

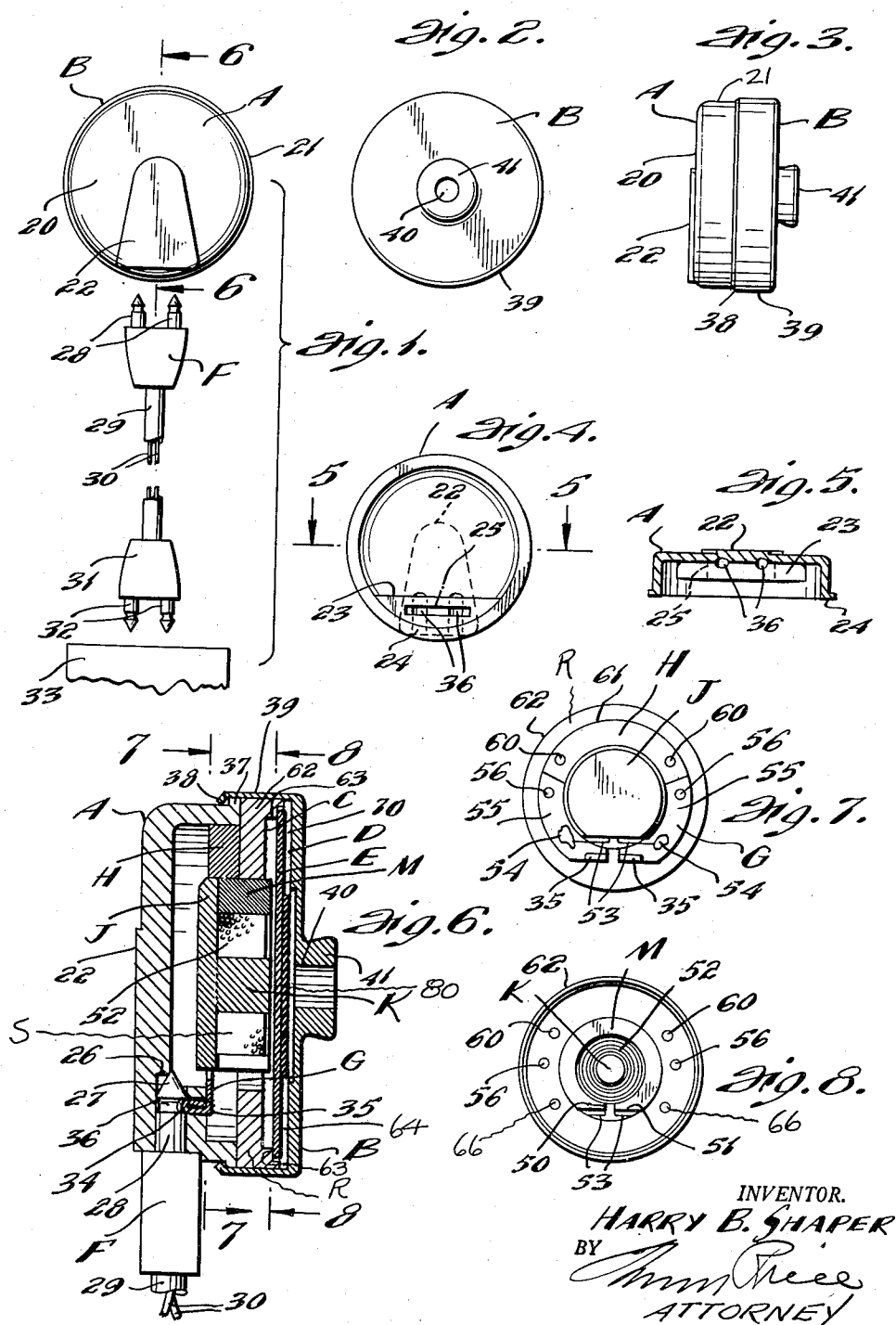
Jan. 15, 1952

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ELECTROMAGNETIC EARPHONE

2,582,287

Filed April 9, 1948

2 SHEETS—SHEET 1



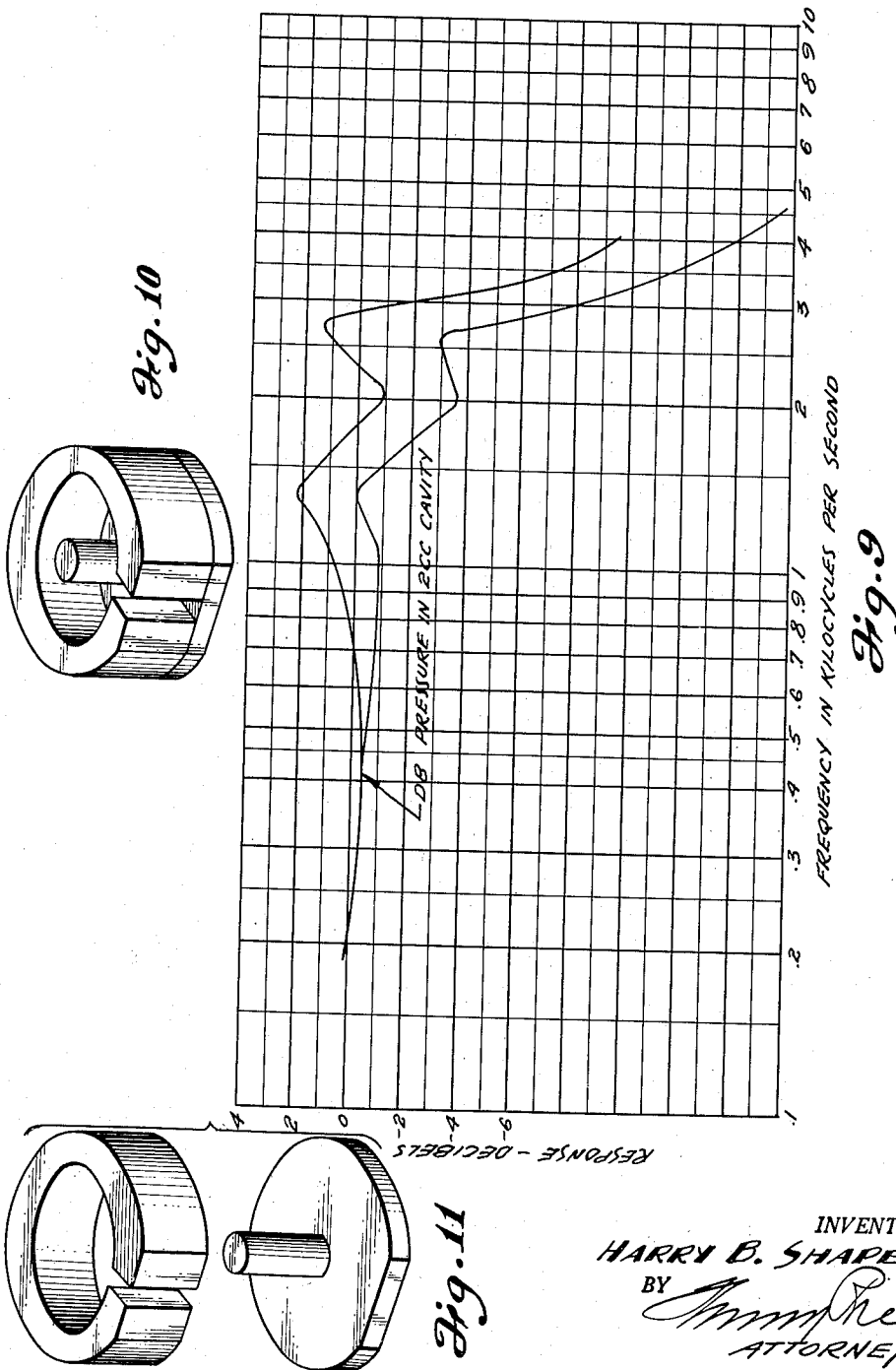
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2 SHEETS—SHEET 2



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ELECTROMAGNETIC EARPHONE

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4 Claims. (Cl. 179-107)

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The present invention relates to electromagnetic sound production and reproduction units, and although not restricted thereto, it particularly relates to such units as are used in connection with hearing aids.

It is among the objects of the present invention to provide a novel, compact, durable and efficient sound reproduction unit for utilization in hearing aids, whether they be of earphone, bone conduction or other types.

Another object is to provide a novel electromagnetic sound production unit having very high fidelity and amplitude of reproduction, although of very small or midget size.

Another object is to provide an electromagnetic sound reproduction system which will give efficient energy conversion even at high audio frequencies and which will give surprising high and faithful conversion of electrical energy into sound energy at high efficiency over an exceedingly wide audio frequency range.

Another object is to provide a novel hearing aid electromagnetic earphone having electrical connection arrangements which will not only enhance the compactness and smallness of size but which will also greatly improve the characteristics of the instrument.

Still further objects and advantages will appear in the more detailed description set forth below, it being understood, however, that this more detailed description is given only by way of illustration and explanation only and not by way of limitation, since various changes therein may be made by those skilled in the art without departing from the scope and spirit of the present invention.

In accomplishing the above objects it has been found to be most satisfactory to provide an electromagnetic earphone having a central cylindrical permeable or soft iron core and an outside annular permanent magnet, with the space between being substantially completely filled with a fine wire driving core for carrying the electrical power, current or energy from the pick-up.

The core and annular magnet are joined at one side by a flat metal connection disk which will carry the magnet flux and at the other side the varying flux will act upon a correctly positioned and accurately spaced diaphragm having a central disk of permeable iron material.

The most important feature of the present invention resides in the slitting or slotting of the annular permanent magnet which surprisingly—contrary to expectation—enhances the reproduction of the sound both in fidelity and volume.

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Although one radial slot is sufficient and is preferred, a number of slots, evenly or unevenly spaced, may be employed, but the amount of slotting should never be in excess of 10% of the total area of the annular magnet.

These slots, or preferably this slot, not only improves the characteristics, but also enables the wire connections to the coil to be removed laterally from the driving core through the slot in the permanent magnet.

The angular terminal may then be readily mounted upon an insulating ring without substantially increasing the thickness or diameter or piercing the connection disk and connection to these terminals may be made through a pocket in one of the casing sections.

The casing sections preferably include one plastic or molded phenol-formaldehyde resin shell upon which is spun or mounted the other shell, desirably of aluminum, which latter embraces the diaphragm side of the device and forms the air chamber.

The invention also consists in certain new and original features of construction and combination of parts, hereinafter set forth and claimed and as to its other objects, features and advantages, the mode of operation and manner of its organization, these may be better understood by referring to the following description considered in connection with the accompanying drawings forming a part thereof in which:

Fig. 1 is a view showing the outside face of the electromagnetic microphone, the connecting cord and other parts of the hearing aid construction.

Fig. 2 is an inside plan view of the opposite side of the electromagnetic earphone device shown at the upper part of Fig. 1.

Fig. 3 is a side elevational view of the electromagnetic earphone device of Figs. 1 and 2.

Fig. 4 is an interior vertical plan view of the outside casing housing removed from the assembly of Figs. 1 to 3.

Fig. 5 is a transverse vertical sectional view upon the line 5-5 of Fig. 4.

Fig. 6 is a transverse vertical sectional view taken upon the line 6-6 of Fig. 1 and upon an enlarged scale as compared with Fig. 1.

Fig. 7 is an interior vertical plan view of the internal construction upon the line 7-7 of Fig. 6, upon a reduced scale as compared to Fig. 6.

Fig. 8 is an interior vertical plan view of the internal construction taken upon the line 8-8 of Fig. 6.

Fig. 9 is a showing of the curves illustrating

the increase in response in decibels when using the present invention.

Figs. 10 and 11 are detail views upon an enlarged scale to more plainly show the detailed construction of the electromagnetic microphone.

Referring to Figs. 1 to 8, the device consists of a base or outside casing A which may be of a molded plastic material such as a phenol formaldehyde resin.

The cover or inside casing B of aluminum or other metal preferably is provided with the air chambers C and D on both sides of the steel or metal diaphragm E. The base element A carries the electrical connection plug F. The base element A also receives the electric spring finger connectors G mounted upon an insulating ring H.

The insulating ring H is mounted on the encircling frame structure R.

The connection plate J serves as a connection between the permeable iron core K and the permanent ring magnet M.

Referring specifically to the base casing A, there is a base 20 with the intumed side walls 21 and an interior enlargement or boss 22. There is also an interior enlargement 23 (see Fig. 4).

This base A has the plug-in openings 24 which cross the slot 25. The slot 25 receives the ends 34 of the spring connectors G.

As indicated best in Fig. 6, there is a shoulder 26 which abuts the conical ends 27 of the prongs 28 of the connection plug F. The connection plug F carries the plastic elongated cord member 29 in which are molded the wires 30 leading to the other connection plug 31. The plug 31 has the prongs 32. The prongs 32 fit in the element 33 of the hearing aid assembly.

Normally, the ends 34 of the bent portions 35 of the spring members G will be received in the recesses 36 of the prongs 28. The base element A is also provided with an outstanding lip or ridge 37 over which is spun the edge 38 of the side wall 39 of the casing element B. The casing element B has a central opening 40 at the nipple 41, which is designed to receive a suitable device for fitting into the ear of the user.

The invention is most particularly directed to the annular magnet M which is slotted, as indicated at 50, and which may also be flattened at 51 to provide clearance. This magnet is mounted upon the flat connection plate J and is braced or soldered thereon. The plate J also carries the central, permeable core K which is similarly affixed thereto.

The space between the core K and the annular magnet M is substantially completely filled by the fine wire coil 52. The coil 52 has connections at 53 extending through the gap, slot or split 50.

These wires or connections 53, extending through gap 50, are soldered at 54 to the arcuate base portions 55 of the spring contact members G. The attaching rivets are indicated at 56.

The insulating ring H upon which the contact elements G are mounted is in turn mounted by the rivets 60 upon the base 61 of the ring 62 of the frame structure R.

The ring 62 has a shoulder 63 for receiving the edge of the diaphragm 64. The thin steel diaphragm E is spaced both from the magnet construction M—K as well as from the interior face 70 of the casing B to give sufficient room for its free vibration under action of the varying flux in the driving coil 52.

The device as shown is particularly designed for use in a midget hearing aid earphone where it is essential to obtain small size, efficient re-

production of electrical energy into sound energy, and to maintain this efficiency over as wide a range of the audio frequency range as possible.

In the embodiment shown in Figs. 1 to 8, electrical power is fed through the electrical connector plug F through the holes 24 and electrical contact is made with the spring connectors G, as shown in Fig. 6. The spring contactors G are insulated from the metal supporting frame R by the insulator ring H.

The driving coil 52 is connected to the spring contactors G through the wire ends 53 of the coil 52.

The electrical current which flows induces a flux in the highly permeable core K and in the magnet H. This flux flows across the air gap C through the diaphragm E. The reluctance of the diaphragm E to the flow of flux is decreased by the addition of permeable material 80.

The flux which varies at an audio frequency rate corresponding to the electric frequency in combination with the uniform flux of the polarized magnet causes the diaphragm to oscillate at audio frequencies.

This causes an audio change in pressure in the cavity D of Fig. 6. This change in pressure in this cavity D is transferred to the ear by the canal 40.

The magnet M, the core K, the coil S, and the supporting frame or brass ring R are made in a circular construction to enable simple machining of parts and it is obvious that other shaped constructions would serve as well. The wire contact terminals G are placed outside the periphery of magnetic structure M—K—S and on the brass ring R to enable most efficient use of the available space. This provides an exceptionally thin earphone particularly useful in a hearing aid in view of its inconspicuousness and light weight.

By slotting the magnet M at 50, a most convenient exit for the coil terminals 53 is provided without requiring increase in the thickness of the unit, as would be the case if the terminals were mounted in back of the magnet plate J.

A most important feature of the slot 50 is the improvement in performance at the higher frequency as shown by the curves of Fig. 9.

In Fig. 9, the upper curve shows the performance with a slot 50 and in terms of decibel pressure in a cavity of 2 cc. volume, about equivalent to the volume of the cavity of the human ear. The lower curve shows the performance without the slot 50, with the other conditions remaining the same.

Surprisingly, with the magnet M slotted as shown at 50, the core loss is reduced to a negligible figure, as the electrical eddy current loss is not determined by the radial width of the annulus of the magnet M as contrasted to a non-slotted magnet M whose eddy current loss is essentially determined by the outside radius of the magnet. The restriction of the path for the eddy current decreases the power loss by an order of magnitude.

Thus the slot 50 in the magnet M decreases the power loss, allows for easy and compact terminal connections to the driving coil S and permits the contact springs G to be mounted peripherally outside of the magnet M. This structure permits an earphone design which is flat, wearable, of light weight and more efficient at the higher audio frequencies.

Although not restricted thereto, in one commercial form of the present invention, the mag-

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net M may be of a magnetic aluminum-nickel-cobalt alloy known as Alnico II, with an internal diameter of 0.290 inch, an external diameter of 0.46 inch, a thickness of 0.16 inch and a slot width of 0.06 inch.

The pole piece of a permeable iron consisting of plate J and core K may be of one piece with the core K 0.123 inch in diameter and 0.16 inch high and the plate J 0.406 inch in diameter and .04 inch in thickness.

The ring R may be of brass or plastic with a thickness of 0.11 inch, an external diameter of 0.78 inch and an internal diameter of 0.437 inch.

The casing A, desirably of insulating material, may have an external diameter of 0.786 inch and a height of 0.23 inch, while the casing B, either of insulating or conducting material, may have a diameter of 0.82 inch and a height of 0.276 inch.

As many changes could be made in the above electromagnetic earphone and many apparently widely different embodiments of this invention could be made without departing from the scope of the claims, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

Having now particularly described and ascertained the nature of the invention, and in what manner the same is to be performed, what is claimed is:

1. An electromagnetic earphone device for a hearing aid of the type adapted to fit into the ear of the user and give high fidelity and amplitude with extremely small space consumption, said device including a central mounting ring, an inside casing member, an outside casing member, a central magnet unit carried by said ring having a split annular permanent magnet, a central permeable cylindrical iron core, and a connection plate upon which said magnet and core are permanently mounted, a metal diaphragm at the opposite side of said magnet unit from said plate, a driving coil substantially filling the space between the annular magnet and central core, an insulating ring mounted on said mounting ring outside of said annular magnet and spring contact fingers mounted on said insulating ring, and connections to said coil from said fingers extending through the split in the annular magnet.

2. An electromagnetic earphone device for a hearing aid of the type adapted to fit into the ear of the user and give high fidelity and amplitude with extremely small space consumption, said device including a central mounting ring, an inside casing member, an outside casing member, a central magnet unit carried by said ring having a split annular permanent magnet, a central permeable cylindrical iron core, and a connection plate upon which said magnet and core are permanently mounted, a metal diaphragm at the opposite side of said magnet unit from said plate, a driving coil substantially filling the space between the annular magnet and central core, an insulating ring mounted on said mounting ring outside of said annular magnet and spring contact fingers mounted on said insulating ring, said spring contact fingers having arcuate elongated base portions mounted on said insulating ring and having upturned bent portions, and connections to said coil from said fingers extend-

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ing through the split in the annular magnet, the inside casing member providing sound chambers, one on each side of said diaphragm, resulting from the space mounting of the diaphragm between the mounting ring and the inside casing member.

3. An electromagnetic earphone device for a hearing aid of the type adapted to fit into the ear of the user and give high fidelity and amplitude with extremely small space consumption, said device including a central mounting ring, an inside casing member, an outside casing member, a central magnet unit carried by said ring having a split annular permanent magnet, a central permeable cylindrical iron core, and a connection plate upon which said magnet and core are permanently mounted, a metal diaphragm at the opposite side of said magnet unit from said plate, a driving coil substantially filling the space between the annular magnet and central core, an insulating ring mounted on said mounting ring outside of said annular magnet and spring contact fingers mounted on said insulating ring, said spring contact fingers having arcuate elongated base portions mounted on said insulating ring and having upturned bent portions, and connections to said coil from said fingers extending through the split in the annular magnet, the outside casing member having a transverse slot adjacent said split in the magnet, said slot receiving the bent portions of said spring contact member.

4. An electromagnetic earphone device for a hearing aid of the type adapted to fit into the ear of the user and give high fidelity and amplitude with extremely small space consumption, said device including a central mounting ring, an inside casing member, an outside casing member, a central magnet unit carried by said ring having a split annular permanent magnet, a central permeable cylindrical iron core, and a connection plate upon which said magnet and core are permanently mounted, a metal diaphragm at the opposite side of said magnet unit from said plate, a driving coil substantially filling the space between the annular magnet and central core, an insulating ring mounted on said mounting ring outside of said annular magnet and spring contact fingers mounted on said insulating ring, and connections to said coil from said fingers extending through the split in the annular magnet, said outside casing member having a recess receiving the ends of said fingers and carrying connections for a connection plug.

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