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(54) HEARING AID APPARATUS

(71) We, TELEX COMMUNICATIONS, INC., a corporation organized and existing under the laws of the State of Delaware, United States of America, of 9600 Aldrich Avenue South, Minneapolis, Minnesota 55420, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to hearing aid apparatus.

It has been discovered that many individuals afflicted with hearing problems have only one ear that has any useful function as far as detecting sound. Under such a condition, substantially all of the sound which approaches the user from the side of the head remote from the ear that is capable of detecting sound is either very confusing or is unheard at all. In order to conduct sound from the side of the head remote from the usable ear, prior art devices have utilized conductors disposed within the structure of an eyeglass type of hearing aid or have provided conductors extending along the back of a head from conventional hearing aid apparatus positioned on the side remote from the good ear to a receiver disposed in sound transmitting relationship to the good ear. For a number of reasons, including the fact that conductors have proven to be unreliable, such forms of hearing aids have had limited success from an operational and acceptance standpoint by those persons who may benefit from the use of the contralateral relocation of sound concept.

According to the present invention there is provided hearing aid apparatus comprising a microphone adapted to receive sound energy and produce an electrical output signal, first signal translating means connected to receive said electrical output signal and comprising an elongate coil and core assembly having a longitudinal axis and arranged to establish an oscillatory magnetic field carrying information representative of the sound energy received by said microphone; and second signal translating means comprising an elongate coil and core assembly having a longitudinal axis arranged to extend substantially parallel with respect to the longitudinal axis of the coil and core assembly of said first signal translating means, said second signal translating means being arranged to receive said magnetic field and to energize a receiver in accordance with said component of said magnetic field.

It will be seen that a preferred form of the apparatus of the invention eliminates the need for conductors, wires and/or tubes to conduct sound from one side of the head to the other as a magnetic signal is produced by the first signal translating means which can be picked up by the second signal translating means.

An embodiment of the invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:—

Fig. 1 is a sketch of an eyeglass type of hearing aid to which the principles of our invention have been applied;

Figs. 2 and 3 are sectional views of the respective templar members of the eyeglass apparatus shown in Fig. 1;

Fig. 4 shows an electrical circuit diagram of a receiver which may be used in the apparatus of Figs. 1, 2 and 3;

Fig. 5 shows an electrical circuit diagram of a transmitter which may be used in the apparatus of Figs. 1, 2 and 3;

Fig. 6 is a rear view of a human head showing the apparatus in position on the head;

Fig. 7 is a schematic and diagrammatic representation of the operation of the apparatus shown in Figs. 1–6;

Fig. 8 is a sketch of a portion of the apparatus shown in Figs. 1–6; and

Fig. 9 is a fragmentary sketch showing the application of the receiver to an ear mold disposed in the ear canal of a user, the head and hearing aid apparatus being shown in fragmentary form.

Referring now to the drawings, Fig. 1 shows a complete eyeglass type of hearing aid which is indicated generally by reference numeral 10 and which includes a frame 11

for receiving and carrying a pair of eyeglass lenses. A right templar member 12 and a left templar member 13 are shown connected, respectively, to hinge members 14 and 15 that are mounted through suitable means (not shown) on frame 11.

Right templar member 12 has a housing 30 having an integrally formed hinge receptacle 31 at its front end for removably disposing right templar member 12 on hinge 14. The housing 30 also includes a microphone 32 disposed near the front end and a front circuit board 33 likewise disposed near the front end. A receiver 34 may be provided and disposed near the middle adjacent to an outlet tube 35. A rear circuit board 36, and a coil 38 (having an axis 110) are shown disposed near to the rear end of the right templar member 12. A battery carrier 37 having a pivotable cover is disposed in the rearmost portion of the housing 30.

Left templar member 13 has a housing 20 having a hinge receptacle 21 disposed at the front end, and a microphone 22 and a front circuit board 23 disposed rearwardly of the hinge receptacle 21 near to the front end of the housing 20. A receiver 24 is disposed substantially centrally of the left templar member 13 adjacent to an outlet tube 125. A rear circuit board 26, and a coil 28 (having an axis 74) are disposed near the rear end of the left templar member 13, and a battery carrier 27 having a pivotable cover 27' is disposed in the rearmost portion thereof.

It will be seen that the left and right templar members 12 and 13 include similar components arranged in a similar manner. In this way it is possible to ensure that the two members have substantially the same size and weight and to ensure that the hearing aid can be simply adapted to meet the particular hearing problems of an individual user. Although the templar members 12 and 13 are shown in section in Figs. 2 and 3 it will be apparent that the housings 20 and 30 may each be conveniently formed from two half members adapted to be fitted together, and, for example, held together by adhesive, to form a complete hollow housing within which the components are contained. It will be seen from Figs. 2 and 3 that the coils 28 and 38 each have a longitudinal axis indicated respectively by reference numerals 74 and 110.

In the embodiment illustrated, left templar member 13 includes a receiver circuit for magnetic signals and a circuit diagram of the receiver circuit is shown in Fig. 4. Similarly, right templar member 12 includes a transmitter circuit for magnetic signals and a circuit diagram of the transmitter circuit is shown in Fig. 5. It will be seen that, if required, the circuits of templar members may be interchanged, or, the positions of the templar members may be reversed by supporting the templar members on the opposite hinges on frame 11.

Fig. 5 shows a circuit diagram of the transmitter circuit. In Fig. 5 a front circuit board 33 is shown separated from a rear circuit board 36 by a dashed line to illustrate the physical separation of elements of the circuit. The disposition of these circuit boards in the templar member 12 is shown in Fig. 3. The microphone 32 is disposed near the front end of the templar member 12 so that it picks up sound on the side of the body of the user at which templar member 12 and thus microphone 32 is positioned. As is illustrated in Fig. 5 the power supply for the transmitter circuit, and hence the microphone 32, is a battery 102 which is preferably a conventional hearing aid battery. An on-off switch 76 for the circuit is also provided and connected in series with the battery 102. In the embodiment illustrated the switch 76 is a rotary switch and is arranged to vary the position of a wiper 85 of a variable resistor 84. The resistor 84 and capacitors 83 and 86 form a tone control circuit connected to the microphone 32 and controlled by the switch 76.

When the switch 76 is switched on the microphone 32 picks up sound signals and produces an electrical output signal which is fed to the input of an amplifier comprising transistors 96, 97 and 98. The amplified signal is applied to the input 92 of a coil and core assembly 38 which includes coil windings 105, 106 and 107 and a core 108. The core 108 is formed from a magnetic material having high permeability, little or no coercivity and low losses at a predetermined frequency of operation. Preferably, the core 108 is formed from manganese ferrite or magnesium ferrite. The coil windings 105, 106 and 107 are selected to present high Q values. The coil windings 105 and 107 are each connected to a respective capacitor 101 and 109, and the windings 105 and 106 are connected to a transistor 104. It will be seen that coil windings 105 and 107 and their respective capacitors 101 and 109 provide an oscillator which oscillates at a frequency determined by the winding 107. Preferably, the frequency is between 150 and 250 KHz. It will thus be seen that the amplified signal applied to the input 92 of the coil 38 will amplitude modulate the signal produced by the oscillator 105, 107 to produce an amplitude modulated signal in the core 108. The coil 38 therefore produces a magnetic field of predetermined frequency which is amplitude modulated by the output signal from the microphone 32.

In Fig. 4, a front circuit board 23 is shown separated from a rear circuit board 26 by a dashed line to illustrate the physical separation of the several elements of which the receiver circuit is comprised.

The receiver circuit of Fig. 4 includes a signal pick-up and translating means in the form of a coil and core assembly 28, including a core 73 of suitable magnetic material exhibiting high permeability, little or no coercivity and low losses at a predetermined frequency of operation and a winding 72 selected to present a high Q. Preferably, the core 73 is formed of manganese ferrite or magnesium ferrite.

The coil and core 28 picks up the amplitude modulated signal output of the transmitter circuit of Fig. 5 and produces an electrical signal which is applied to a demodulator comprising a transistor 52. The demodulated output signal is then amplified in an amplifier comprising transistors 53, 69 and 70 and applied to a drive transistor 71 for the receiver 24. The power supply for the receiving circuit shown in Fig. 4 is a battery 41, which is preferably a conventional hearing aid battery. An on-off switch 54 is provided for the receiving circuit and is connected in series with the battery 41. In the embodiment illustrated the switch 54 is a rotary switch which is arranged to vary the position of a wiper 67 of a variable resistor 66 which is connected to control the volume of the receiver 24.

The receiver 24 produces an audio signal and may be placed in or near the ear of the user to apply sound thereto. The microphone 22 of the templar member 13 may also be directly connected to the receiver 24 so that sounds from both sides of the user are applied to the usable ear of the user.

Referring to Fig. 6 of the drawings, the head of a user is indicated generally by reference character 112 and the right and left ears are indicated by the letters L and R. Templar members 13 and 12 are shown disposed and extending downwardly over the rear of the ears of the wearer with the axes 74 and 110 of coil and core assemblies 28 and 38 extending substantially parallel with respect to the vertical axis. In addition, as may be seen from Fig. 1 of the drawings, axes 74 and 110 extend substantially parallel with respect to one another. This is also shown in Fig. 8 of the drawing in which the coil and core assemblies 28 and 38 are shown displaced by a variable distance, D, to indicate that there is a difference in a width of the head of a user or that there may be a difference in the relative dispositions of the two elements when the principles of our invention are applied to other forms of hearing aids.

Preferably the cores 73 and 108 of the two assemblies 28 and 38 are of the same shape and are preferably cylindrical in shape. In addition, the cores 73 and 108 are preferably of the same size.

In Fig. 7, the respective signals that may be present on either side of the head of a user are illustrated for alternative situations. Looking at the right half of Fig. 7, it may be seen that two signals represented by the compressional wave diagrams 116 and 115 are applied to the same left ear of a user under a condition in which it is assumed that the left ear may properly function to sense sound while the right ear is unable to properly sense sound energy. Under this condition, sound energy 115 is converted to a modulated field of magnetic energy and the solid line proceeding from right to left indicates the transmission of the modulated magnetic field to the left ear whereat it is converted to sound energy as represented by reference character 115. Both of the sounds impinging on the left ear are thereafter sensed by the left ear. In some circumstances, there is only one sound impingement on the person of the user, this being either the sound represented by reference character 115 or the sound represented by reference character 116 and in either event the user is made aware of the source and direction of the sound so that an increased awareness of the existence of sound energy in proximity to the body of the wearer may be attained.

On the left-hand side of Fig. 7, the usable ear is assumed to be on the right side and it will be seen that the opposite phenomena will occur.

Fig. 9 illustrates the application of the two sources of sound to the one good or usable ear of a user in which templar member 13 is shown in proximity to the ear of a wearer having a sound tube 120 extending into an ear mold 121 that is positioned in the ear of the wearer. If the ear mold is a complete ear mold, it might be furnished with a vent 122 to allow transmission of sound from that side of the body directly into the ear canal so that the signals represented by reference character 116 and by reference character 115, as illustrated on the left-hand end of Fig. 7, may be singly or concurrently applied to the usable ear of the wearer.

One operative embodiment of the invention has been operated very satisfactorily at a nominal frequency of 200,000 hertz to provide, when utilized in conjunction with the above described components, a low power consumption that is substantially free from interference from other sources, such as electrostatic energy. At the desired frequency of operation of the magnetic carrier field, a very selective transmission of

energy from one side of the wearer to the other is obtained. The use of suitable circuit and component design to provide the magnetic carrier field results in a stable and efficient performance that, when the Q of the resonant circuit is maintained at a relatively high value, results in a low power consumption. The magnetic field is easily transmitted through the bone and tissue from one side of the user's body to the other, whereas other forms of energy transmission are believed to be inefficient or inoperative from a practical standpoint. Further, operation at the nominal frequency of 200–250 Khz allows for a range of separation between the templar members or transmitter and receiver that is compatible with the range of dimensions existing in the bodies of the users.

It may also be noted that the principles of the invention are also applicable to other forms of hearing aids, including behind-the-ear types. In this case, the receiving circuit would be included in one behind-the-ear type hearing aid placed on one ear of the user whilst the microphone and transmitting circuit would be included in a second behind-the-ear type hearing aid placed on the other ear of the user.

In the embodiment described above audio signals are translated into electrical signals which amplitude modulate the electrical signals may alternatively be arranged to frequency modulate the carrier wave.

The hearing aid apparatus described and illustrated above provides contralateral relocation of sound without the need for conductors, wires and/or tubes to conduct sound from one side of the head to the other as a magnetic signal is transmitted at a radio frequency on one side of the head and received by a receiver on the other side of the head. This provides a great deal of flexibility and eliminates the problems formerly associated with the use of such apparatus.

WHAT WE CLAIM IS:—

1. Hearing aid apparatus comprising a microphone adapted to receive sound energy and produce an electrical output signal, first signal translating means connected to receive said electrical output signal and comprising an elongate coil and core assembly having a longitudinal axis and arranged to establish an oscillatory magnetic field carrying information representative of the sound energy received by said microphone; and second signal translating means comprising an elongate coil and core assembly having a longitudinal axis arranged to extend substantially parallel with respect to the longitudinal axis of the coil and core assembly of said first signal translating means, said second signal translating means being arranged to receive said magnetic field and to engage a receiver in accordance with said component of said magnetic field.

2. Apparatus as claimed in claim 1 in which the first and second signal translating means are each disposed in a respective templar member of a pair of eyeglasses.

3. Apparatus as claimed in claim 1 in which the first signal translating means and microphone are arranged to be placed on one ear of a user and the second signal translating means and receiver are arranged to be placed on the other ear of a user.

4. Apparatus as claimed in any preceding claim, in which the cores of the coil and core assemblies are comprised of material exhibiting high permeability, low coercivity and low loss at the frequency of the magnetic field.

5. Apparatus as claimed in claim 4, in which the cores are comprised of manganese ferrite or magnesium ferrite.

6. Apparatus as claimed in any preceding claim, in which the predetermined frequency is between 150 and 250 KHz.

7. Apparatus as claimed in any preceding claim, in which the shape of said cores is substantially the same.

8. Apparatus as claimed in claim 7, in which each of said cores is cylindrical in shape.

9. Hearing aid apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

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1559611 COMPLETE SPECIFICATION

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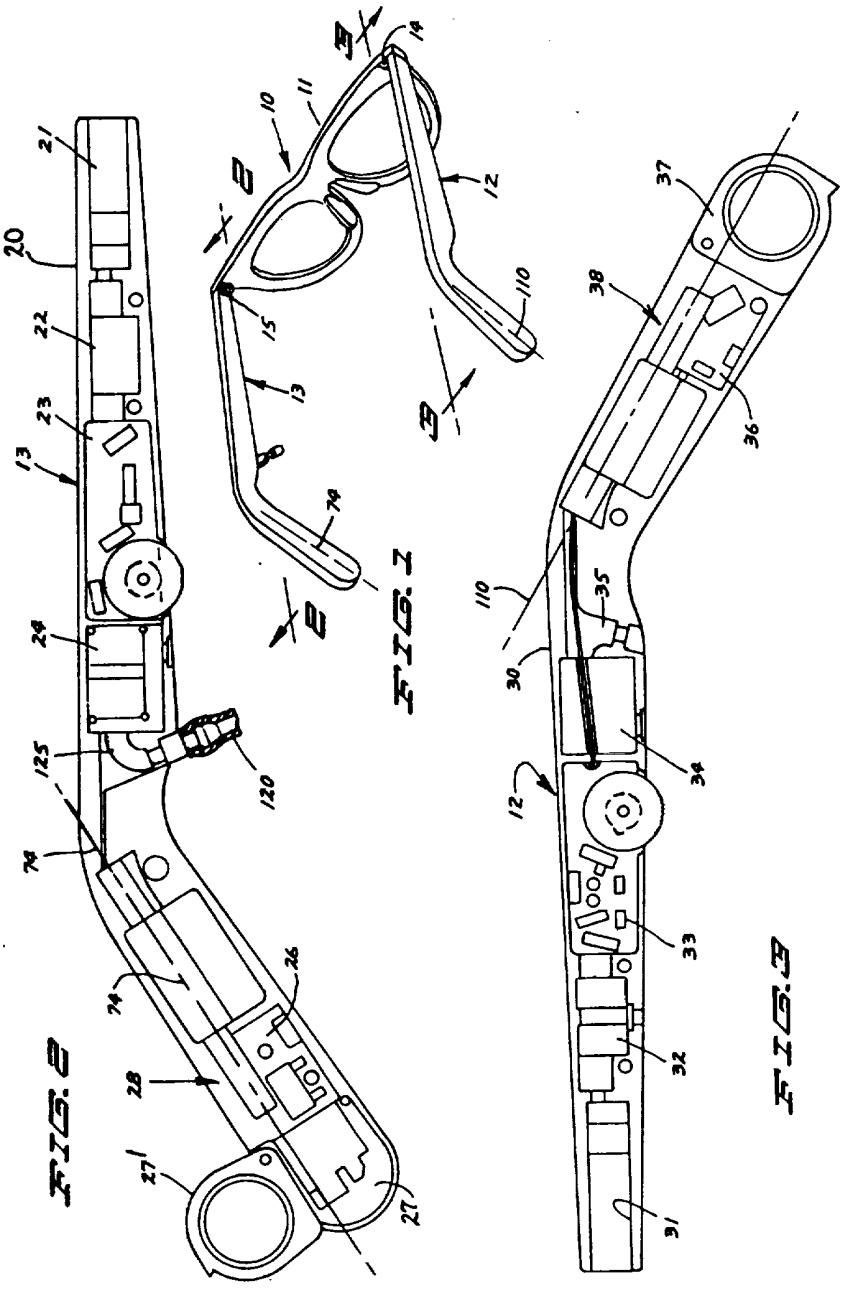

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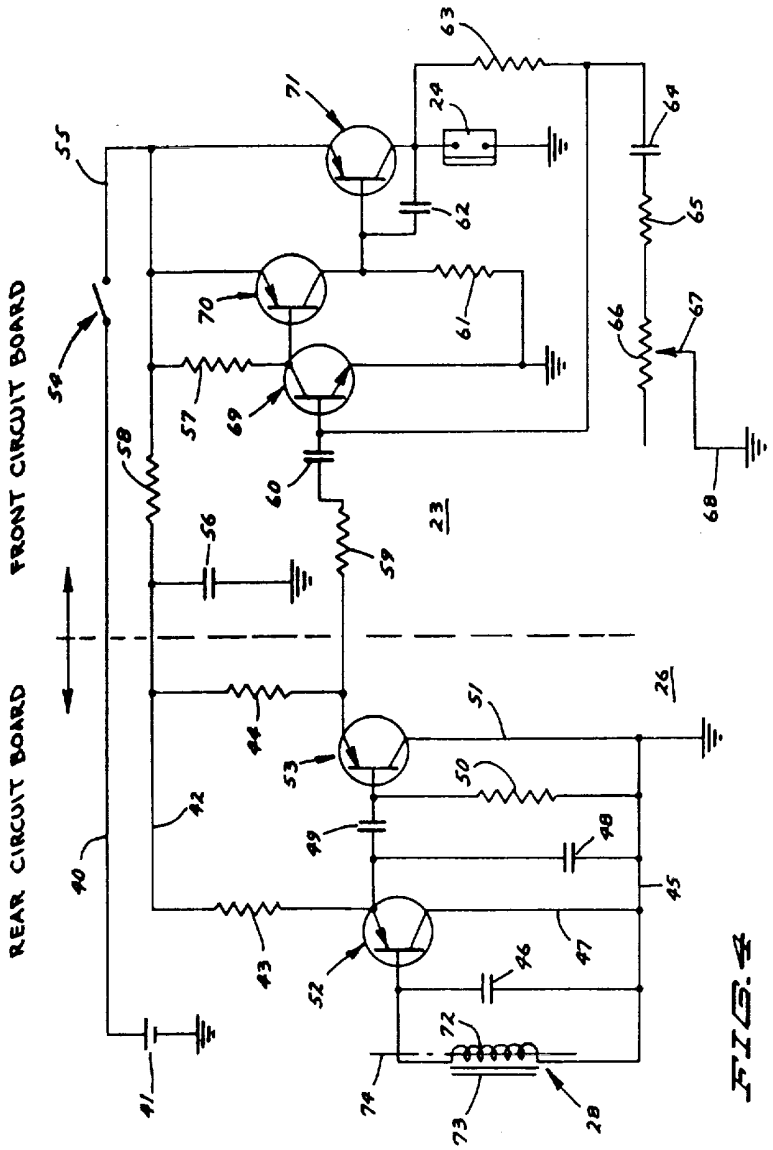

FIG. 4

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Sheet 3

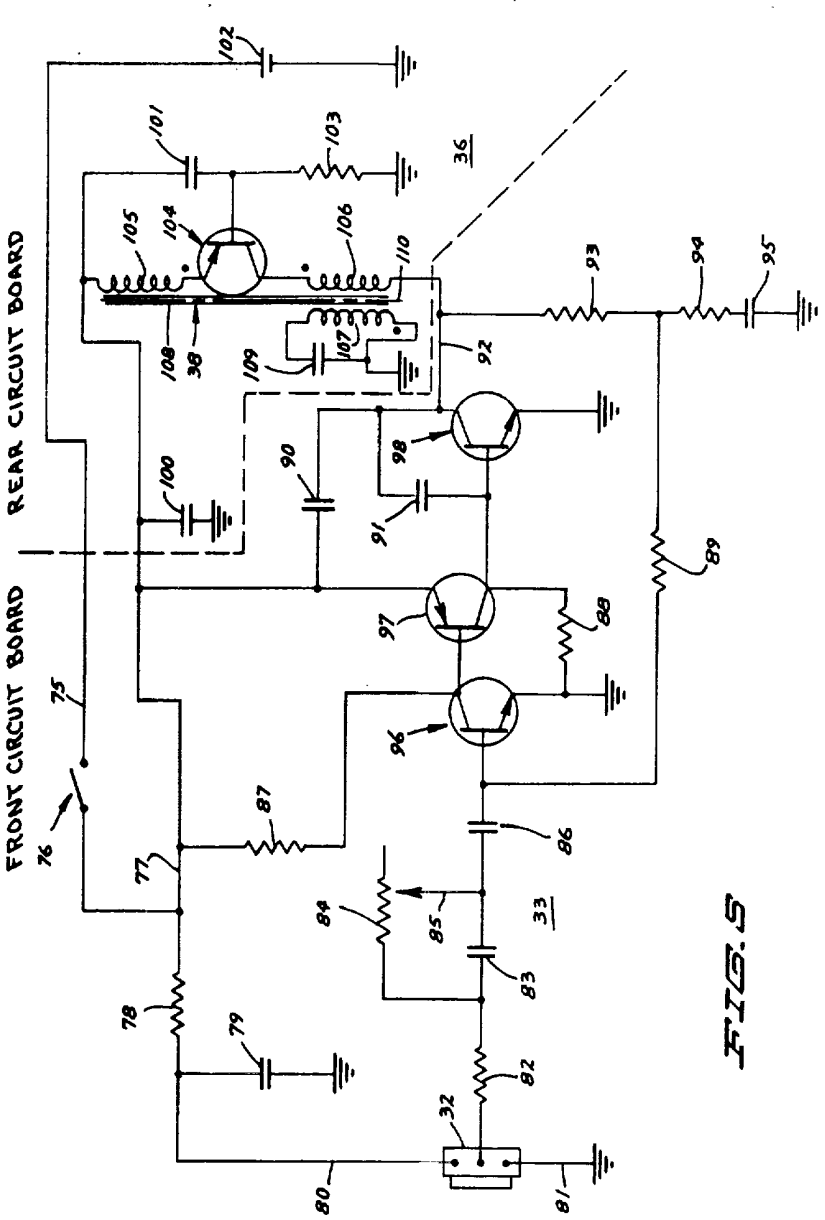


FIG. 5

FIG. 6

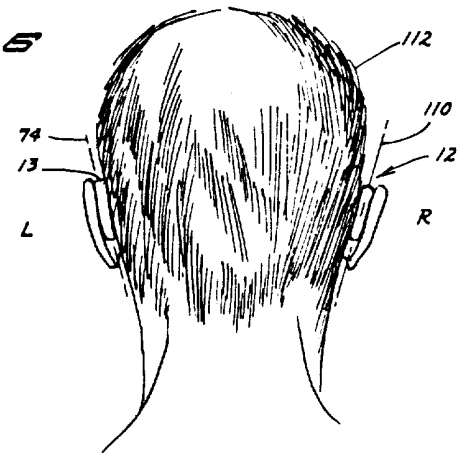


FIG. 7

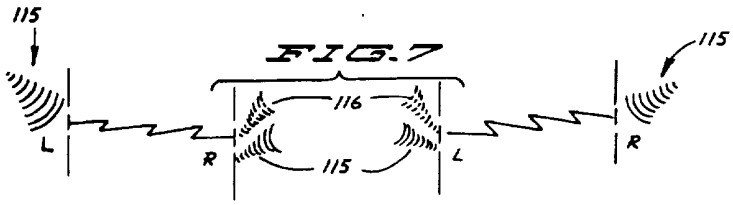
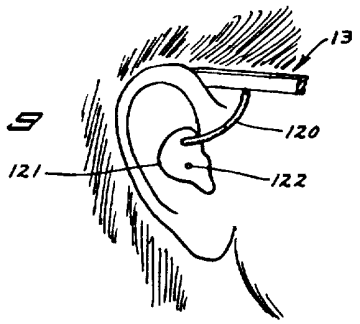


FIG. 9



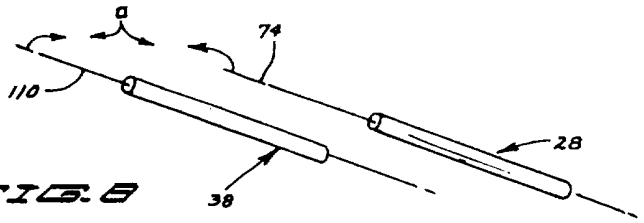


FIG. 8