Oct. 25, 1938. E. H. GREIBACH Re. 20,896

BONE CONDUCTION HEARING DEVICE

Original Filed Nov. 11, 1933 2 Sheets-Sheet 1

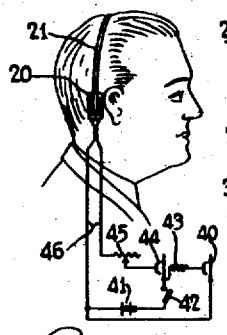


Fig. 1.

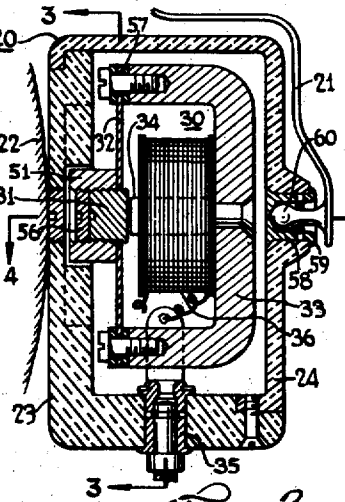


Fig. 2.

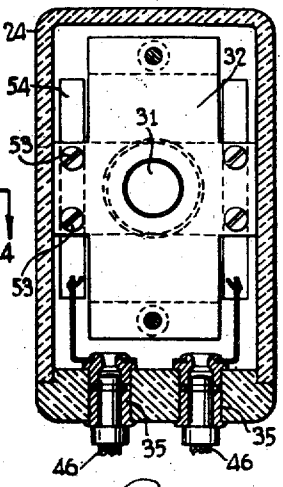
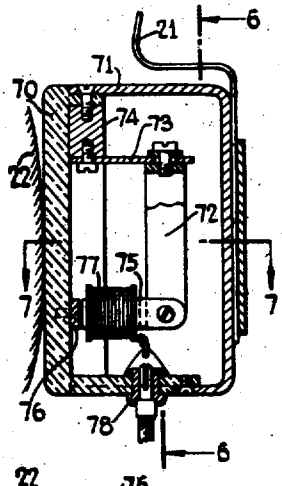


Fig. 3.

Fig. 5.



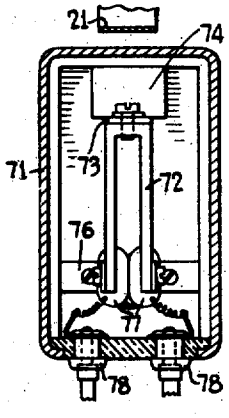


Fig. 6.

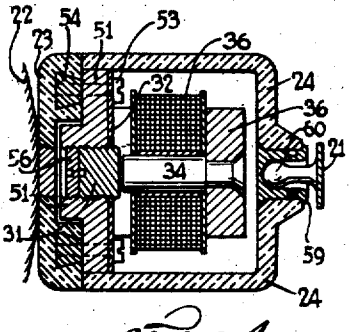


Fig. 4.

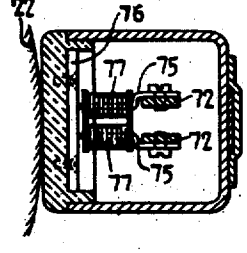


Fig. 7.

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Oct. 25, 1938. E. H. GREIBACH Re. 20,896

BONE CONDUCTION HEARING DEVICE

Original Filed Nov. 11, 1933 2 Sheets-Sheet 2

Fig. 8.

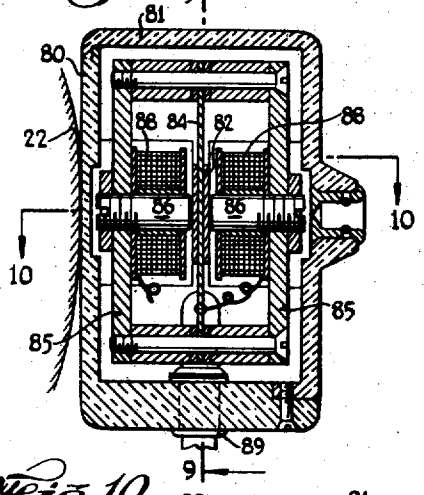


Fig. 9.

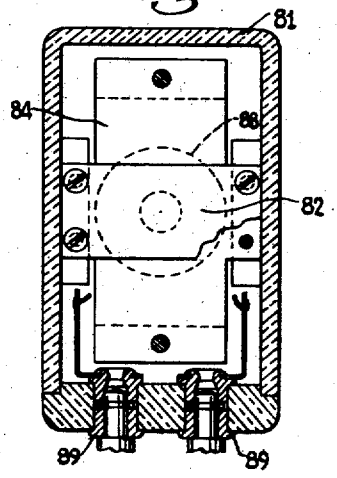


Fig. 10.

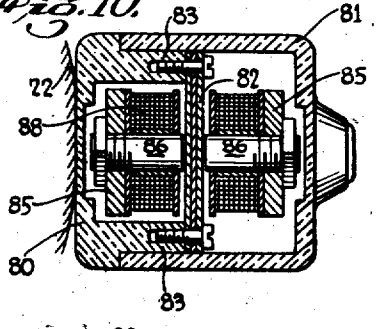
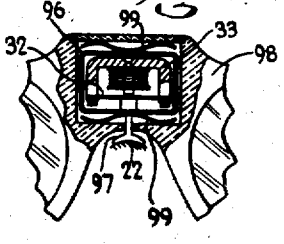


Fig. 12.



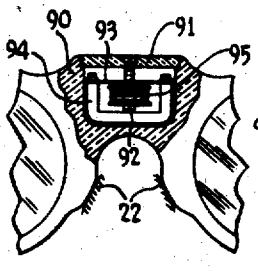


Fig. 11.

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UNITED STATES PATENT OFFICE

20,896

BONE CONDUCTION HEARING DEVICE

Emil Henry Greibach, Brooklyn, N. Y.

Original No. 2,127,468, dated August 16, 1938, Serial No. 697,673, November 11, 1933. Application for reissue September 2, 1938, Serial No. 228,191

REISSUED

49 Claims. (Cl. 179—107)

This invention relates to bone-conduction hearing devices and it has particular relation to bone conduction receivers for hearing aids or audiphones.

Among the objects of the invention is a bone conduction receiver suitable for wearable hearing aids that is small enough for inconspicuous wear in contact with hearing-inducing bones of the user and is powerful enough for imparting to the bones the vibratory energy required for conducting the sound vibrations over the bones of the head to the hearing nerves of the inner ear and induce hearing.

In the bone conduction receiver of the invention a vibratory structure which is set into vibrations by electric oscillations of the audible frequency range has one of its vibratory portions coupled to hearing-inducing bones of the user so as to support in a floating condition another vibratory portion having sufficient inertia and being subjected to sufficient acceleration for imparting through its inertia reaction vibratory energy to the hearing inducing bones.

In such bone conduction receiver the coupled vibratory portion may be utilized to form a protective casing around the floating vibratory portion so as to prevent the pressure with which the coupled vibratory portion is held against the bones from affecting the efficiency of the vibratory motion between the floating and coupled vibratory portions of the vibratory structure. Such bone conduction receiver may be made in the form of a tiny vibratory casing carrying in its interior the floating vibratory driving mass portion which is instrumental in producing the inertia reaction hearing-inducing forces transmitted through the casing to the bone structure.

The foregoing and other objects of the invention will be best understood from the following description of the exemplifications thereof illustrated in the accompanying drawings in which

Fig. 1 is a diagrammatic view of a wearable bone conduction hearing aid showing a bone conduction receiver of the invention worn on the head of a deafened person;

Fig. 2 is an enlarged sectional view of a bone conduction receiver exemplifying the invention;

Figs. 3 and 4 are vertical and horizontal sectional views, respectively, along lines 3—3 and 4—4 of Fig. 2;

Fig. 5 is an enlarged sectional view of another bone conduction receiver exemplifying the invention;

Figs. 6 and 7 are vertical sectional views, respectively, along lines 6—6 and 7—7 of Fig. 5;

Fig. 8 is an enlarged sectional view of another bone conduction receiver exemplifying the invention;

Figs. 9 and 10 are vertical and horizontal sectional views, respectively along line 9—9 and 10—10 of Fig. 8;

Figs. 11 and 12 are sectional views of other types of bone conduction receivers exemplifying the invention.

It has long been known that the majority of the deafened persons have impaired middle ears and can hear much better sound vibrations conducted through the bones of the head to the inner ear than sound transmitted through the air in the ear canal. However, prior to the present invention, only telephone hearing aids which transmitted sound through air in the ear canal and the middle ear have been available for the deafened. All prior efforts to make a bone conduction hearing device followed the principles underlying the telephone receivers and utilized an externally supported heavy driving mass of a vibratory structure for vibrating a driven vibratory member pressed against the bones. Since the bone structure is hard and not as yielding as the air, the back pressure of the bones forced the driven vibratory member against the externally supported heavy driving mass of the vibratory structure and brought about operating difficulties. As a result all prior operative bone conduction hearing devices had to be large, heavy and cumbersome.

The invention overcomes these difficulties by utilizing the principle of preservation of the center of gravity of a moving mass system for producing by the inertia reaction of a driving floating mass portion of a vibratory structure the hearing inducing forces of small amplitude transmitted to the hard bones of the user by a driven portion of the vibratory structure which is held pressed against the hearing-inducing bones and carries in a floating condition the driving vibratory mass portion of the vibratory structure.

In accordance with the invention, a vibratory structure which vibrates under the actions of electric oscillations of the audible frequency range has a portion which is held coupled under pressure to hearing inducing bones of the user so as to support in a floating position a massive portion of the vibratory structure which has a sufficient inertia and is subjected to sufficient acceleration for producing by the inertia reaction of the floating driving mass the vibratory forces required for impressing on the vibratory portion held against the bones corresponding audiofre-

quency vibrations which are transmitted through the bones to the inner ear and induce hearing by bone conduction.

This arrangement makes it possible to shape the coupled vibratory portion so that it forms a casing enclosing the floating vibratory portion. As a result, the bone conduction receiver of the invention may be made in the form of a very small vibrating casing which is held pressed against the hearing inducing bones of the user for securing efficient transmission of the vibratory forces to the bones without affecting the efficiency of the vibratory motion between the driven vibratory casing which is held against the bones and the interior floatingly carried driving mass portion which imparts to the casing the inertia reaction hearing inducing vibratory forces.

A wearable bone conduction hearing aid equipped with a bone conduction receiver exemplifying the principles of the invention is shown in Figs. 1 to 4. It comprises a bone conduction receiver shaped in the form of a small vibrating casing **20** which is held pressed against hearing inducing bones of the user outside the ear canal, for instance, the mastoid bone **22**, by a resilient head band **21**, of steel, for instance.

The casing **20** consists of a rigid base **23** and a rigid cover **24** suitably secured to the base and engaged by the head band **21** so as to press the casing **20** against the bones **22**.

The receiver casing **20** is a part of a vibratory structure formed of an electromagnetic vibrating unit **30** comprising a magnetic armature core **31** clamped to the base **23** and carrying on a resilient magnetic armature diaphragm **32** a floating magnetic core **33** having a central pole piece **34** forming with the adjacent face of the armature a small magnetic gap. The vibratory structure is actuated with electric audiofrequency current oscillations supplied through terminal bushings **35** provided in a terminal block extending from the base **23** to the actuating windings of coil **36** mounted on the pole piece **34** so as to produce a vibratory motion between the mass of the floating core **33** and the armature core **31** which forms a part of the casing **20**.

The floating core **33** has a substantial mass and its inertia resists the vibratory motion. As a result the floating core **33** acts as a driving member and exerts on the armature core **31** and the casing **20** which is coupled to the hard bones of the head inertia reaction forces proportional to the floating mass and the acceleration imparted to it by the electric current oscillation in the windings of the coil **36**. Since the casing **20** and armature **31** which is clamped to it are in engagement with the bones, these inertia reaction forces drive the casing against the hard bones and impress on the bones relatively large oscillatory inertia reaction forces of small amplitude which are conveyed through the bones to the hearing nerves where they induce hearing corresponding to the audiofrequency oscillations impressed on the vibratory structure.

Although the principles underlying the bone conduction receiver using an electromagnetic vibrating structure shown in Figs. 2 to 4, lends itself for the construction of bone conduction receivers actuated by other types of vibrating structures, electromagnetic vibrating structures are particularly suitable for use in such bone conduction receivers because they permit the design of highly efficient vibrating structures with very small magnetic operating gaps of less than one thousandth of an inch. Such design assures extremely efficient operation of electro-magnetic bone conduction receivers, and makes possible the construction of bone conduction receivers of extremely small size and relatively large power output required for satisfactory wearable bone conduction hearing aids.

Inertia reaction bone conduction receivers of the invention constructed with electromagnetic vibrating structures have also the further advantage that they may be used as a part of a standard wearable hearing aid worn hidden in the clothing of the user, by substituting the bone conduction receiver for the air conduction receiver without having to resort to special transformers or other accessories required when such bone conduction receivers are constructed with other types of vibrating structures.

In Fig. 1 is shown how the electro-magnetic inertia reaction bone conduction receiver of the invention is connected in the operating circuit of a prior-art wearable hearing aid. A conventionally illustrated microphone transmitter **40** is connected in series with a supply battery **41** and a cut-off switch **42** to the actuating coil **43** of a conventionally illustrated amplifier microphone **44** which is connected in series with the battery **41** and the cut-off switch **42** by way of a rheostat **45** to the leads **46** which have terminal plugs engaging the terminal bushings **35** on receiver casing and lead to the actuating winding **36** of the receiver.

With such wearable hearing aid assembly, sound waves of the principal audible frequency range, or the frequency range of intelligible speech, impinging on the microphone transmitter **40** will produce in the primary circuit including the amplifier winding **43** corresponding electric audiofrequency oscillations and actuate the amplifier microphone **44** to produce corresponding amplified oscillations which are delivered to the energizing coil **36** of the bone conduction receiver which is held pressed against the bones and transmits through the bones corresponding inertia reaction hearing inducing vibratory forces to the inner ear of the user, or his auditory center.

The actual size of the bone conduction receiver shown in Figs. 2 to 4 is only about one-third the size in which it is shown in the original drawings. Its floating core **33** is formed of a U-shaped permanent magnet and its central core piece **34** is formed of soft iron and secured as by riveting to the center of the core **33**. The permanent magnet **33** is magnetized so that its outer arms are of one polarity and its center portion to which the core piece **34** is joined of opposite polarity.

The end surfaces of the two outer core arms of the floating core **33** have their outer surfaces on the same level as the pole face of the central core **34**, their surfaces being preferably ground to the same level. The armature diaphragm **32** is made of a magnetically conducting spring steel and has its center portion stiffened by integrally uniting it, as by soldering or brazing, to a heavy rigid anchoring cross bar **51** of iron, for instance, extending transversely across the diaphragm **32**.

The central portion of the armature diaphragm **32** extends over the full length of the cross bar **51** and is integrally united thereto as by soldering or brazing. The center portion of the anchor bar **51** is provided with a threaded hole **218** in which is threadedly mounted the armature core **31** having at its exterior end a slot for turning it

to adjust the distance of its pole face from the pole face of the core piece 34.

The end portions of the cross bar 51 are undercut and fit the side walls of a groove provided in the base 23 of the receiver, which may be molded of a synthetic resin. The cross bar 51 is tightly clamped to the base 23 by four screws 53 which are screwed into metal anchorers 54, imbedded within the base. An opening in the base 23 is enclosed by sealing plug 55 to give access to the groove of the armature 31 for adjusting the gap. Once the adjustment is made, the armature 31 may be locked in place, for instance, by a lock member 56. To the ends of the armature diaphragm 32 are united, as by soldering or brazing, reinforcing plates 57 so as to provide a solid clamping joint between the arms of the floating core 33 and the ends of the armature diaphragm 32.

However, the gap adjustment may be made before the armature supporting bar 51 is clamped to the base and the base may be made with a solid outer surface.

The head band 21 has a detachable universal joint connection with the cover 24. A socket 58 with a lock spring 59 arranged similar to a familiar snap fastener is embedded in the wall of the cover 24, and a shank 60 extending from the head band has a ball-shaped end which may be inserted into the socket to form with it a detachable universal joint connection. This universal joint connection assures that, when the head band 21 presses the receiver casing 20 against the bones, the contact surfaces of the receiver will automatically adjust itself to secure an efficient coupling engagement with the bones.

Instead of a head band, any other suitable arrangement for coupling the receiver structure to the bones may be used.

In manufacturing the bone conduction receiver of Figs. 2 to 4, the floating core 33 with the coil 36 and the armature diaphragm 31—32 with the cross bar 51 may be assembled as a self-contained unit and the gap between the armature 31 and the core piece 34 adjusted by turning the armature 31 until its pole face contacts with the core piece 34. Thereupon the armature 31 is turned back on its thread until a magnetic gap of the desired small length is provided between the adjacent pole surfaces and the armature 31 is locked in place. In this adjusted position the assembled vibrator structure may be tested and after final adjustment clamped to the base 23.

A practical bone conduction receiver constructed as shown in Figs. 3 to 4, with the following principal dimensions, will give satisfactory results: Permanent magnet core of a total outer length of 1''; a core thickness of $\frac{1}{8}$''; a core height of about $\frac{1}{4}$''; a core width of about $\frac{7}{16}$''; a center core diameter of about .120''; and a diaphragm thickness of about .014''. The magnetic gap is of the order of one thousandth of an inch. The floating permanent magnet core and the center core of the dimensions given above, have a mass of about 8 grams. The foregoing data show that a satisfactory bone conduction receiver of the invention, suitable for inconspicuous wear by the user, may be constructed to have an overall volume which is only a fraction of three cubic inches, while utilizing an efficient magnetic vibrating structure operating with a gap of less than ten thousandths of an inch and a floating driving mass of more than four grams.

Because of the relatively large mass of the head, the coupled portion of the receiver will under the action of the vibratory forces have only an imperceptible vibratory movement and will be practically stationary. As a result of this vibratory movement, relatively large reactive forces will be imparted by the mass of the floating core to the bones of the head, transmitting thereto vibrations of small amplitude and large force sufficient to convey by bone-conduction speech and music to the auditory center of the head. The magnetic gap is made very small, of the order of a mil or less, thereby securing a high negative stiffness and efficient vibrations. The armature diaphragm 32 is made of sufficient cross section to permit flow of a strong permanent flux through the gap and also to permit inducing strong alternating fluxes through the magnet gap by the action of the sound-frequency current oscillations passing through the actuating coil. The thickness of the armature diaphragm is made large enough to overcome the negative stiffness and secure stable vibrations under the action of the fluctuating magnetic field in the gap.

By making the joint between the diaphragm 32 and the bar 51 by which it is held clamped to the base solid and firm, as by soldering, the center portion of the diaphragm strip does not participate in the vibratory movement of the lateral diaphragm portions, eliminating distortion that might occur otherwise. By providing at the ends of the diaphragm 32 reinforcing strips 57 which are integrally united with the diaphragm, disturbances due to non-uniform clamping of the diaphragm ends are prevented, eliminating distortion.

The high negative stiffness secured by the small magnetic gap enables the use of a relatively thick diaphragm 32 having sufficient cross section for carrying the flux while at the same time making its effective stiffness opposing the negative magnetic stiffness sufficiently small to operate with a resonance frequency at which good response is secured over a large sound-frequency range.

In the electromagnetic bone conduction receiver described in connection with Figs. 2 to 4, the relatively large floatingly mounted vibratory mass of the receiver is utilized to produce the inertia reaction forces required for imparting hearing by bone conduction and a very stiff spring member is utilized to carry the floating vibratory mass so as to give a resonance frequency which assures a good response over the speech frequency range. The use of such stiff spring makes possible the operation of the electromagnetic vibrating structure with an extremely small magnetic gap distance at which the high flux densities and large magnetic forces in the gap do not produce fringing or freezing of the pole faces bordering the gap. Such small gaps are made possible by the utilization of the coupled vibratory portion of the vibrating structure as casing which protects the floating mass against any disturbance by external forces. This combination of elements assures an extremely efficient vibratory structure and makes possible the development of relatively large power in a very small receiver unit.

In Figs. 5 to 7 is shown a bone conduction receiver of the invention constructed with a cantilever-type vibratory structure for producing the inertia reaction forces required for inducing hearing by bone conduction. It comprises a vibratory casing, formed of a rigid base 70 and a

cover 71, held pressed against hearing inducing bones 22 by a head band 21 engaging a channel member formed in the cover 71. The casing 70—71 is a part of a vibratory structure of the cantilever-type formed of a U-shaped permanent magnet core 72 floatingly supported by a spring 73 clamped to a block 74 extending from the base 70, and pole pieces 75 extending from the arms of the magnet core 72 to form magnetic gaps with a magnetic armature core 76 clamped to the base of the casing. A vibratory motion is produced between the floating magnet core 72 and the armature 76 with its casing 7—71 by actuating the vibratory structure with audiofrequency current oscillations supplied to actuating windings mounted on the pole pieces 77 through the terminal bushings 78 provided in a terminal block extending from the base 70.

Since the floating core 72 has a substantial mass and the gap formed between its pole pieces 75 and the armature 76 is very small, relatively large inertia rection forces will be exerted by the floating core 72 on the armature 76 and therethrough over the casing to the bones for inducing hearing by bone conduction.

In order to secure efficient operation of the vibratory structure with a very tiny gap of the order of one thousandth of an inch or less, the spring 73 has a longitudinal slot for permitting adjustment of the position of the floating magnet core 72 on the spring 73 so as to assure operation at a minimum gap distance between the pole faces of the pole pieces 75 and the armature 76 without causing fringing of the adjacent pole faces.

In Figs. 8–10 is shown a bone conduction receiver embodying a balanced magnetic vibratory structure for producing the inertia reaction hearing-inducing vibrations.

It comprises a vibratory casing formed of a base 80 and a cover 81 held pressed against hearing inducing bones 22 by a head band 21 having a universal joint connection with the cover 81, as in the bone receiver of Figs. 2 to 4. The casing 80—81 is a part of a vibratory structure formed of a magnetic armature core 82 having its opposite ends clamped to two base projections 83 and carrying on its magnetic diaphragm extensions 84 a floating balanced magnetic core system formed of magnetic core blocks 87 and core bars 85 having central core pole pieces 86 facing the opposite faces of the armature 82 to form therewith two magnetic gaps. The magnetic system is magnetized so that the two pole pieces 86 are of opposite polarity and pass a permanent magnetic flux from one pole piece 86 across the armature 82 and its two gaps to the other pole piece 86, the path of the permanent flux being completed by the magnetic core blocks 87 through which the ends of the opposite magnet bars 85 are clamped to the reinforced ends of the diaphragm 84 without using the diaphragm extensions 84 for carrying the permanent flux.

On each pole piece 86 are mounted coils of actuating windings 88 which are supplied with electric audiofrequency oscillations through terminal bushings 89 mounted on a terminal block extending from the base 80. The two coils 88 are so connected that when actuated by audiofrequency current oscillations the flux in one magnetic gap is reduced while it is increased in the other gap, the diaphragm extensions 84 serving as return paths for the alternating flux. Since the armature 82 is rigidly clamped to the base 80, the audiofrequency flux variations in the two armature gaps will produce a vibratory motion between the floating core bars 85 and the armature 82 and the inertia reaction of the floating mass will exert on the armature 82, and therethrough, by way of the casing wall, on the bones of the user, inertia reaction forces which induce hearing by bone conduction.

To secure efficient operation of the magnetic vibrating structure, the core pole pieces 86 are threadedly mounted in holes of the magnet bars 85 so as to make possible adjustment of the gaps between the pole faces of the core pieces 86 and the gap faces of the armature 82 at which the gaps will be a minimum without causing fringing of the adjacent pole faces during the operation of the receiver. Lock nuts provided on the exterior threaded ends of the core pole pieces 86 permit locking of the pole pieces 86 in their adjusted positions.

By using a balanced magnetic system in the bone conduction receiver of the invention, of the type shown in Figs. 8 to 10, even harmonic distortion is eliminated and objectionable saturation of the flux paths is avoided.

Since the permanent flux acting on the opposite pole faces of the armature is balanced, the armature diaphragm is not subjected to any permanent deflection. Furthermore, the maximum amplitude of the vibrations between the armature and the floating core is limited by the small magnetic gaps of the order of one thousandth of an inch on the opposite sides of the armature.

Accordingly, flexing of the armature diaphragm beyond its elastic limit is prevented, and even if the receiver is dropped, and the momentum of the heavy floating mass tends to impart a large deflection to the armature diaphragm, this deflection will be limited by the small gaps on the opposite sides of the armature to a value at which the elasticity of the diaphragm will automatically restore the normal gap spacing.

As a result, the receiver may be dropped without damage, and it may be operated with smaller gaps than receivers without balanced magnetic core systems, thereby increasing its efficiency.

In Figs. 11 and 12 are shown two other exemplifications of an inertia reaction bone conduction receiver of the invention. In the arrangement of Fig. 11, a receiver housing formed of a casing 90 and a top wall 91 has clamped to the top wall 91 an extension of a magnetic core piece 92 on which is mounted a magnetic diaphragm 93 carrying a floating U-shaped magnet core 94 which has a central pole face forming a magnetic gap with the pole face of the core piece 92. The vibratory structure is actuated by a coil 95 mounted on the core piece 92 clamped to the top 91 of the casing to produce under the action of audiofrequency currents a vibratory motion between the floating core 94 and the core piece 92. As a result, the inertia reaction of the floating core exerts hearing inducing vibratory forces on the core piece 92 and therethrough, over the casing 90 on the hearing-inducing bones engaged by the casing.

The casing of the bone conduction receiver shown in Fig. 11, is illustrated in the form of a bridge member of a spectacle frame and its exterior walls are shown curved to form a concave contact surface for securing intimate coupling engagement with the bones 22 of the nose and secure an efficient transmission of the hear-

ing-inducing vibratory energy from the receiver casing to the bones.

In the arrangement of Fig. 12 is shown an inertia reaction bone conduction receiver of the invention having an electromagnetic vibrating structure similar to that shown in Figs. 2 to 4. It comprises a floating magnetic core **33** carried by an armature diaphragm **32** which is clamped to a wall of an enclosing casing **96** having a projecting contact member **97** with a curved concave contact surface held in engagement with hearing inducing bones **22** of the user. This bone conduction receiver is likewise designed for mounting in a bridge member of a spectacle frame **98** forming a housing around the receiver casing **96** and supporting it between two springs **99** so as to prevent the inertia reaction vibrations of the receiver casing **96** which are transmitted by the contact member **97** to the bones of the nose from being transmitted to the spectacle frame **98**.

The performance and the quality of the reproduction in the bone conduction receivers of the invention described above may be increased without increasing their weight and size by employing instead of ordinary steel diaphragms special materials of high magnetic permeability, such as Hypernik, A-metal or Permalloy. These materials have a much higher magnetic permeability than ordinarily used spring steel. They accordingly reduce the flux reluctance and enable development of larger fluxes increasing the power output of a given size and weight of structure.

In the bone conduction receivers described above, such high permeability materials may be used notwithstanding their relatively smaller elasticity, because the small amplitudes with which the diaphragms are required to operate produce only small strains in such diaphragms, and these strains are within their elasticity limits. By using such materials for diaphragms, they may be given a relatively great thickness without unduly increasing their stiffness, thus providing a large cross section of highly permeable magnetic material for producing a large flux and providing at the same time the required elasticity for operating with a desirable degree of stiffness.

The principles of the invention described above in connection with various types of electromagnetic vibrating structures will suggest to those skilled in the art many other ways of making small inertia reaction bone conduction receivers with various other types of vibratory structures. It is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention within the art.

I claim:

1. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory structure comprising a driven magnetic core portion having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, and a driving floatingly carried magnetic core portion resiliently joined to said driven core portion to form therewith a magnetic flux path including a gap, and means for actuating said vibratory structure with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about three cubic inches, the driving core portion has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core portion and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

2. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising an elastically deformable magnetic core member forming a magnetic flux path including a gap, said core member having a driven core portion with a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user and a driving core portion floatingly carried relatively to said driven core portion, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core portions across said gap, said driving core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces through said contact surface upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

3. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, means for holding said driven core member coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying said driving core member in a floating condition, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

4. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory member comprising two resiliently joined magnetic core portions forming a magnetic flux path including a gap, one of said core portions having a rigid contact surface element arranged to be held coupled under pressure to hearing inducing bones of the user and floatingly carrying another of said core portions, and means for actuating said vibratory member with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core portions across said gap, said floatingly carried core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said contact surface element and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core portions being sufficiently large to secure a vibratory motion of said

core portions at a gap spacing of less than four thousandths of an inch without fringing of said gap.

5. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory member comprising two resiliently joined magnetic core portions forming a magnetic flux path including a gap, one of said core portions having a rigid contact surface element arranged to be held coupled under pressure to hearing inducing bones of the user and floatingly carrying another of said core portions, and means for actuating said vibratory member with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core portions across said gap, said floatingly carried core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said contact surface element and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core portions being sufficiently large to secure a vibratory motion of said core portions at a gap spacing of less than four thousandths of an inch without fringing of said gap, said contact surface element being arranged and shaped to protect said floatingly carried core portion against external forces.

6. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, said driven core member having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, said driving core member being floatingly carried relatively to said driven core member, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about two cubic inches, the driving core member has a sufficiently large mass greater than about four grams and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, said driven core member being arranged and shaped to protect said driving core member against external forces.

7. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, means for holding said driven core member coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying said driving core member in a floating condition, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, said driven core member being arranged and shaped to protect said driving core member against external forces.

8. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory member having two resiliently joined magnetic core portions forming a magnetic flux path including a gap, one of said core portions forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user and floatingly carrying another of said core portions within said casing, and means for actuating said vibratory member with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core portions across said gap, said floatingly carried core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

9. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that, at an overall size of the vibratory structure having a volume of less than about two cubic inches and a magnetic gap spacing of less than ten thousandths of an inch, the driving core member has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

10. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, said driven core member forming a part of a rigid casing having a contact surface arranged for coupling under pressure to hearing inducing bones of the user outside the ear canal, said driving core member being floatingly carried relatively to said driven core member within said casing, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to pro-

duce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about three cubic inches, the driving core member has a sufficiently large mass of the order of eight grams or more and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

11. In an inconspicuous bone conduction hearing device, a vibratory structure comprising a rigid vibratory casing having an external contact surface arranged for coupling under pressure to hearing inducing bones of the user and a driven magnetic core portion operatively exposed to the interior of said casing, a driving magnetic core portion resiliently carried in a floating condition within said casing to form with said driven core portion a magnetic flux path including a gap, and means for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said resiliently carried driving core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said casing and therethrough upon said bones for imparting thereto vibratory energy required for transmitting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

12. In an inconspicuous hearing imparting device, a vibratory structure comprising a rigid vibratory casing having an extended external vibration transmitting surface and a driven magnetic core portion operatively exposed to the interior of said casing, a driving magnetic core portion resiliently carried in a floating condition within said casing to form with said driven core portion a magnetic flux path including a gap, and means for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said floatingly carried magnetic core portion having a mass sufficiently larger than the mass of said casing and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said casing for imparting thereto vibratory energy required for transmitting from the external surface of said casing corresponding vibrations to the inner ear of the user and induce intelligible hearing.

13. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, means including a casing for holding said driven core member coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying said driving core member in a floating condition within said casing, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

14. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user, and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of less than four thousandths of an inch without fringing of said gap.

15. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, said driven core member forming a rigid casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, said driving core member being floatingly carried relatively to said driven core member within said casing and windings interlinked with said flux path for actuatng said vibratory structure with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about two cubic inches and a magnetic gap spacing of less than about ten thousandths of an inch, the driving core portion has a sufficiently large mass of the order of eight grams or more and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

16. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and means

for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a mass sufficiently larger than the mass of said driven core member and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of the order of one thousandth of an inch without fringing of said gap.

17. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined into a magnetic flux path including a gap, said driven core member forming a rigid casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, said driving core member being floatingly carried relatively to said driven core member within said casing, and windings interlinked with said flux path for actuating said vibratory structure with electric oscillations substantially throughout the speech frequency range to produce corresponding vibrations of said core members across said gap said driving core member having a mass sufficiently larger than the mass of said driven core member and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of the order of one thousandth of an inch without fringing of said gap.

18. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driving core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about three cubic inches and a magnetic gap spacing required for good operating efficiency, the driving core portion has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

19. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a rigid casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user, and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driving core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of less than four thousandths of an inch without fringing of said gap.

20. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driving core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about two cubic inches and a magnetic gap spacing of less than about ten thousandths of an inch, the driving core portion has a sufficiently large mass greater than about four grams and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

21. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driven core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said

core members across said gap, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of less than four thousandths of an inch without fringing of said gap.

22. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a rigid casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driven core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about three cubic inches and a magnetic gap spacing required for good operating efficiency, the driving core portion has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

23. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure comprising a driven magnetic core member forming part of a casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and a driving floatingly carried magnetic core member resiliently joined to said driven core member within said casing to form therewith a magnetic flux path including a gap, and windings interlinked with said driven core member for actuating said vibratory structure with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said core members across said gap, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory structure having a volume of less than about three cubic inches and a magnetic gap spacing of less than about ten thousandths of an inch, the driving core member has a sufficiently large mass greater than about four grams of the mass of the vibratory structure and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

24. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having two resiliently joined core portions forming a magnetic flux path including two gaps, one of said core portions having two surfaces on opposite sides of said one core portion forming pole faces for said two gaps, the other core portion having two pole surfaces facing said pole faces on opposite sides of said two gaps, and windings interlinked with said flux path of actuating said core portions with electric oscillations substantially throughout the speech frequency range for producing corresponding vibrations of said core portions across said two gaps so as to increase one gap while the other gap is decreased, a casing for holding one of said core portions coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying the other of said core portions in a floating condition with said casing, said floating core portion having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said coupled core portion and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

25. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined to form a magnetic flux path including two gaps, said driven core member having a set of two surfaces on opposite sides of said driven core member forming pole faces for said two gaps, said driving core member including core portions extending toward the pole faces of said driven core member to form the opposite pole faces of said two gaps, and windings interlinked with said flux path for actuating said core members with electric oscillations of the principal audible frequency range for producing corresponding vibrations of said core members across said two gaps so as to increase one gap while the other gap is decreased, means including a rigid casing for holding said driven core member coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying said driving core member in a floating condition within said casing, said driving core member having a sufficiently large mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

26. In a bone conduction hearing device suitable for inconspicuous wear by a user, a vibratory structure having a driving magnetic core member and a driven magnetic core member resiliently joined to form a magnetic flux path including two gaps, said driven core member having a set of two surfaces on opposite sides of said driven core member forming pole faces for said two gaps, said driving core member including core portions extending toward the pole faces of said driven core member to form the opposite pole faces of said two gaps, and windings interlinked with said flux path for actuating said core members with electric oscillations of the principal audible frequency range for producing corresponding vibrations of said core members across said two gaps so as to increase one gap while

the other gap is decreased, means including a casing for holding said driven core member coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying said driving core member in a floating condition within said casing, said driving core member having a mass sufficiently larger than the mass of said driven core member and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said driven core member and therethrough upon the coupled bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing, the stiffness of the resilient junction between said core members being sufficiently large to secure a vibratory motion of said core members at a gap spacing of less than four thousandths of an inch without fringing of said gap.

27. The method of inducing hearing with an electromagnetic vibratory hearing aid structure having two resiliently joined magnetic core members that vibrate under the action of electric oscillations of the audible frequency range, which resides in holding one core member coupled under pressure against hearing inducing bones of the user so as to carry the other core member having a relatively large mass in a floating condition, and utilizing the floatingly carried core member to exert vibratory inertia reaction forces upon the coupled core member and therethrough upon the bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

28. The method of inducing hearing with a vibratory hearing aid structure that vibrates under the action of electric oscillations of the audible frequency range, which resides in holding a vibratory portion of said structure coupled under pressure against hearing inducing bones of the user so as to carry the other vibratory portion of said structure having a relatively large mass in a floating condition, and utilizing the floatingly carried vibratory portion to exert vibratory inertia reaction forces upon the coupled vibratory portion and therethrough upon the bones for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear and induce intelligible hearing.

29. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, an elastically deformable vibratory member having two vibratory portions and means for actuating said vibratory member with electric oscillations substantially throughout the speech frequency range for producing corresponding vibrations of said vibratory portions, one of said vibratory portions having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user and floatingly carrying the other of said vibratory portions, the floating vibratory portion having sufficient mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon the coupled vibratory portion and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

30. In a bone conduction hearing device suitable for inconspicuous wear by the user, an elastically deformable vibratory member comprising a driven vibratory portion having a contact surface element arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and a driving vibratory portion floatingly carried relatively to said contact surface portion, and means for actuating said vibratory member with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions, said vibratory member and its several parts being so designed and proportioned that at an overall size of the vibratory member having a volume less than about three cubic inches, the driving vibratory portion has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon the contact surface element and therethrough upon the bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce therein intelligible hearing.

31. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, an elastically deformable vibratory member having two vibratory portions and means for actuating said vibratory member with electric oscillations substantially throughout the speech frequency range for producing corresponding vibrations of said vibratory portions, one of said vibratory portions having a rigid contact surface element arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and floatingly carrying the other of said vibratory portions, said vibratory member and its several parts being so designed and proportioned that at an overall size of the vibratory member having a volume less than about two cubic inches, the driving vibratory portion has a sufficiently large mass greater than about four grams and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said rigid contact surface element and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

32. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory structure having two vibratory portions, means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said vibratory portions, and means for holding one of said vibratory portions coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying the other vibratory portion of said vibratory structure in a floating condition, said floating vibratory portion having sufficient mass and exerting under the action of the electric oscillations sufficient inertia reaction for imparting to the coupled bones of the user the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

33. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory structure having one vibratory portion with a contact surface arranged for coupling under pressure to hearing inducing bones of the user and another vibratory portion floatingly carried by said bone coupled vibratory portion, means for actuating said vibratory structure with

electric oscillations of the principal audible frequency range for producing corresponding vibrations between said vibratory portions, the floatingly carried vibratory portion having a mass sufficiently larger than the mass of said bone coupled vibratory portion and exerting under the action of the electric oscillations sufficient inertia reaction forces upon the bone coupled vibratory portion and therethrough upon the bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the coupled bones to the inner ear of the user and induce intelligible hearing.

34. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory structure having two vibratory portions and means for actuating said vibratory structure with electric oscillations substantially throughout the speech frequency range for producing corresponding vibrations of said vibratory portions, one of said vibratory portions having a rigid contact surface element arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal and floatingly carrying the other of said vibratory portions, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory member having a volume less than about three cubic inches, the driving vibratory portion has a sufficiently large mass and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said contact surface element and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing, said bone coupled vibratory portion being arranged and shaped to protect said floating vibratory portion against external forces.

35. In a bone conduction hearing device suitable for inconspicious wear by the user, a vibratory structure having two vibratory portions, means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said vibratory portions, and means for holding one of said vibratory portions coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying the other vibratory portion of said vibratory structure in a floating condition, the floating vibratory portion having sufficient mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon the bone coupled vibratory portion and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing, said bone coupled vibratory portion being arranged and shaped to protect said floating vibratory portion against external forces.

36. In a bone conduction hearing aid device suitable for inconspicuous wear by a deafened person, a vibratory structure having two vibratory portions and means for actuating said vibratory structure with electric oscillations substantially throughout the speech frequency range for producing corresponding vibrations of said vibratory portions, one of said vibratory portions forming a casing having a contact surface arranged to be held coupled under pressure to hearing inducting bones of the user, the other of said vibratory portions having sufficient mass and being floatingly carried within said casing so as to exert under the action of the electric oscillations sufficient inertia reaction forces upon the coupled vibratory portion and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

37. In an inconspicuous hearing imparting device, a vibratory structure comprising a rigid vibratory casing having an extended external vibration transmitting surface, a vibratory portion floatingly carried within said casing, means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said floatingly carried vibratory portion and said casing, said floatingly carried vibratory portion having sufficient mass larger than the mass of said casing and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said casing for imparting thereto vibratory energy required for transmitting corresponding vibrations from the external surface of said casing to the inner ear of the user and induce intelligible hearing.

38. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory structure comprising a driven vibratory portion forming a part of a rigid casing having a contact surface arranged to be held coupled under pressure to hearing inducing bones of the user outside the ear canal, a driving vibratory portion floatingly carried within said casing, and means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said vibratory portions, said vibratory structure and its several parts being so designed and proportioned that at an overall size of the vibratory member having a volume less than about three cubic inches, the driving vibratory portion has a sufficiently large mass of the order of eight grams or more and exerts under the action of the electric oscillations sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

39. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory structure having two vibratory portions, means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said vibratory portions, and a rigid casing for holding one of said vibratory portions coupled under pressure to hearing inducing bones of the user outside the ear canal and carrying the other vibratory portion of said vibratory structure in a floating condition within said casing, said floating vibratory portion having sufficient mass and exerting under the action of the electric oscillations sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

40. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibra-

tory structure comprising a casing having a contact surface arranged for coupling under pressure to hearing inducing bones of the user, a vibratory portion floatingly carried within said casing, and means for actuating said vibratory structure with electric oscillations of the principal audible frequency range for producing corresponding vibrations between said floatingly carried vibratory portion and said casing, said floatingly carried vibratory portion having a mass sufficiently larger than the mass of said casing and exerting under the action of the electric oscillations sufficient inertia reaction forces upon the casing and therethrough upon the bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

41. In a portable audiphone, the combination of electromagnetic means adapted to respond to varying currents substantially throughout the audible frequency range, a relatively stiff vibrating member carrying the means and forming a narrow gap between the member and the means of fixed dimension subject to the vibration imparted to the member by the means and which is less in amplitude than the width of the said air gap, and means for supporting the member in operative connection with the bone-structure of the user.

42. In a portable audiphone, the combination of a vibratory portion, an electromagnetic portion carried by said vibratory portion and including a speech coil and adapted when the coil is energized by varying currents to effect vibration of said vibratory portion, said electromagnetic portion having greater inertia than said vibratory portion, and means for holding the vibratory portion in operative connection with the bone structure of the user, whereby the vibrations of the vibratory portion are conducted through the bone structure to the inner ear of the user.

43. In a portable audiphone, the combination of a vibratory member, electromagnetic means carried by the member and adapted to respond to varying currents substantially throughout the audible frequency range for vibrating said member, and means for supporting the member in operative connection with the bone structure of the user, whereby the vibrations of said member are conducted through the bone structure to the inner ear of the user.

44. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory magnetic core portion and a driving vibratory magnetic core portion having a resilient junction portion floatingly carrying said driving core portion relatively to said driven core portion so as to form therewith a magnetic flux path including a magnetic gap, means including windings interlinked with said flux path for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions across said gap, and means including a substantially rigid casing enclosing said driving vibratory portion with its resilient junction portion and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about three cubic inches, the driving vibratory portion has a sufficiently large mass and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

45. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory magnetic core portion and a driving vibratory magnetic core portion having a resilient junction portion floatingly carrying said driving core portion relatively to said driven core portion so as to form therewith a magnetic flux path including a magnetic gap, means including windings interlinked with said flux path for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions across said gap, and means including a substantially rigid casing enclosing said driving vibratory portion with its resilient junction portion and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about two cubic inches, and a magnetic gap spacing of less than about ten thousandths of an inch, the driving vibratory portion has a sufficiently large mass greater than about four grams and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

46. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory magnetic core portion and a driving vibratory magnetic core portion having a resilient junction portion floatingly carrying said driving core portion relatively to said driven core portion so as to form therewith a magnetic flux path including a magnetic gap, means including windings interlinked with said flux path for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions across said gap, and means including a substantially rigid casing enclosing said driving vibratory portion with its resilient junction portion and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about two cubic inches, and a magnetic gap spacing securing good operating efficiency, the driving vibratory portion has a sufficiently large mass of the order of eight grams or more and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting there-

to the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

47. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory magnetic core portion and a driving vibratory magnetic core portion having a resilient junction portion floatingly carrying said driving core portion relatively to said driven core portion so as to form therewith a magnetic flux path including a magnetic gap, means including windings interlinked with said flux path for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions across said gap, and means including a substantially rigid contact surface element arranged and shaped to protect said driving vibratory portion with its resilient junction portion against external forces and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about three cubic inches, the driving vibratory portion has a sufficiently large mass of the order of eight grams or more and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said contact surface element and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

48. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory portion and a driving vibratory portion having a resilient junction portion floatingly carrying said driving vibratory portion relatively to said driven vibratory portion, means for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions, and means including a substantially rigid casing enclosing said driving vibratory portion with its resilient junction portion and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about three cubic inches, the driving vibratory portion has a sufficiently large mass greater than about four grams and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said casing and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

49. In a bone conduction hearing device suitable for inconspicuous wear by the user, a vibratory unit comprising a driven vibratory portion and a driving vibratory portion having a resilient junction portion floatingly carrying said driving vibratory portion relatively to said driven vibratory portion, means for actuating said vibratory portions with electric oscillations of the principal audible frequency range to produce corresponding vibrations of said vibratory portions, and means including a substantially rigid contact surface element arranged and shaped to protect said driving vibratory portion with its resilient junction portion against external forces and forming a part of said driven vibratory portion for holding said driven vibratory portion coupled under pressure to hearing inducing bones of the user outside the ear canal, said vibratory unit and its several parts being so designed and proportioned that, at an overall size of the unit having a volume of less than about two cubic inches, the driving vibratory portion has a sufficiently large mass of the order of eight grams or more and is subjected under the action of the electric oscillations to sufficient accelerations so that it exerts sufficient inertia reaction forces upon said contact surface element and therethrough upon the coupled bones of the user for imparting thereto the vibratory energy required for conducting corresponding vibrations through the bones to the inner ear of the user and induce intelligible hearing.

EMIL HENRY GREIBACH.