear hearing aid according to the invention, is explained in an illustrative manner below with reference to figures which show a presently preferred embodiment of said hearing aid.

Fig. 1 shows, in a simplified longitudinal section, a behind-the-ear hearing aid according to the invention;

Fig. 2 shows a perspective representation of the hearing aid according to the invention;

Fig. 3 shows a perspective representation of the preferred design of a battery compartment lid on the hearing aid according to the invention;

Fig. 4 shows the top view of the lid according to Fig. 3 with areas for left/right ear coding;

Fig. 5 shows a perspective representation of, on the one hand, the main housing of the hearing aid according to the invention and, on the other hand, an add-on

module which is or can preferably be provided;

Fig. 6 shows an enlarged representation of the electric/acoustic transducer unit on the hearing aid according to the invention as per Fig. 1;

Fig. 7 shows a simplified and schematic representation of an actuating member preferably provided on the hearing aid according to the invention, and

Fig. 8 shows a schematic representation of the unit according to Fig. 6 in order to illustrate the acoustic couplings.

The behind-the-ear hearing aid according to the invention is represented in its entirety in Fig. 1, in a partially simplified longitudinal section, and its individual operational blocks or operational parts will be described first. The hearing aid 1 comprises a tubular main body which is curved in a horn shape, with a center axis A, and which has, acting as acoustic output at the thinner, curved end, a connector piece 5 for a coupling tube leading into the ear. The connector piece 5 is exchangeably pushed or screwed onto a tubular piece 9 which sits on a main housing 3.

The inner channel 7 of the connector piece 5 continues

through the tubular piece 9 into a transfer channel 11 in the main housing 3. The transfer channel 11 is in turn coupled to an electric/acoustic transducer arrangement 15 in a section 13 of the main housing 3.

As can be seen from Fig. 1, the transfer channel 11 extends along the inner curvature of the main housing 3 in such a way that there is space for a microphone unit 17 on the side of the outer curvature. A lid 19 is formed integrally on the main housing 3 in this area, and it is stopped by means of a pin shaft 21 in the region of the maximum point of the curve of the hearing aid. As can be seen in particular in Fig. 2, the lid 19 extends along generatrices M of the hearing-aid body as far as (Fig. 1) the area of the electric/acoustic transducer unit 15. The microphone unit 17 is accessible on removal of the hinged lid 19 and preferably makes electrical contact only at a flexprint strap (not shown), is closed over the transfer channel 11 and rests against an acoustic input slot 23.

When the lid 19 is closed, at least two microphone apertures of the microphone unit 17 lie opposite an insert 25 in a slot 23 of the lid 19. The insert 25 is acoustically "transparent" and has a multiplicity of passages between the environment U and a compensating volume V, the latter being left free between the

discrete microphone inlet apertures (not shown) and said insert. The insert 25 is preferably made of a sintered material, in particular of sintered polyethylene, and is also preferably provided with a water-repellant coating. It also forms a mesh fineness of between 10 μm and 200 μm , with an open-pore rate of preferably above 70%. Moreover, the microphone unit 17 and the insert 25 in the slot 23 are arranged in the hearing aid 1 in such a way that, when the hearing aid is being worn, they are shielded as far as possible from any dynamic air pressure of the environment U by being positioned, as can be seen from Fig. 1, in the area of the apex of the horn-shaped curved tubular main body. In particular, as regards the embodiment of an acoustic/electric transducer with directional characteristics using the abovementioned at least two mutually spaced microphones, the gap volume V, entailing a common mode suppression, tends to cancel identical acoustic signals differently coupled-in along the insert 25 on account of the compensating effect of the volume V.

The insert 25 also acts as a shield against soiling and, by virtue of its preferred water-repellant coating, can be easily cleaned.

A further advantage of the insert 25 with its

multiplicity of through-openings is, closely linked to the aspect of the aforementioned common mode suppression, that any soiling will affect both microphones equally and, as a result, the directional characteristics will not be adversely affected, something which represents a central problem in conventional directional microphones with two or more discrete apertures.

Regarding this insert 25 and its effects, reference is made to EP-A-0,847,227 of the same Applicant.

In the main housing 3, the electric/acoustic transducer arrangement 15 is followed by an electronics unit 27, then by a battery compartment 29. An actuator switch 31 is provided on the outside of the main housing of the hearing aid, in the area between battery compartment 29 and electronics unit 27. The connector piece 5, the main housing 3, the lid 19 with acoustic input slot 23 and insert 25, and the actuator switch 31 can be seen particular clearly in the perspective representation of Fig. 2.

Battery compartment

In the battery compartment 29 formed in the end of the main housing 3, a cylindrical flat battery or a

correspondingly shaped accumulator 33 is inserted in such a way that the axis of the battery cylinder, with its end faces 33_u and 33_o, lies at least substantially coaxial to the longitudinal axis A of the main body.

Provided on the base 30 of the battery compartment 29, and centered on the axis A, there is a first spring-loaded contact 35, and a second one 37 is in resilient contact with the side surface of the battery 33. The battery compartment 29 can be closed by a lid 39 which in the closed position is transverse to the axis A and which is mounted in a pivotable or bayonet-lock manner on the main housing 3, at 41, or on the battery compartment 29.

This transverse arrangement of the battery 33 in the hearing aid affords considerable advantages: The surface closed off by the lid 39 is relatively large, and this can be exploited still further, as will be explained below. Because the battery compartment lid 39 is arranged at the deepest part of the hearing aid and the lid areas abutting the main housing 3 lie transverse to the axis A, penetration of perspiration into the battery compartment is hardly critical. Moreover, in this design of the battery compartment, the contacts 37 and 35 are protected inside the compartment, and the lid 39 has no electrical contacts.

Also, because the substantially cylindrical interior of the main body 3 is fully exploited, there is practically no space left unused.

Fig. 3 shows a perspective representation of a preferred embodiment of the battery compartment lid 39, designed as a hinged lid. With the snap-on hinge part 43, it can be easily released from or snapped into the pivot bearing 41 according to Fig. 1. In a preferred embodiment, it also has a lock 45 and in addition a resilient pawl 46.

Fig. 4 shows an outside view of the lid 39 according to Fig. 1. The lock 45 can be operated from the outside only using a tool, for example a screwdriver, and for this purpose it has an engagement slot 49 on a rotary disk 47. The disk 47, which is integrated in the hinged lid 39 only when the lock 45 is installed, is colored in a specific manner, in two ways, for example red and blue, so that this part at the same time serves as an indicator of whether the particular hearing aid is for the left ear or right ear.

As has been stated, the represented embodiment of the battery compartment 29, in particular the fact that the flat cylinder of the battery lies coaxial to the axis A of the hearing aid, has a further important advantage.

The hearing aid shown in Fig. 1 effectively represents a basic configuration.

It is often desirable to equip this basic configuration with add-on options, for example with an interface unit for wireless signal transmission, a programming plug-in unit, a further audio input, a larger accumulator compartment, a mechanical actuator unit, etc. To this end, the battery compartment shown in Fig. 1 is redesigned as shown in Fig. 5. The battery 33 is removed from the compartment and in its place the plug-in part 34 of a corresponding add-on module 51 is inserted and is made to electrically contact at the contacts 35a and 37a corresponding to the battery contacts.

Regarding the use of such add-on modules, it is readily possible to provide further contacts in the compartment 29.

The compartment 29a now acting as the actual battery compartment, with the battery 33, is now provided on the add-on module 51, and, likewise, the lid 39, which is removed for example from the main housing 3, is snapped onto the add-on module or locked onto it in the manner of a bayonet lock. If appropriate, several such modules 51 can be stacked onto the basic module of the

hearing aid represented in Fig. 1. The add-on modules 51 are in each case fixed preferably with a locking part 43a provided on the modules 51 and analogous to the hinge part 43 on the hinged lid 39, and with a snap-in part 46a designed analogously to the snap-in part 46 on said hinged lid 39, or, in the case of bayonet locking, by appropriate insertion and rotary locking.

In this way, the hearing aid can be built up in modular fashion in an extremely simple way and in the manner desired, and the battery and accumulator 33 are at all times readily accessible from outside.

Electric/acoustic transducer arrangement

Fig. 6 shows, in a simplified manner, the design and the support of the abovementioned arrangement 15 on the main housing 3 and in a view according to Fig. 1. The arrangement 15 comprises, encapsulated in a loudspeaker housing 53, the loudspeaker arrangement (not shown) with a loudspeaker diaphragm. By way of coupling apertures indicated schematically at 55, the acoustic waves generated by the loudspeaker diaphragm are coupled from the diaphragm-side space in the loudspeaker housing 53 into the surrounding space U_{53} of the loudspeaker housing 53. From the space on the front

side of the diaphragm, the acoustic signals are coupled, as indicated by the arrow S, into the transfer channel 11 shown in Fig. 1.

The loudspeaker housing 53 is supported on all sides in a substantially freely vibrating manner in resilient and preferably rubber-elastic bearings 57. The relatively large space U_{53} is defined, by the supports 57, between the outer wall of the loudspeaker housing and a capsule 59, said large space significantly enhancing the bass tones. The resonance chamber on the reverse side of the diaphragm is increased by a multiple by the space U_{53} . To ensure that the space U_{53} is acoustically effective about its entire circumference, the capsule 59 and its support 61 are tightly connected.

In this way, the storage volume for the loudspeaker arrangement is used to the optimum extent acoustically. The capsule 59 also preferably acts as a magnetic shield housing and for this purpose is preferably made of μ -metal. It is beaker-shaped and is hooked sealingly in the form of a plastic bearing part into the support 61. The abovementioned resilient and preferably rubber-elastic bearings 57 are tensioned between capsule 59 and support 61, on the one hand, and the loudspeaker housing 53.

The acoustic coupling discussed above is shown in purely diagrammatic terms in Fig. 8. The diaphragm 54 of the loudspeaker in the housing 53 defines, in said housing, a first space R_1 , which is coupled to the acoustic output of the hearing aid, as indicated by S, and a second space R_2 which is coupled via one or more openings 55 to the space U_{53} formed between capsule 59 and housing 53.

Actuator switch 31

Fig. 7 shows a preferred embodiment of the actuator switch 31, in a simplified and diagrammatic representation. The actuator switch 31 comprises a toggle key 63 which is mounted in a tilting manner on one side, at 65.

The toggle support 65 is formed integrally on a slide 67 which, as is shown by the double arrow F, is mounted so as to be displaceable linearly with respect to the main housing 3. As is shown diagrammatically by the spring contact 69, fixed in relation to the main housing 3, and the bridging contact 70 on the slide 67, the hearing aid is switched on and off by pushing the slide to and fro via the key 63.

A continuous channel 72 is formed in the slide 67, and a contact pin 73 fixed to the housing 3 protrudes through this channel. This contact pin is covered by a resilient contact part 75 which is arranged on the slide 67 and which as a keypad element is preferably made of rubber-elastic and at least partially electrically conductive plastic, as is known for example from remote-control keyboards. When toggling the toggle key 63, as is indicated by the double arrow K, the contact part 75 comes into contact with the contact pin 73 and establishes an electrical connection between these elements. Although a number of possible electrical connections suggest themselves to the skilled person, including the switching path S_1 , actuated by the slide motion F, and the switching path S_2 , actuated by the toggle movement K of the toggle key 63, it is preferable, as is indicated by broken lines in Fig. 7, to connect the spring contact 69 to the hearing-aid battery 33, the bridging contact 70 to the contact part 75, and the contact pin 73 then acts as an electrical output of the switch arrangement.

The actuator switch 31 thus acts both as an on/off slide switch and additionally, in the on position, as a toggle switch, as a result of which the electronics unit 27 according to Fig. 1 can be acted on in steps, for example for rapid individual adjustment of

amplification.

Accordingly, the actuator switch 31 combines two functions, namely slide switch and toggle switch, which combination of functions is highly advantageous in particular for the behind-the-ear hearing aid according to the invention. The operational differential ensures that there is no confusion of the functions, which confusion is substantially more critical if two switches are provided for said two functions.

Structure of the housing 3

As can be seen in particular from Fig. 5, the main housing 3 is formed by a curved and correspondingly shaped tubular part. In a preferred embodiment, this part 3 is made in one piece, preferably of plastic, but unlike the conventional structure of such hearing aids it cannot be separated into two shells along generatrices indicated by M in Fig. 5. In this way, the assembling of the individual units into the main housing 3 is also defined: They are simply introduced into the tube, which is much easier than assembling on opened shells. A further advantage of a tubular one-piece embodiment is its much greater stability compared to a divided housing. It is thus possible to reduce the thickness of the housing wall and in so doing to reduce

its size, or, for a given outer volume, to increase the useful internal volume.

Advantages of the overall configuration

Referring to Fig. 1, it is clear, particularly from the preferred one-piece design of the main housing 3, that the individual structural units, in particular 11, 15, 27, 29 and/or 51, are assembled by being pushed axially and sequentially into the main housing 3. The shape of the housing 3 with its corresponding guides thereby ensures rapid and exact positioning, the mutual electrical contact between the electrically powered units being solder-free and effected by means of spring-loaded contacts. Thus, the units to be provided can be pre-tested and dimensioned and thereafter assembled without any fear of their being damaged. This assembling can be easily automated. The entire housing including main housing 3 and lid 19, if appropriate 39, fitted with appropriate seals at the contact zones, can be easily sealed off.

The preferred embodiment of the electric/acoustic transducer arrangement 15 ensures optimum magnetic shielding of the loudspeakers and optimum acoustic shielding in respect of hearing-aid acoustics.

Patent Claims:



1. A behind-the-ear hearing aid with a hook-shaped curved hearing-aid body substantially along a similarly curved longitudinal axis (A) of the hearing aid, in which acoustic/electric transducers (17), electric/acoustic transducers (15) and electronics units (27) are integrated, the electric/acoustic transducer unit (15) having at least one loudspeaker with membrane built into a loudspeaker housing (53), characterized in that this housing (53) is spring-mounted in a capsule (59) which defines an intermediate space (U_{53}) with the loudspeaker housing (53), a first space in the housing (53) on one side of the loudspeaker membrane (54) being coupled to the acoustic output (5) of the hearing aid, and a second space in the housing (53) on the other side of the membrane being coupled to the intermediate space (U_{53}).
2. The hearing aid as claimed in claim 1, characterized in that the capsule (59) acts as a magnetic shield and for this purpose is preferably made of μ -metal.
3. The hearing aid as claimed in either of claims 1 and 2, characterized in that the capsule (59)



comprises a cup which on one side is fixed on the hearing-aid housing (3).

4. The hearing aid as claimed in one of claims 1 through 3, characterized in that the loudspeaker housing (53) is substantially cube-shaped and is tensioned along four of its parallel edges by means of elastic mounting blocks (57) in relation to the capsule (59).
5. The hearing aid as claimed in one of claims 1 through 4, characterized in that the transducer unit (15) is introduced into the hearing-aid housing (3) with a form fit and makes electrical contact without solder points.
6. The hearing aid as claimed in one of claims 1 through 5, characterized in that the capsule (59) is fitted releasably on the housing (3) of the hearing aid.
7. The hearing aid as claimed in one of claims 1 through 6, characterized in that the capsule (59) and the loudspeaker housing (53) define an intermediate space (U) which substantially encloses the latter on all sides.