Feb. 4, 1941. S. F. LYBARGER 2,230,500

BONE CONDUCTION RECEIVER

Filed Jan. 14, 1939

Fig. 1.

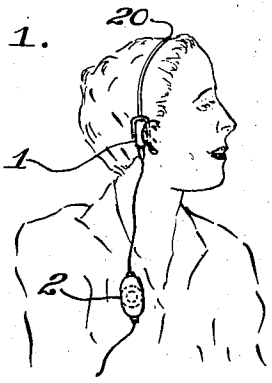


Fig. 2.

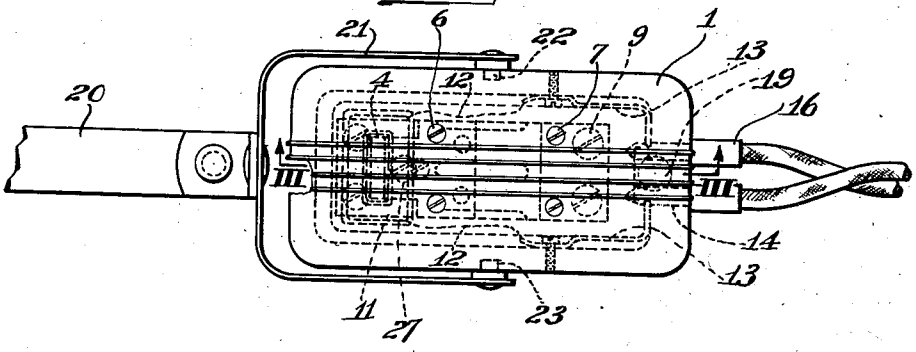


Fig. 3.

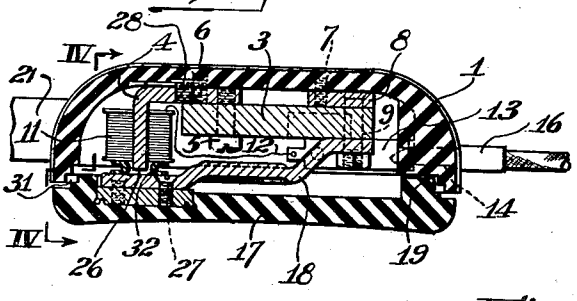


Fig. 4.

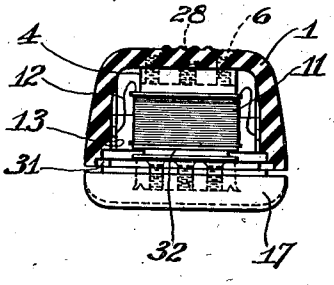


Fig. 5.

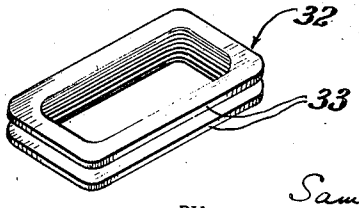
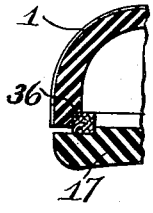


Fig. 6.



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UNITED STATES PATENT OFFICE

2,230,500

BONE CONDUCTION RECEIVER

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Application January 14, 1939, Serial No. 251,039

7 Claims. (Cl. 179—107)

This invention relates to hearing-aid receivers for hard-of-hearing people, and more particularly to bone conduction receivers of the direct action type.

A commercial form of this type of receiver is illustrated in my patent application Serial No. 233,343, filed October 5, 1938. As there shown, electromagnetic means, including a pole-piece, is mounted in a case which has an open side. Extending across this open side of the case is a rigid plate-like vibratory member that is resiliently supported adjacent the pole-piece with an air gap between them. The case is supported by a head-band for holding the vibratory member against a hearing-inducing bone of the user. To permit the vibratory member to vibrate relative to the case, it is spaced from the case, and this space is closed by a gasket.

In this type of receiver where the area of the vibratory surface engaging the head is approximately the same size as the rest of the receiver, the problem of air radiation from the surfaces of the receiver becomes of considerable importance. That is, with a gasket which offers considerable resistance to passage of air through it, the receiver is in effect a closed cavity, the surfaces of which vibrate. It is therefore similar to a telephone receiver and, like the latter, has a fairly high radiation efficiency, especially at high frequencies. Such a receiver operates satisfactorily as a bone conduction receiver as long as there is not sufficient amplification in the system to cause the sound radiated by the receiver into the air to be transmitted through the air back to the microphone where it is re-amplified and presented again to the receiver. With such a condition howling or acoustic feed-back would be produced. In cases where the microphone is located at a considerable distance from the receiver, as in a theater or church where a wiring distribution system is used from a microphone on the platform, this effect would not impair the bone conduction reception, although it might produce enough radiated sound to disturb the people in the immediate vicinity of the receiver. But in general the microphone is worn on the upper part of the body of the user where it is relatively close to the receiver, and can therefore more or less easily pick up sound radiations therefrom, if they are loud.

It is among the objects of this invention to provide a bone conduction receiver which can be used with very high amplification without producing acoustic feed-back to the microphone, and in which the effect of sound radiation from surfaces of the receiver is minimized. Other objects are to provide such a receiver with means that permits freedom of air flow in and out of the case but prevents dust and other foreign matter from fouling the air gap.

In accordance with this invention, a substantially rigid vibratory member adapted to be pressed against a hearing-inducing bone of a hard-of-hearing person, such as the mastoid bone, is disposed across an opening in a case that contains an electromagnet. The vibratory member is so supported by resilient means mounted in the case that an air gap is formed between the electromagnet and the vibratory member. The vibratory member is spaced a sufficient distance from the case to permit enough freedom of air flow in and out of the case to avoid objectionable sound radiation therefrom. That is, the area of the receiver which is effective in radiating sound is materially reduced because air is more or less freely admitted to both sides of the vibratory member, whereby the sound radiated from one side of the vibratory member tends to cancel the sound of opposite phase radiated from its other side. In one form of the invention the walls of the space between the case and vibratory member are provided with stepped or otherwise irregularly shaped portions to prevent foreign objects from being inserted through that space. A more desirable form of the invention seals this space with a flexible or resilient gasket that prevents objectionable foreign particles, such as dust, from entering the case, but which is porous enough to offer only a small amount of resistance to flow of air in and out of the case. In the preferred embodiment of the invention the space between the vibratory member and case is unobstructed by any gasket, but a sealing member surrounds the air gap itself in close proximity thereto so as to prevent foreign matter from fouling it. This gasket encloses a very small volume of air and therefore forms only a small closed cavity behind the vibratory member, whereby the effective radiation area of the receiver is greatly reduced.

The invention is illustrated in the accompanying drawing in which Fig. 1 is a view illustrating the positions in which a bone conduction receiver and a microphone are generally worn by a hard-of-hearing person; Fig. 2 is an enlarged plan view of the receiver as seen when it is lying with its vibratory member face down; Figs. 3 and 4 are longitudinal and transverse sections, respectively, taken on the lines III—III and IV—IV of Fig. 2; Fig. 5 is an enlarged perspective view

of the sealing member that surrounds the air gap; and Fig. 6 is a fragmentary section showing a modification of this invention.

Referring to Figs. 2, 3 and 4 of the drawing, an integral case 1, which is approximately rectangular in cross section, has top and depending side and end walls and an open bottom. Mounted in this case is electromagnetic means for driving a vibratory member in accordance with variations in electric current caused by a microphone 2 (Fig. 1) responding to sound waves. The electromagnetic means or system includes a permanent bar magnet 3 to one end of which is secured a metal pole-piece 4 that has a portion extending substantially at right angles to the magnet and towards the open bottom of the case. The inner end of the pole-piece is preferably disposed between the magnet, to which it is connected by screws 5, and the top of the case. The pole-piece and magnet are rigidly attached to the top of the case by screws 6 threaded into the pole-piece, and by screws 7 connected to a spacer member 8 between the opposite end of the case and the magnet to which the spacer member is attached by screws 9. The outwardly projecting portion of the pole-piece is encircled by an electromagnetic coil 11 connected by wires 12 to metal spring strips 13 secured at one end to the sides of the case with their other ends projecting part way across a pair of openings 14 through the adjoining end wall of the case. These openings are adapted to receive electric plugs 16 that engage springs 13 and connect them with the microphone 2 or amplifier unit (not shown) of the hearing-aid system.

Extending across the open bottom of the case and forming a cover therefor is a rigid plate-like button or vibratory member 17 adapted to engage a hearing-inducing bone, such as the mastoid bone, of a hard-of-hearing person. Of course, engagement with a bone means contact with the skin overlying the bone. This vibratory member is supported from the interior of the case in predetermined spaced relation with the outer end of the pole-piece by means of spring 18 which is resilient wholly or in part to permit the vibratory member to be vibrated by the electromagnet. As the vibratory member is rigid, it must also be spaced a slight distance from case 1 so that its movements will not be prevented by the case. Being a direct action type receiver, the vibratory member is pressed against the head or other bone structure by the case through spring 18, the case being directly supported by suitable means, such as a headband. To prevent spring 18 from being sprung out of shape in case someone pinches the vibrating member and case together at the end opposite to the pole-piece, the inner face of the vibratory member is provided with a projection 19 that is spaced only a slight distance from the end wall of the case.

As shown in Figs. 1 and 2, the band includes a curved strip 20 of spring metal adapted to fit over the head, and a yoke 21 pivotally connected to the metal strip and straddling the case. The ends of the yoke are provided with pins 22 that are pivotally mounted in holes 23 in the opposite sides of the case so that the case can tilt vertically relative to the yoke to better adjust itself to the contour of the head. The outer surface of the vibratory member is preferably curved longitudinally to give a greater area of contact with the head in order to rest more comfortably against it, and also to better retain the vibratory member in position.

Spring 18 is connected to the vibratory member adjacent the pole-piece by screws 27, and extends away from both of them towards the opposite end of the case to which it is connected either directly or indirectly. Preferably, this inner end of the spring is connected to magnet bar 3 at the end opposite to the pole-piece by screws 9. By making spring 18 of magnetic metal its outer end can serve as an armature for the electromagnetic system when extended across the end of the pole-piece, as shown in Fig. 3. In spite of the pole-piece being rigidly mounted in the case, it can be sprung away from magnet 3 a very slight amount by set screw 28 to increase the width of air gap 26.

It is a feature of this invention that the vibratory member is spaced far enough from case 1 to permit sufficient freedom of air flow into and out of the case for diminishing radiation of sound through the air from the surfaces of the receiver to a point where the radiations are not objectionable to the user or those near him. The vibratory member or case therefore corresponds to a vibratory plate freely suspended in air so that sound radiated from one side of the plate tends to cancel that radiated from the other side and which is of opposite phase. As shown in Figs. 3 and 4, the walls of the space between the vibratory member and case are preferably provided with stepped portions 31 forming a series of right angles so that foreign objects can not readily be inserted through this space into the receiver.

It is also highly desirable to protect air gap 26 against being fouled by dust or other foreign matter that may find its way into the receiver through the small space between vibratory member and case. In accordance with this invention this protection is obtained by surrounding the air gap itself with a sealing member 32. This member is flexible or resilient so that it will not interfere with the necessary vibrations of the vibratory member, and it engages the electric coil and spring 18 below it in order to seal the space immediately surrounding the air gap. The annular sealing member is very small so that it will enclose only a small volume of air, whereby only a very small area of the vibratory member forms a wall of a sealed cavity or chamber. Consequently, the effective air radiation surface of the relatively large plate-like vibratory member or of the case is reduced to such an extent that the sound radiated by it through the air is too weak to cause acoustic feed-back or to disturb people near the hard-of-hearing person.

Preferably, the sealing member is substantially of the shape shown in Fig. 5. That is, it has spaced upper and lower marginal portions 33 extending laterally outwardly in the same general direction from the central portion of the seal. This shape makes the seal very flexible for its size, and the marginal portions tend to spread apart and engage spring 18 and the adjacent end face of the coil between which the seal is most effectively located. It is also desirable to cement the marginal portions of the seal to the surfaces they engage.

A receiver made in accordance with this invention has the advantage of the comfort of a relatively large plate-like surface engaging the head, without the disadvantage of acoustic feed-back or excessive sound radiation through air generally found with receivers of this type. The

interior of the receiver is protected from damage arising from the insertion of pins and the like through the space between case and vibratory member, and the vital air gap is prevented from being fouled by small foreign particles, such as dust.

In the modification shown in Fig. 6, sealing member 32 and stepped portions 31 of the receiver may be dispensed with, and the function of both performed by a resilient or flexible gasket 36 mounted in the space between case wall and vibratory member. To permit flow of air into and out of the case to be free enough to accomplish the object of this invention, this gasket must be formed of a material of relatively great porosity. However, the gasket must not be so porous as to permit penetration by dust particles and the like which might foul the air gap. A material that has been found suitable for this gasket is a porous felt, although there are doubtless other materials, such as muslin, etc., that would be satisfactory.

According to the provisions of the patent statutes, I have explained the principle and construction of my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. A bone conduction receiver comprising a case open at one side, a relatively large plate-like vibratory member forming a closure for said opening and overlapping the case but spaced from the case sufficiently to permit unrestricted flow of air into and out of the case to render air radiation of sound from the receiver unobjectionable when said vibratory member is positioned against the head, the space between said case and vibratory member being entirely open, electrically controlled means mounted in the case for actuating said vibratory member, and resilient means in the case supporting the vibratory member.

2. A bone conduction receiver comprising a case having an open side, electromagnetic means mounted in the case, a relatively large plate-like vibratory member forming a wall for and overlapping the open side of the case and spaced therefrom sufficiently to permit enough freedom of air flow into and out of the case when said vibratory member is positioned against the head to render air radiation of sound from the receiver unobjectionable, and resilient means in the case supporting the vibratory member, the walls of the space between the case and vibratory member being formed with stepped portions for preventing the insertion of foreign objects through said space.

3. A bone conduction receiver comprising a case having an opening in one side, a pole-piece mounted in the case, a vibratory member extending across said opening and spaced from the case, resilient means in the case supporting the vibratory member adjacent the pole-piece with an air gap between them, and a flexible sealing member surrounding said air gap in close proximity thereto.

4. A bone conduction receiver comprising a case having an opening in one side, a pole-piece mounted in the case, an electric coil surrounding the pole-piece, a vibratory member forming a closure for said opening and spaced from the case, resilient means in the case supporting the vibratory member adjacent the pole-piece with an air gap between them, and a flexible sealing member surrounding said air gap in close proximity thereto, said member having laterally extending spaced marginal portions connected to the vibratory member and the adjacent end of the coil.

5. A bone conduction receiver comprising a case having an opening in one side, a pole-piece mounted in the case, an electric coil surrounding the pole-piece, a vibratory member forming a closure for said opening and spaced from the case, the walls of the space between the case and vibratory member being formed with stepped portions for preventing the insertion of foreign objects through said space, resilient means in the case supporting the vibratory member adjacent the pole-piece with an air gap between them, and a flexible sealing member surrounding said air gap in close proximity thereto, said member having laterally extending spaced marginal portions connected to the vibratory member and the adjacent end of the coil.

6. A bone conduction receiver comprising a case having an opening in one side, a pole-piece mounted in the case, a vibratory member extending across said opening and spaced from the case, resilient means in the case supporting the vibratory member adjacent the pole-piece with an air gap between them, and means entirely inside the case protecting the air gap from foreign matter.

7. A bone conduction receiver comprising a case having an opening in one side, a pole-piece mounted in the case, an electric coil surrounding the pole-piece, a vibratory member forming a closure for said opening and spaced from the case, resilient means in the case supporting the vibratory member adjacent the pole-piece with an air gap between them, and a flexible sealing member surrounding said air gap in close proximity thereto between the end face of the coil and the vibratory member.

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