April 20, 1937. H. LIEBER 2,077,426

BONE CONDUCTION HEARING AID DEVICE

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Fig. 1.

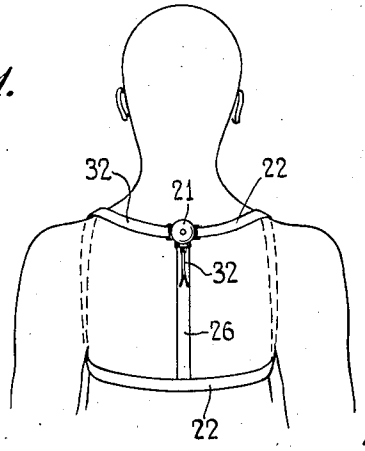


Fig. 3.

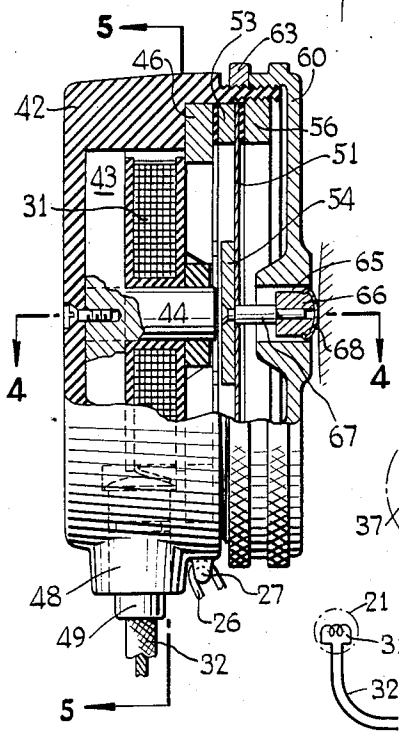


Fig. 4.

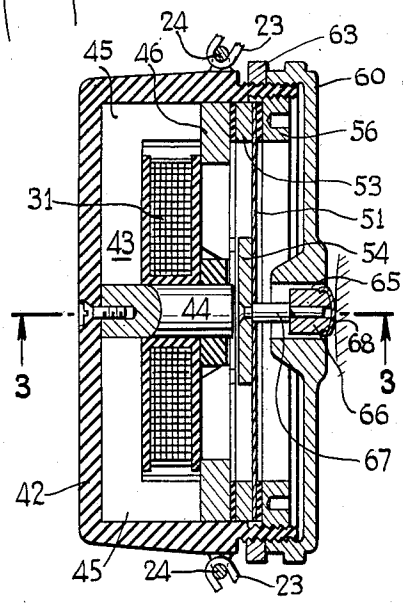


Fig. 2.

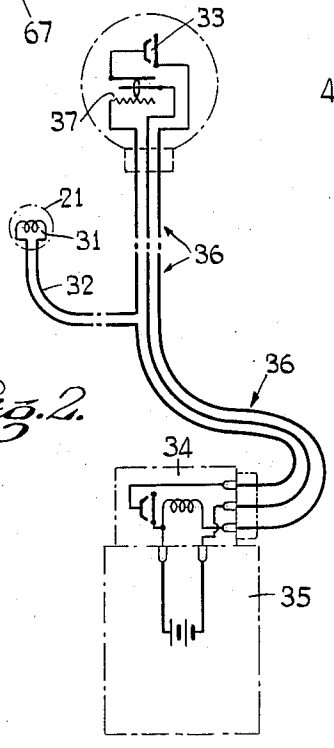
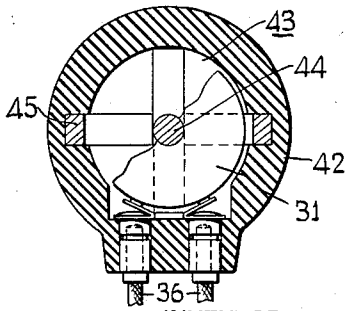


Fig. 5.



INVENTOR
HUGO LIEBER
BY S M Pinales
ATTORNEY

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Fig. 6.

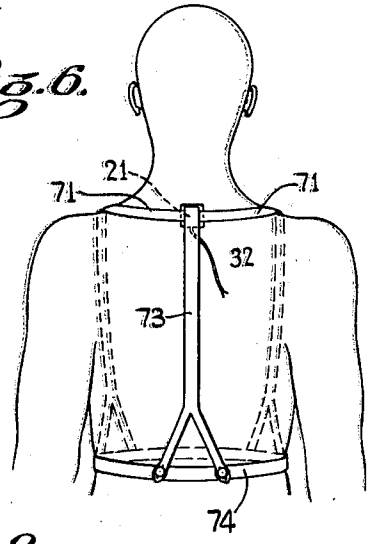


Fig. 7.

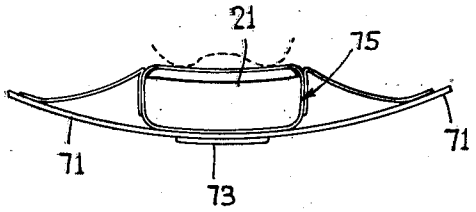


Fig. 8.

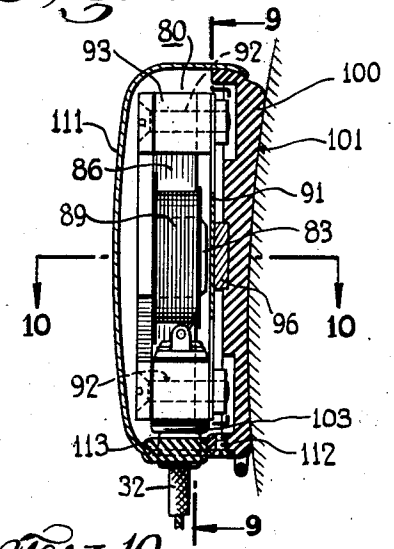


Fig. 9.

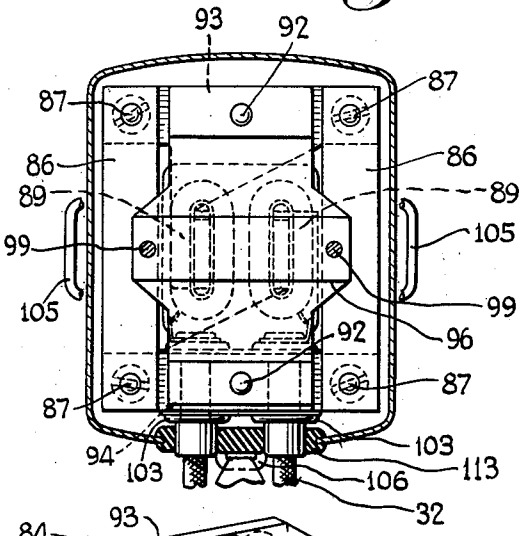
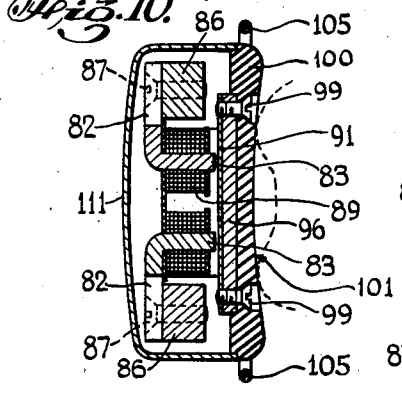


Fig. 10.



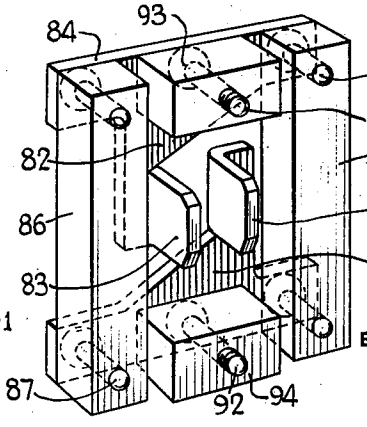


Fig. 11.

INVENTOR
HUGO LIEBER
BY S M Pincles
ATTORNEY

Patented Apr. 20, 1937 2,077,426

UNITED STATES PATENT OFFICE

2,077,426

BONE CONDUCTION HEARING AID DEVICE

Hugo Lieber, New York, N. Y., assignor to Lieber Patents Corporation, New York, N. Y., a corporation of New York

Application May 16, 1935, Serial No. 21,706

3 Claims. (Cl. 179—107)

This application is a continuation in part of the copending application, Serial No. 648,733, filed December 24, 1932.

This invention relates to bone-conduction hearing-aid devices and has among its objects an improved wearable bone-conduction hearing-aid device for deafened persons having impaired middle ear organs utilizing a bone-conduction receiver held coupled to the vertebrae of the spinal column for transmitting to the bone structure of the head vibratory energy which induces hearing in the hearing nerves of the inner ear of the user.

The foregoing and other objects of the invention will be best understood from the following description of an embodiment thereof, reference being had to the accompanying drawings in which

Fig. 1 is a view of a hearing-inducing bone vibrator unit with a support coupling the vibrator unit to the vertebrae of the upper portion of the spinal column of a deafened person in accordance with the invention;

Fig. 2 is a diagram illustrating the arrangement of the electrically operated actuating elements of the device;

Fig. 3 is a vertical sectional view of a vibrator unit of the device along line 3—3 of Fig. 4;

Fig. 4 is a vertical sectional view of a vibrator unit along line 4—4 of Fig. 3;

Fig. 5 is a vertical sectional view of the vibrator unit along line 5—5 of Fig. 3;

Fig. 6 is a view similar to Fig. 1 illustrating a modified form of support;

Fig. 7 is a top view of the vibrator support of Fig. 6;

Fig. 8 is a vertical sectional view of another form of vibrator unit of the invention;

Fig. 9 is a vertical sectional view of the vibrator unit along line 9—9 of Fig. 8;

Fig. 10 is a horizontal sectional view of the vibrator unit along line 10—10 of Fig. 8; and

Fig. 11 is a perspective view of the magnetic structure of the vibrating unit of Fig. 8.

Those familiar with deafened persons have long realized that in most cases their hearing impairment is caused by defective middle ear organs which obstruct and prevent satisfactory transmission of sound vibrations over the normal hearing channel by way of the ear canal.

It has also been long known that most of the deafened have satisfactory interior hearing organs and that they are able to hear well sound imparted in the form of mechanical vibrations to the bone structure of the head of the deafened.

Since most of the deafened are anxious to conceal their impairment, a practical hearing-aid for the deafened must not only be able to restore to the deafened his ability to hear well but the hearing-aid must be suitable for concealed wear on the person of the deafened so as to enable him to hear without making his impairment conspicuous.

These difficulties are overcome by the present invention by providing a bone-conduction receiver of small size able to impart to the bone structure of the deafened an amount of mechanical vibratory energy required to induce satisfactory hearing with a support which holds the vibrator unit pressed and coupled to the bones of the spinal column in the region of the cervical vertebrae and the thoracic vertebrae, making possible concealed wear of substantially all the elements of the hearing-aid device.

The vibrator support is in the form of a harness 22 attached to and fitting the trunk of the deafened. It consists of a flexible strap having a center portion extending over back of the user, below the shoulder blades and the arm pits, and end portions looped over the front sides of the shoulders, to the rear of the neck over the region adjacent the junction of the neck and the trunk. The strap ends have hooks 23 engaging eyelets 24 provided on the opposite sides of the vibrator unit 21 and exert a lateral pull thereon, pressing it against the bones of the spine. An additional strap portion 25 extending from the center of the strap 22 to a hook 26 engaging an eyelet 27 on the bottom side of the vibrator unit and exerting a downward pull thereon may be provided as a part of the harness.

The vibrator unit 21 is actuated by supplying its actuating winding 31 through flexible cords 32 with sound-frequency current oscillations from a portable electrical amplifying hearing-aid, for instance, of the type disclosed in U. S. Patent 1,939,627, comprising a transmitter microphone 33 and an amplifier 34 connected to a dry cell battery 35 by a flexible cord and controlled by a control unit 37. The several elements of the hearing-aid are small and are suitable for inconspicuous wear in the clothing of the deafened.

Sound waves imparted to the diaphragm of the transmitting microphone 33 vary its resistance generating in the circuit of the current impulses which produce in the amplifier 34 amplified current oscillations which are supplied through cord 32 to actuating winding 31 of the bone vibrator

unit 21. These current oscillations produce a vibratory motion of the vibrator unit and cause it to impart mechanical vibrations to the bone structure of the upper portion of the spinal column to which it is coupled. These mechanical vibrations are transmitted over the vertebrae of the upper portion of the spinal column to the bones of the head and therethrough to the auditory center of the deafened and induce therein hearing sensations like those which reach a person of ordinary hearing through the ear canal.

One form of a vibrator unit suitable for use in accordance with the invention is shown in detail in Figs. 3, 4, and 5. It comprises a casing 42 of insulating material, such as a phenolic condensation product, within which is mounted a core 43, an electromagnet comprising a central soft iron core 44 with two L-shaped permanent magnets 45 held in grooves in the bottom and the side walls of the casing by a slotted circular pole plate 46 placed on the top of the magnets 45, the pole plate having a central perforation surrounding the end of the central core. The actuating winding 31 is mounted on the center core 44 and is connected with two terminal bushings to receive the terminal tips of the cord 32 which is connected to the electrical actuating circuit of the device. Above the pole plate is mounted a diaphragm 51 consisting of a circular resilient metal sheet diaphragm which is held radially tensioned by a tension ring 53. The tension ring is made from a split ring of large diameter compressed to the diameter of the diaphragm and soldered to the edge thereof so that under the action of the forces tending to restore the ring to its original position, a uniform radial tension is applied to the diaphragm increasing its stiffness.

To the underside of the diaphragm is secured, as by soldering, a circular armature 54 of soft iron. The lower surface of the armature is parallel to the pole faces of the central core member 44 and the surrounding pole plate 46 and is spaced therefrom by a small gap completing the flux path of the electromagnet over the gaps formed between the pole faces. The diaphragm unit is held clamped in place by a threaded locking ring 56 which is screwed to the inner threaded casing wall, thin washers serving to adjust the spacing of the diaphragm. The top of the casing 42 is enclosed by a cover 60 threaded over the casing, a lock ring 63 serving to lock the cover in position. The central portion of the cover has a cylindrical opening 65 for guiding a contact button 66 carried at the end of a rod 67 secured to the center of the armature 54. The outer surface of the vibrating member 66 is preferably provided with a thin cap 68 of non-oxidizing material, for instance, gold.

The construction of the vibrator unit described above is similar in its general construction to a standard telephone, and upon actuation by means of sound-frequency current impulses produced by the transmitter 24, a vibratory motion will be produced between the armature 54 and the large mass of the vibrator unit.

In distinction from the construction used in ordinary telephones, the diaphragm 51 is made of relatively large stiffness and the pole face of its armature 54 is maintained during operation at a small gap distance from the pole faces of the central core and the surrounding pole plate in the way described in the U. S. Kranz Patent 1,540,783. Such vibrator unit, when held pressed with the vibrating button against the bone structure of a person and actuated by amplified sound current oscillations supplied by the transmitter, will impart corresponding mechanical vibrations of a large force and relatively small amplitude to the bone structure of a person. Such vibrations imparted to the sound structure will be propagated over the bones leading to the part of the bones which act directly on the hearing nerve center inducing corresponding hearing sensations like those transmitted to the hearing nerve center over the ear canal.

By making the armature gap small, a relatively large amount of mechanical vibratory energy can be developed with a small unit sufficient to induce satisfactory hearing in the auditory center of the user. In order to prevent accidental freezing of the armature to the core pole faces by pressing with excessive force on the button, the button 66 is so proportioned that when it is pressed inwardly to lie flush with the surrounding surface of the casing, the armature will not be in contact with the core pole face. This eliminates the danger of freezing and at the same time makes possible the use of a very small gap.

A vibrator unit of the size of a small flat telephone operating with a gap of the order of 2 mils will develop sufficient vibratory power for inducing by bone conduction satisfactory hearing. An additional thin flat spacer of non-magnetic material having a thickness, say, of about ½ mil, may be attached, as by soldering, either to the pole face of the core or the pole face of the armature so as to prevent under all circumstances the armature surface from coming into direct contact with the core pole faces.

Instead of using a vibrator support like that shown in Fig. 1, other types of supports may be used for coupling the vibrator unit to a hearing-inducing bone portion of the spinal column. In Fig. 6 is shown a vibrator support made in the form of conventional suspenders. Such a suspender has its two shoulder straps 71 joined to the back strap 73 in the region adjacent the junction of the cervical and thoracic vertebrae where the vibrator unit is to be held pressed to the bone structure of the spinal column in the way shown in Fig. 6. The lower ends of the suspender straps may be attached to a belt 74 and may also serve to support the clothing of the user. To hold the vibrator unit 21 coupled to the bone structure, the junction of the three straps 71, 73 is provided with a small pocket 75 having a portion of thin material on the side facing the spinal column to permit insertion of the vibrator unit into the pocket and the effective coupling of the vibrator unit to the bone structure. The vibrator unit is held pressed against the bone structure by the tension exercised through the overlying shoulder straps 71 supplemented by the tension of the back strap 73.

In Figs. 8 to 11 is shown another form of a hearing-inducing vibrator unit 80 for imparting hearing vibrations to the upper portion of the spinal column in accordance with the invention. The vibrator unit is constructed in accordance with the principles disclosed in the copending application, Serial No. 697,673, filed November 11, 1933. It comprises a floating magnetic core structure of substantial mass formed of two soft iron pole pieces 82 having inwardly extending pole arms 83 of reduced width and laterally extending supporting brackets 84 joined to two permanent magnet bars 86 by screws 87. The two inwardly extending pole arms 83 extend longitudinally through the space between the two

magnet bars 86 and are provided with two actuating windings 89.

In front of the pole arms 83 is mounted a second magnetic structure in the form of a diaphragm strip 91 which has its ends attached to the opposite ends of the two pole pieces by suitable screws 92, spacer blocks 93, 94 being interposed at the junction to keep the pole faces of the pole arms spaced from the opposite pole face of the diaphragm 91 by a very small gap. The center portion of the diaphragm 91 has lateral extensions on the opposite sides of the pole pieces and is provided with a reinforcing strip 96 united with the diaphragm 91, for instance, by soldering. The laterally extending reinforced portions of the diaphragm 91 are in turn firmly attached by screws 99 to a base 100 having an outer contact surface 101 and acts as the vibrating member which is held pressed against the bone structure for transmitting the vibratory energy produced by the vibrator unit to the bone structure.

The spacer block 94 is of insulating material and has mounted therein two terminal bushings 103 connected to the ends of the windings 89. Detachable cord leads 32 with plug pins fitting the bushings 103 supply sound-frequency current oscillations to the windings of the vibrating unit. A cover 111 secured to the base 100 by screws 112 forms a complete enclosure around the vibrating unit. A perforated flexible insert 113 of rubber, for instance, attached to an opening of the casing provides a tight seal around the cord tips inserted into the bushings in the interior of the sealed vibrating unit.

Sound-frequency current oscillations supplied to the windings 89 produce a vibratory motion between the large mass of the magnet structure 81 and the small mass of the diaphragm 91. By holding the vibrator unit coupled to the bone structure through the base 100, the vibratory motion will impart corresponding hearing-inducing mechanical sound-frequency vibrations to the bones of the spine. The base is held pressed to the bone structure by providing on the opposite sides of the base and on its downward side thereof eyelets 105 and 106 for attaching it to a harness like that shown in Fig. 1. Alternatively, the vibrating unit may be coupled to the bones of the spine by inserting it into the pocket 75 of the support shown in Fig. 6, the pressure exerted by the straps 71, 73 overlying the vibrator unit holding it pressed against the bone structure.

Substantially the entire space in the interior of the vibrating unit is thus utilized for housing the floating mass of the vibrator, enabling the construction of a small vibrator unit of large power output. By using the construction described above, the height of the electromagnetic vibrating unit can be made very small, for instance, only about 250 mils or less, and the height of the unit with the casing can be made only about 400 mils or less. The principles of the invention are not limited to the specific embodiment described above and many other arrangements for coupling a bone-conduction receiver to vertebrae of the spinal column for transmitting hearing-inducing vibratory energy to the hearing nerves will suggest themselves to those skilled in the art. 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 hearing-inducing bone-vibrating device for inconspicuous wear on a person, a vibrator unit having a movable vibrating member and means for subjecting said vibrating member to the action of sound-frequency electric oscillations producing a corresponding vibratory motion of said member, and supporting means attachable to the trunk of a person including a strap portion fitting a body portion of the person in the region adjacent the junction of the cervical and thoracic vertebrae of the spinal column for holding said vibrating member coupled to a vertebra of said person and imparting thereto hearing-inducing mechanical vibrations by the vibratory motion of said member.

2. In a hearing-inducing bone-vibrating device for inconspicuous wear on a person, a vibrator unit having a movable vibrating member and means for subjecting said vibrating member to the action of sound-frequency electric oscillations producing a corresponding vibratory motion of said member, and a harness fitting the trunk of a person including a strap portion fitting a body portion of the person in the region adjacent the junction of the cervical and thoracic vertebrae of the spinal column and a strap portion extending below the shoulders of said person for holding said vibrating member coupled to a vertebra of said person and imparting thereto hearing-inducing mechanical vibrations by the vibratory motion of said member.

3. In a hearing-inducing bone-vibrating device for inconspicuous wear on a person, a vibrator unit having a movable vibrating member and means for subjecting said vibrating member to the action of sound-frequency electric oscillations producing a corresponding vibratory motion of said member, supporting means attachable to the trunk of a person including a strap portion fitting a body portion of the person in the region adjacent the junction of the cervical and thoracic vertebrae of the spinal column, and a strap portion fitting a body portion extending below said junction for holding said vibrating member coupled to a vertebra of said person and imparting thereto hearing-inducing mechanical vibrations by the vibratory motion of said member.

HUGO LIEBER.