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W. A. ZARTH

2,402,480

BONE CONDUCTION AUDIPHONE

Original Filed April 8, 1939

FIG. 1.

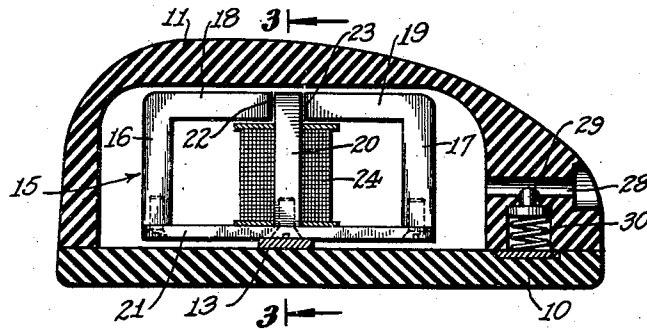


FIG. 3.

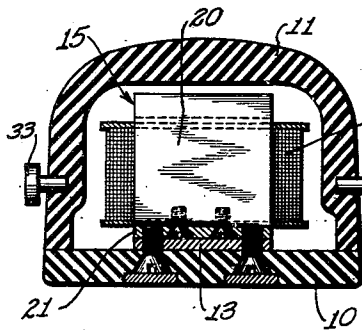


FIG. 2.

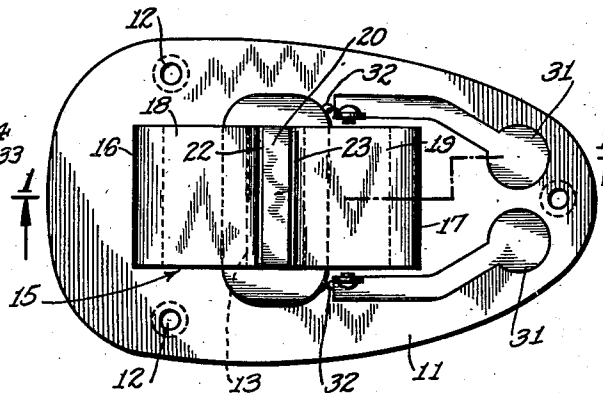
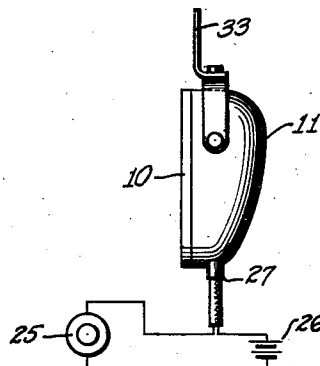


FIG. 4.



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BONE CONDUCTION AUDIPHONE

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266,757. Divided and this application Novem-
ber 7, 1941, Serial No. 418,171

3 Claims. (Cl. 179—107)

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This invention relates to audiphones, and has particular reference to bone conduction audiphones having a vibratory member adapted to be placed in operative connection with the bone structure of the user for transmitting there-through to the inner ear the audible sounds picked up by a suitable microphone. This application is a division of application Serial No. 266,757, filed April 8, 1939, now Patent No. 2,262,082.

In general, the prior bone conduction audiphones may be divided into two classes. In one class, the electromagnetic means is supported by a headband or the like, with its vibratory member held in operative connection with the bone structure of the user, so that the vibrations thereof across the magnetic gap are normal to the bone it engages and are applied directly thereto. An example of this type of audiphone is illustrated in Patent No. 2,144,458, issued January 17, 1939, to Henry Koch. In the other class of bone conduction audiphones, the vibratory member of the electromagnetic means is supported by a headband or the like, with the relatively massive part of the electromagnetic means floatingly mounted with respect thereto, so that while the vibrations across the air gap are normal to the bone surface, they are applied indirectly thereto, being reactive vibrations of the vibratory member relatively to the said massive part because of the high relative inertia of the latter. An example of this class of audiphone is illustrated in Patent No. 2,148,024, issued February 21, 1939, to Henry Koch. While both classes of audiphones have proven generally satisfactory, there are certain objections to each. For example, with the first, or direct-acting class, the free vibrations of the reed connected to the vibratory member are liable to be suppressed to a certain degree by reason of the contact of the latter with the bone, unless the headband pressure and the resilient connections between the relatively vibrating parts are carefully proportioned, although it has the advantage of low power expenditure. With the second or inertia reaction class, the relatively heavy masses which are desirable in order to secure the requisite vibration cause the expenditure of a considerable amount of power, although it has the advantage that neither the air gap nor the vibrations of the vibratory member are affected by pressure of the latter on the bone.

In accordance with the present invention, a bone conduction audiphone is provided which has certain distinct advantages over the aforemen-

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tioned classes of bone conduction audiphones, embodies their principal advantages and does not embody their disadvantages. In a preferred embodiment of the invention, the vibratory member adapted to be placed in operative connection with the bone structure of the user, carries an electromagnetic means having a vibratory element which vibrates independently of the member and in a direction generally parallel to the surface of the bone which the member engages, instead of normal thereto, as in the case of both classes of prior audiphones, whereby the vibrations of the member are not suppressed by its contact with the bone and the inertia of the parts is not relied on to provide the requisite vibration, so that less power is required.

More particularly, the audiphone of this invention comprises a contact plate serving as the vibratory member, to which is secured one side of a flattened, generally ring-shaped core slotted transversely at a point substantially opposite its point of connection with the member. A second core extends normally to the face plate or vibratory member, with its end lying in the space between the opposite ends of the first core, thereby forming a generally E-shaped structure having two flux paths and two air gaps.

It will be seen that the bone conduction audiphone of this invention is a very simple and effective device for securing efficient vibrations of the bone without expenditure of a large amount of power and without variation of the air gap, due to pressure of the receiver on the bone. Because the inertia of the electromagnetic means is not utilized during the operation of the new device, the mass thereof need not be great but only sufficient to provide an efficient flux path to secure the vibrations necessary for audible and intelligible audition.

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 a preferred embodiment of the bone conduction audiphone of this invention, as seen along the line 1—1 of Fig. 2;

Fig. 2 is a plan view thereof with the cover removed;

Fig. 3 is a transverse section thereof as seen along the line 3—3 of Fig. 1; and

Fig. 4 illustrates the manner of supporting the audiphone on a headband and the manner of connecting it in a microphone circuit.

Referring to Fig. 1 of the drawing, numeral 10 designates the contact plate, preferably of non-

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metallic material such as synthetic resin, having a relatively substantial area on the order of one square inch, and being relatively flat for placement in operative connection with the bone structure of the user to serve as the vibratory member which transmits vibrations to the inner ear through the bone structure of the user. The contact plate 10 may serve as a wall of a casing, the other walls of which are provided by a hollow cover 11 suitably attached to the contact plate 10 by screws passing through holes 12 shown in Fig. 2.

The upper or inner surface of the vibratory member of contact plate 10 is provided with a narrow transversely extending boss 13 which may be integral with the contact plate 10 or it may be a separate piece, such as a washer. Mounted on this boss 13 is a ring-shaped element 15 of magnetically permeable or permanently magnetizable material, such as iron, soft steel, nickel-aluminum alloy, cobalt-iron alloy, or the like. The element 15 is not a completely closed ring but the inwardly-turned ends 18 and 19 of the two upwardly extending L-shaped arms 16 and 17 are spaced apart to accommodate the free end of the third arm 20, which is secured in a vertical position so as to extend normally to the contact plate 10.

In order that the arms 16 and 17 may have the required resiliency for vibration, the base of the element 15 is preferably a stiff steel spring 21 having appropriate magnetic permeability. The vertical arm 20 may be screwed thereto in the manner illustrated in Fig. 3, with the arms 16 and 17 also screwed to the opposite ends of the spring 21 in the manner shown.

The entire core constituting the L-shaped arms 16 and 17 and the vertical arm 20 accordingly is generally E-shaped with narrow air gaps 22 and 23 formed between the ends 18 and 19 of the arms 16 and 17 and the corresponding opposed faces of the vertical arm 20. The width of these air gaps is on the order of $\frac{1}{1000}$ of an inch, more or less. Alternatively, arms 16 and 17 and spring 21 may be a single piece of magnetically permeable material constructed to be resilient about its support 13 in the manner illustrated in the said copending application.

It will be observed that the element 15 is of low height compared to its transverse dimension, so that a substantial leverage for arms 16 and 17 is obtained about the point 13, which may be regarded as a fulcrum about which the vibration takes place.

Mounted on the vertical arm 20 is a single voice coil 24 which, when traversed by voice currents picked up by the microphone 25 shown in Fig. 4, causes variation of the flux across the air gaps 22 and 23, resulting in relative vibration of the arms 16 and 17 about support 13 with respect to each other and with respect to the vertical arm 20.

The voice coil 24 is connected in circuit with the microphone 25 and a source of power, such as the battery 26, and this circuit preferably includes a suitable amplifier, not shown. The contact plugs 27 in this circuit are adapted to be removably received in corresponding holes 28 in the cover 11, as shown in Fig. 1. Extending into each of these holes 28 is a contact member 29 electrically connected by spring 30 to a connecting strip 31, which extends into cover 11 and is connected by a corresponding filament 32 to a terminal of coil 24.

It will be observed that with this arrangement two flux paths, one traversing spring 21, arm 16,

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air gap 22, and vertical arm 20, and the other flux path traversing spring 21, arm 17, air gap 23 and the vertical arm 20. These two flux paths are accordingly relatively short and because of the flux density traversing the air gaps they may be made very narrow, thus enhancing the efficiency of the device. If desired, two speech coils mounted on arms 16 and 17 may be used instead of single voice coil 24, as illustrated in said copending application, or they may be additional to the coil 24, depending upon requirements.

In operation, with the contact plate 10 held against the bone structure of the user by means of the headband 33 pivoted thereto, and with voice currents energizing the coil 24, the arms 16 and 17 are vibrated about the center support 13, owing to the restricted flexing of the stiff spring 21. The vibration is accordingly in a direction substantially parallel to the surface of the contact plate or vibratory member 10, and by reason of the aforementioned substantial leverage of the claims 16 and 17 about fulcrum 13, there is a powerful although small component of this vibration in a direction normal to the contact plate 10, and it is this component of vibration which is transmitted to the bone. Although this component of vibration is so minute that it is practically unmeasurable, the vibrations are powerful and are readily heard and intelligible by deafened persons, it appearing that the comparatively large amplitudes of vibrations of the two classes of prior bone conduction audiphones being unnecessary to good bone audition.

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 variations in form and detail within the scope of the appended claims. For example, the cores 15 and 15' may be any shape with the speech coils mounted on the horizontal arms instead of the vertical arms, so long as the general direction of the vibration across the air gap is substantially parallel to the contact plate surface engaging the bone.

I claim:

1. In a bone conduction audiphone, the combination of a vibratory member having a body-contacting surface, electromagnetic means comprising a core attached to said member and a winding thereon, said core having a portion extending substantially parallel to said surface and secured to said member at a zone between the ends of said portion, a pair of first arm portions extending substantially normal to and from said first portion in spaced relation and having their free ends turned inwardly, and a third arm interposed between said first arm portion and forming with the said inwardly turned ends thereof a pair of narrow magnetic gaps across which the said ends of said first arms relatively vibrate inwardly and outwardly in opposing phase, said core having a transverse dimension parallel to said surface which is at least as great as its dimension normal to said surface, whereby a component of the said vibrator normal to said surface is transmitted to said member for conduction through the bone structure to the inner ear of the user.

2. In a bone conduction audiphone, the combination of a casing having a body-contacting portion, an E-shaped core having a middle and two end arms, said core being connected to said portion at a zone substantially in alignment with the middle of said E-shaped core, the remainder of

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said core being spaced from said casing, intumed ends on the end arms of said member defining narrow gaps between said ends and said middle arm, a winding on said middle arm for varying the magnetic flux across said gaps when energized by voice currents to cause said arms to vibrate in opposing phase and produce a component in alignment with said middle arm for conduction through said portion and the bone structure to the inner ear.

3. In a bone conduction audiphone, the combination of a hollow audiphone casing having a wall portion for engaging the body, a core member comprising a stiff, substantially flat spring secured at its midportion to said wall and ex- 15

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tending substantially parallel thereto, arms extending outwardly in the same direction from opposite ends of said plate, a middle arm extending outwardly from said midportion of said plate and between said end arms, intumed outer ends on said end arms forming narrow magnetic gaps between said end and middle arms, a winding on said middle arm adapted to receive voice currents to vary the magnetic flux across said gaps and cause said end arms to vibrate in opposing phase, whereby a component of said vibration in alignment with said middle arm is transmitted to said wall for conduction through the bone structure to the inner ear of the user.

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