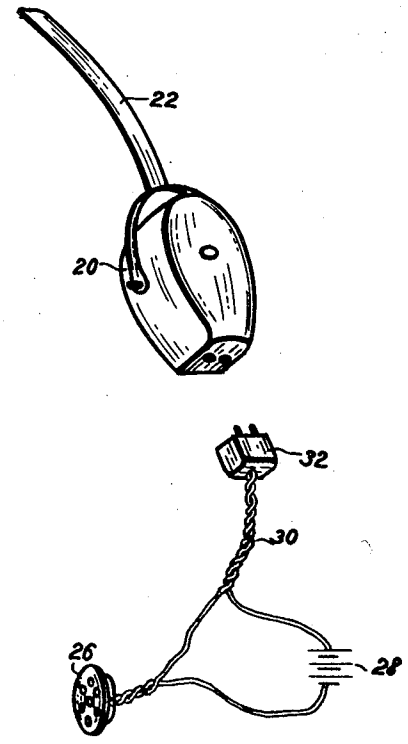
Dec. 11, 1956 H. E. CHRISTIANSEN 2,773,941

HEARING AID APPARATUS

Filed July 15, 1952 3 Sheets-Sheet 1

Fig. 1.



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HEARING AID APPARATUS

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Fig. 2.

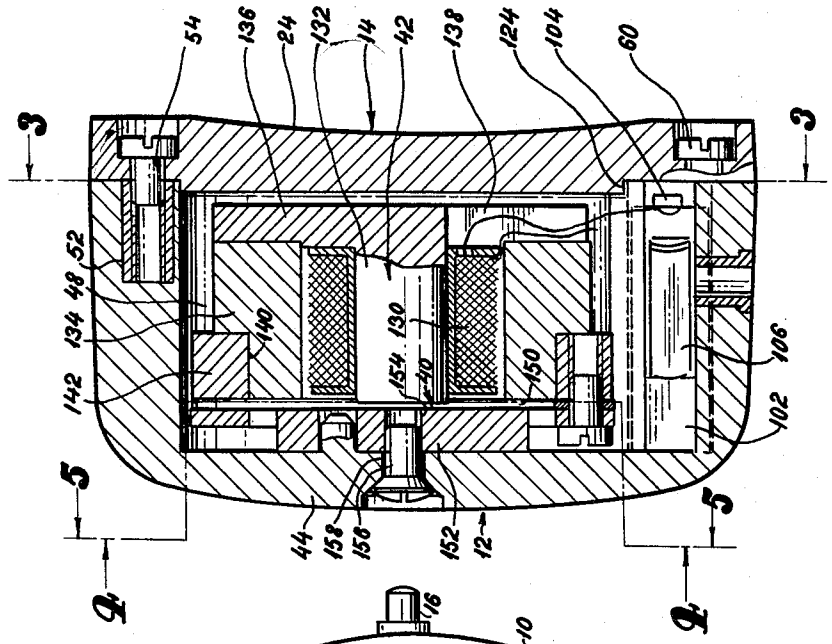
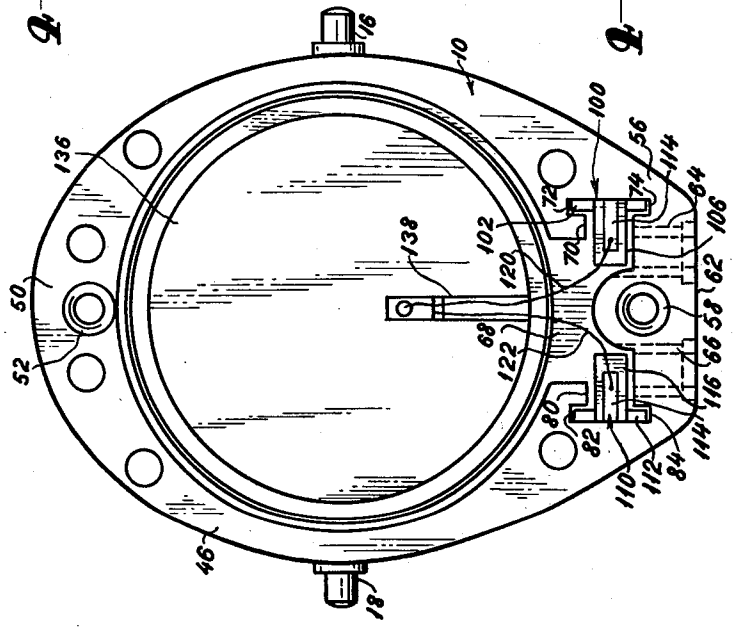


Fig. 3.



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HEARING AID APPARATUS

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Fig. 4.

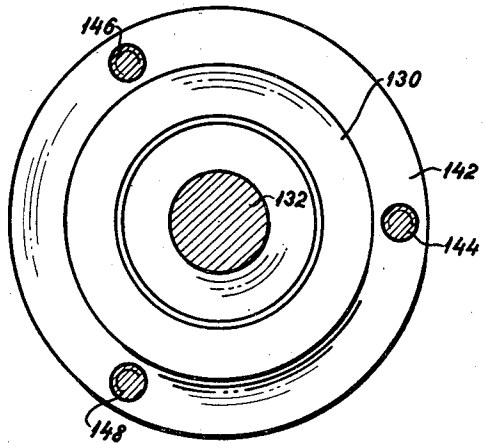
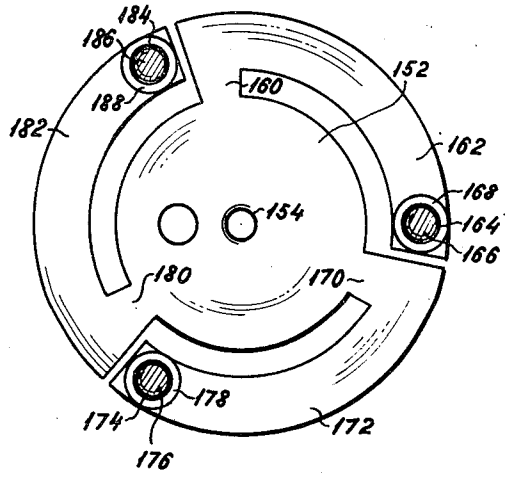


Fig. 5.



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2,773,941

HEARING AID APPARATUS

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Application July 15, 1952, Serial No. 298,909

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10 Claims. (Cl. 179—107)

This invention relates to hearing aid apparatus and more specifically to bone conduction receivers of the electromagnetic type for converting electrical energy to vibrations to be transmitted to the bone structure of the user.

Bone conduction receivers may be divided into two general classes, direct acting and reaction. More specifically my invention relates to the reaction type of receiver in which the bone engaging contactor such as the exterior casing of the apparatus is supported by a head band or the like; the electromagnetic system hangs freely and inasmuch as this system has substantial mass it remains stationary while the contactor vibrates relatively thereto by reaction.

In bone conductors of the class here referred to one problem is to avoid unlineary distortion.

Another problem in connection with bone conductors of the class referred to is to avoid a resonance peak within the audible range. A further problem is to avoid a decreased sensibility on either side of said resonance peak.

The Patent No. 2,522,099 to Demant discloses a bone conductor in which an armature member is fastened inside the exterior casing and connected with a resilient diaphragm supporting along its edge the electromagnetic system so as to form a substantial airtight interior space.

This structure aims to decrease the resonance peak, but it is not capable of amplifying the frequency range at either side of the resonance peak with the result that the sensibility of the bone conductor is not up to the standards of practical requirements.

It is one object of my invention to provide a hearing aid apparatus of the kind referred to which is more up to the standards of practical requirements than the prior devices known.

It is a further object of my invention to provide a device which has an improved utilization of the available small space.

It is a further object of my invention to provide a bone conductor enabling an improved yield in the electromagnetic system.

Still a further object of my invention is to provide a bone conductor having an improved frequency characteristic with a reduced non-linear distortion.

Still another object of my invention is to provide an apparatus of the kind referred to which enables a minimum of air gap between the energizing magnetic system and its armature.

Still another object resides in providing an apparatus of the kind referred to having improved facilities for parallellizing the armature with the pole faces.

Still a further object of my invention is to provide a bone conduction receiver type apparatus of high efficiency and with a robust and simple mechanical construction.

With these and other objects in mind which will appear from the following specification my invention resides in a novel combination of features which will be understood from the following specification in connection with the drawings in which:

Figure 1 illustrates the bone conduction receiver supported on a head band and connected in a microphone circuit,

Figure 2 is a longitudinal section through the receiver illustrating the interior construction thereof,

Figure 3 is a section along the line 3—3 in Figure 2,

Figure 4 is a section along the line 4—4 in Figure 2, and Figure 5 is a section along the line 5—5 in Figure 2.

Referring now to Figure 1 the bone conduction receiver includes a casing **10** of insulating material. As a suitable material for the casing any convenient plastic or other mouldable material may be used. The casing comprises as more clearly shown in Figure 2 two portions, viz. a main portion **12** defining an interior cavity to receive the electromagnetic system and a cover portion **14** the exterior surface of which is preferably slightly curved so as to be better adapted to the ear bone structure of the user.

Extending from opposite sides of the casing portion **12** there is arranged a pair of pivot pins **16** and **18** to be received in bearings in a bifurcated portion **20** of the headband **22** which is of a convenient resilient material enabling the apparatus to be kept in position with the curved surface **24** of the cover **14** in engagement with the ear bone structure of the user.

The electrical means is energized by voice current picked up by a suitable microphone **26** in circuit with a battery or other sorts of power **28** and preferably a vacuum tube amplifier (not shown) connected to the electrical means within the casing by the flexible electric cord **30** having a separable plug type connector **32** plugged into the casing.

The vacuum tube amplifier does not form part of the present invention and further belongs to the general know-how of those skilled in the art, so for these reasons it will not in the following be described in any detail.

The aforementioned electrical means within the casing is of the electromagnetic type and will be more detailed described with reference to Figures 2–5.

As mentioned hereinbefore my hearing aid apparatus is of the reaction type and comprises basicly an exterior casing referred to as **10**, an armature member **40** secured to the casing and an electromagnetic system **42** resiliently supported by said armature in spaced relationship thereto.

As mentioned the casing comprises two parts **12** and **14**. The part **12** is provided with a bottom **44** and a substantially annular wall **46** so as to define an interior cavity **48**. As most clearly shown in Figures 2 and 3 the wall **46** is at opposite ends provided with portions having increased thickness. The left hand portion **50** is provided with a bushing **52** having interior screw threads adapted to receive a screw **54** serving the purpose of holding the cover **14** in position closing the cavity **48** and having its head counter-sunk in the surface of the cover.

The right hand end **56** is in a similar manner provided with a bushing **58** for receiving another screw **60** the head of which is also counter-sunk in the surface of the cover.

The end of the casing portion **56** is flattened at **62** and from the flattened surface there extend through the wall two bushings **64** and **66** adapted to receive the contact pins of the plug **32**.

In the portion **56** of the casing there is provided a chamber **68** communicating with the interior cavity **52**. From the chamber **68** there are extending in opposite direction notches **70** and **80**. From the notch **70** there extend at the bottom oppositely directed notches **72** and **74** and in a similar manner there extend from the notch **80** at the bottom thereof oppositely directed notches **82** and **84**. In either of these notches there are arranged contact members generally referred to as **100** and **110** respectively. With reference to Figures 2 and 3 the contact mem-

ber **100** comprises a strip like body portion **102** received in the notches **72** and **74**. At the top end of the strip **102** there is provided a strip **104** extending inwardly in direction of the chamber **68** substantially vertical to the strip **102**. The strip **104** is by means of a soldering or in any other convenient manner connected with an electric wire **120** leading to one end of the magnetic winding of the electromagnetic system. Spaced from the top strip **104** there is on the main strip member **102** provided another strip **106**, for instance by stamping a part of the material of the strip **102** out of the plane and bending it inwardly as indicated most clearly in Figure 3 to such an extent that the surface of the strip **106** will form a resilient contact member cooperating with the plug pin introduced through the bushing **64**.

In a similar manner the contact member **110** is provided with a main strip **112**, a top soldering strip **114** connected with the other wire **122** and a resilient contact strip **116** adapted to cooperate with the other plug pin introduced through the bushing **66**.

Preferably the interior cavity **48** is of circular cross section as shown in Figure 3 but may within the scope of the invention have any other convenient form. In order to center the cover **14** with respect to the casing portion **12** the cover may as shown in Figure 2 be provided with an annular shoulder **124** corresponding to the interior cross section of the cavity **48**.

The electromagnetic system comprises a magnetic coil **130** which as mentioned by means of the wires **120** and **122** are connected with the terminals **100** and **110**. The coil is arranged on a central core **132** and is surrounded by an annular magnetic member **134** which is connected with the core by means of a yoke **136** preferably of circular configuration and provided with a recess **138** for receiving the wires **120** and **122**.

The exterior end of the annular magnet remote from the yoke is turned down to smaller diameter and shouldered at **140** to receive an exterior ring **142** in the surface of which there is provided a plurality of screw threaded holes **144, 146** and **148**. In the present embodiment there are provided three holes, but it will be understood that any other convenient number of holes such as four, five or six may be used within the scope of the invention.

Spaced from the electromagnetic system here described by means of an air gap **150** there is provided the armature structure generally referred to as **40** and shown in detail in Figure 5. The armature comprises a central disk-formed portion **152** preferably of circular configuration and having a central screw threaded hole **154** adapted to receive a screw **156** introduced through a central hole **158** in the bottom portion **44** of the casing so as to thereby secure the armature firmly to the casing. As shown the head of the screw **156** is preferably counter-sunk in the surface of the bottom. From the central armature portion **152** there are extending radial arms **160, 170** and **180**, from the ends of which there are extending elongated arms **162, 172** and **182**. More specifically the elongated arms **162, 172** and **182** are of arcuate configuration. As apparent from Figure 5 either of said three arms forms an angle with radius through the center of the armature portions. Preferably the arcuate arms are extending substantially concentric with the periphery of the armature portion. As shown most clearly in Figure 2 the central armature portion **152** is thicker than the radial arms and the arcuate extensions thereof. As an example the arms and their arcuate extensions may be something like half the thickness of the central armature portion. It is important that the thickness of the arms and their arcuate extensions are so adapted to the material used for the armature structure that the arcuate extensions are resilient to a certain extent.

As material for the armature structure there is therefore preferably used an alloy of magnetizable material, which also has resilient qualifications. Such alloy will easily be selected between the known materials by those skilled in the art.

Adjacent the ends of the arcuate extensions **162, 172** and **182** there are provided holes **164, 174** and **184** for receiving screws **166, 176** and **186** by means of which the armature is connected with the electromagnetic structure by screwing the screws in the holes **144, 146** and **148**. As apparent from the specification and the drawings either of the arms will provide a one-sided suspension of the magnetic system comprising the annular magnet **134**, the center magnet **132**, the yoke **136** and the magnetic coil **130**.

Due to the fact that the direction of the arms differs from the direction of the radius, an improved frequency characteristic is obtained as will be further explained in connection with the operation of the bone conductor.

Between the armature and the electromagnetic structure there are provided distance washers **168, 178** and **188** so as to space the electromagnetic structure from the armature to form the air gap **150**. Either the ring **142** or the screws **166, 176, 186** together with the washers **168, 178, 188** is of non-magnetizable material.

As it will be understood from this description the armature is firmly secured in the casing and supports resiliently the electromagnetic structure on the arms **162, 172, 182** only.

Hereby the mode of operation will be as follows:

When the magnet coil **130** is energized by sound current picked up by the microphone **26** and applied to the apparatus over the plug **32** and the terminals **100** and **110**, the magnetization of the system will be caused to vary in accordance with the sound waves. In view of the resiliency of the periphery portion of the armature structure allowing a resilient relative movement between the electromagnetic system and the armature the air gap will vary in accordance with the sound waves. As explained hereinbefore either of the three arms is to be considered as a one-sided supported resilient system. The support is that end of the arm which is connected with the armature. The other end of the arm is free and carries the magnetic system. In such a one-sided suspended system the elasticity characteristic, i. e. the curve showing the power as a function of the amplitude is linear so that unlinear distortion is avoided. The whole system is firmly secured to the casing with the electromagnetic system hanging freely inside the casing supported on the arms. Inasmuch as the electromagnetic system has substantial mass it will due to the inertia remain substantially stationary with the result that the variations of the air gap will cause the armature and the whole casing firmly secured thereon to vibrate in accordance with the sound waves so that the casing the arcuate surface **24** of which is held in contact with the ear bone of the user will transfer the vibrations to the bone structure with the result that the vibrations will be transferred to the ear and thereby made audible in form of sound waves.

Furthermore the specific support of the electromagnetic structure on the resilient periphery portion of the armature enables an improved parallelizing of the armature with the pole faces. Furthermore this improved parallelizing enables a smaller air gap to be used which also contributes to an improved efficiency of the apparatus. It will be understood that the embodiment of my apparatus hereinbefore described is only to be considered as an example. Such for instance the ring **142** may be omitted in which event the screws **166, 176** and **186** and the distance disks **168, 178** and **188** must be of non-magnetizable material. As shown, however, the radial extension of the central armature portion is only slightly larger than the radial extension of the electromagnetic coil so as to concentrate the majority of the magnetic field on the central portion. As apparent from the drawing there is left outside the central armature portion only a relatively narrow annular surface of the annular magnet **134**. This annular portion is further within the orbit of

the arcuate arms. Hereby the magnetic field is concentrated substantially in the airgap between the armature and the annular magnet without any substantial stray field.

I claim:

1. In a hearing aid apparatus of the reaction type in combination: an exterior casing defining a cavity, an armature having a substantially circular rigid armature portion firmly secured in the interior of said casing and a plurality of arms extending from said central armature portion, either of said arms having a resilient arcuate extension spaced from said central armature portion and substantially following the periphery thereof, an electromagnetic structure supported exclusively on said armature structure on spaced points adjacent the ends of either of said arcuate extensions in spaced relationship to said central armature portion and means for energizing said electromagnetic system by sound currents.

2. In a hearing aid apparatus of the reaction type in combination: an exterior casing defining a cavity, a rigid armature firmly secured in the interior of said casing, a plurality of resilient arms extending from said armature, either of said arms following substantially the periphery of said armature in spaced relationship thereto, an electromagnetic structure supported exclusively on said arms adjacent the free ends thereof in spaced relationship to said armature and means for energizing said electromagnetic system by sound currents.

3. In a hearing aid apparatus of the reaction type in combination: a vibration responsive plate having a surface adapted to engage the body of the user, electromagnetic means comprising an energizable magnet and an armature spaced from said magnet by means of an air gap, said armature having a rigid central portion and a plurality of resilient arms extending therefrom either of said arms forming an angle with radius through the center of said central armature portion, means for energizing said electromagnetic means for varying said air gap responsive to sound currents, a direct connection between said rigid central armature portion and said vibration plate and means for supporting said energizable magnet adjacent the ends of either of said resilient arms only.

4. In a hearing aid apparatus of the reaction type in combination: a vibration responsive plate having a surface adapted to engage the body of the user, electromagnetic means comprising an energizable magnet and an armature spaced from said magnet by means of an air gap and being substantially concentric, said armature having a rigid central portion and a plurality of resilient arms substantially concentric therewith, means for energizing said electromagnetic means to vary said air gap responsive to sound currents, a rigid connection between said central armature portion and said vibration plate and a connection between the ends only of said resilient arms and said energizable magnet.

5. In a hearing aid apparatus of the reaction type in combination: a vibration responsive member having a surface adapted to engage the body of the user, electromagnetic means comprising a magnetic system including a center core, an annular magnet surrounding said center core, a magnetic yoke connecting said center core and said annular magnet and an energizer coil for said magnetic system and an annular armature spaced from said magnetic system by means of an air gap, said armature and said magnetic system being substantially concentric, an exterior ring surrounding said annular magnet, a plurality of resilient arms extending from said armature substantially concentric therewith, a rigid connection between said armature and said vibration member and a connection between the end only of either of said resilient arms and said ring that surrounds said annular magnet so as to resiliently support said magnetic system on said arms spaced from each other by said air gap.

6. In a hearing aid apparatus of the reaction type in combination: an exterior casing defining a cavity and having a surface adapted to engage the body of the user, an electromagnetic structure comprising an annular armature and an energizable annular electromagnetic structure spaced from one another by an air gap, said armature being rigidly connected with said casing in the interior thereof, said armature further having three resilient arms, means for supporting said electromagnet on the ends only of either of said resilient arms only, and means for energizing said electromagnetic structure by sound currents.

7. In a reaction type hearing aid apparatus having a vibration member adapted to be held in contact with the bone of the user, an armature firmly secured to said vibration member, a plurality of arms firmly secured to said armature, either of said arms having a radial portion and a non-radial extension having a free end, a magnetic system supported on the free ends only of said extending arms in a position spaced from said armature with an air gap and means for energizing said magnetic system with currents of sound frequency.

8. In a reaction type hearing aid apparatus having a vibration member adapted to be held in contact with the bone structure of the user, an armature firmly secured to said vibration member, a plurality of arms firmly secured to said armature and extending from the periphery thereof, either of said arms having a portion extending freely at an angle with respect to radius through the center of said armature and having a free end, a magnetic system supported on the free ends of said extending arm portions in a position spaced from said armature by an air gap and means for energizing said magnetic system with current of sound frequency.

9. In a reaction type hearing aid apparatus of the bone conduction type including a driving structure and having a vibration member adapted to be held in contact with the bone structure of the user, said driving structure including an energizable electromagnetic structure comprising an electromagnetic system for producing an electromagnetic field and an armature spaced from said electromagnetic structure by means of an air gap, said armature being rigidly secured to said vibration member, said armature having resilient arms extending outside its periphery, either of said resilient arms being located substantially in the plane of said armature and being inclined with respect to the periphery thereof, a rigid supporting connection between said electromagnetic structure and said arms at the ends thereof only and means for energizing said electromagnetic system with currents of sound frequency.

10. In and for a hearing aid apparatus of the reaction type comprising a vibration responsive member adapted to engage the bone structure of the user and an electromagnetic system adapted to be energized by currents of sound frequency and resiliently connected with said vibration responsive member, an armature structure comprising an armature portion for said electromagnetic structure and a plurality of resilient arms extending substantially in the plane of said armature portion outside the periphery thereof in inclined relationship with respect to said periphery and means connecting the end only of either of said resilient arms with said electromagnetic structure in a relative position of said electromagnetic structure and said armature portion defining therebetween an air gap.

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