

Nov. 19, 1957

E. M. WILLIAMS

2,813,933

HEARING AID

Filed May 26, 1953

2 Sheets-Sheet 1

Fig. 2.

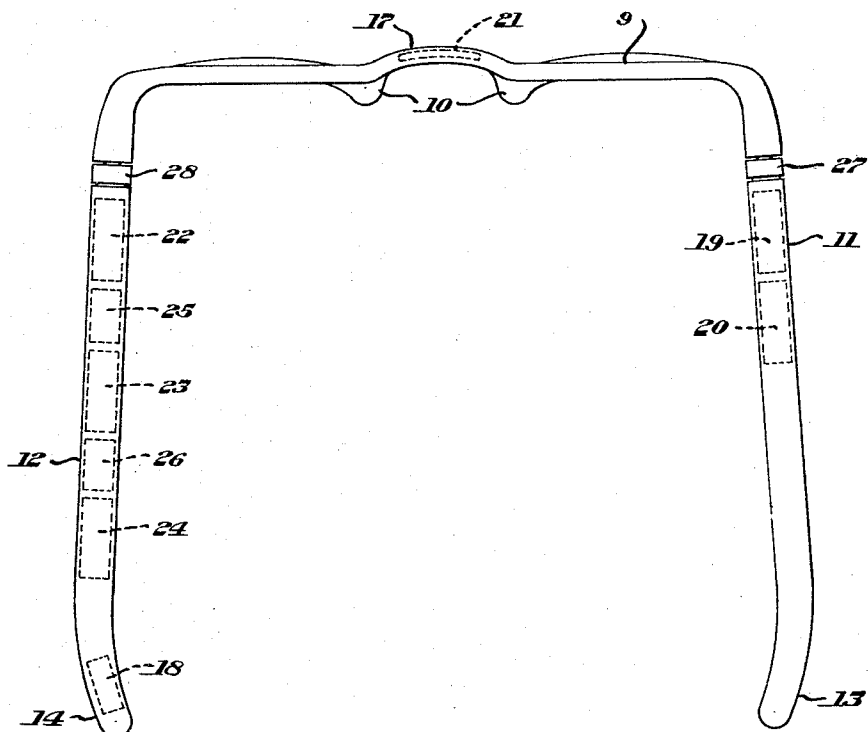


Fig. 3.

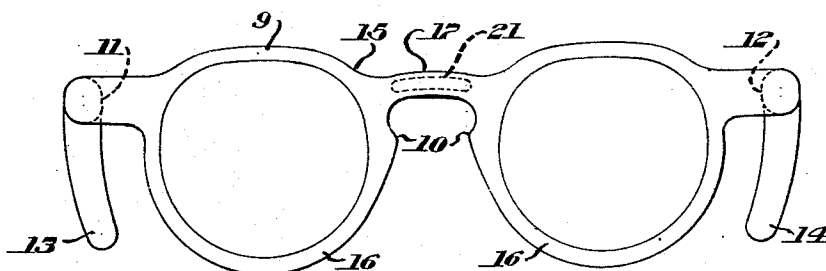
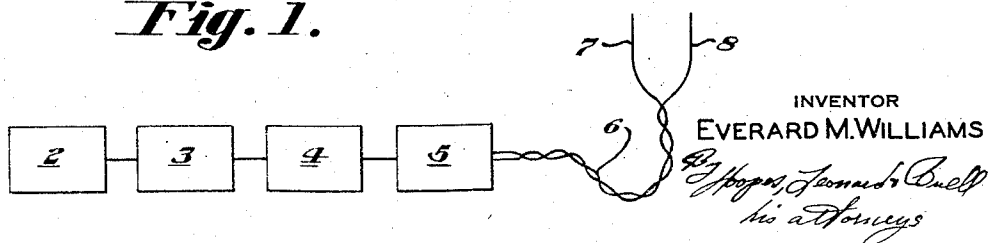


Fig. 1.



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Fig. 4.

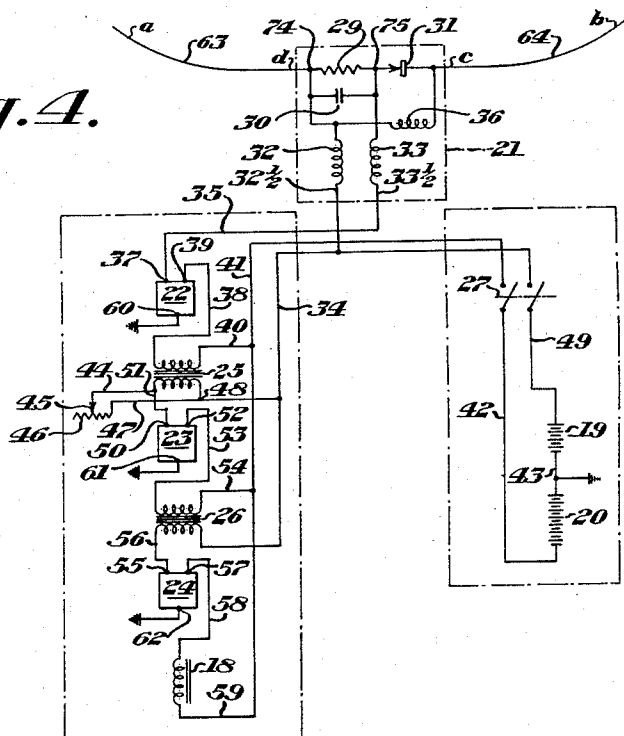


Fig. 5.

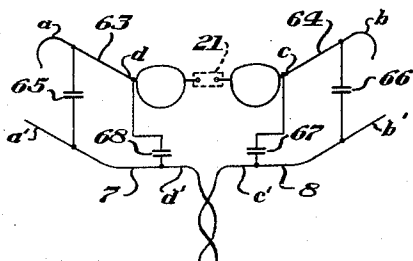


Fig. 6.

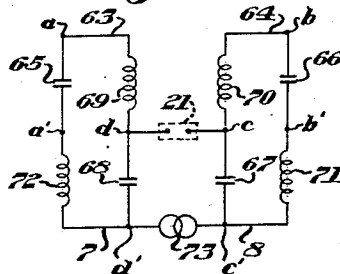
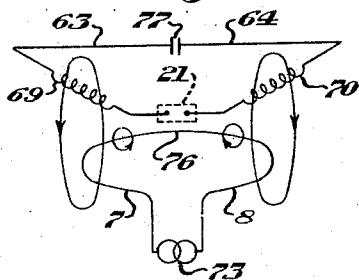


Fig. 7.



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2,813,933

HEARING AID

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3 Claims. (Cl. 179—107)

This invention relates to hearing aids and is in the nature of an improvement over the invention of United States Patent No. 2,613,282. In that patent there is disclosed a hearing aid characterized by its inconspicuousness and compactness shown as being contained within a support having the general configuration of a spectacle frame. In that hearing aid the sound vibration receiving portion is disposed in the bridge of the spectacle frame. A sound reproducer is carried by the support near the ear of the user and means are provided whereby sound vibrations received by the sound vibration receiving portion are converted into audible sounds in the sound reproducer, the hearing aid being confined entirely within the support and having no exterior wires, ear plug or connections of any kind.

The hearing aid of said patent is satisfactory but requires the bridge portion of the support to be undesirably large and also has limitations as to capacity and life because all of the operating parts must be confined within very small spaces.

I provide a hearing aid in which I utilize a first unit worn upon the user's body converting sound vibrations into electric and magnetic field oscillations together with a second unit physically entirely separate from and unconnected with the first unit worn upon the user's head receiving oscillations from the first unit and converting the same into audible sounds adjacent the user's ear.

It has previously been proposed to provide a hearing aid having two separate units, one carried by the user upon his torso and the other constituting an ear plug without connecting wires, the user's body being relied upon as a portion of the conducting circuit rendering the device operable. This requires that there be two body electrodes in firm contact with the body of the user, one at the torso and the other at the ear. Such a hearing aid is unsatisfactory, first, because of the necessity of the provision of the body electrodes and, second, because the ear plug is unsightly and makes known the fact that the user is hard of hearing. Special clothing must be provided to enable application of the body electrode to the torso of the user while the microphone is disposed outside the clothing.

My hearing aid does not employ the body of the user as a portion of an electrical circuit necessary to operation of the hearing aid and hence requires no body electrodes and no special clothing; and also my hearing aid dispenses with an ear plug. It has all of the advantages of the hearing aid of Patent No. 2,613,282 and the additional advantages that a smaller and less conspicuous bridge portion may be provided in the support which has the general configuration of a spectacle frame and that a much more powerful unit for receiving and converting sound vibrations may be employed since that unit is worn upon the user's body below the head and hence may be of substantial size. Such unit may be concealed beneath the outer clothing of the user; and it may be completely out of contact with the user's body. Actually such unit may be of considerably smaller size than a conventional

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hearing aid which is worn upon the user's body and connected by wires with an ear plug or bone conducting unit carried by a head clamp.

My hearing aid may take different forms, one form comprising means worn upon the user's body converting sound vibrations into an oscillating electric field and means physically entirely separate from and unconnected with the first mentioned means worn upon the user's head intersecting the electric field created by the first mentioned means and converting the electrical oscillations induced in its conductors by this field to audible sounds adjacent the user's ear, and another form comprising means worn upon the user's body converting sound vibrations into an oscillating magnetic field and means physically entirely separate from and unconnected with the first mentioned means worn upon the user's head intersecting magnetic flux in said field and converting electrical oscillations induced in its conductors by this field to audible sounds adjacent the user's ear. Actually the sound vibration converting means converts the sound vibrations into electric and magnetic field oscillations and in the first mentioned form of hearing aid the electric field is utilized primarily as the means of inducing oscillations for producing audible sounds while in the second mentioned form of hearing aid the magnetic field is utilized primarily as the means of inducing oscillations for producing audible sounds. Indeed, electromagnetic waves of the radio type are also generated but they are so weak in comparison with the electric and magnetic field oscillations that they are not relied upon for operation of the hearing aid although they might be so employed.

The sound converting means of my hearing aid may include a conductor worn at least partially about the user's neck. When the oscillating electric field is utilized the conductor need not extend completely about the user's neck but should have portions extending at least to the sides of the neck. When the magnetic field is utilized the conductor should extend completely about the user's neck. I find it convenient to dispose the conductor in a necktie. The conductor may take various forms, one preferred form being a braid of Phosphor bronze which has the desired electrical properties and is very flexible so that it may be deformed and knotted with the necktie. The end of the conductor extending downwardly from the neck is connected with a microphone unit. The microphone unit may be worn upon the clothing of the user completely out of contact with the user's body.

Sound vibrations are converted into electric and magnetic field oscillations in the conductor which extends at least partially about the user's neck and those oscillations in turn produce in conductors in the temples of the support worn on the user's head a current of electricity which is converted into audible sounds adjacent the user's ear. The conductors in the temples of the support intersect the electric or magnetic field emanating from the conductor which is disposed at least partially about the user's neck whereby a current flow is induced in the former.

Other details, objects and advantages of the invention will become apparent as the following description of certain present preferred embodiments thereof proceeds.

In the accompanying drawings I have shown certain present preferred embodiments of the invention in which:

Figure 1 is an electrical diagram of one form of the unit of the hearing aid which is adapted to be worn upon the user's body;

Figure 2 is a somewhat diagrammatic illustration of one form of the unit of the hearing aid which is adapted to be worn upon the user's head, the unit being shown in Figure 2 as viewed from above looking down;

Figure 3 is a front view of the hearing aid unit shown in Figure 2;

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Figure 4 is an electrical diagram of the hearing aid unit shown in Figures 2 and 3;

Figures 5 and 6 are diagrams illustrating the operation of the form of hearing aid shown in Figures 1-4; and

Figure 7 is a diagram illustrating the operation of another form of my hearing aid.

The means for converting sound vibrations into electric and magnetic field oscillations which is worn upon the user's body is illustrated diagrammatically in Fig. 1. In that figure there is shown a microphone 2, an audio amplifier 3, an audio modulator 4, an oscillator 5 and a conductor designated generally by reference numeral 6. The microphone 2, the audio amplifier 3, the audio modulator 4 and the oscillator 5 may be connected in conventional manner as well known to those skilled in the art and may be disposed within a small and inconspicuous case. The conductor 6 extends from the oscillator out of the case as shown in Figure 1 and has two branches 7 and 8 extending alongside the user's neck at opposite sides thereof. The branches 7 and 8 may be connected together at the rear of the user's neck forming a complete loop if the magnetic field is to be utilized for operation of the hearing aid. If the electric field is to be utilized it is not necessary that the branches 7 and 8 be joined together at the rear of the user's neck, those branches having the desired function because they are respectively generally below and parallel to the conductors in the temples of the support worn on the user's head as will presently be described.

I find it most practical to incorporate the conductor 6 in a necktie and to make the conductor continuous lengthwise of the necktie. While, as indicated above, a continuous conductor capable of forming a closed loop is required when the magnetic field is to be utilized although not required when the electric field is to be utilized, such a continuous conductor may be employed in either case. I desirably dispose a Phosphor bronze braid inside the necktie and after the necktie has been tied I connect together the ends of the braid at the ends of the necktie and connect the same to the oscillator. Sound impinging on the microphone 2 causes weak audio frequency currents which are amplified by the audio amplifier and fed to the audio modulator which modulates the high-frequency carrier produced by the oscillator. Modulated carrier currents are fed to the conductor 6.

The portion or unit of the hearing aid which is worn upon the user's head and which has the general configuration of a spectacle frame is shown in Figures 2 and 3. The support is designated generally by reference numeral 9 and as shown in Figures 2 and 3 has the general configuration of a spectacle frame. It has spaced apart bearing portions 10 adapted to bear on the nose of the user. It has opposed temples 11 and 12 extending to positions adjacent the ears of the user and having slightly curved end portions 13 and 14 respectively which are adapted to lie atop the ears and press against the user's head, as against the mastoid bone, and to cooperate with the portions 10 to maintain the support in position on the head. The portions 10 are integral or connected with a front part 15 of the support 9. The front part 15 has two portions 16 shaped as lens frames connected by a bridge 17. When the portions 10 bear on the user's nose the bridge 17 is disposed at the front of the upper portion of the nose as is conventional.

The sound reproducer is disposed in the curved end portion 14 of the temple 12 of the support 9 and is shown diagrammatically at 18 in Figure 2. The sound reproducer 18 is of the bone conduction type and is by the temple 12 of the support pressed against the mastoid bone generally above the user's left ear. The sound reproducer is suitably mounted in the portion 14 so that when it is activated it will in turn through the mastoid bone of the user activate the auditory nerve of the user or in other words produce audible sounds adjacent the user's ear. The principle of operation of the bone conduction

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type sound reproducer 18 is the same as the principle of operation of any bone conduction type sound reproducer but the sound reproducer is rendered inconspicuous or, indeed, invisible by disposing it within the support.

The power unit for the portion of the hearing aid carried by the support 9 is disposed within the temple 11 of the support and may comprise two batteries 19 and 20 electrically connected as will presently be described. The batteries are of appropriate capacities, the battery 19 desirably having a voltage of the order of 3 volts and the battery 20 desirably having a voltage of the order of 30 volts. The function of the power unit consisting of the batteries 19 and 20 is to supply the necessary electrical energy to operate the portion of the hearing aid carried by the support 9.

The support 9 carries, desirably in the bridge 17, a detector designated diagrammatically by reference numeral 21 in Figures 2 and 3 and which will be described in detail below. The detector may be quite small and completely concealed within a normal sized spectacle bridge, obviating the necessity of providing an abnormal and unsightly bridge of large size containing a microphone as in United States Patent No. 2,613,282.

Three transistors 22, 23 and 24 and two transformers 25 and 26 may be disposed within the temple 12 as shown in Figure 2. A switch 27 for closing and opening the electrical circuit is provided in the temple 11, the switch comprising a turnable ring operable by the fingers of the user, the circuit being closed when the ring is in one rotative position and being open when the ring is in another rotative position. A similar ring 28 is provided in the temple 12 for volume control. The required conductors are not shown in Figures 2 and 3 but are disposed within the support 9. Preferably the support is hermetically sealed; at least the transistors should be hermetically sealed to exclude moisture.

The portion of the hearing aid worn upon the user's head is, in general, like that shown in United States Patent No. 2,613,282 and reference is made to that patent for details of construction which do not constitute the present invention.

One electrical circuit which may be employed in the portion of the hearing aid worn upon the user's head is shown in Figure 4. The detector unit 21 comprises a resistance unit 29, a capacitance unit 30 in parallel with the resistance unit 29 and a rectifier 31 connected as shown in Figure 4. The voltage is fed by way of chokes 32 and 33 to conductors 34 and 35, respectively. A choke 36 is also provided to constitute a return path of direct current components passing through the detector.

The conductor 35 extends to the emitter electrode 37 of the transistor 22. A conductor 38 extends from the collector electrode 39 of the transistor 22 to one side of the transformer 25. The circuit through that side of the transformer 25 is completed by a conductor 40 which extends to a conductor 41 which extends to the switch 27 and a corresponding conductor 42 which extends from the switch 27 to the battery 20. The batteries 20 and 19 are connected in series by a conductor 43.

The opposite side of the transformer 25 is connected through a conductor 44 with a contact member 45 operated by the ring 28 cooperating with a resistance pad 46. A conductor 47 from the resistance pad 46 is connected to the transformer 25 at 48. The conductor 47 is connected with the conductor 34 which extends to the switch 27. A conductor 49 extends from the switch 27 to the battery 19.

The transformer 25 is connected with the emitter electrode 50 of the transistor 23 by a conductor 51. The collector electrode 52 of the transistor 23 is connected with the transformer 26 by a conductor 53. A conductor 54 leads from the transformer 26 to the conductor 41.

The transformer 26 is connected with the emitter electrode 55 of the transistor 24 by a conductor 56. The collector electrode 57 of the transistor 24 is connected

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with the sound reproducer 18 by a conductor 58. A conductor 59 leads from the sound reproducer 18 to the conductor 41.

The ground electrode 60 of the transistor 22, the ground electrode 61 of the transistor 23 and the ground electrode 62 of the transistor 24 are grounded, as is the conductor 43. A ground conductor may connect the ground electrodes 60, 61 and 62 and the conductor 43.

The unit worn on the user's head serves to pick up a high frequency voltage from the branches 7 and 8 of the conductor 6. A voltage is developed in the detector 21 by reason of the electric field coupling between the branches 7 and 8 of the conductor 6 and conductors 63 and 64 disposed within and extending lengthwise of the temples 11 and 12, respectively. The detector demodulates the high frequency signal and delivers an audible-frequency voltage output to conductors 32½ and 33½. Such audio-frequency voltage is conducted through conductor 35 to the emitter electrode 37 of the transistor 22. Changes in current between the emitter electrode 37 and the ground electrode 60 of the transistor 22 produce changes in current in the transistor path between collector electrode 39 and ground electrode 60 which by virtue of the relatively high voltage of the battery 20 have energy greater than that exerted by the current in the conductor 35, emitter electrode 37 and ground electrode 60. Transformer 25 reduces the voltage of the amplified speech currents from transistor 22 to match the resistance of the circuit between the emitter electrode 50 and ground electrode 61 of transistor 23. The resistance pad 46 acts in the nature of a rheostat to vary the amplitude of the electrical vibrations reaching transistor 23 in order to control the volume of current employed for operating the hearing aid and hence the loudness of the sounds emanating from the sound reproducer 18. The energy of the electrical impulses originating in the path between the collector electrode 52 and the ground electrode 61 of the transistor 23 derived from the battery 20 is fed to the sound transformer 26 which matches the impedance between the output of the transistor 23 and the input of the transistor 24 in a manner well known in the art. The output of transistor 24 derived from the circuit including collector electrode 57, sound reproducer 18, battery 20 and ground electrode 62 represents impulses originating in detector 21 so that the user's auditory nerve is activated.

I shall now explain how voltage is developed in the detector 21. This will be done with reference to Figure 5 which is a diagram showing the relationship between the units carried upon the user's body and carried upon the user's head, respectively, and with reference to Figure 6 which is an equivalent electrical circuit diagram.

Stray capacitances are inherent between the branches 7 and 8 of the conductor 6 and the respective conductors 63 and 64. The outer end of the conductor 63 is designated *a* and the outer end of the conductor 64 is designated *b*. The inner end of the conductor 64 is designated *c* and the inner end of the conductor 63 is designated *d*. These same letters are uniformly applied in all of Figures 4, 5 and 6. The outer end of the branch 7 is designated *a'* and the outer end of the branch 8 is designated *b'*. The inner end of the branch 8 is designated *c'* and the inner end of the branch 7 is designated *d'*. The stray capacitances are designated symbolically in Figure 5 as follows: 65 between *a* and *a'*; 66 between *b* and *b'*; 67 between *c* and *c'*; and 68 between *d* and *d'*.

Figure 6 shows in addition to the stray capacitances above mentioned the self-inductances of the conductors as follows: the self-inductance 69 of the conductor 63; the self-inductance 70 of the conductor 64; the self-inductance 71 of the branch 8 of the conductor 6; and the self-inductance 72 of the branch 7 of the conductor 6. The source of voltage in the conductor 6 is indicated diagrammatically in Figure 6 at 73. The voltage across source 73 tends to cause current to flow from *c'* to *c*,

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through detector 21 to *d* and back via *d'* to 73. This path has a relatively high impedance to current and the result is a very small voltage across detector 21. The voltage across source 73 also tends to cause current to flow from *c'* through inductance 71 to *b'* and thence from *b'* through stray capacitance 66 to *b*; thence via inductance 70 to *c*, through detector 21 to *d*, thence via inductance 69 to *a*, thence via stray capacitance 65 to *a'* and thence via inductance 72 to *d'* and back to 73. The reactances of the inductances and stray capacitances are opposed in accordance with well known properties of these circuit elements so that the second mentioned path of current flow has a lower impedance, resulting in fairly large voltages across detector 21. This high frequency amplitude-modulated voltage is detected by the combination of resistance 29, capacitance 30 and rectifier 31 (Fig. 4) so that an audio-frequency voltage and steady direct current component appear across points 74 and 75. This voltage is fed by way of chokes 32 and 33 to the amplifier. These chokes serve to keep undesired high-frequency voltages induced in the amplifier leads in a manner similar to the voltages described above from interfering with the operation of the amplifier. Choke 36 serves to provide a return path for direct current components passing through the detector.

Figure 7 is a diagram illustrating the operation of a hearing aid in which a magnetic field is relied upon for operation. In Figure 7 the branches 7 and 8 of the conductor 6 are connected together behind the user's neck as shown at 76. The unit carried upon the user's head operates as a closed circuit consisting of inductance 69, detector 21, inductance 70 and stray capacitance 77 behind the user's head. Current flows in the loop 73—7—76—8—73 due to the voltage at 73. Such current flow causes the setting up of a magnetic field which is intersected or pierced by the conductors 63 and 64; in other words, lines of magnetic flux from the magnetic field link the circuit of the unit worn upon the user's head. Voltages are induced in that circuit and appear at the detector 21.

While I have shown and described certain present preferred embodiments of the invention it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied within the scope of the following claims.

I claim:

1. A hearing aid comprising means worn upon the clothing of the user completely out of electrical contact with the user's body, said means converting sound vibrations into electric and magnetic field oscillations, and means physically entirely separate from and unconnected with the first mentioned means mounted in a support having the general configuration of a spectacle frame worn upon the user's head receiving oscillations from the first mentioned means and converting the same into audible sounds adjacent the user's ear.

2. A hearing aid comprising means worn upon the clothing of the user completely out of electrical contact with the user's body, said means converting sound vibrations into electric and magnetic field oscillations, and means physically entirely separate from and unconnected with the first mentioned means comprising a support having the general configuration of a spectacle frame worn upon the user's head and mechanism therein, said second mentioned means receiving oscillations from the first mentioned means and converting the same into audible sounds adjacent the user's ear.

3. A hearing aid comprising means including a conductor worn at least partially about the user's neck completely out of electrical contact with the user's body, said means converting sound vibrations into electric and magnetic field oscillations, and means physically entirely separate from and unconnected with the first mentioned means mounted in a support having the general configuration of a spectacle frame worn upon the user's head re-

ceiving oscillations from the first mentioned means and converting the same into audible sounds adjacent the user's ear.

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