Feb. 7, 1961 H. M. BUSSE 2,971,065

EAR INSERT HEARING AID

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Fig. 1.

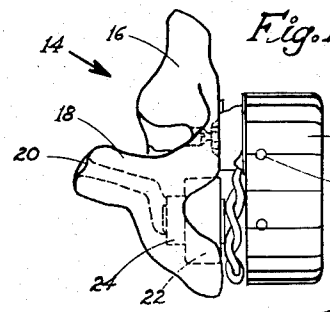


Fig. 2.

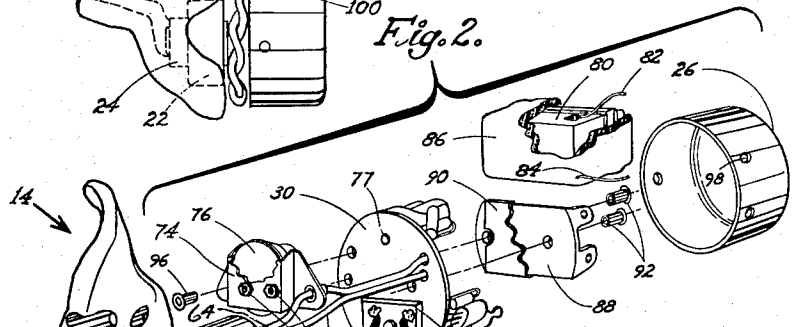


Fig. 3.

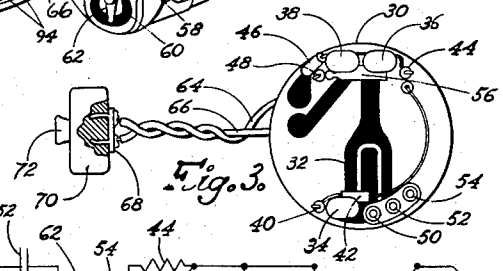
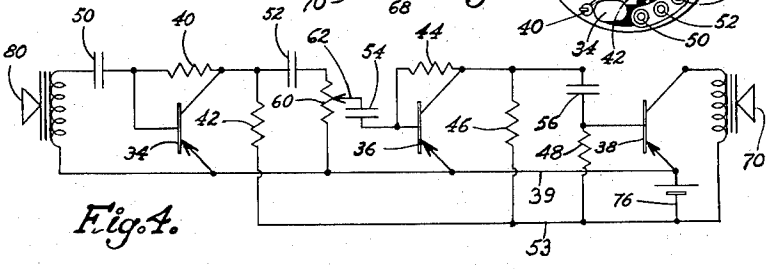


Fig. 4.



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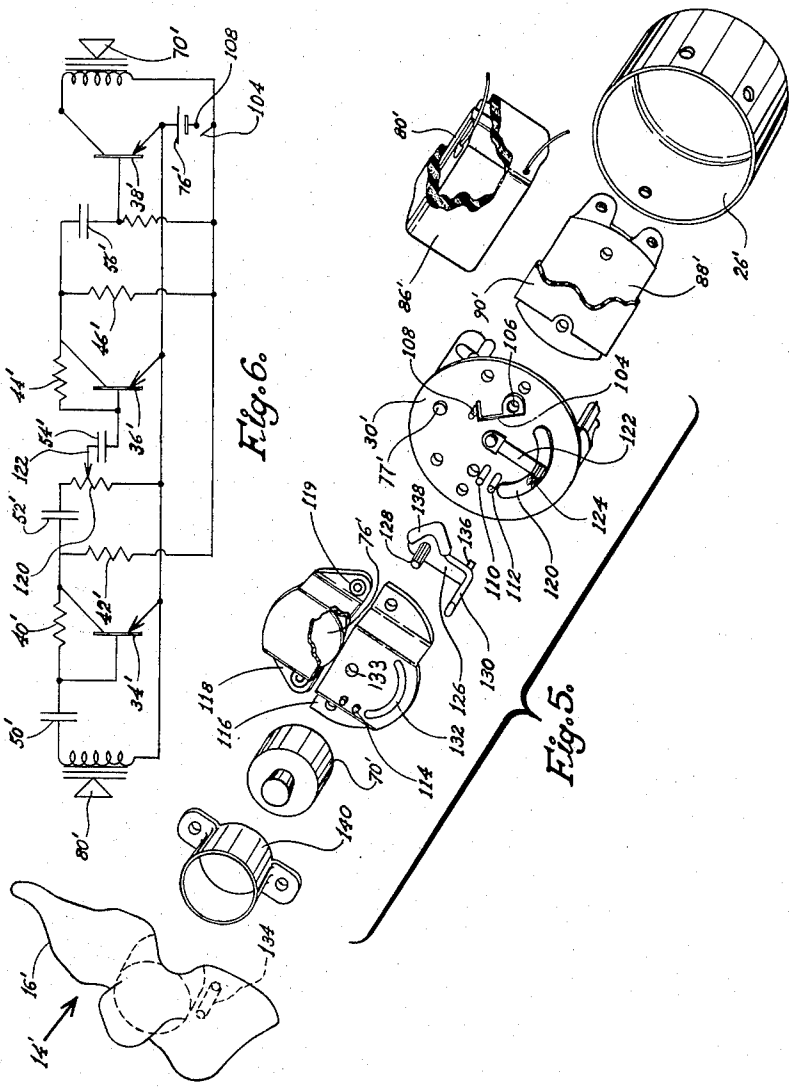


Fig. 6.

Fig. 5.

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FIG. 8.

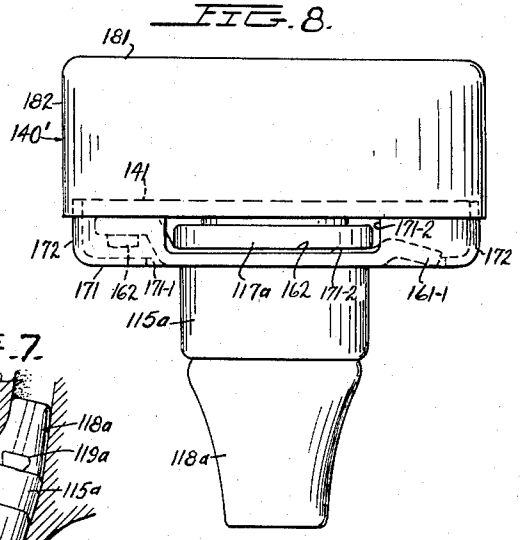


FIG. 7.

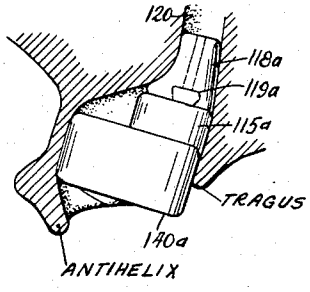
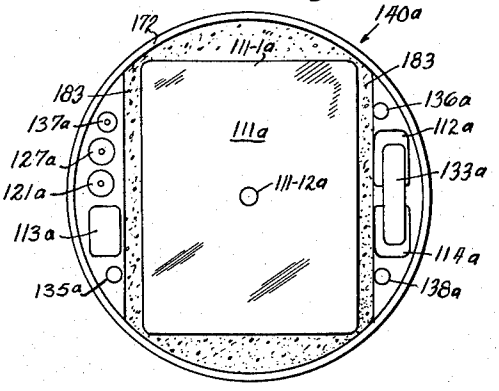


FIG. 9.



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FIG. 10.

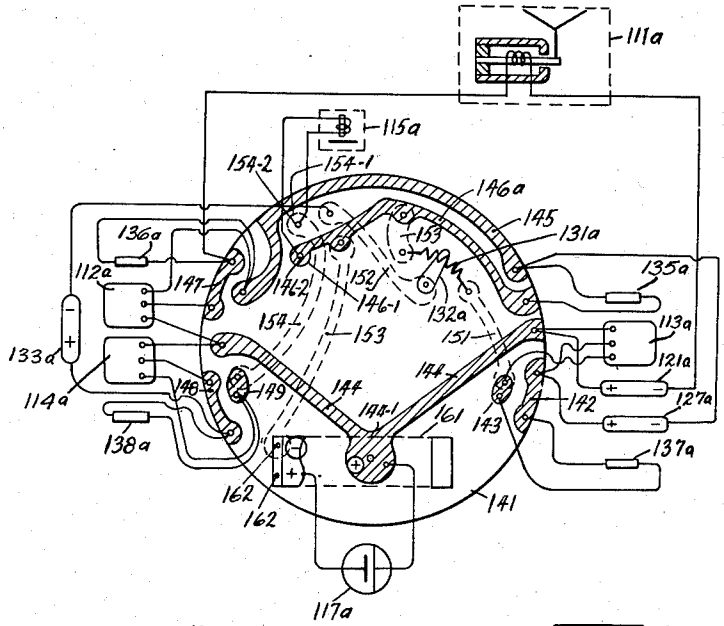
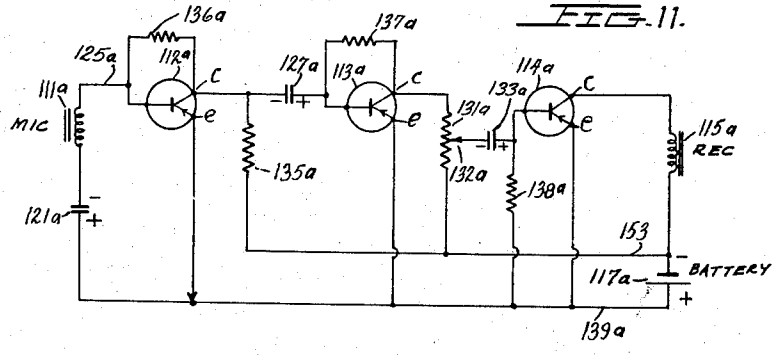


FIG. 11.



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FIG. 12.

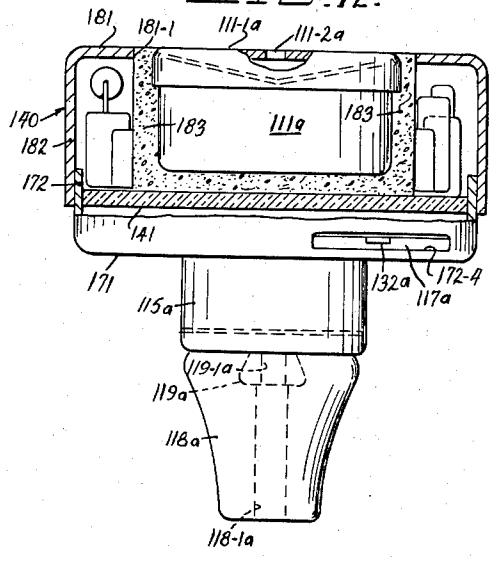
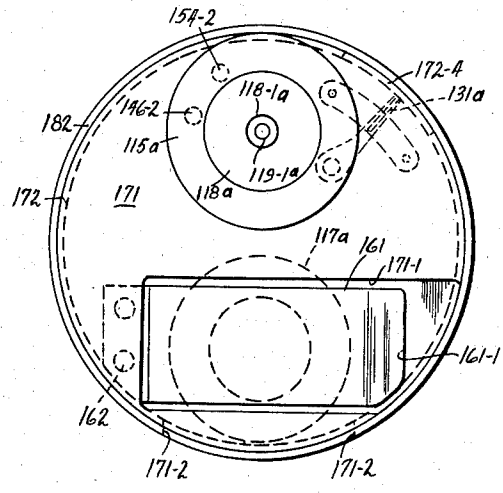


FIG. 13.



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FIG. 14

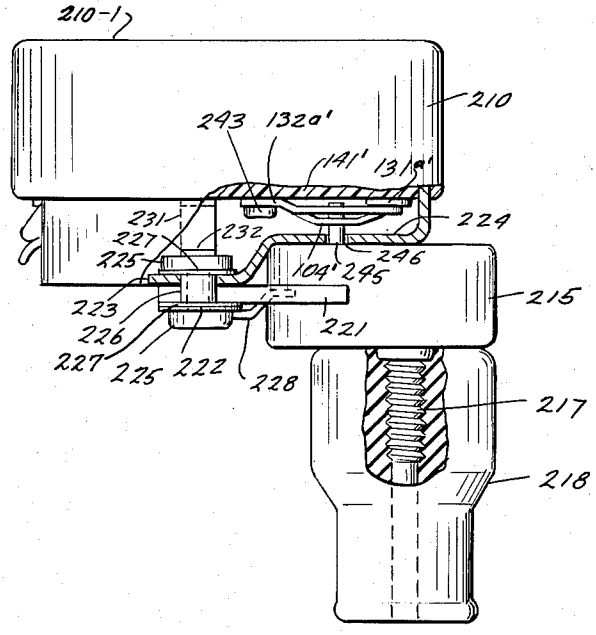


FIG. 15

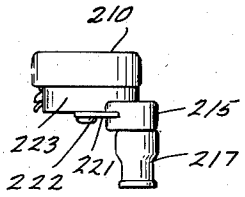
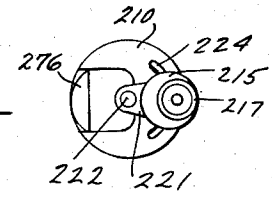


FIG. 16



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United States Patent Office 2,971,065 Patented Feb. 7, 1961

2,971,065

EAR INSERT HEARING AID

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Filed Dec. 30, 1957, Ser. No. 705,949

7 Claims. (Cl. 179—107)

This application is a continuation-in-part of my applications Serial No. 615,189, filed October 10, 1956, now abandoned, and Serial No. 634,368, filed January 15, 1957, now abandoned.

This invention relates to transistor amplifier hearing aids wherein electric signals of a microphone are amplified by a transistor amplifier and supplied by it to an earphone or receiver held in the ear of the user for enabling him to hear better.

Among the objects of the invention is a transistor amplifier hearing aid of the foregoing type in which all its elements, including the microphone, receiver, transistor amplifier and the energizing battery are combined in a subminiature ear-insert unit which is small enough to be confined in and fit within the outer ear cavity of the user, wherein the earphone or receiver is eccentric relatively to the more outward assembly, and which eliminates cords or sound-conducting tubes of the type used in prior-art hearing aids.

Among the objects of the invention is such hearing aid insert unit small enough to fit the outer ear cavity of the user and having at least one movable element which enables the user to control the battery connection to the amplifier, or the volume of the delivered sound, or both the battery connections and the sound volume.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the following drawings, wherein:

Fig. 1 is an enlarged view of one form of an ear-insert transistor hearing-aid amplifier unit exemplifying the invention;

Fig. 2 is an enlarged exploded isometric view showing all parts of the hearing aid of Fig. 1;

Fig. 3 is an enlarged view of the back side of the amplifier chassis of Fig. 2, from the back side thereof;

Fig. 4 is a circuit diagram of the hearing aid of Figs. 1 to 3;

Fig. 5 is an exploded view similar to Fig. 2, of another form of hearing aid of the invention;

Fig. 6 is a circuit diagram of the hearing aid of Fig. 5;

Fig. 7 shows how an ear-insert hearing aid unit of the invention is held in its operative position within the outer ear cavity of the user;

Fig. 8 is an elevational view of the hearing aid unit of Fig. 7;

Fig. 9 is a top view of the hearing aid unit of Fig. 8;

Fig. 10 is a partially exploded view of the chassis plate of Figs. 7–9, as seen from the bottom side of Fig. 8;

Fig. 11 is a circuit diagram of the hearing aid of Fig. 10;

Fig. 12 is a side view similar to Fig. 8, showing the opposite side thereof;

Fig. 13 is a bottom view of the unit of Fig. 12;

Fig. 14 is a side elevational view similar to Fig. 8, with some of the parts in cross-section, of a modified form of ear-insert hearing aid unit of the invention;

Fig. 15 is an elevational view similar to Fig. 1, of the same ear-insert hearing aid unit, showing it in approximately actual size; and

Fig. 16 is a bottom view of the same ear-insert hearing aid unit, as seen from the bottom side of Fig. 15.

Referring to Figs. 1–4, the hearing-aid insert unit 12 has an ear mold which is individually molded for each person. The ear mold 14 has a portion 16 that fits within the concha of the ear and a channel portion 18 that extends into the ear canal. Channel or duct portion 18 has an outlet opening 20 extending from a wider cavity 22 having a smaller interior cavity 24.

To the right of ear mold 14 is an outer casing 26, which surrounds the amplifier chassis 30, the battery cell 76, the microphone 80, and associated elements. The assembly of Fig. 1 is adapted to fit within the outer ear cavity of the user with only the casing 26 being visible on the front of the ear, and between casing 26 and ear mold 14 are mounted all of the transistor circuit elements, the sound-receiving and reproducing elements, as well as the source of power or battery, thereby enabling the user to carry the entire hearing aid at the ear and without connections to other portions which would require the use of exterior wire or cords.

The chassis disc or plate 30 (Fig. 2) is formed of electrical insulating material, its back side being shown in larger scale in Fig. 3. The insulating chassis plate 30 has printed conductors or a printed electrical circuit, composed of conductive material printed or etched thereon. Mounted on the surface of chassis disc 30 and connected to the printed circuit are the electrical circuit components of the amplifier, shown in circuit diagram of Fig. 4. The operation of this circuit is conventional, and requires no further explanation. The amplifier has three transistors 34, 36 and 38, five resistors 40, 42, 44, 46 and 48, and four capacitors 50, 52, 54 and 56. On the opposite surface of chassis disc 30, as seen in Fig. 2, is mounted an insulating plate 58 having a resistance 60 thereon which is connected to conductor 32, and engages a movable metallic wiper contact arm 62 which is also connected to the amplifier circuit. A pair of circuit leads 64, 66 extend from chassis disc 30, and from its circuit to a double-pronged plug 68 (Fig. 3) that is adapted to be inserted into an earphone or receiver 70, which may be embedded in the mold recess 22. The receiver 70 is of the conventional electromagnetic type and has a sound outlet projection or duct 72, which may be embedded in the smaller mold recess 24.

To the left of chassis disc 30 (Fig. 2) is secured a sheet metal battery casing 74, providing a compartment housing a small disc-like battery 76. The battery casing 74 makes contact with one battery pole, and is electrically connected to the printed circuit on chassis disc 30. The other pole of battery 76 engages an electric contact 77 on chassis disc 30 which is also connected to the printed circuit in the manner shown in Fig. 4.

To the right of chassis disc 30 (Fig. 2) is a microphone 80 of conventional electromagnetic design having a pair of electrical conductors 82, 84 extending therefrom, which are adapted to be suitably joined to the printed circuit. The microphone 80 is embedded in or separated from the other parts of the insert unit 12 by a layer of sound-damping material 86, such as foam rubber or the like, which is designed to suppress transmission or feedback of sound vibrations from the receiver 70 to the microphone 80. Microphone 80 is enclosed on its inward side by a metallic shield plate 88 of magnetic shield material of high permeability. The shield plate 88 is covered with a layer of electric insulating material 86 for insulating it from printed circuit 32 and other electrical components carried on the facing surface of chassis disc 30. Alternatively, the microphone 80 may be enclosed

in a casing of magnetic shield material which shields it from the magnetic field of receiver 70 and vice versa.

The hearing aid is assembled as follows: The several transistors, resistors, capacitors, and switch and volume control, are mounted on the chassis plate 30 and are connected with its printed circuit in the manner shown in Fig. 4. The microphone 80 with its plate 88 and the underlying sound insulating layer 86 is then secured to chassis disc 30, as by a pair of rivets 92. The ear mold 14, which may be individually molded to conform to the shape of the ear cavity of the user, has seated therein the receiver 70 which may form an integral part of the mold 14, or may be secured by cement or a bracket, not shown, to the chassis disc 30. The battery holder 74 may be secured to the chassis disc 30 by one or more rivets 96, or it may be secured to the ear mold 14 by cement or screws, not shown. The outer casing 26 is made of thin sheet material and is retained in assembled position by screws or rivets 100 passing through casing holes 98 and secured to the lateral flanges of the metallic microphone mounting plate 88 in the manner seen in Fig. 1. A small opening in the outer casing 26, not shown, permits sound to propagate to the microphone 80.

Fig. 5 shows how the ear-insert hearing aid unit 12 of the invention described above, in connection with Fig. 1, may be modified to provide certain additional features including a circuit switch which disconnects the battery, a control of the sound volume by the user of the hearing aid, and means for readily removing the battery for replacement thereof. Where the same parts are used in both the hearing aid of Figs. 1–4 and that of Fig. 5, they have similar reference numerals.

In Fig. 5, the chassis disc 30′ is relatively movable, and has on its opposite surfaces printed or etched circuits (not shown) of the type disclosed in Fig. 3, which connect a similar group of electrical components of transistor amplifier hearing aid shown in circuit diagram of Fig. 6. Battery 76′ engages chassis contact 77′ and its other pole engages metallic battery cover section 118 which contacts the printed circuit by a rivet or pin 119.

The hearing aid shown in the exploded view of Fig. 5 and in the circuit diagram of Fig. 6, has a chassis disc 30′ with printed circuits on its opposite surfaces facing the ear mold 141 and the microphone 80′ respectively, as in the unit of Figs. 1–3. To the printed circuit elements on the right surface of the chassis disc 30′ facing the microphone 80′ (as seen in Fig. 5) with its printed circuit, are interconnected the transistors 34′, 36′, 38′, the four resistors 40′, 42′, 44′, and 46′, the resistor 48′ which is connected between capacitor 56′ and battery switch elements 104, 108, and the four capacitors 50′, 52′, 54′, 56′, in accordance with the circuit diagram of Fig. 6. On the opposite left surface of the chassis disc 30′ is pivotally mounted a metallic switch arm 104 which is biased to keep the battery circuit closed by engaging with its outer end a stationary switch contact 108 of the chassis disc. The left side of chassis disc has also affixed thereto two stiff projecting metallic pins 110, 112 connected with the printed circuit and arranged to engage, hold, and make metallic circuit connections with the receiver 70′ held positioned between the chassis disc 30′ and the ear mold 14′. The receiver pins 110, 112 perform functions similar to the receiver conductors 64, 66 and plug 68 of the hearing aid insert unit of Fig. 3. As in the unit of Figs. 1–3, the receiver 70′ is held in a position eccentric relative to the wider chassis assembly which fits the more outward part of the ear cavity. When the receiver 70′ rotates with the chassis 30′, they may be mounted concentrically.

The left surface of the chassis disc 30′ also carries along its surface an arcuate rheostat element 120 and a pivotally mounted metallic rheostat wiper arm 122 having grips 124 of electrically insulating material arranged to enable control of the amplifier gain by a pivotal movement between the rheostat 120 and its wiper 122. To the left side of the chassis disc 30′ are also arranged to be secured, battery and rheostat cover sections 118, 116, respectively. Rheostat cover section 116 has an arcuate slot 132 substantially coextensive with the arcuate rheostat 120 of the chassis disc 30′. A relatively stationary control lever or member 126 is positioned between the rheostat cover 116 and chassis disc 30′. Control member 126 has a pivot pin 128 on which is pivotally seated the pivot hole 133 of the rheostat cover section 116 so that when the latter is secured to the chassis disc 30′, it may be rotated around the stationary control member pin 128. Control member 126 has a lateral retainer projection 130 passing through arcuate slot 132 of rheostat cover section 116 and seated and affixed in an opening 134 of the ear mold 14′ for holding it stationary and affixed to the ear mold 14′ while the chassis 30′ and other parts carried thereby are rotated around the fixed control-member pivot pin 128.

Control member 126 carries an angular cam 138 with a cam surface shaped so that when the chassis disc 30′ is rotated in clockwise direction around pivot 128 (as seen on the left chassis side in Fig. 5), the corner portion of cam 138 engages switch arm 104 and moves it from its biased, closed position to open position. In the further clockwise movement of chassis disc 30′, the upper region of control arm cam 138 engages and pushes the adjacent edge of battery 76′, under the battery cover 118, in a laterally outward direction, whereupon the exposed outer edge of the battery 76′ may be gripped by the user's fingers for removing or replacing it in the amplifier.

The rheostat and battery cover sections 116, 118, respectively, are suitably affixed in their aligned position shown, to the adjacent chassis disc 30′ for instance by rivet pins, not shown, extending through aligned holes, also not shown, provided in them. The microphone 80′ with its sound-attenuating layer 86′ and its magnetic shield 88′, are secured to the right side of the amplifier chassis disc 30′ (as seen in Fig. 5), together with their surrounding casing 26′, in the same manner as in the hearing aid unit of Figs. 1–3. The earphone 70′ may be affixed to the chassis 30′ as by securing it with a mounting ring 140 having mounting ears with holes by which it may be secured to the chassis 30′, as by the same rivets, not shown, with which the rheostat and battery cover sections 116, 118 are secured thereto. With such arrangement, the earphone 70′ will rotate with the chassis plate around control member pivot 128 when adjusting the volume control of rheostat 120 and/or opening the switch 104, and/or ejecting the battery when the chassis 30′ is turned by the user's grip on the chassis casing 26′ exposed along the exterior of the outer ear cavity. However, the earphone 70′ may be secured, as by cement, to and made a stationary part of the ear mold 14′, in which case the earphone coil may be connected by flexible leads, such as indicated at 64, 66 in the unit of Figs. 1–3, to the printed circuit earphone terminals 110, 112 of the chassis disc 30′.

In the ear-insert hearing aid unit shown in the exploded view of Fig. 5, and in the circuit diagram of Fig. 6, rotary movement imparted to the chassis disc 30′ by turning its outer casing 26′, will cause the pointed central part of the control arm cam 138 to first open battery switch 104 and thereafter the cam 138 will cause the battery 76′ to be nudged upwardly as seen in Fig. 5, from its battery holder compartment to permit grasping the battery by the finger tips of the user for removal and/or replacement thereof. From the hearing aid unit described in connection with Figs. 1–4, the ear-insert hearing aid unit of Figs. 5 and 6 differs by the rotatable arrangement of the parts which are affixed to the outer casing 26′ which may be gripped by the user along the exterior of the ear, whereby the outer casing 26′ together with the other elements secured to the chassis disc 30′ including the battery switch arm 104 and rheostat 120, may be moved relatively to the relatively fixed parts held in the ear of the user, such as the ear insert with or

without the earphone secured thereto, for adjusting the volume of the sound and/or cutting off the amplifier without removing any part of the hearing aid from its position within the ear of the user. This arrangement thus permits the user to readily adjust the volume of sound or to open the battery circuit when he prefers silence, thereby also saving on battery usage. It also facilitates easy replacement of the battery when it is worn out.

In the hearing aid amplifier of the invention, all components are combined into a subminiature ear insert of lateral dimensions small enough so that a large or major part, including the receiver, transistors, amplifier, microphone elements and other parts thereof, may be held and confined within the outer ear cavity or concha of a human ear, such as shown in Fig. 7. As shown in Fig. 7, in accordance with the invention, the components including the microphone, transistor amplifier elements, and the receiver, are assembled and combined into a unitary hearing aid having its lateral dimensions sufficiently small so as to fit within the concha cavity of the outer ear between the anti-helix and tragus thereof, with the receiver having a sound outlet duct connected through a flexible ear tip fitting within and acoustically sealing the ear canal **160** of the user.

Another form of such hearing aid is shown in Figs. 8 to 13. Referring to the exploded and diagrammatic view of Figs. 10 and 11, it comprises an electromagnetic microphone **111***a* as in Figs. 1–4, the output of which is impressed on an amplifier operating with three transistors **112***a*, **113***a*, **114***a*, which also deliver the amplifier output to electromagnetic receiver **115***a*, as in Figs. 1–4. The circuits of all three transistor stages are energized from the same battery **117***a*. The output of the microphone **111***a* is delivered through by-pass capacitor **121***a* and lead **125***a* to the base and emitter of the first transistor **112***a*. The output developed between the emitter and collector of the first transistor **112***a* is delivered through by-pass capacitor **127***a* to the base and emitter of second transistor **113***a*. The output developed across the emitter and collector of second transistor **113***a* is impressed upon a volume control resistance **131***a*. The output developed at the tap **132***a* of volume control resistance **131***a* is delivered through by-pass capacitor **133***a* to the base and emitter of the third power stage transistor **114***a*. The output developed across the emitter and collector of the power stage transistor **114***a* is delivered to the coil of the receiver **115***a*. The emitters of all three transistors are connected to a common supply lead **139***a* of battery **117***a*. The collectors of the three transistors are connected to the opposite pole of the battery **117***a* through resistor **135***a*, volume control resistor **131***a*, and the resistance of the coil receiver **115***a*, respectively. Proper bias and operating connections are provided by circuits including resistors **136***a*, **137***a* and **138***a*.

In accordance with the invention, the foregoing components of the transistor amplifier hearing aid are combined into a compact amplifier-microphone unit **140***a* having lateral dimensions which fit within the outwardly opening concha cavity of the human ear between the anti-helix and tragus bordering the sides of the ear cavity, with the receiver **115***a* extending eccentrically inwardly away from the wider amplifier-microphone unit **140***a*, and having at most half of its cross-sectional area, so that its sound outlet duct opens and transmits sound directly into the ear canal **160** while the microphone **111***a* is exposed on the outer side of the amplifier-microphone unit **140***a*. As shown in Fig. 7, an ear canal insert **118***a* of flexible material held on sound outlet duct **119***a* of receiver ear insert **118***a*, fits against the walls of the ear canal **160** and forms therewith an acoustic seal for suppressing feedback of sound from the ear canal **160** towards the microphone **111***a* positioned along the outer wall of the unit **140***a*.

As shown in Fig. 10, the microphone **111***a* and the receiver **115***a* each have electromagnetic transducer structures wherein a ferromagnetic core and windings interlinked with the core along a respective magnetic transducer axis of a winding-core section thereof operates to transduce acoustic or sonic signals into electric signals and vice versa. Furthermore, the magnetic transducer axis of the microphone **111***a* extends transversely to the magnetic transducer axis of the receiver, thereby materially reducing the magnetic linkage between them and serving to keep the over-all feedback from the receiver **115***a* to the microphone **111***a* below the level sufficient to start disturbing sustained feedback oscillations and receiver whistling.

The ear canal insert **118***a* has a sound outlet passage **118–1***a* into which opens the sound passage **119–1***a* of the sound outlet nipple **119***a* of the receiver ear insert **118***a* (Figs. 7, 12, 13). The flexible sound outlet ear insert **118***a* may be made of any of the known synthetic, elastic, rubber-like resin materials. The wider ear insert portion may be formed of a materially stiffer material than its outward narrower end, which should be sufficiently flexible so as to adjust itself to different directional shapes of the ear canal **160**.

The circuit components of the hearing aid unit are positioned and assembled along a support chassis plate **141** which forms part of a printed circuit (Fig. 10). Support chassis plate **141** may be made of conventional, strong and electrically insulating material having affixed thereto or therein printed metallic circuit portions of the amplifier circuit. One set of these printed metallic circuit elements **142**, **143**, **144**, **145**, **146**, **147**, **148** and **149**, is exposed along the downwardly facing surface of the chassis plate **141** (Fig. 12). The other set of printed metallic circuit elements **151**, **152**, **153** and **154**, is exposed along the upwardly facing surface of the insulating chassis plate **141** (Fig. 12). The rectangular microphone **111***a* is positioned along the upwardly facing surface of the chassis plate **141** so that its outer microphone wall **111–1***a* picks up sound through openings **111–2***a* for generating corresponding electric signals as in the device of Figs. 1–3. The microphone **111***a* is enclosed in a casing of magnetic shielding sheet material to suppress interlinkage thereof with the receiver **115***a* by their stray magnetic fields.

Along one border region of the outward chassis surface are positioned transistors **112***a* and **114***a*, resistance elements **136***a* and **138***a*, and capacitor **133***a*. Along the opposite border region of this chassis surface are positioned transistor **113***a*, capacitors **121***a* and **127***a*, and resistors **135***a* and **137***a*. As indicated in diagrammatic Fig. 10, the three wire ends of transistor **112***a* pass through openings in and are soldered to printed circuit portions **145**, **147** and **144** of chassis plate **141**. The wire lead ends of transistor **114** are similarly joined to printed chassis circuit elements **144**, **148** and **149**. The two wire ends of resistor **138***a* are similarly joined to printed chassis circuit elements **148**, **149**, to which the wire lead ends are joined as by soldering. The wire ends of resistor **136***a* are similarly joined to printed chassis elements **145**, **147**. The two leads of capacitor **133***a* are similarly joined to printed chassis circuit elements **148**, **152**.

Transistors **113***a*, capacitors **121***a* and **127***a*, and resistors **135***a* and **137***a* have their respective wire ends similarly joined to their associated printed chassis circuit elements and other circuit components, as indicated in wiring diagram of Fig. 10.

Printed chassis element **154** overlaps the printed circuit portion **149** on the other side of chassis **141** and is joined thereto by a wire or molten solder in a chassis perforation. In a similar way, other printed circuit elements are joined to proper overlapping printed chassis portions on the opposite chassis side. Two stiff conductors **146–2**, **154–2** pass through chassis **141** and are soldered to printed circuit portions **146**, **154** so that they

project in downward direction, as seen in Fig. 10, for making connections from the amplifier circuit to the receiver **115***a*.

Arcuate volume control rheostat **131***a* is positioned on the downward side of chassis **141** and it has a pivoting contact arm **132***a* for varying the volume of the sound output.

The small flat battery **117***a* is detachably held on the inward side of chassis **141** by an overlying, bendable, springy stiff battery cover **161** of spring metal, having one end suitably secured, as by rivets **162**, to the chassis **141**. The battery cover arm **161** is electrically connected through one of its connecting rivets **162** to printed chassis portion **153** and connects thereto one flat terminal of battery **117***a*. The opposite flat terminal battery **117***a* is held pressed against battery terminal portion **144–1** of the printed chassis circuit **144**.

The springy battery cover **161** provides a nesting space for the battery **117***a*. By gripping and flexing the free end of battery cover **161**, the battery **117***a* is released for removal or replacing it.

On the inward side of chassis plate **141** is eccentrically mounted the much narrower inwardly projecting receiver **115***a* so that its center is eccentrically positioned relatively to the center of the amplifier assembly or unit **140** and its electromagnetic microphone **111**. The receiver **115***a* may be held mounted in its eccentric position on the chassis **141**, for instance, through engagement of its terminal sleeves (not shown), with terminal pins **154–2**, **146–2** of chassis **141**. The receiver **115***a* may also be held in its eccentric position on the chassis **141** by making the casing of receiver **115***a* a protruding part of the wider inner casing wall **171**, which is suitably secured to chassis **141**, as by securing ear projections to the edge of chassis plate **141** with screws or cement. The inward casing wall **171** is formed of thin sheet metal and has a casing rim portion **172** engaging the peripheral edge of the amplifier chassis plate **141** which is suitably secured thereto.

Battery cover **161** is positioned in an opening **171–1** of casing wall **171** along which the battery cover **161** is exposed. Casing opening **171–1** permits gripping and flexing of battery cover edge **161–1** for releasing the battery **117***a* from chassis **141**. Casing rim **172** has also an opening **172–4** (Fig. 12) for actuating rheostat arm **132***a* and adjusting the sound output.

The outer side of chassis **141** holding microphone **111***a* and other circuit parts of the amplifier is enclosed by outer casing **181** which is secured, as by screws to the rim of inner casing **171** for enclosing the hearing aid assembly.

The outer casing **181** may have opening **181–1** for exposing outer casing wall **111–1***a* of microphone **111***a*. A relatively thick layer **183** of sound vibration attenuating material, such as sponge rubber, is placed between the microphone **111***a* and the adjoining parts of the hearing aid, and particularly its receiver **115***a*, for suppressing transmission or feedback of disturbing vibrations and sound from the receiver to the microphone that would set up whistling sound generation.

Alternatively, outer casing wall **181** may extend over microphone **111***a* and have openings through which propagated sound is transmitted to the microphone **111***a*. In such case, the microphone **111***a* is held separated in floating condition from the overlying casing wall **181**, for instance, by a border of sound-attenuating sponge rubber or the like.

The structure of the hearing aid shown in Figs. 7–13 may be readily designed so that the casing side walls are of D-shape conforming to the shape of the concha.

Figs. 14–16 show how the unitary ear-insert hearing aid described above in connection with Figs. 7–13, may be modified in the manner explained in connection with the hearing aid unit of Figs. 5 and 6, so that rotation of its wider outer amplifier sections relatively to its inward eccentrically mounted receiver imparts a control motion to internal control elements for adjusting the volume of the sound output of the hearing aid unit and/or for selectively controlling the energization of its amplifier circuit by the battery, in the manner explained in connection with the hearing aid unit described above in connection with Figs. 5 and 6. The ear-insert hearing aid unit of Figs. 14–16 comprises an outer wider microphone-amplifier unit **210** and an inward receiver unit **215** positioned eccentrically relatively to the amplifier unit **210** and having a lateral cross-sectional area at most about one-half the lateral cross-sectional area of the amplifier unit **210**. The microphone-amplifier unit **210** and the inward receiver unit **215** embody and consist of substantially the same elements as the corresponding wider outer amplifier unit **140** and the inward receiver **115***a* of Figs. 7–13, or as the corresponding outer amplifier unit housed in casing **26′** and the inward receiver unit **70′** of the instrument of Figs. 5 and 6. The receiver **215** is provided with a relatively long protruding sound outlet duct **217** having an interior sound passage through which sound produced in the receiver is transmitted to the ear canal of the user. An ear canal insert **218**, similar to the ear canal insert **118***a* of Figs. 7–13, is seated over and in tight coupling engagement with the threaded outer surface of sound outlet duct **217** of the receiver **215**. The ear canal insert **218** is shaped to fit with its flexible exterior against the walls of the ear canal of the user so as to form therewith an acoustic seal which suppresses feedback of sound from the receiver sound outlet duct **217** toward the microphone positioned behind the outer casing wall **210–1** of the outer microphone-amplifier unit **210**.

The casing of the eccentrically positioned receiver **215** has a relatively rigid pivot arm **221** which is pivotally mounted on a pivot pin **222** with which it is pivotally secured to an inwardly protruding wall section **223** of the inner casing wall **224** of the outer microphone-amplifier unit **210**. The casing of receiver **215** and its pivot arm **221** are of metal and one end of the receiver winding is electrically connected to the receiver casing and its metallic pivot arm **221** and therethrough to the metallic casing of amplifier unit **210**, corresponding to the connection of receiver **115***a* of Fig. 11 to the negative terminal of battery **117***a*. The pivot pin **222** of the receiver pivot arm **221** is likewise of metal and it, together with its two metallic clamping heads **225**, are electrically insulated from the metallic receiver pivot arm **221** and the metallic casing wall **223** of the amplifier unit **210**, as by an insulating sleeve **226** surrounding the metallic pivot pin **222** and two insulating washers **227** interposed between the metallic heads **225** of the pivot pin **222** and the underlying metal portions of the receiver pivot arm **221** and casing wall **223**. The other end of the receiver coil that is not connected to the receiver casing and its pivot arm **221**, is connected through an insulated conductor **228** to the pivot pin **222**. A contact spring arm **231** having one end secured as by a rivet to a metallic circuit portion of printed circuit chassis plate **141**, has its free end contact portion **232** biased into contact engagement with the adjacent pivot pin head **225**, thereby completing the connection of the winding of receiver **215** to the amplifier circuit, for instance, to the collector of transistor **114***a* of the amplifier of the circuit diagram of Fig. 11.

The pivot pin **222** is arranged to permit pivotal movement of the casing of the microphone-amplifier unit **210** relatively to the eccentric receiver **215** when it is held fixed in sealing engagement with the ear canal of the user, as described above. The printed circuit amplifier chassis plate **141** is provided with an arcuate rheostat element **131***a′* and a cooperating pivotally mounted rheostat arm **132***a′* pivotally mounted on the chassis plate as by a pivot pin **243**, for adjusting the amplifier gain in

the manner explained, for instance, in connection with the circuit diagram of Fig. 11 or Fig. 6.

The rheostat arm 132*a'* is moved along its rheostat 131*a'* by the control motion of a control rod 245 extending from the receiver 215 through an arcuate slot 246 of the amplifier casing wall 224 into coupling engagement with a coupling portion of the rheostat arm 132*a'*. The control rod 245 is relatively rigid, and is formed of insulating material such as nylon, or it has an exterior insulating coating, so that it provides only a mechanical motion-transmitting link between the receiver 215 and the rheostat control arm 132*a'*, without making any electrical connections between them. With this arrangement, a casing wall portion of the microphone-amplifier unit 210 exposed along the open side of the wider ear cavity, may be gripped by fingers of the user and rotated on pivot 222 relatively to the fixed control rod 245 of the fixed receiver 215 for imparting to the rheostat arm 132*a'* a control motion which adjusts the gain of the amplifier and the sound output of the receiver 215 in the same manner as explained above in connection with the embodiments of Figs. 8–13, Figs. 1–4, and Figs. 5 and 6.

The amplifier of the hearing aid units of Figs. 14–16 may have an amplifier circuit such as described in connection with Fig. 6, or with Fig. 11, with the amplifier circuit including an energizing switch 104' cooperating with a fixed switch contact, not shown but similar to 108, such as shown in Fig. 6, for selectively energizing or deenergizing the amplifier circuit by pivotal motion of the switch arm 104'. The movable switch arm 104' and its stationary contact are suitably mounted on the printed-circuit chassis plate 141' of Figs. 14–16 in the manner described in connection with the corresponding elements of the hearind aid unit of Figs. 5 and 6, wherein the movable switch arm 104' is biased, as by spring action, to a closed circuit position. A portion of the switch arm 104' is arranged to come in engagement with the fixed insulating control pin 245 of the receiver 215 near the end of the pivotal volume-reducing movement of the amplifier unit 210 so that at the end portion of this volume-reducing movement, the receiver control pin 245 comes into engagement with energizing switch arm 104' for moving it to the circuit opening position in which the battery 276 is disconnected from the transistor-amplifier circuit. With this arrangement, and assuming that the casing of the amplifier unit 210 is in a position in which the energizing switch 104' is retained in its open position, the initial part of the rotary movement imparted by the fingers of the user to an exposed casing portion of the microphone-amplifier unit 210 in a gain-increasing direction, will first release the amplifier energizing switch 104' to its energizing position in which it makes contact with its fixed switch contact and energizes the transistor amplifier. Further movement of the amplifier unit 210 in the same gain-increasing direction will cause the receiver control rod 245 to move the rheostat control arm 132*a'* over its rheostat element 131*a'* for adjustably increasing the gain of the amplifier and the sound output of the receiver to the level desired by the user. A similar opposite gain-decreasing rotary movement imparted by the finger of the user, to an exposed casing wall portion of the microphone-amplifier unit 210, will cause the receiver control rod 245 to move the rheostat control arm 132*a'* in opposite direction for adjustably reducing the gain and sound output of the amplifier, the end portion of this gain-reducing movement causing the receiver control rod 245 to bring switch arm 104' from the closed-circuit position to the open-circuit position in which the battery cell 276 is disconnected from the amplifier circuit, as explained in connection with Figs. 5 and 6. Otherwise, the ear insert hearing aid unit described above in connection with Figs. 14–16, may have the same construction as the ear insert hearing aid unit of Figs. 8–13, or Figs. 5 and 6, or 1–4.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof, will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims, they shall not be limited to the specific exemplifications of the invention described above.

I claim:

1. In a hearing aid device, an inward housing section with a sound outlet duct projecting inwardly toward the user's ear canal and an outward housing section joined to and extending from the outward side of said inward housing section and being opposite said sound outlet duct, said inward housing section having a lateral cross-sectional area materially smaller than said outward housing section and said two housing sections forming together an integral unit having laterally dimensions fitting the outer ear cavity between the anti-helix, tragus and anti-tragus, said inward housing section having mounted therein a receiver comprising an electromagnetic acoustic transducer having a sound outlet space connected to said outlet duct, said outward housing section having mounted therein a battery cell, a microphone with an electromagnetic transducer exposed to exterior sound and transistor amplifier means electrically connected to said cell between the transducers of said microphone and said receiver for supplying to said receiver amplified microphone signals, each of said electromagnetic transducers comprising a ferromagnetic core and windings interlinked with said core along a winding-core section and transducing axis thereof, the winding-core section of said receiver being laterally displaced in an eccentric position relatively to the winding-core section of said microphone, a magnetic shield element of magnetic sheet metal interposed between the core and winding of the microphone and receiver transducers, said receiver having a transducing axis extending transversely to the transducer axis of said microphone for suppressing in conjunction with said shield element magnetic signal feedback from the receiver transducer to the microphone transducer and maintaining the over-all feedback between them below a level sufficient to start sustained electric feedback oscillations and whistling.

2. In a hearing aid device having dimensions fitting within a user's outer ear cavity between its anti-helix, tragus and anti-tragus, an inward housing section and an outward housing section including an outside wall, said two housing sections mechanically joined in a side-to-side relationship in which said outward section is rotatable with respect to said inward section, a receiver mounted within said inward housing section and directed toward the user's ear canal through a sound outlet duct, an interior space between said inward housing section and the outside wall of said outward housing section, said interior space having mounted therein a battery cell, a transistor amplifier having at least two transistors and a microphone exposed to exterior sound, said battery cell electrically connected to said amplifier which is electrically connected between said receiver and said microphone, said amplifier including amplifier current control means having a movable control element mechanically coupled to said inward housing section and moved by relative rotation between said inward and outward housing sections.

3. In a hearing aid device as claimed in claim 2, said receiver and said microphone are electro-magnetic and have axes eccentric with respect to each other.

4. In a hearing aid device as claimed in claim 3, a magnetic shield element interposed between said receiver and said microphone.

5. In a hearing aid device as claimed in claim 2, said current control means including volume control means and an open-close circuit switch between said battery cell and said transistor amplifier, said switch

operated by movement of said control element outside of a volume control range of movement.

6. In a hearing aid device as claimed in claim 2, said control element having a volume control range of movement and said battery cell is movably mounted in and is ejected from said outward housing section by movement of said control element outside of its volume control range of movement.

7. In a hearing aid device as claimed in claim 2, said movable control element having a volume control range of movement and two separate ranges of movement outside its volume control range of movement, the first separate range of movement operates an open-close circuit switch between said battery cell and said transistor amplifier and the second separate range of movement ejects said battery cell from said outward housing section in which said battery cell is movably mounted.

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