Oct. 14, 1941. W. A. ZARTH 2,258,638

BONE CONDUCTION AUDIPHONE

Filed Feb. 5, 1940

Fig. 1.

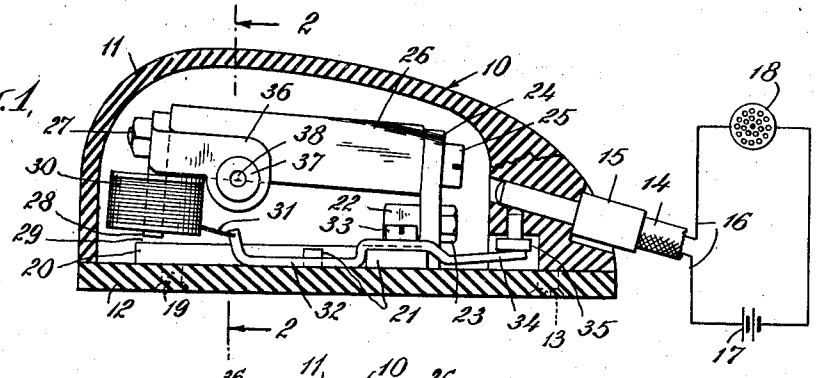


Fig. 2.

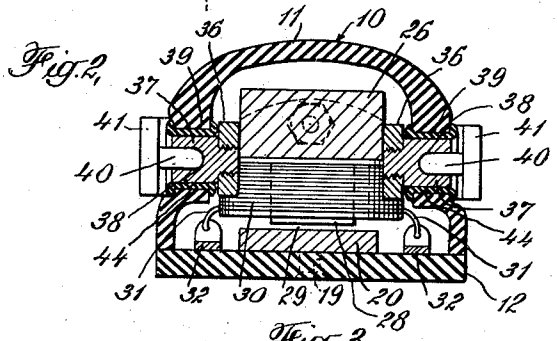


Fig. 3.

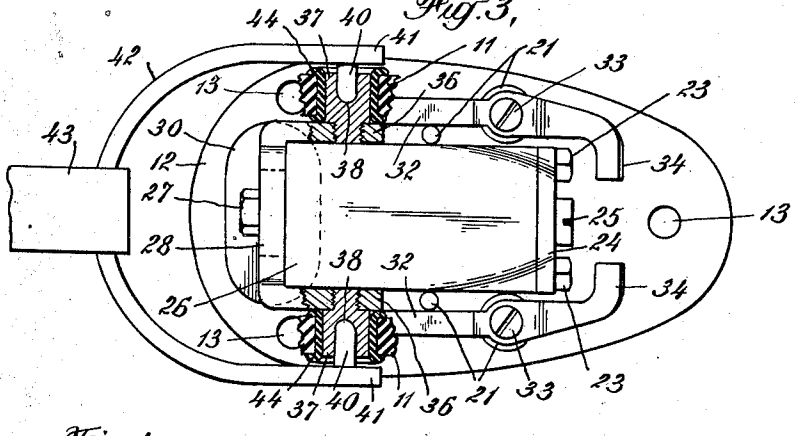
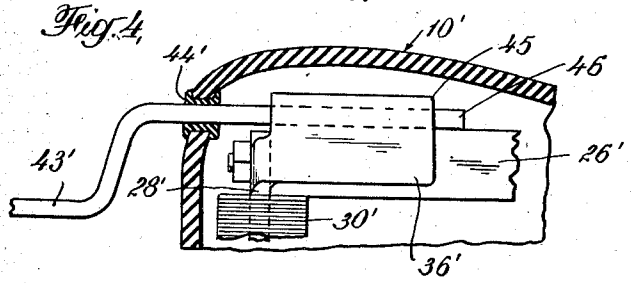


Fig. 4.



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BONE CONDUCTION AUDIPHONE

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Application February 5, 1940, Serial No. 317,259

8 Claims. (Cl. 179—107)

This invention relates to audiphones and has particular reference to audiphone receivers having a vibrating element adapted to be placed in operative connection with the bone structure of the user for transmitting therethrough to the inner ear the audible sounds picked up by a suitable microphone.

In Patent No. 2,144,458, issued January 17, 1939, to Henry Koch, there is disclosed a form of bone conduction audiphone receiver which combines the advantages of the reaction type receiver, in which a closed casing is vibrated bodily by reaction and communicates its vibration to the bone, with the advantages of the so-called button type receiver, in which a button is directly vibrated against the bone, and the present invention is directed to an improvement on the aforementioned form of receiver disclosed in said patent.

In accordance with the present invention, a bone conduction audiphone receiver is provided in which the advantages of the reaction type in so far as immunity to pressure on the casing, sealed casing and powerful vibrations are concerned, are combined with the advantages of the button or direct action type in so far as low power consumption, high quality roproduction and direct concentration of the reed vibrations on the bone are concerned, in addition to certain novel features of construction and operation peculiar to the present invention.

In a preferred embodiment of the present invention, the electromagnetic means carries the reed, which is vibrated relatively to the means when the latter is energized by voice currents, and the enclosing casing is secured to the reed, so that when the electromagnetic means is supported as by a headband, with the contactor side of the casing placed in operative connection with the bone structure of the user, the vibrations of the reed are transmitted directly therethrough to the inner ear, without vibration of the relatively heavy magnetic structure or the headband. The headband connection to the magnetic structure enclosed within the casing is made through an opening in the latter providing sufficient clearance for the headband connection to avoid suppression of the vibration of the casing. Preferably this opening is sealed against dirt and moisture by resilient sealing means interposed between the wall opening and the headband connection, and this means also prevents suppression of the vibration when excessive pressure is inadvertently applied to the headband.

It will be seen that the direct acting bone conduction audiphone receiver of this invention not only includes all the advantages of that general type of direct action receivers but also the advantages of the reaction type, without embodying the disadvantages of either, so that, with the advantages inherent in its structure a more effective and efficient instrument is provided.

For a more complete understanding of the invention, reference may be had to the accompanying drawing, in which:

Figure 1 is a longitudinal section through the casing of the new bone conduction audiphone receiver of this invention and illustrating the interior thereof, as well as a schematic circuit including the receiver;

Fig. 2 is a transverse section therethrough, as seen along the line 2—2 of Fig. 1;

Fig. 3 is a plan view of the receiver with the casing cover removed; and

Fig. 4 is a fragmentary longitudinal section through the receiver and illustrating a modified form of headband connecting arrangement.

Referring to the drawing, the bone conduction receiver includes the casing 10 of hard rubber, phenolic resin, or the like, comprising the cover 11 and the face plate 12 rigidly secured to the cover 11 by screws or the like passing through holes 13, so that a unitary enclosure is formed. The plate 12 is adapted to operatively engage the bone and accordingly serves as the contactor. An electric cord 14, connectible by separable electrical connectors 15 to the electromagnetic energizing means within the casing 10, includes two wires 16 in circuit with the battery or other power source 17 and with the microphone or transmitter 18. Suitable amplifying means, not shown, is usually provided.

Secured at one end to the face plate or contactor 12 by means of a rivet 19 is a flat reed 20, which though substantially free at its other end, is nevertheless relatively stiff so as to resist substantial flexing. This free end of the reed 20 is centered between abutments 21 on the base plate 12 and is provided with an enlargement 22 to which is secured by stud bolts 23 the relatively stiff upwardly-extending spring 24.

Secured by screws 25 at one end to spring 24 so as to extend cantilever-fashion in substantially parallel spaced relation to reed 20 is a permanent bar magnet 26. Rigidly mounted by stud bolts 27 on the free end of magnet 26 and depending therefrom toward the reed 20 is the pole piece 28 forming with the adjacent surface of the reed 20 a narrow air gap 29 having a width on the order of a few thousandths of an inch.

The voice coil 30 is mounted on pole piece 28 and its terminals are connected by filamentary wires 31 to connecting strips 32 secured to studs 21 by screws 33 and extending along the face plate 12 into a cavity in the end of the cover 11. The upturned ends 34 of these strips 32 form contact springs urging corresponding contact pins 35 into frictional and electrical contact with corresponding connectors 15, so that voice coil 30 is in circuit with the microphone 18 and power source 17.

It will be understood that energization of the voice coil 30 by audible sounds picked up by the microphone 18 varies the flux across the air gap 29 and causes relative movement between the reed 20 and the remainder of the electromagnetic means, as provided by the semi-flexibility of the spring 24. For purposes of this disclosure, the reed 20 is considered as a separate element, whereas the magnet 26, pole piece 28 and voice coil 30 are considered as the electromagnetic means. However, it is to be understood that the invention is not limited to this interpretation, for within the scope of this invention the electromagnetic means, or its equivalent, may be any electrical arrangement whereby relative vibratory movement is imparted to the reed 20, or its equivalent, in response to energization by audible frequency currents.

Preferably formed integrally with the pole piece 28 are a pair of arms 36 extending rearwardly and parallel to the opposite sides of the magnet 26, so as to be rigid with respect thereto. Screwed into the free end of each of these arms 36 is a laterally extending stud 37 having a concentric socket 38. The studs 37 pass through corresponding enlarged openings 39 in the side walls of the casing 11 and lie substantially flush with the surface thereof with the socket 38 readily accessible. It will be observed that the cover 11 of the casing 10 cannot be placed over or removed from the electromagnetic means on base 12 unless the studs 37 are removed, so that in assembly, the cover 11 must first be emplaced on base 12 and then the studs 37 are inserted through the openings 39 and screwed in place into arms 36, the studs 37 thus becoming an integral part of the electromagnetic structure consisting of the parts 26, 28, 30 and 36, which vibrates relatively to the reed 20 and casing 10, and vice versa.

Adapted to be inserted into the exposed socket 38 at opposite sides of the casing 10 for pivotal connection therewith are the pins 40 extending inwardly from the corresponding tines 41 of the fork 42 of the headband 43. Because the fit between pin 40 and the socket 38 is close, the connection of the magnetic structure to the headband is firm, and since the headband forms a stationary support when the device is in use, it holds the magnetic structures 26, 28, 30, 36 and 37 stationary while the reed 30 and casing 10 vibrate relatively thereto.

Preferably a short length of soft rubber tubing 44 encircles each stud 37 as a sleeve and fills the annular gap between the stud and the wall of the opening 39 in the casing 10. This rubber sleeve 40 does not restrain the vibration described, but prevents closing of the gap 29 during excessive pressure between the headband and the casing 10, as well as inhibiting the entrance of dirt and moisture into casing 10.

In operation, the headband 43, or other supporting means connected firmly to the studs 37, holds the contactor 12 in operative connection with the bone structure of the user, such as the mastoid eminence. Energization of the voice coil 30 by currents within the audible frequency range, results in relative vibration between the reed 20 and the magnet 26 in the manner described. Because the magnetic structure is held stationary on the headband 43 in the manner described, the reed 20 and casing 10 vibrate relatively thereto and to the headband 43, and the vibration of the contactor 12, which is part of the casing 10, is transmitted through the connected intervening bone structure to the inner ear of the user, who accordingly hears the sounds picked up by the microphone 18.

Inasmuch as neither the heavy magnetic structure nor the headband is vibrated and as the casing 10 is light in weight, the consumption of power is lower than with the reaction type receiver. Also, since the vibrations of the reed 12 are directly applied to the bone, the reproduction is clear and faithful without the "barrel" sound that frequently accompanies the operation of the reaction type by reason of its indirect action. Furthermore, since the casing 10 is an integral unit, pressure thereon will not affect the airgap 29 or suppress the vibration, and if the headband should be accidentally pressed toward the contactor 12 with sufficient force to overcome the stiffness of the spring 24, the rubber sleeves 44 of the studs 37 prevent this excessive pressure from closing the air gap 29 or otherwise temporarily suppressing the vibration. Moreover, since the headband pivot axis, passing through sockets 38, is spaced rearwardly from the air gap, toward the spring 24, the effect on the air gap of any excessive pressure on the headband is minimized.

Instead of employing a pivoted type of headband or holder, a straight rigid connection to the headband may be used as indicated in Fig. 4. There the pole piece 28' is provided with lateral extensions 36' as before, but with the upper edges thereof extending above the magnet 26' and turned inwardly at 45 to form a channel into which the end 46 of the headband 43' firmly fits, so that the headband holds the magnet 26' stationary therewith. A rubber gasket 44' interposed between headband extension 46 and the walls of the corresponding opening in casing 10' serves the same functions as sleeves 44 in Fig. 2. It will be understood that the operation of the modification of Fig. 4 is the same as that of Figs. 1 to 3 inclusive.

While certain preferred embodiments of this invention have been illustrated and described herein, it is to be understood that the invention is not limited thereby, but is susceptible of changes in form and detail within the scope of the appended claims.

I claim:

1. In a bone-conduction audiophone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in the opposite sides of the wall thereof, electromagnetic means within said casing including a magnet member, a voice coil adapted to be energized by varying currents within the audible frequency range and a reed member magnetically coupled to said coil and resiliently connected to said magnet member, means securing one of said members to said contactor, mechanical coupling means secured to one of said members and extending through said openings in the opposite sides of

the wall of said casing and supporting means firmly connected to said mechanical coupling means for holding the corresponding member substantially stationary for vibration of said other member relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means.

2. In a bone-conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side-walls, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, mechanical coupling means rigidly connected to said electromagnetic means and projecting through the corresponding openings in the casing, and supporting means firmly connected to said mechanical coupling means for holding said electromagnetic means substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means.

3. In a bone-conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side walls, electromagnetic means within said casing having an air gap and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means across said air gap and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, mechanical coupling means at opposite sides of said electromagnetic means and rigidly secured thereto, and supporting means firmly connected to said mechanical coupling means through said openings in the wall of said casing at a point spaced from said air gap for holding the electromagnetic means substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means.

4. In a bone-conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side walls, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, lateral extensions rigidly connected to opposite sides of said electromagnetic means and projecting at least partially through said corresponding openings in the side walls of said casing, and supporting means firmly connected to said extensions for holding the electromagnetic means substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means.

5. In a bone conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side walls, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and means and affording limited relative movement between them, lateral extensions rigidly connected to opposite sides of said electromagnetic means and projecting at least partially through said corresponding openings in the side walls of said casing, and supporting means pivotally connected to said extensions for holding the electromagnetic means substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means.

6. In a bone-conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side walls, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, supporting means extending through said openings in the wall of said casing and firmly connected to said electromagnetic means at a point between said coil and spring means for holding the same substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means, and resilient means interposed between supporting means and the adjacent wall of the casing for limiting relative movement between them under excessive pressure.

7. In a bone-conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, said casing having openings in its opposite side walls, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, lateral extensions rigidly connected to opposite sides of said electromagnetic means and projecting at least partially through said corresponding openings in the side walls of said casing, supporting means firmly connected to said extensions for holding the electromag-

netic means substantially stationary for vibration of said reed and connected casing relatively thereto when said voice coil is energized, whereby the contactor transmits said vibrations through the bone to the inner ear when connected thereto by said supporting means, and resilient means interposed between said extensions and the edge of the corresponding openings in the wall of the casing for limiting relative movement between them under excessive pressure.

8. In a bone conduction audiphone, the combination of a casing having a surface serving as a contactor adapted to be operatively connected with the bone structure of the user, electromagnetic means within said casing and including a voice coil adapted to be energized by varying currents within the audible frequency range, a reed magnetically coupled to said means and secured to said casing, relatively stiff spring means connecting said reed and electromagnetic means and affording limited relative movement between them, a mechanical coupling member rigidly secured to the magnet of said electromagnetic means and extending at opposite sides of said magnet, said casing having openings in its opposite walls registering with said mechanical coupling member, supporting means, and aligned pivots connecting said supporting means to said mechanical coupling member through said casing openings, whereby said supporting means is firmly connected to said electromagnetic means for holding the latter stationary for vibration of said reed and connected casing relatively to said supporting and electromagnetic means in use.

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