(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 835 987 A1**

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
11.02.2015 Bulletin 2015/07

(51) Int Cl.:
H04R 25/00 *(2006.01)*

(21) Application number: **13196025.4**

(22) Date of filing: **06.12.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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(54) Hearing aid having controllable vent

(57) A hearing aid (44) is disclosed. The hearing aid (44) comprises an earpiece (46) for insertion into the ear canal of the user of the hearing aid (44). A through-going vent (2) is provided in the earpiece (46) and a receiver (36) is provided in the earpiece (46). The hearing aid (44) comprises activation means (20, 36, 42) for automatically changing the acoustical impedance of the vent (2). Hereby it is possible to provide a hearing aid (44) having a limited occlusion effect and limited acoustic feedback.

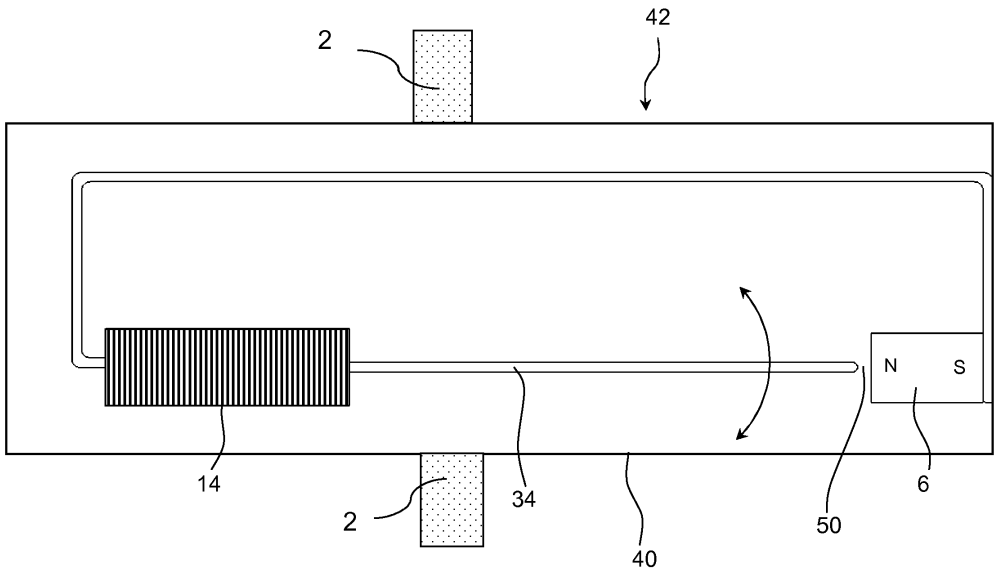


Fig. 4

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Description

Field of invention

[0001] The present invention generally relates to a hearing aid. The present invention more particularly relates to a hearing aid that is configured to reduce the acoustical feedback and occlusion effects for hearing aid users.

Prior art

[0002] The following account of the prior art relates to one of the areas of application of the present application, air conduction hearing aids.

[0003] Acoustic feedback problems in hearing aids are difficult to avoid, since the hearing aid microphone must be arranged next to the ear drum in order to preserve a recorded sound signal as it would have been perceived naturally by the user. The hearing aid loudspeaker transmits an output signal to the ear drum of the user. In practice, the microphone will normally pick up the loudspeaker signal as a feedback signal.

[0004] Some types of hearing aids comprise an earmould or a hearing aid shell to be placed in the user's ear canal. One of the challenges associated with these types of hearing aids is the acoustic leaks between the earmould (or the hearing aid shell) and the ear canal.

[0005] The unpleasant feeling of a closed ear canal is also referred to as occlusion effect (or just occlusion). To avoid occlusion, a ventilation channel referred to as vent is typically used on the earmould or the hearing aid shell. Alternatively, an open dome solution which allows the ear to remain partially open can be applied.

[0006] It is known from the prior art to insert a valve in a venting channel to allow a modification of its properties. EP2071872A1 describes one such solution wherein a valve is connected to a servo device allowing movement of the valve and a consequent variation of the acoustic attenuation of the channel.

[0007] The impulse response of feedback paths in a hearing aid is determined by the acoustic leaks, the vent size, parameters of the microphones and loudspeakers including the amplification circuits.

[0008] Hearing aid users are often suffering from occlusion effects but at different levels. Occlusion occurs when noises generated by the hearing aid user (e.g. chewing cornflakes or talking) are amplified as the hearing aid seals the inner ear. Occlusion can be reduced by use of vents in the hearing aid, but too large a vent will affect the effective hearing aid gain as well as provoke acoustical feedback.

[0009] Hearing aids that are provided with a vent are subjected to acoustical feedback as the vent allows the amplified sound from the hearing aid receiver to escape and couple to the hearing aid microphone(s).

[0010] An open fitting (dome or mould with a large vent) supports high listening comfort and reduces the occlusion effect. On the other hand an open fitting does not attenuate environmental noise and further attenuates the lower frequencies in the ear. Accordingly, an open fitting type hearing aid has limited control of the sound scene in loud noise entering directly through the open fitting/large vent.

[0011] Environmental noise can therefore be uncomfortable and mask sounds of interest such as speech or music from the environment or wirelessly or wired transmitted to the hearing aid that the user wants to listen to and focus on. Comfort, sound quality and speech intelligibility is compromised by the noise.

[0012] It is desirable to have a hearing aid that simultaneously has a limited occlusion effect and limited acoustic feedback.

[0013] It is an object of the present invention to provide a hearing aid having a reduced occlusion effect and reduced acoustic feedback.

Summary of the invention

[0014] The object of the present invention can be achieved by a hearing aid as defined in claim 1. Preferred embodiments are defined in the dependent sub claims and explained in the following description and illustrated in the accompanying drawings.

[0015] The hearing aid according to the invention is a hearing aid comprising an earpiece for insertion into the ear canal of the user of the hearing aid, the earpiece comprising a through-going vent, and a receiver. The hearing aid further comprises activation means for automatically (e.g. controllable by electrical means, e.g. according to a predefined criterion or algorithm) changing the acoustical impedance of the vent.

[0016] Hereby it becomes possible to provide a hearing aid with reduced occlusion effect and reduced acoustic feedback compared with the prior art hearing aids.

[0017] The earpiece may comprise an earmould provided with a vent. The earpiece may e.g. form part of a behind-the-ear (BTE) hearing aid. The earpiece may alternatively constitute or form part of an in-the-ear model (ITE) hearing aid or a completely-in-canal (CIC) hearing aid or an in-the-canal (ITC) hearing aid with an integrated vent.

[0018] The vent is preferably a through-going vent that is provided for the purpose of preventing/reducing occlusion effects. The vent may have any desirable (longitudinal and transversal) shape. The vent may by way of example be cylindrical or conical.

[0019] The activation means for automatically changing the acoustical impedance of the vent may be of any suitable type and shape.

[0020] It may be an advantage that at least a portion of the activation means is provided in the vent and that the activation means comprises regulation means for providing a magnetic field and for changing the orientation of this magnetic field and that the activation means comprises at least one moveably mounted body member

that is configured to change the acoustical impedance of the vent upon changing the magnetic field by means of the activation means.

[0021] Hereby it is possible to provide a simple and reliable regulation mechanism that can be implemented in a hearing aid, including hearing aids of small size.

[0022] It may be beneficial that the activation means is arranged within the vent.

[0023] Hereby it is possible change the acoustical impedance of the vent in a simple and reliable manner. Moreover, it is possible to provide a secure way of changing the magnetic field by means of the activation means.

[0024] It may be advantageous that the activation means is detachably arranged in the vent. Hereby it is possible to replace the activation means during service of the hearing aid. Moreover it is possible to change the activation means in case that such replacement is desirable e.g. if activation means of another type or function is required.

[0025] In an embodiment, the activation means comprises a magnet. In an embodiment, the magnet comprises a permanent magnet. In an embodiment, the magnet comprises an electromagnet, comprising an inductor coil wound around a core of a soft magnetic material (e.g. iron), whose magnetic field can be influenced (e.g. controlled) by varying the current though the inductor coil (and reduced to a minimum value (e.g. substantially zero), when no current flows through the inductor coil). In an embodiment, the activation means comprises an electromagnet in combination with a permanent magnet.

[0026] It may be beneficial that the activation means comprises one or more magnets (e.g. permanent magnets), a rotably or slidably mounted armature made in a magnetisable material and a coil arranged in such a manner that the coil is capable of magnetising the armature, where the permanent magnets are arranged in such a manner that the armature can be positioned in at least two positions, and that the permanent magnets are arranged in such a manner that the armature can be maintained in one or two or more positions by means of the permanent magnets.

[0027] Hereby it is possible to provide a simple, reliable and cost-efficient way of changing the acoustical impedance of the vent. It is possible to create and change the magnetic field by means of a coil and hereby magnetise the armature in order to move it by means of magnetic attraction or repulsion.

[0028] It may be an advantage that the activation means comprises an electrical coil and one or more (permanent) magnets, a rotably or slidably mounted magnetic plug member configured to be arranged in at least a first position and a second position, where the electromagnet is arranged in such a manner that it can generate magnetic field(s) that causes movement of the plug member between at least a first position and a second position.

[0029] Hereby it is possible to provide a simple, cost-efficient and reliable valve member that can be used to change the acoustical impedance of the vent.

[0030] It may be advantageous that the plug member comprises a conical portion and that the electrical coil has a conical portion or is arranged in a housing having a corresponding a conical portion corresponding to the shape of the conical portion of the plug member, where essentially no gap (or a gap that is significantly smaller than the width of the vent) is provided between the plug member and the electrical coil when the plug member is arranged in the first position and where a larger (non-zero) gap is provided between the plug member and the electrical coil when the plug member is arranged in the second position.

[0031] Hereby it is possible to change the size of the opening in the vent by simple means. Moreover this solution is reliable, easy to implement and service.

[0032] It may be beneficial that the activation means comprises a first permanent magnet arranged in such a manner that the permanent magnet is capable of maintaining the plug member fixed in a first position without activating the electrical coil.

[0033] Hereby it is possible to maintain the plug member in a desired position without using electrical power to maintain the position. Moreover, a firm attachment of the plug member can be achieved.

[0034] It may be advantageous that the activation means comprises a second permanent magnet arranged in such a manner that the permanent magnet is capable of maintaining the plug member fixed in a second position without activating the electrical coil.

[0035] Hereby it is possible to maintain the plug member in a second desired position without using electrical power to maintain the position. It is beneficial that the plug member can be maintained in two different desired positions without using electrical power to maintain the position and that, a firm attachments of the plug member can be achieved in both positions.

[0036] It may be advantageous that the plug member is detachably mounted in the vent.

[0037] Hereby it is possible to replace the plug member during service or when a plug member of different type or size is required.

[0038] It may be an advantage that the electrical coil is integrated in the vent. Hereby is it possible to provide a robust and reliable hearing aid that is configured to receive an insert member that can be used to change the acoustical impedance of the vent upon changing the magnetic field generated by the electrical coil. The magnetic field generated by the electrical coil may be regulated by changing the current flowing through the wires of the coil.

[0039] It may be beneficial that a receiver is arranged in the vent and the receiver comprises means for changing the acoustical impedance of the vent.

[0040] Hereby it is possible to use a component (the receiver) that already is comprised in the hearing aid to regulate the acoustical impedance of the vent.

[0041] It may be advantageous that the hearing aid comprises means for monitoring sound signals.

[0042] It may be beneficial that the means for monitoring sound signals includes means for detecting acoustical feedback.

[0043] It may be an advantage that the means for automatically changing the acoustical impedance of the vent changes the acoustical impedance of the vent on the basis of sound signals provided by the means for monitoring sound signals.

[0044] Hereby it is possible to regulate the impedance of the vent on the basis of measurements carried out by using detected sound signals. Accordingly, it is possible to provide a hearing aid that is capable of providing an automatic regulation of the acoustical impedance of the vent.

[0045] It may be beneficial that the hearing aid comprises means for manually changing the acoustical impedance of the vent. Such change may e.g. be implemented via an activation element on the hearing aid or via a user interface on another device, e.g. a remote control, e.g. implemented as an APP of a SmartPhone. In such case, the smartphone may be used to illustrate for the user a current recommended setting of the acoustical impedance of the vent, e.g. based on an analysis of the frequency content of a current acoustic environment (e.g. as picked up by a microphone of the SmartPhone or remote control).

[0046] Hereby it is possible for the user to changes settings manually when desired.

[0047] The hearing aid according to the invention makes it possible for the user to change the open fitting to a more closed fitting when the situation calls for it.

[0048] By regulation of the vent size in closed or semi-closed earpieces the environmental noise may be reduced, so that listening comfort, the perceived sound quality and speech intelligibility can be improved.

[0049] The invention makes it possible to optimise the sound characteristics to take full benefit of different types of attached earpieces, including an open fitting (domes or moulds with a large vent) for normal use and alternatively a closed or semi-closed fitting (earpieces).

[0050] The hearing aid according to the invention can switch either automatically or by manual operation to alternative settings when the (semi)closed earpieces are mounted (and put in place).

[0051] Accordingly, the hearing aid provides a better control of the acoustic scene and can apply all its implemented sound processing schemes with full effect and user benefit.

[0052] In a preferred embodiment of a hearing aid according to the invention, the hearing aid comprises control means in which automatic settings switching to match alternative sets of earpieces can be triggered by monitored sound signals including changes in the acoustic feedback path.

[0053] The hearing aid according to the invention may comprise means for performing active reduction of acoustical feedback by use of phase cancellation.

[0054] The hearing aid may comprise a microphone attached to the vent to estimate the sound passing through the vent.

[0055] The hearing aid may comprise a feedback system provided in the hearing aid, which feedback system is configured to estimate the acoustical feedback caused by the vent.

[0056] It may be an advantage that the hearing aid comprises a receiver arranged in the vent and that the receiver is adapted to generate an electrical signal propositional with the sound in the vent.

[0057] The hearing aid may comprise a vent that is designed with a secondary branch forming an acoustical filter that will allow for phase cancellation of the acoustical signal coming from the hearing aid receiver.

[0058] In the present context, a "hearing aid" refers to a device, such as e.g. a hearing instrument, a listening device or an active ear-protection device, which is adapted to improve, augment and/or protect the hearing capability of a user by receiving acoustic signals from the user's surroundings, generating corresponding audio signals, possibly modifying the audio signals and providing the possibly modified audio signals as audible signals to at least one of the user's ears.

[0059] A "hearing aid" further refers to a device such as an earphone or a headset adapted to receive audio signals electronically, possibly modifying the audio signals and providing the possibly modified audio signals as audible signals to at least one of the user's ears. Such audible signals may e.g. be provided in the form of acoustic signals radiated into the user's outer ears, acoustic signals transferred as mechanical vibrations to the user's inner ears through the bone structure of the user's head and/or through parts of the middle ear as well as electric signals transferred directly or indirectly to the cochlear nerve and/or to the auditory cortex of the user.

[0060] A hearing aid may be configured to be worn in any known way, e.g. as a unit arranged behind the ear with a tube leading air-borne acoustic signals into the ear canal or with a loudspeaker arranged close to or in the ear canal, as a unit entirely or partly arranged in the pinna and/or in the ear canal, as a unit attached to a fixture implanted into the skull bone, as an entirely or partly implanted unit, etc. A hearing aid may comprise a single unit or several units communicating electronically with each other. Likewise, the hearing aid may comprise multiple speakers. A purpose of using several speakers may be to reduce vibrations and feedback or to improve LF and HF performance (e.g. by using specific units for each frequency range).

[0061] More generally, a hearing aid comprises an input transducer for receiving an acoustic signal from a user's surroundings and providing a corresponding input audio signal and/or a receiver for electronically receiving an input audio signal, a signal processing circuit for processing the input audio signal and an output means for providing an audible signal to the user in dependence on the processed audio signal. Some hearing aids may comprise multiple input transducers, e.g. for providing

direction-dependent audio signal processing. In some hearing aids, the receiver may be a wireless receiver.

[0062] In some hearing aids, the receiver may be e.g. an input amplifier for receiving a wired signal. In some hearing aids, an amplifier may constitute the signal processing circuit. In some hearing aids, the output means may comprise an output transducer, such as e.g. a loudspeaker for providing an air-borne acoustic signal or a vibrator for providing a structure-borne or liquid-borne acoustic signal. In some hearing aids, the output means may comprise one or more output electrodes for providing electric signals.

[0063] An aid may be a part of a "hearing system" that refers to a system comprising one or two hearing aids, and a "binaural hearing system" refers to a system comprising one or two hearing aids and being adapted to cooperatively provide audible signals to both of the user's ears.

[0064] Hearing systems or binaural hearing systems may further comprise "auxiliary devices", which communicate with the hearing aids and affect and/or benefit from the function of the hearing aids. Auxiliary devices may be e.g. remote controls, remote microphones, audio gateway devices, mobile phones, public-address systems, car audio systems or music players. Hearing aids, hearing systems or binaural hearing systems may e.g. be used for compensating for a hearing-impaired person's loss of hearing capability, augmenting or protecting a normalhearing person's hearing capability and/or conveying electronic audio signals to a person.

[0065] In the present context, a SmartPhone, may comprise

- a (A) cellular telephone comprising a microphone, a speaker, and a (wireless) interface to the public switched telephone network (PSTN) COMBINED with
- a (B) personal computer comprising a processor, a memory, an operative system (OS), a user interface (e.g. a keyboard and display, e.g. integrated in a touch sensitive display) and a wireless data interface (including a Web-browser), allowing a user to download and execute application programs (APPs) implementing specific functional features (e.g. displaying information retrieved from the Internet, remotely controlling another device, combining information from various sensors of the smartphone (e.g. camera, scanner, GPS, microphone, etc.) and/or external sensors to provide special features, etc.).

Description of the Drawings

[0066] The invention will become more fully understood from the detailed description given herein below. The accompanying drawings are given by way of illustration only, and thus, they are not limitative of the present invention. In the accompanying drawings:

Fig. 1 a) shows a valve of a hearing aid according to the invention. The valve is closed;

Fig. 1 b) shows the valve shown in Fig. 1 a) in a semi open state;

Fig. 1 c) shows the valve shown in Fig. 1 a) and in Fig. 1 b) in an open state;

Fig. 2 a) shows a schematical view of a portion of a housing of a hearing aid according to the invention. A removably mounted valve has been inserted in a vent of the housing;

Fig. 2 b) shows a schematical view of the hearing aid shown in Fig. 2 a) in a state where the removably mounted valve has been removed from the vent;

Fig. 3 shows a schematical view of a ventilated hearing aid receiver of a hearing aid according to the invention;

Fig. 4 shows a schematical view of a regulation member according to the invention;

Fig. 5 shows a schematical view of a regulation member according to the invention arranged in three different states of operation;

Fig. 6 a) shows a schematical view of a hearing aid according to the invention;

Fig. 6 b) shows a schematical close-up view of an earmould of the hearing aid shown in Fig. 6 a) and

Fig. 6 c) shows a schematical close-up view of another earmould of the hearing aid shown in Fig. 6 a).

Detailed description of the invention

[0067] Referring now in detail to the drawings for the purpose of illustrating preferred embodiments of the present invention, different views of a valve 20 of a hearing aid according to the invention are illustrated in Fig. 1.

[0068] Fig. 1 illustrates shows schematically cross-sectional view of a valve 20 of a hearing aid according to the invention. The valve 20 is shown in a closed state of operation.

[0069] The valve 20 is configured to be arranged in or integrated in a vent of a hearing aid. The valve 20 comprises a basically cylindrical vent tube 4 having a longitudinal axis X, first opening 22 and a second opening 24. The vent has an inside comprising the volume confined by the vent; the confined volume comprising (mainly) air. The cross-sectional form (perpendicular to the longitudinal axis X) of the vent may take on any form that is appropriate for the function of the valve. In an embodiment, the vent has a rectangular (e.g. square) cross-section.

[0070] The valve 20 comprises a first radially polarised ring-shaped permanent magnet 6, where the North Pole N is on the inside. The valve 20 also comprises a second radially polarised ring-shaped permanent magnet 8, where the South Pole S is on the inside of the vent.

[0071] An electrical coil 18 is provided at the central portion of the vent tube 4. The coil 18 comprises a conical

portion 14 and a straight portion 26. The coil 18 is sandwiched between the two permanent magnets 6, 8.

[0072] A plug member 10 is sealingly arranged in the vent 2. The plug member 10 has a conical portion 16 that matches the conical portion 14 of the coil 18. The plug member 10 also has a straight portion 26' that matches the straight portion 26 of the coil 18. The plug member 10 is a magnet having a North Pole N at the right side (facing first opening 22) and a South Pole S at its left side (facing second opening 24).

[0073] In Fig. 1 a) the vent 2 is closed. The plug member 10 has been arranged in a position in which the South Pole S of the second permanent magnet 8 attracts the North Pole N of the plug member 10 and hereby maintains the plug member 10 in a fixed position relative to the vent tube 4.

[0074] The coil 18 is electrically connected to control means (not shown). These control means can send a current through the windings of the coil (not shown) and hereby create a magnetic field that can cause a resulting force capable of mowing the plug member 10 to the left. Accordingly, the plug member 10 can be moved to the left (towards the second open end 24 of the vent 2) along the longitudinal axis X of the vent tube 4 simply by coupling the coil 18 to an electrical power source that may be electrically connected to the battery of the hearing aid.

[0075] When the plug member 10 is arranged in the position corresponding to the one shown in Fig. 1 a, the position of the plug member 10 can be maintained merely by means of the second permanent magnet 8. Accordingly, no energy source is required in order to keep the plug member 10 fixed in the shown position.

[0076] Fig. 1 b) illustrates the valve 20 shown in Fig. 1 a) in a semi open state of operation. Current is running through the coil 18 of the vent 2 and accordingly, a magnetic field is generated. The generated magnetic field will move the plug member 10 along the longitudinal axis X of the vent tube 4 towards the second opening 24 of the vent 2 (by proper choice of the direction and size of the current in the coil).

[0077] The straight portion 26' of the plug member 10 will slide on the straight portion 26 of the coil 18. A gap 12 is provided between the plug member 10 and the coil 18. The size of the gap 12 influences the (acoustically) attenuating effect of the vent 2.

[0078] In Fig. 1 c) the plug member 10 has been moved into an open position. In the open position the South Pole S of the plug member 10 is fixed to the first permanent magnet 6 by means of attraction between the North Pole N of the first permanent magnet 6 and the South Pole of the plug member 10. A gap 12 is provided between the plug member 10 and the coil 18. The gap 12 has its maximum size when the plug member 10 is arranged like shown in Fig. 1 c), thereby providing minimum acoustic attenuation. By varying the angle of the conical portion 14 (and the corresponding part of the plug) with the longitudinal axis X and/or the difference in extension of the respective conical parts along the longitudinal axis X, the difference in acoustic attenuation (gap) between the closed (or minimally open) and maximally open state of the valve 20 can be controlled. The larger the angle, and/or the larger the difference in length, the larger the difference in attenuation.

[0079] Due to the magnetic attraction between the North Pole N of the first permanent magnet 6 and the South Pole S of the plug member 10 it is possible to maintain the plug member 10 in the shown open position without use of any power. When vent 2 has to be closed in order to passively reduce the acoustical feedback, the plug member is moved along the longitudinal axis X of the vent tube 4 towards the first opening 22, in order to form an acoustical filter that attenuates the sound traveling through the vent 4.

[0080] By introducing a current in the windings of the coil 18 it is possible to change the position of the plug member 10 and hereby alter the acoustical filter properties of the vent 2. Thus, the sound traveling through the vent 4 can be attenuated in different ways.

[0081] By appropriate selection of materials and/or coating of the respective surfaces of the vent and plug surfaces (in particular the straight portions 26 and 26') that have direct (sliding) contact, the friction forces that have to be overcome by the magnetic field of the coil 18 (and this the necessary current, and hence the power consumption) can be minimized.

[0082] It is possible to have detection means for detection and/or monitoring of sound signals. The detection means may be applied to provide data that can be used to establish an automatic regulation of the vent 2 according to predefined settings. Hereby it is possible to provide a hearing aid that has a build-in automatic vent regulation function that ensures that the most appropriate vent settings are applied (e.g. in dependence of the level and/or frequency spectrum of the current sound signal; the valve being e.g. automatically shifted towards a more closed state, the larger the magnitudes of signal components at relatively low frequencies, e.g. below 2 kHz, and vice versa. In an embodiment, an algorithm relating frequency content to valve opening is stored in a memory of the hearing aid and applied (e.g. in a specific mode of operation of the hearing aid) to automatically (dynamically) set the valve opening according to the current sound signal. In an embodiment, the hearing aid comprises a frequency analysing unit allowing an analysis (preferably continuous) of magnitude (or magnitude squared, or power spectral density (psd)) versus frequency of a signal of the forward path of the hearing aid ('the sound signal').

[0083] Fig. 2 a) schematically illustrates a (longitudinal) cross-sectional view of a portion of a housing 28 being part of a hearing aid according to the invention. A removably mounted insert member 32 has been inserted in a vent 2 of the housing 28. The housing 28 may be the housing of an earmould with a build-in receiver by way of example. The housing 28 may also be a housing of an ITE hearing aid.

[0084] The housing comprises a valve 20 consisting of the insert member 32 and an electromagnet 30 (comprising an inductor coil) integrated in the housing 28.

[0085] The vent 2 is basically cylindrical and comprises a vent tube 4 having an opening 22. By sending a current through the windings of the electromagnet 30, it is possible to change acoustical filter properties of the vent 2. Although not shown in detail, the insert member 32 may have an opening that can be changed in size so that the sound traveling through the vent 4 can be attenuated in different ways.

[0086] It may be an advantage that the hearing aid comprises regulation means that can control the acoustical filter properties of the vent, 2 e.g. in dependence on monitored parameters, e.g. of a current sound signal around the hearing aid and/or a current direct electric input signal (e.g. wired or wirelessly received by the hearing aid and played for the user via an output transducer of the hearing aid).

[0087] Fig. 2 b) schematically illustrates a cross-sectional view of the portion of a housing 28 illustrated in Fig. 2 a). The removably mounted insert member 32 has been removed from the vent 2 of the housing 28. This may be desirable during service of the hearing aid. By having a removably mounted insert member 32 it is possible to replace the insert member 32 by a new one.

[0088] It may be an advantage that the removably mounted insert member 32 is maintained in its position by means of magnetic forces or by means of other suitable mechanical means, e.g. a threaded portion configured to be screwed into a threaded portion provided in the first opening 22 of the vent 2.

[0089] Fig. 3 schematically illustrates a view of a ventilated hearing aid receiver 36 of a hearing aid according to the invention. The ventilated hearing aid receiver 36 comprises a casing 40 (e.g. a metal casing). The ventilated hearing aid receiver 36 is placed as a part of the traditional hearing aid vent.

[0090] The ventilated hearing aid receiver 36 comprises a first opening (or port) 22 and a second opening (or port) 24. The hearing aid receiver 36 is a two-port component that is configured to be an integrated part of a vent 2. Accordingly, the sound must pass through the hearing aid receiver 36. The term 'two-port' is intended to refer to the receiver comprising a vent inlet and a vent outlet (2).

[0091] The hearing aid receiver 36 comprises a coil 14 arranged to generate a magnetic field when current is flowing through the wires of the coil 14. The windings 141 of the inductor coil are arranged around a central longitudinal element 341 of a soft magnetic material (i.e. magnetically soft, easily (reversibly) magnetisable, such material comprising e.g. iron), so that a current sent through the windings of the coil induce a magnetic field along the axis of the central longitudinal element 341 and (amplified by the magnetic material) in the element.

[0092] The hearing aid receiver 36 comprises a rotably mounted (E-form) iron armature 34 configured to be magnetised by the coil 14 when current is flowing through the wires 141 of the coil 14 (the polarity of the resulting armature magnet being determined by the direction of the current in the coil). Hereby it is possible to move the central longitudinal part 341 of armature 34 between a first permanent magnet 6 (applying current in a first direction) and a second permanent magnet 8 (applying current in a second direction). In Fig. 3a), the first permanent magnet 6 as well as the second permanent magnet 8 have a North Pole N in the top portion of the magnets 6, 8 and a South Pole S in the bottom portion of the magnets 6, 8 (it might alternatively be the reverse). The permanent magnets 6, 8 are magnetically coupled to the armature 34. The term 'rotationally mounted' is in the present context taken to mean that the central longitudinal element 341 (the central part of the E-form) can flex around rotational point R, as indicated by the two-way arrow). The armature 34 (here the central longitudinal element 341 of the armature) is mechanically connected to a membrane M via a (schematically indicated) connecting element CE to thereby transfer the movements of the central longitudinal element 341 of the armature 34 to the membrane M.

[0093] When current is applied to the coil 14 and the armature is magnetised, the central longitudinal element 341 of armature 34 will be mowed towards either the first magnet 6 or the second magnet 8 due to magnetic attraction and/or magnetic repulsion. Thus, the magnetic field of the coil 14 will change the acoustical resistance of the hearing aid receiver 36. In this manner it is possible to reduce acoustical feedback by attenuation of sound from the main hearing aid speaker (through the vent). The 'main hearing aid speaker' is preferably (but not necessarily) another receiver element than receiver element 36 described in Fig 3.

[0094] It may be an advantage that the hearing aid comprises means for estimating the amount and the nature of the acoustical feedback through the vent. Estimation of the feedback through the vent can be performed by means of a microphone (not shown) that is attached to the vent and configured to estimate the sound passing through the vent. It is also possible to provide a feedback system in the hearing aid and use this feedback system to estimate the acoustical feedback caused by the vent (e.g. using an adaptive filter). It is possible to arrange a receiver that is capable of generating an electrical signal propositional to the sound pressure level (measured in the vent), in the vent.

[0095] Fig. 4 illustrates a schematical view of a regulation member 42 according to the invention. The regulation member 42 comprises an outer two-port casing 40 that basically has the same shape as the hearing aid receiver 36 shown in Fig. 3. Schematic (two-port) entries of a vent 2 (e.g. a tube) are indicated. The exact location of each of the vent entries is not decisive for the function the component. The connections allowing air from the vent to be exchanged with the volume of the regulation member 42 (as determined by the casing 40) are e.g.

through going holes in the casing to which the vent-canal is connected (e.g. in a flange tube arrangement). By restricting the movement of the armature (controlled by the current through the coil) more or less, the acoustic attenuation of the component and thus the vent can be increased or decreased correspondingly.

[0096] The regulation member 42 has an internal armature 34 that is airtight connected to the casing 40 by means of flexible material. The regulation member 42 moreover comprises a coil (solenoid) 14 adapted to magnetise the armature 34. The regulation member 42 also comprises a permanent magnet 6 magnetically coupled to the armature 34 at one terminal and havening the other terminal at the distal end of the armature 34. An air gap 50 is provided between the distal end of the armature 34 and the magnet 6.

[0097] When current flows in the coil 14 the movement of the armature 34 will be damped by the magnetic forces in the air gap 50. The regulation member 42 will attenuate sound transmitted through two-port regulation member 42. The stiffness of the armature 34 can be regulated by the current applied. If current is applied to coil 14 to induce a magnetic field in armature 34 providing a south pole of the armature at the air gap 50, this will create a stiff structure having a relatively large attenuation of acoustic vibrations in the vent. The regulation member 42 cannot generate sound but only alter its acoustical impedance when subjected to selected stimuli (because no membrane is included).

[0098] Fig. 5 shows schematical views of a regulation member 42 according to the invention arranged in three different states of operation (providing a multi-state element, here tri-state). The regulation member 42 comprises a two-port casing 40 and an internal armature 34. The regulation member 42 has a coil (solenoid) 14 adapted to magnetise a rotably mounted armature 34. The regulation member 42 comprises a first permanent magnet 6 and a second permanent magnet 8 arranged in a distance from each other.

[0099] The armature 34 extends through the space between the two magnets 6, 8 and a plug (or aperture) member 38 is attached to the distal end of the armature 34. The permanent magnets 6, 8 are arranged with their North Pole N upwards and the South Pole S downwards. The permanent magnets 6, 8 are not magnetically coupled to the armature 34 (the armature is located in a stable position (e.g. midway) between the two magnets 6, 8). The plug (or aperture) member 38 can e.g. be arranged to cover holes in an appropriately formed plate (not shown) to thereby allow a different opening area (and this acoustic attenuation) depending on the location of the plug (or aperture) member 38 (Fig. 5a, 5b, 5c).

[0100] The regulation member 42 is a bi- (or tri-) stable electromechanical system as the armature 34 can be brought into a position in which the armature 34 is magnetically attached to one of the two permanent magnets 6, 8. The magnetic attachment is established by supplying current to the coil 14 and hereby magnetising the armature.

[0101] In Fig. 5 a) the armature 34 of the regulation member 42 is arranged between the two permanent magnets 6, 8. No current is supplied to the coil 14.

[0102] In Fig. 5 b) a positive current is supplied to the coil 14. The current will magnetise the armature 34 and cause a rotation (or bending) of the armature 34 into the position shown in Fig. 5 b). The armature 34 is brought into physical contact with the first permanent magnet 6. When the contact is established there is no need for keeping the armature 34 magnetised as the iron armature will be maintained in the position by magnetic attraction from the first permanent magnet 6. Alternatively, it is only *bended towards* the first permanent magnet 6.

[0103] In Fig. 5 c) a negative current has been supplied to the coil 14. This current causes an opposite magnetisation of the armature 34. Accordingly, the armature 34 will experience magnetic repulsion from the first permanent magnet 6 and at the same time be subject to magnetic attraction from the second permanent magnet 8. Therefore, the armature 34 will be brought into physical contact with the second permanent magnet 8. When the contact is established there is no need for keeping the armature 34 magnetised as the iron armature will be maintained in the position by magnetic attraction from the second permanent magnet 8. Alternatively, it is only *bended towards* the second permanent magnet 8.

[0104] From a power perspective it is important that when the armature 34 has attached itself to either of the two permanent magnets 6, 8, current is no longer needed to maintain the armature 34 in the established position (corresponding to Fig. 5 b) and Fig. 5 c)). The regulation member 42 will only need current in order to *change* the configuration of the regulation member 42. The regulation member 42 has will acoustically have two different modes (e.g. closed or open). Such bi-state (or tri-state) components providing 2 (or 3) different acoustic attenuation values of the vent, which can be electrically controlled, and which require only a minimum of power (to change its state from one value to another) can be of high value in a hearing aid device comprising a part for being located in an ear canal of a user (cf. e.g. Fig. 6), in particular if such part comprises an earmould comprising a loudspeaker and a vent to minimize occlusion.

[0105] Fig. 6 illustrates a schematical view of a hearing aid 44 according to the invention. The hearing aid 44 is a receiver-in-the-ear (RITE) type hearing aid 2 comprising (instead of an open dome-like part) an earmould 46 for insertion into the ear canal of the user of the hearing aid 44.

[0106] Fig. 6 b) illustrates a schematical close-up view of the earmould 46 of the hearing aid 44 shown in Fig. 6 a). A cylindrical vent 2 extends through the earmould 46. A receiver 36 is arranged in the vent 2. The receiver 36 is electrically connected to the amplifier (not shown) of the hearing aid 44 by means of electrical wires 52. The sound leaves the earmould 46 through an outlet 48.

[0107] The receiver 36 is configured to vary it's acous-

tical impedance so that the sound traveling through the vent 4 can be attenuated in different ways, as e.g. discussed in connection with Fig. 3 (or in combination with features of Fig. 3, 5).

[0108] Fig. 6 c) illustrates a schematical close-up view of another earmould 46 of the hearing aid 44 shown in Fig. 6 a). A cylindrical vent 2 extends through the earmould 46. A regulation member 42 is (e.g. centrally) arranged in the vent 2. The receiver 36 is electrically connected to the amplifier (not shown) of the hearing aid 44 by means of a electrical wires 52. The sound leaves the earmould 46 through an outlet 48.

[0109] The regulation member 42 is configured to vary it's acoustical impedance e.g. by means of electric stimuli of a coil (not shown) or by means of any suitable mechanical means, e.g. an actuator. By changing the acoustical impedance of the regulation member 42 the sound traveling through the vent 4 can be attenuated according to specific demands (e.g. depending on the nature, e.g. its frequency content, of the acoustic signal).

List of reference numerals

[0110]

2	- Vent
4	- Vent tube
6	- Permanent magnet
8	- Permanent magnet
10	- Plug member
12	- Gap
14	- Conical portion
16	- Conical portion
18	- Coil
20	- Valve
22	- First opening
24	- Second opening
26, 26'	- Straight portion
28	- Housing
30	- Electromagnet
32	- Insert member
34	- Armature
36	- Receiver
38	- Plug member
40	- Casing
42	- Regulation member
44	- Hearing aid
46	- Earmould
48	- Outlet
50	- Air gap
52	- Wire
N	- North Pole
S	- South Pole
X	- Longitudinal axis
M	- Membrane
R	- Rotation point
CE	- Connecting element

Claims

1. A hearing aid (44) comprising an earpiece (46) for insertion into the ear canal of the user of the hearing aid (44), where a through-going vent (2) is provided in the earpiece (46), where a receiver (36) is provided in the earpiece (46), **characterised in that** the hearing aid (44) comprises activation means (20, 36, 42) for automatically changing the acoustical impedance of the vent (2).

2. A hearing aid (44) according to claim 1, **characterised in that** at least a portion of the activation means (20, 36, 42) is provided in the vent (2) and that the activation means (20, 36, 42) comprises regulation means (18, 30) for providing a magnetic field and changing the orientation of this magnetic field and that the activation means (20, 36, 42) comprises a moveably mounted body member (10, 32, 34) that is configured to change the acoustical impedance of the vent (2) upon changing the magnetic field by means of the activation means (20, 36, 42).

3. A hearing aid (44) according to claim 1 or claim 2, **characterised in that** the activation means (20, 36, 42) is arranged within the vent (2).

4. A hearing aid (44) according to claim 3, **characterised in that** the activation means (30) is detachably arranged in the vent (2).

5. A hearing aid (44) according to one of the preceding claims, **characterised in that** the activation means (20, 36, 42) comprises one or more permanent magnets (6, 8), a rotably or slidably mounted armature (34) made in a magnetisable material and a coil (14) arranged in such a manner that the coil (14) is capable of magnetising the armature (34), where the permanent magnets (6, 8) are arranged in such a manner that the armature (34) can be positioned in at least two positions, and that the permanent magnets (6, 8) are arranged in such a manner that the armature (34) can be maintained in one or two or more positions by means of the permanent magnets (6, 8).

6. A hearing aid (44) according to one of the preceding claims 1-4, **characterised in that** the activation means (18, 20, 36, 42) comprises an electrical coil (18) and one or more permanent magnets (6, 8), a rotably or slidably mounted magnetic plug member (10) configured to be arranged in at least a first position and a second position, where the electromagnet (30) is arranged in such a manner that it can generate magnetic field(s) that causes movement of the plug member (10) between the at least a first position the a second position.

7. A hearing aid (44) according to claim 6, **characterised in that** the plug member (10) comprises a conical portion (16) and that the electrical coil (18) has a conical portion (14) or is arranged in a housing having a corresponding conical portion (14) corresponding to the shape of the conical portion (16) of the plug member (10), where essentially no gap (12) (or a gap that is significantly smaller than the width of the vent (2)) is provided between the plug member (10) and the electrical coil (18) when the plug member (10) is arranged in the first position and where a larger non-zero gap (12) is provided between the plug member (10) and the electrical coil (18) when the plug member (10) is arranged in the second position.

8. A hearing aid (44) according to claim 7, **characterised in that** the activation means (18, 20, 36, 42) comprises a first permanent magnet (6) arranged in such a manner that the permanent magnet (6) is capable of maintaining the plug member (10) fixed in a first position without activating the electrical coil (18).

9. A hearing aid (44) according to claim 8, **characterised in that** the activation means (18, 20, 36, 42) comprises a second permanent magnet (8) arranged in such a manner that the permanent magnet (8 is capable of maintaining the plug member (10) fixed in a second position without activating the electrical coil (18).

10. A hearing aid (44) according to one of the preceding claims 6-9, **characterised in that** the plug member (10) is detachably mounted in the vent (2).

11. A hearing aid (44) according to one of the preceding claims 6-10, **characterised in that** the electrical coil (18) is integrated in the vent (2).

12. A hearing aid (44) according to one of the preceding claims, **characterised in that** a receiver (36) is arranged in the vent (2) and the receiver (36) comprises means (6, 8, 14, 34, 40) for changing the acoustical impedance of the vent (2).

13. A hearing aid (44) according to one of the preceding claims, **characterised in that** the hearing aid (44) comprises means for monitoring sound signals.

14. A hearing aid (44) according to claim 13, **characterised in that** the means for automatically changing the acoustical impedance of the vent (2) changes the acoustical impedance of the vent (2) on the basis of sound signals provided by the means for monitoring sound signals.

15. A hearing aid (44) according to one of the preceding claims, **characterised in that** the hearing aid (44) comprises means for manually changing the acoustical impedance of the vent (2).

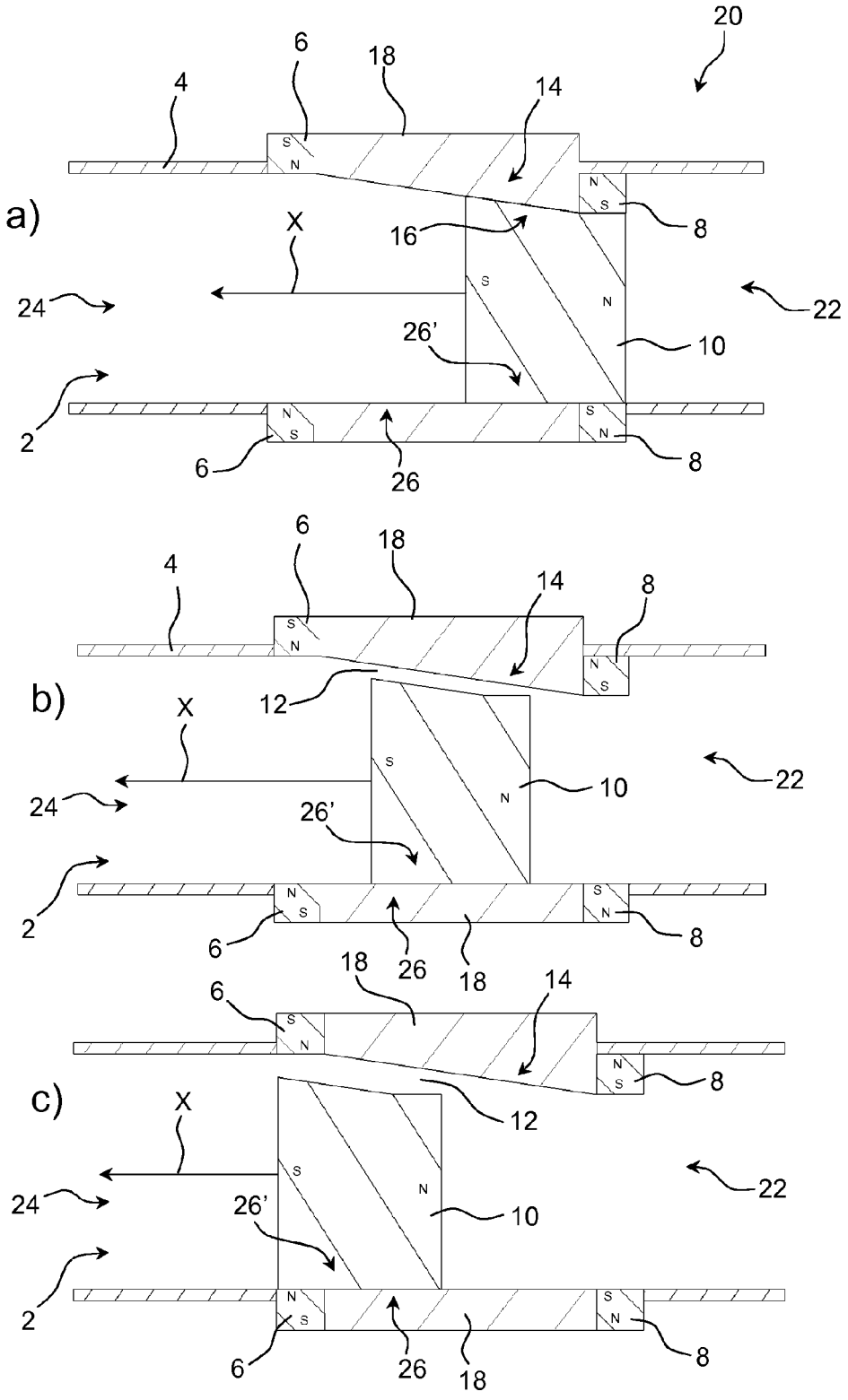


Fig. 1

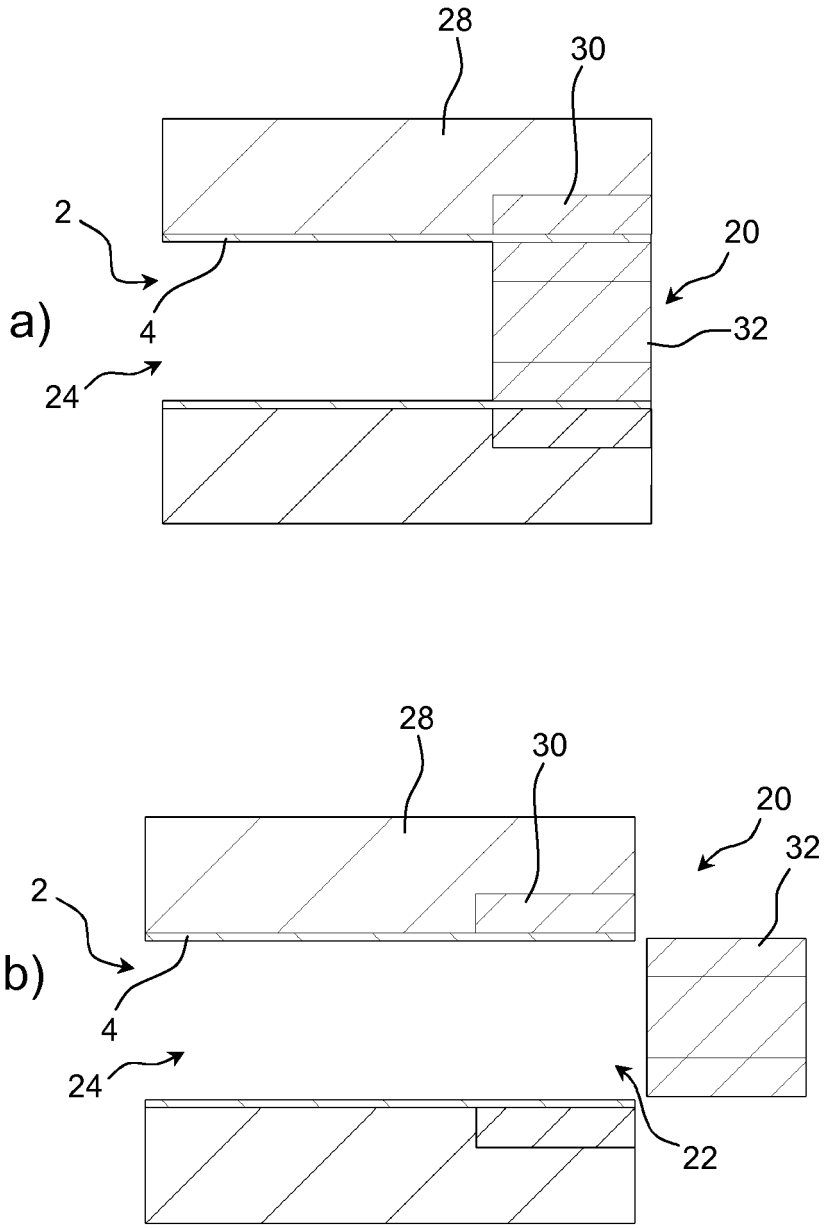


Fig. 2

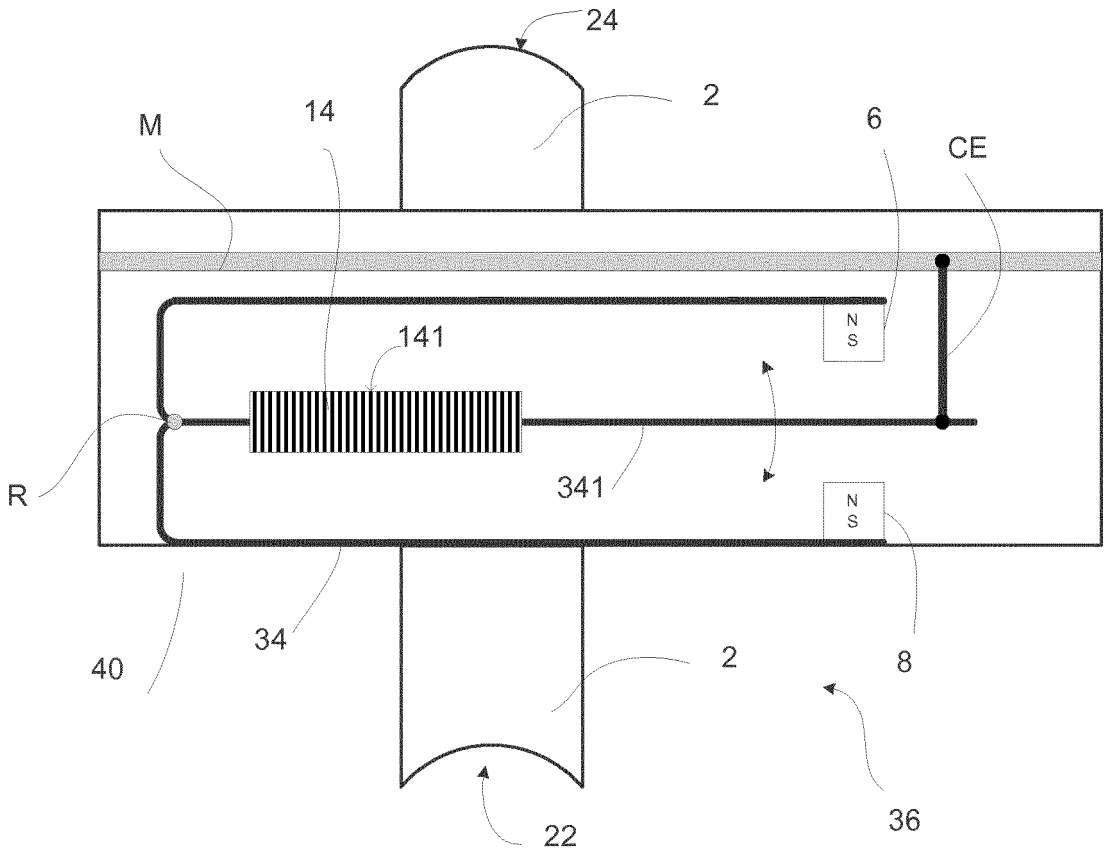


Fig. 3

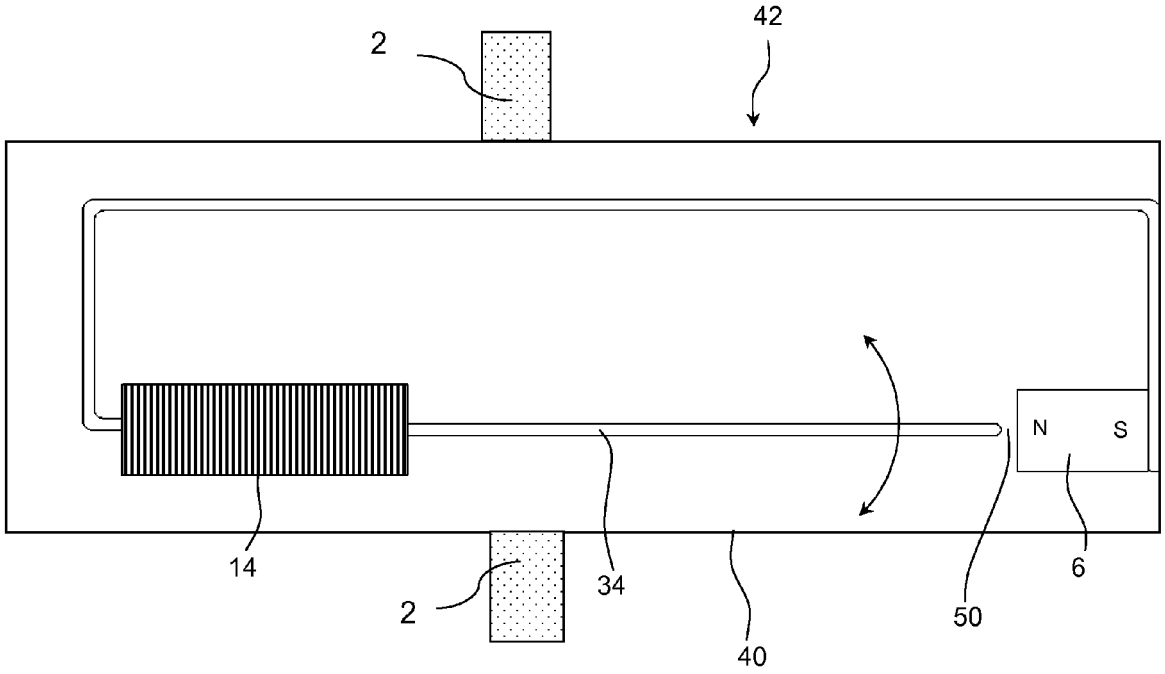


Fig. 4

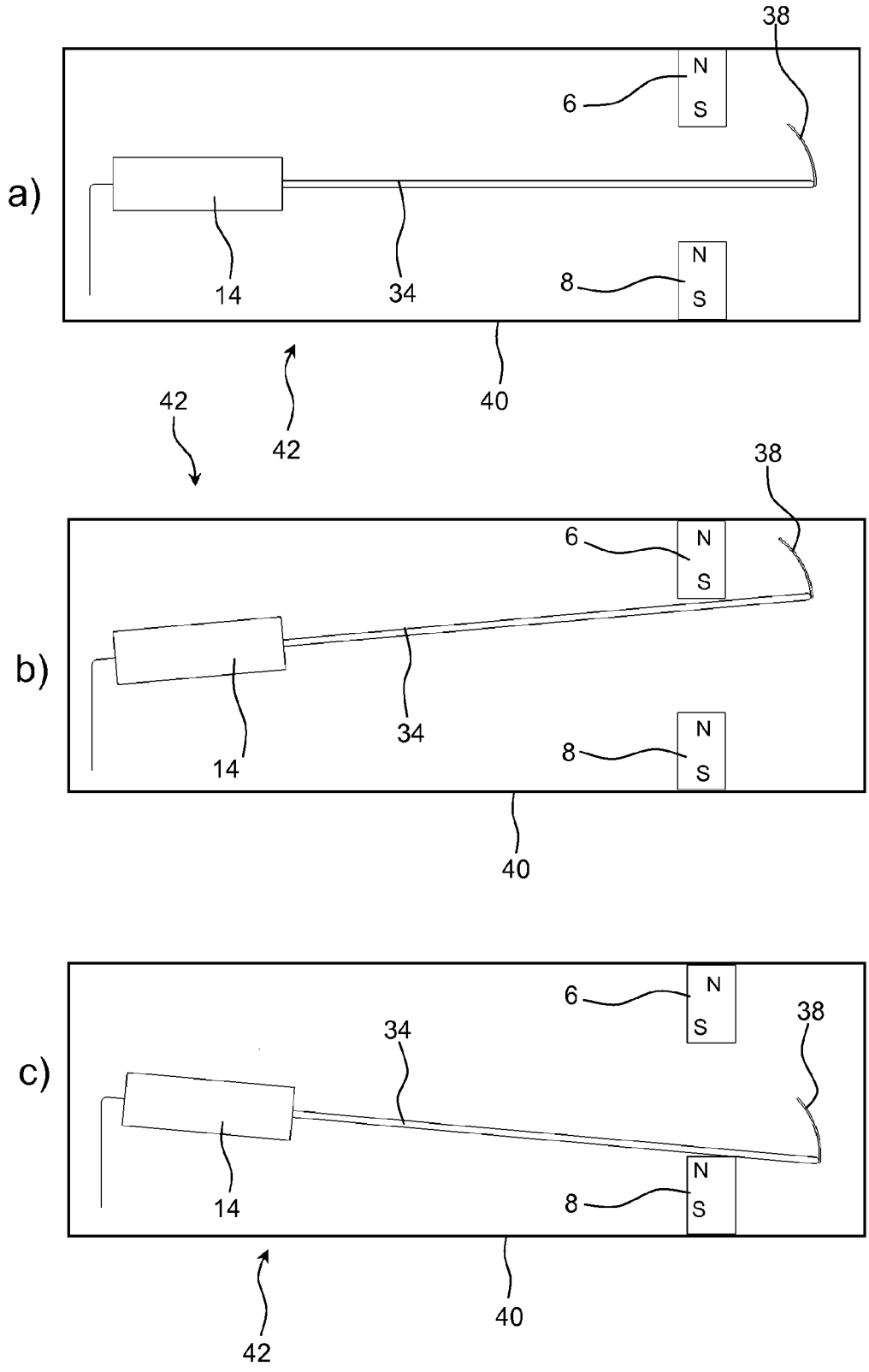

a)
38
N
S
6
14
34
8
N
S
40
42
42
b)
38
6
N
S
14
34
8
N
S
40
c)
6
N
S
34
38
14
8
N
S
42
40

Fig. 5

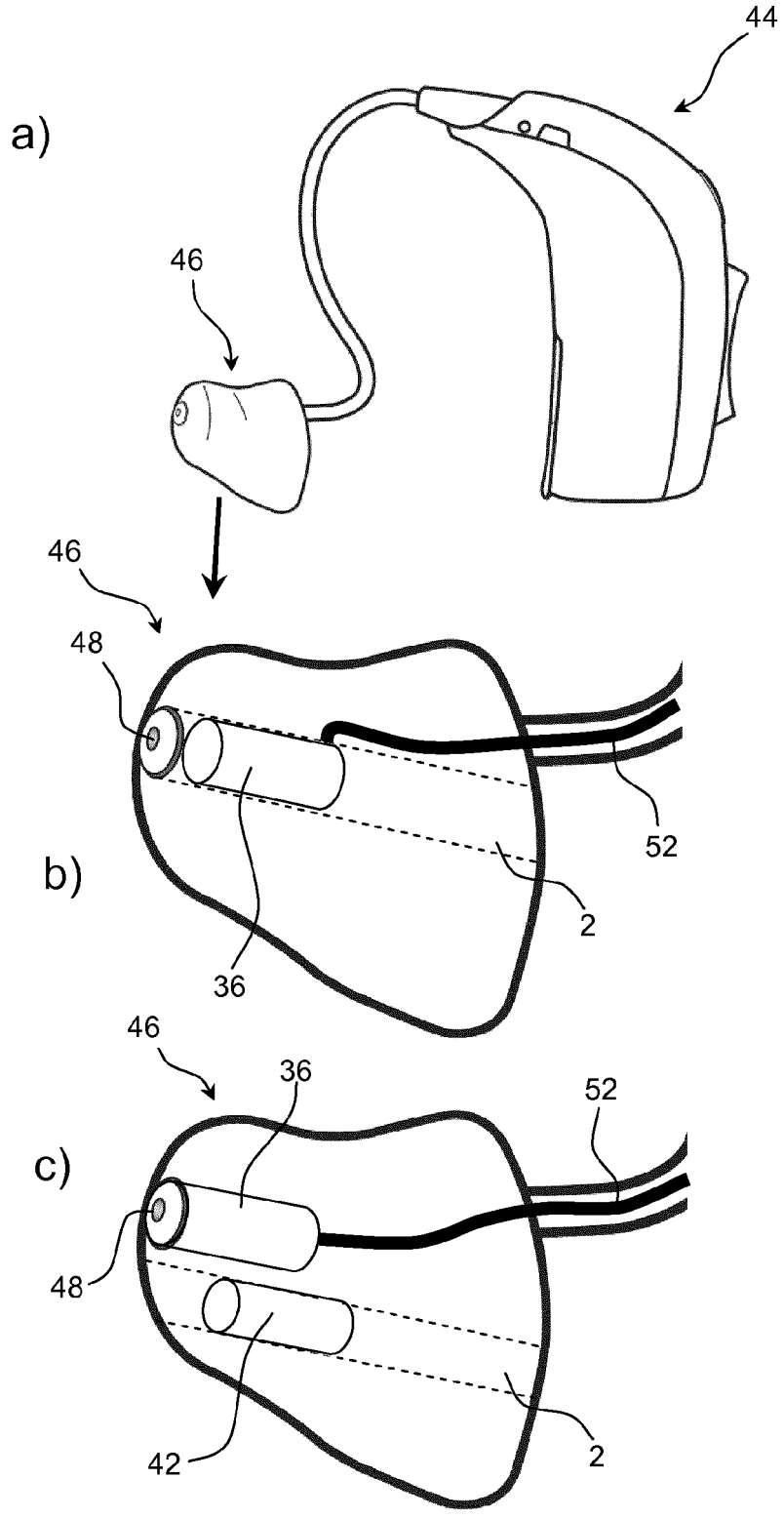


Fig. 6

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 6025

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	4 April 2014	Peirs, Karel

CATEGORY OF CITED DOCUMENTS

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