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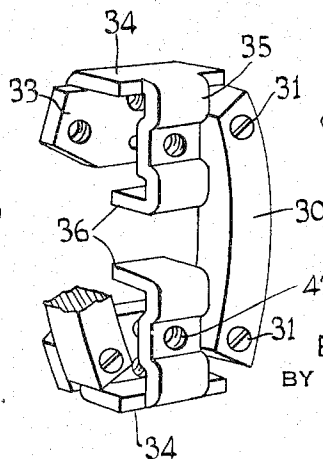
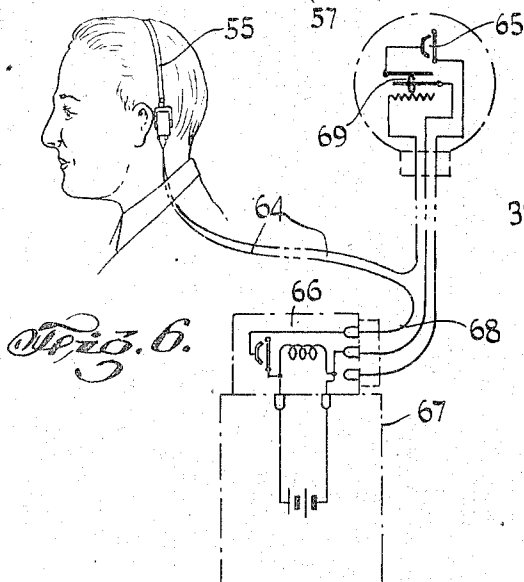
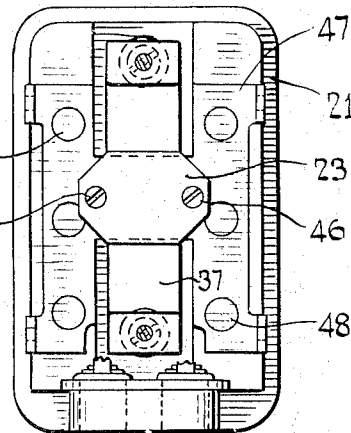
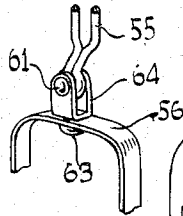
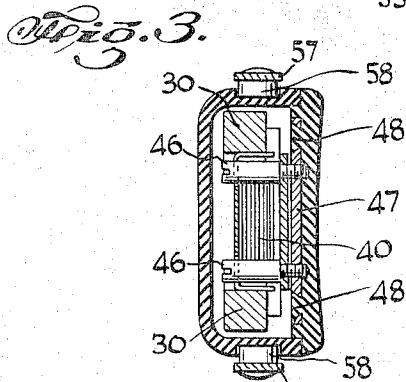
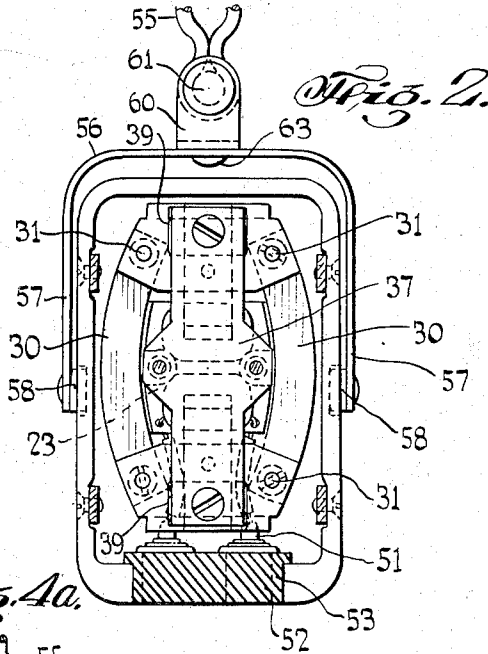
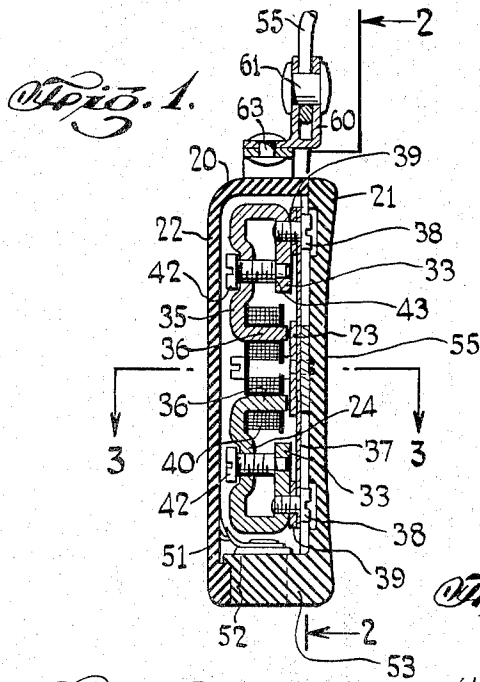
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2,143,130

BONE CONDUCTION HEARING-AID DEVICE

Filed July 1, 1936

2 Sheets-Sheet 1



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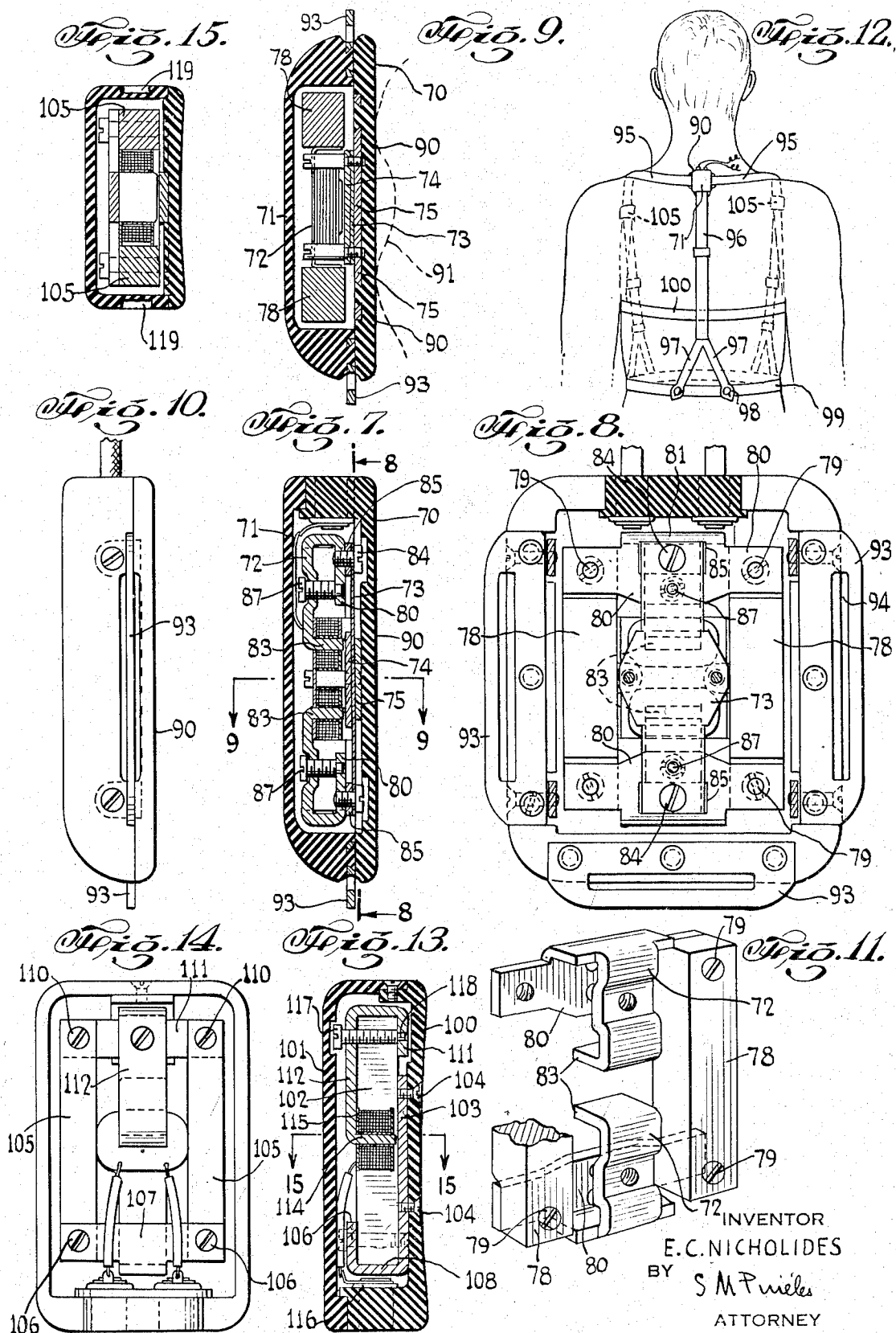
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BONE CONDUCTION HEARING-AID DEVICE

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2 Sheets-Sheet 2



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2,143,130

BONE CONDUCTION HEARING-AID DEVICE

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4 Claims. (Cl. 179-107)

This invention relates to bone conduction hearing-aid devices and has among its objects a flat small bone conduction receiver for inconspicuous wear in contact with hearing inducing bone structure of a deafened person designed to operate with high efficiency in imparting to the bone structure of the user the hearing inducing vibratory energy required for inducing satisfactory hearing.

The objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings, wherein

Fig. 1 is a vertical cross sectional view of a bone conduction receiver of the invention with the head-band support;

Fig. 2 is an elevational view of the receiver of Fig. 1 partially in cross section, along line 2-2 of Fig. 1;

Fig. 3 is a horizontal sectional view of the receiver along line 3-3 of Fig. 1;

Fig. 4 is a top view of the inner side of the base of the receiver of Fig. 1 with the armature mounted in place;

Fig. 4a is a perspective view of a modified head-band swivel support;

Fig. 5 is a perspective view of the core assembly of the receiver of Fig. 1;

Fig. 6 is a diagram illustrating a hearing-aid device with a bone conduction receiver of the invention as used by a deafened person;

Fig. 7 is a view similar to Fig. 1 of a bone conduction receiver adapted for coupling to hearing-inducing vertebrae of a deafened person;

Fig. 8 is an elevational view of the receiver with the cover removed, along line 8-8 of Fig. 7;

Fig. 9 is a horizontal sectional view of the receiver along line 9-9 of Fig. 7;

Fig. 10 is a side elevation of the receiver of Fig. 7;

Fig. 11 is a perspective view of the core assembly of Fig. 7;

Fig. 12 is a view of the bone conduction receiver of Fig. 7 and its coupling support;

Fig. 13 is a view similar to Fig. 1 of a bone conduction receiver embodying a modified form of the invention;

Fig. 14 is a plan view of the receiver of Fig. 7 with the cover removed; and

Fig. 15 is a horizontal sectional view of the receiver along line 15-15 of Fig. 13.

It has been long known that most of the deafened are anxious to conceal their impairment and that a practical hearing aid for a deafened person must not only be able to make the deafened hear sound substantially like a normal person, but that

the hearing-aid must be suitable for concealed wear by the user.

In accordance with the invention a small efficient bone conduction receiver suitable for inconspicuous wear in contact with hearing-inducing bone structure of a deafened person is made with a flat floating magnetic vibrating structure of substantial mass formed by two magnetic bars of the opposite ends of the bars into a flat rigid structure which substantially fills the interior of the receiver casing and confines the actuating winding and pole members of the vibrating structure within the space between the magnet bars, thus limiting the over-all height of the receiver to a minimum.

In Figs. 1 to 5 is illustrated one form of such bone conduction receiver intended for wear in contact with the mastoid bone behind the ear of the user: It comprises a flat small casing formed of a base 21 and a detachable cover 22 enclosing an electromagnetic vibrating structure consisting of a driven armature core member 23 which is clamped to the base 21 and supports in a floating condition a driving flat magnetic core structure 24 of substantial mass which fills substantially the entire interior space of the casing.

The floating magnetic core structure 24 is formed of two longitudinal slightly curved permanent magnetic bars 30, the opposite ends of which are attached by screws 31 to cross pieces 33 of two T-shaped core members 34 which have angularly bent longitudinally extending central pole projections 35 terminating in inwardly projecting pole pieces 36 which face the armature 23.

The armature 23 is united as by soldering with a diaphragm strip 37, which has its ends firmly clamped to the core cross pieces 33 by non-magnetic screws 38, and non-magnetic spacers 39, of a thickness equal to the thickness of the armature 23 to separate the ends of the diaphragm 37 from the cross piece 33, and prevent a magnetic short circuit between the core pieces of opposite polarity. On the pole pieces 36 are mounted actuating windings in the form of coils 40, and the coils as well as the pole pieces are confined within the space between the magnet bars 30.

Efficient operation of the electromagnetic vibrating structure, formed of the armature 23 and the large mass of the floating magnetic core 24, is secured by fixing the gaps between the pole pieces 36 and the armature 23 at a very small distance the order of about one-half of a thousandth of an inch at which the amplitudes of the core vibra-

tions across the gap is of the order of the gap lengths while eliminating freezing.

Accurate manufacture of bone conduction receivers, with the small gap distance of the order of one-half of a thousandth of an inch essential for efficient operation is made possible by providing each inward pole core projection 35 with a set screw 42 having shoulder portions 43 engaging the opposite surfaces of the core cross piece 33 so that by turning the set screw 42 the pole piece core is deformed and withdrawn from its contact with the armature and retained in a fixed position in which a small effective magnetic gap of a fraction of a thousandth of an inch is maintained between the pole faces of the pole pieces 36 and the armature 23 during the operation of the receiver.

In order to permit accurate fixing of the effective magnetic gaps in the manufacture of such receivers, the surface of the assembled floating core structure 24 facing the armature is ground flat and the pole faces of the pole pieces 36 are made level with the aligned surfaces of the cross pieces 33 so that when the armature 23 is clamped to the core structure 24, the inward ends of the pole pieces 36 make contact with the armature.

The vibratory magnetic structure is then given the fixed dimensions required for operation with the optimum effective magnetic gap length of a fraction of a thousandth of an inch by turning the set screws 42 in the screw holes 42' of the pole cores 35 till the pole pieces 36 are moved away from contact with the armature and the effective magnetic gap is fixed at the desired small length at which the accelerating magnetic forces acting through the gap impart to the core members a vibratory motion across the gap of the order of the gap length without danger of freezing or fringing between the pole faces. The set screws 42 have a small pitch so that a substantial angular turn of the set screw produces only a small motion of the pole piece, permitting accurate setting of the optimum fixed gap distance upon which the efficiency of the receiver depends.

The assembled vibrator unit formed of the floating core structure 24 and the armature 23 is mounted as a unit on the base 21 by two screws 46 which clamp the center portion of the armature to a metallic anchor plate 47 rigidly imbedded in the molded base 21. Sound frequency currents are supplied to the pole windings 40 by flexible leads 51 extending to terminal bushings 52 mounted in a terminal block 53, provided on one end of the base.

The bone conduction receiver of Figs. 1 to 5 is designed for coupling to the mastoid bone back of the ear of a deafened person and the outer surface of the base 21 has a curved external contact surface 55 gripping a substantial portion of the bone structure of the user so that under the action of the inertia reaction forces exerted on the casing by the vibratory motion of the floating magnetic structure inside the casing, the base will impart through its contact surface hearing inducing vibratory forces to a substantial portion of the bone structure engaged by the concave contact surface of the base and thus secure a good impedance match between the small vibrating unit and the bone structure enabling efficient transmission of hearing inducing vibratory energy to the inner ear of the user.

The bone conduction receiver is provided with an inconspicuous head-band 55 made from two

looped spring wires bent to fit comfortably over the head of the user without making his impairment conspicuous and carrying on its end a bracket 56 with arms 57 having pivot pins engaging openings in the side walls of the receiver casing for holding the receiver and pressing its base 21 against the mastoid bone behind the ear of the user.

To secure an efficient coupling connection between the receiver base 21 and the bone structure of the user, the lower end of the head-band wire loop 55 is bent to form a bearing sleeve in which is journaled a pivot pin 61 extending between the arms of a link 60 provided with an offset pivot pin engaged by the center portion of the receiver bracket 56. The articulated connection between the head-band 55 and the bracket 56 with the two pivot pins 61 and 62 permits lateral as well as angular movement of the receiver against the head-band and secures automatic alignment of the contact surface of the receiver base 21 with the bone structure against which it is held pressed by the head-band. Fig. 4a shows an articulated link connection between the wire head-band and the receiver bracket, using a straight link 64 pivotally interconnected by pivot pin 61 with the offset bearing portion of the wire loop and by the straight downward pin 63 with the receiver bracket 56.

The bone conduction receiver of the invention is designed for use in a wearable hearing-aid device which may be operated by supplying its actuating winding 40 through flexible cords 64 with sound frequency current oscillations from a wearable electric amplifying hearing aid, for instance, of the type disclosed in United States Patent No. 2,046,738, comprising a transmitter microphone 65 and an amplifier unit 66 connected to a small battery 67 by a flexible cord 68 and controlled by a single button control unit 69 combined with the transmitter, all the parts of which may be hidden in the clothing of the user.

Sound waves imparted to the diaphragm of the transmitting microphone generate sound frequency impulses which produce in the amplifier 66 amplified current oscillations which are supplied through the cord 64 to the actuating windings 40 of the bone conduction receiver. These current oscillations induce in the small gaps between the pole pieces 36 and the armature 23 corresponding vibratory forces which tend to produce a vibratory motion between the armature 23 and the floating core structure 24. Since the floating core structure has a mass of substantial inertia, it resists the vibratory motion and exerts on the armature inertia reaction forces proportional to the mass of its floating core structure and its acceleration, which are, in turn, transmitted through the contact surface of the receiver base 21 to the bone structure of the user for inducing hearing in his inner ear.

In the bone conduction receiver shown in Figs. 1 to 5, the height of the receiver casing is held down to a minimum and each part of the space within the tiny receiver casing is efficiently utilized for housing the large mass of the floating magnetic core structure which combines within the small space confined to the height of the magnetic bars the core pole pieces with their actuating windings as well as the gap setting mechanism for fixing the dimensions of the vibratory structure required to maintain the fixed effective gap spacing of the order of a fraction

of a thousandth of an inch essential for producing with the small receiver the large mechanical hearing inducing energy that has to be imparted to bones of the user in order to induce in his inner ear organs satisfactory hearing.

In Figs. 7 to 11 is shown a modification of the bone conduction receiver of the invention designed to impart hearing-inducing vibrations to the vertebrae of the spinal column of a deafened person and make him hear by bone conduction in the way disclosed in the applications of Hugo Lieber, Serial No. 648,733, filed December 24, 1932, Patent No. 2,077,425, issued April 20, 1937, and Serial No. 21,706, filed May 16, 1935, Patent No. 2,077,426, issued April 20, 1937.

The bone conduction receiver of Figs. 7 to 10 comprises a flat casing formed of a base 70 and a cover 71 enclosing a flat hollow space within which is mounted a flat floating magnetic core structure 72 carried by the ends of a resilient diaphragm 73 of a magnetic armature member 74 clamped to an anchor plate 75 imbedded in the molded base. The floating magnetic core structure 72, which fills substantially the entire space within the casing, is formed of two longitudinal permanent magnet bars 78, having ends of reduced thickness attached by screws 79 to cross pieces 80 of T-shaped pole core members bent in the way shown in Fig. 7 so that the total height of the floating structure does not substantially exceed the height of the permanent magnet bars 78.

As in the bone conduction receiver of Figs. 1 to 5, the pole core members 81 are provided with inwardly extending pole piece projections 83, and the floating core structure is attached to the ends of the armature diaphragm 73 by means of screws 84, the diaphragm being magnetically insulated from the core members 81 by non-magnetic spacers 85. Set screws 87 extending through the intermediate portions of the pole projections 83 and engaging the cross pieces 80 of the pole core members enable accurate fixing of the dimensions of the vibratory structure required to maintain the effective magnetic gap distance of the order of a fraction of a thousandth of an inch essential for efficient operation of the receiver. The pole pieces 83 are provided with energizing coils 88 confined between the magnet bars 78 and supplied with sound frequency current through the terminal bushing 89, mounted on the bushing support extending from the upper end of the base 70.

In order to permit effective coupling of the external contact surface 90 of the base 70 to the spinal vertebrae 91 of the bone structure, indicated in dotted line in Fig. 9, the bottom wall and the side walls of the casing cover 71 are provided with fastening strips 93 formed, for instance, of metal molded as a unit with the casing cover in the way shown in Figs. 7 and 9. Each fastening strip is provided with a slot 94 to which are attached two lateral straps 95 and one rear strap 96 which form a suspender-like harness by means of which the coupling surface 90 of the vibrator is held pressed against the bone structure of the spinal vertebrae 91. Each of the straps 95 and 96 may be provided with end straps 97 which may be attached to buttons 98 of a belt 99. The three straps 95 are provided with buckles 100 similar to those used in standard suspenders permitting adjustment of the length of the three straps 96 so as to secure the desired coupling connection between the base

70 of the bone conduction receiver and the spinal vertebrae.

The suspender-like harness may be further provided with an additional cross strap 100 extending from both sides of the rear strap 96 over the back of the user below the shoulder blades and armpits, with its end portions looped over the front sides of the shoulders and attached to the front sides of the suspender straps 95 by means of clasps 105 to cooperate with the suspender straps 95 and 96 in pressing the receiver base 70 against the vertebrae of the spinal column.

In Figs. 13 to 15 is shown an inertia-reaction bone conduction receiver of the cantilever type constructed in accordance with the invention. It comprises a flat casing having a base 100 and a detachable cover 101 enclosing a flat magnetic core structure 102 floatingly carried by an armature member 103 clamped to the base by screws 104. The floating core structure 103, which fills substantially the entire space within the receiver casing, is formed of two longitudinal permanent magnet bars, the ends of which are attached by screws 106 to the upwardly projecting overlying cross piece 107 of the T-shaped doubly bent pole core member 108, the lower end of which forms the armature 103 which is clamped to the receiver base 100 so that the two magnet bars 105 are floatingly carried by the upward armature extension 108 in the space within the casing.

The other ends of the permanent magnet bars 105 are attached by screws 110 to an underlying cross piece 111 of a T-shaped pole core member 112 having a center portion bent in the way shown in Fig. 13 to form a pole piece 114 with a pole face lying opposite a pole face portion of the armature member 103 located in the center of the receiver base 100 which serves as the coupling wall of the receiver. The central pole piece 114 of the receiver is provided with an actuating coil 115 which is energized through flexible leads connected to terminal bushings 116 located in the terminal block extending from one end of the base.

Accurate and simple manufacture of such bone conduction receivers with the minute fixed effective magnetic gap length between the pole faces of the vibratory structure is made possible by a set screw 117 extending through the intermediate portion of the T-shaped pole core 112 and engaging with its tip the mid-portion of the cross piece 111, so that by turning the set screw 117 the pole piece 114 is withdrawn from its position in contact with the armature pole face and the effective magnetic gap is fixed at its optimum minimum length essential for the efficient operation of the small receiver.

In the cantilever-type inertia reaction receiver shown in Figs. 13 to 15, the pole piece 114 is located above the center of the base and the magnetic forces are developed in the center of the receiver unit. As a result the inertia reaction forces exerted by the floating mass of the vibratory structure on the base will transmit vibratory energy over the major part of the base area and the receiver base may be provided with a large concave coupling surface which is pressed against the bone structure by the pins of a head band bracket which engage the holes 119 of the receiver casing.

The principle of construction of small flat bone conduction receivers which, notwithstanding extremely small height and over-all size, are able to

house a large floating magnetic core structure operating at great efficiency with a fixed minute effective gap length of a fraction of a thousandth of an inch secured by utilizing the elements of the floating core structure as a positive gap fixing mechanism will suggest to those skilled in the art many other embodiments of the invention. It is accordingly desired that the appended claims be given a broad construction commensurate with the scope of the invention.

I claim:—

1. In a wearable bone conduction hearing-aid receiver for a deafened person, a receiver casing, a magnetic vibratory core structure of substantial mass enclosed in said casing comprising two spaced permanent magnet bars and two core cross pieces joining the opposite ends of said bars into a rigid flat core of substantial mass, one of said cross pieces constituting a part of a pole piece extending from said cross piece and confined in the space between said bars, and a driven core member united with a wall of said casing floatingly carrying the flat core within said casing, said flat core filling substantially the entire space within said casing and constituting with said driven core member an electromagnetically actuated vibratory structure of fixed dimensions forming a low reluctance magnetic flux path including a gap.
2. In a wearable bone conduction hearing-aid receiver for a deafened person, a receiver casing, a magnetic vibratory core structure of substantial mass enclosed in said casing comprising two spaced permanent magnet bars and two core cross pieces joining the opposite ends of said bars into a rigid flat core of substantial mass, each of said cross pieces constituting a part of a pole piece extending from said cross piece and confined in the space between said bars, and a driven core member united with a wall of said casing floatingly carrying the flat core within said casing, said flat core filling substantially the entire space within said casing and constituting with said driven core member an electromagnetically actuated vibratory structure of fixed dimensions forming a low reluctance magnetic flux path including a gap.
3. In a wearable bone conduction hearing-aid receiver for a deafened person, a receiver casing, a magnetic vibratory core structure of substantial

mass enclosed in said casing comprising two spaced permanent magnet bars and two core cross pieces joining the opposite ends of said bars into a rigid flat core of substantial mass, one of said cross pieces constituting a part of a pole piece extending from said cross piece and confined in the space between said bars, and a driven core member united with a wall of said casing floatingly carrying the flat core within said casing, said flat core filling substantially the entire space within said casing and constituting with said driven core member an electromagnetically actuated vibratory structure of fixed dimensions forming a low reluctance magnetic flux path including a gap of the order of a fraction of a thousandth of an inch between said pole piece and said driven core member, and set screw means extending through said pole piece and engaging another spaced portion of said pole piece for fixing the structural relation of the floating flat core relatively to the driven core member and maintaining between said pole piece and said driven core member an effective magnetic gap.

4. In a wearable bone conduction hearing-aid receiver for a deafened person, a receiver casing, a magnetic vibratory core structure of substantial mass enclosed in said casing comprising two spaced permanent magnet bars and two core cross pieces joining the opposite ends of said bars into a rigid flat core of substantial mass, each of said cross pieces constituting a part of a pole piece extending from said cross piece and confined in the space between said bars, and a driven core member united with a wall of said casing floatingly carrying the flat core within said casing, said flat core filling substantially the entire space within said casing and constituting with said driven core member an electromagnetically actuated vibratory structure of fixed dimensions forming a low reluctance magnetic flux path including a gap of the order of a fraction of a thousandth of an inch between said pole piece and said driven core member, and set screw means extending through each of said pole pieces and engaging another spaced portion of said pole pieces for fixing the structural relation of the floating flat core relatively to the driven core member and maintaining between said pole piece and said driven core member an effective magnetic gap.

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