Sept. 21, 1948. W. F. KNAUERT 2,449,557

ELECTROMAGNETIC EARPHONE RECEIVER

Filed Feb. 4, 1944

Fig. 1.

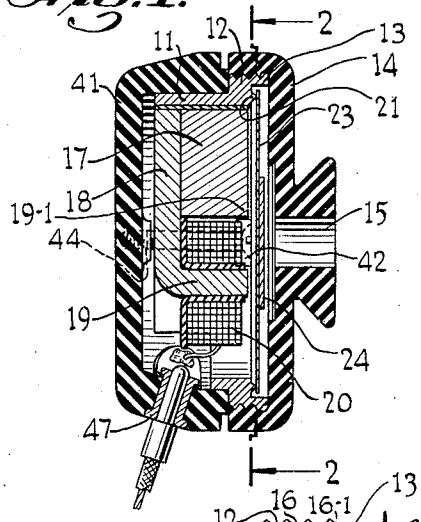


Fig. 2.

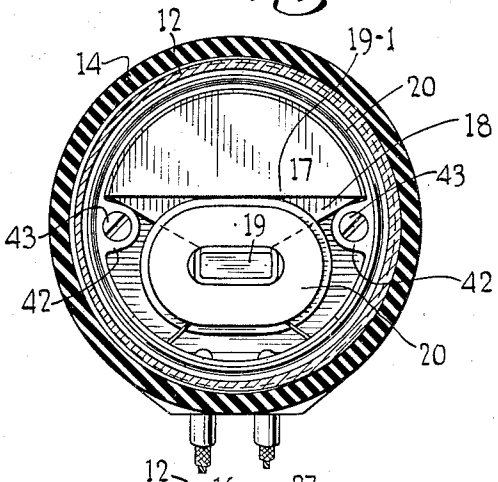


Fig. 4.

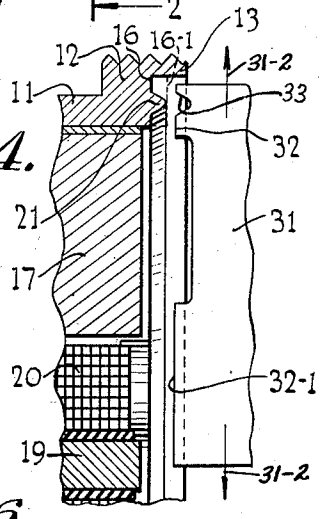


Fig. 3.

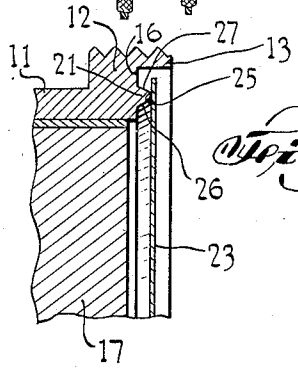


Fig. 6.

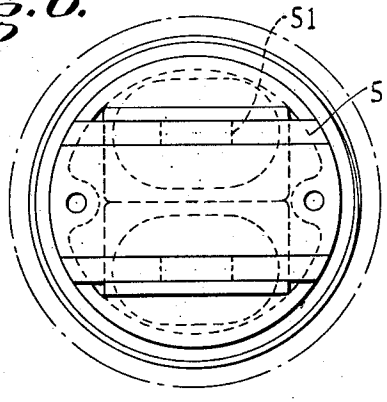
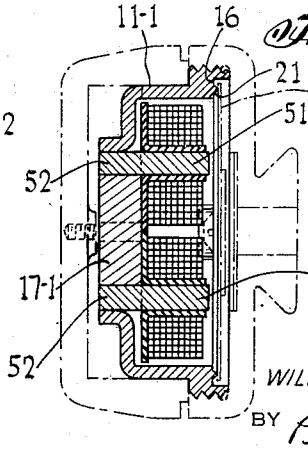


Fig. 5.



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ELECTROMAGNETIC EARPHONE RECEIVER

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5 Claims. (Cl. 179—114)

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This invention relates to earphone receivers, and particularly to midget-size earphones of the type in which the vibratory diaphragm forming part of the acoustic transmitting space of the receiver is held in its operative position opposite its driving electro-transducing structure by the space forces, such as the electromagnetic forces exerted on the central portion of the diaphragm and without in any way clamping the periphery of the diaphragm.

Among the objects of the invention is an improved earphone receiver of the foregoing type, the electro-transducing structure of which has a continuous, circular seating ridge projection engaging a peripheral region of the diaphragm which is inwardly spaced from its edge, the seating ridge having depressed inner and outer circular regions adjoining the circular surface region which engages the diaphragm so as to give the ridge portion facing the diaphragm a curved convex cross-section and assure that under all operating conditions a raised circular region of the seating ridge shall maintain engagement with the continuous peripheral region of the diaphragm.

Another phase of the invention is the manufacture of such earphone receivers, involving the steps of determining the frequency response characteristics of the receiver diaphragm which is to be used in a given receiver, and machining the seating ridge projection of the given receiver with such diameter as to cause the diaphragm to operate with a resonant frequency at which the acoustic transmitting space exhibits predetermined desired frequency response characteristics.

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

Fig. 1 is a vertical cross-sectional view of a midget earphone receiver exemplifying one form of the invention, in a position in which it is held against the ear of the user;

Fig. 2 is a view along line 2—2 of Fig. 1 with the cover and diaphragm of the receiver removed;

Fig. 3 is a greatly enlarged detailed view similar to Fig. 1 showing a peripheral portion of the receiver diaphragm and its seat arrangement;

Fig. 4 is an enlarged view showing the relative positions of the receiver and a ridge-cutting tool used for machining the diaphragm seat of the receiver;

Fig. 5 is a view similar to Fig. 1 illustrating a receiver of the invention equipped with a modified form of electromagnetic driving mechanism; and

Fig. 6 is a rear view of the electromagnetic unit of Fig. 5.

Referring to Figs. 1 to 3, the earphone comprises an electro-acoustic transducing structure

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having its driving elements supported by a circular aligning member 11, which is shown formed of a cylindrical shell of metal, such as brass, having on its outer open side an enlarged circular rim portion 12 provided with a flanged outer region forming a cover seating shoulder 13, the exterior of which is threaded so that the cover wall 14 with its outlet duct 15 may be positioned and held thereon in the spaced position which is fixed by the height of the seating shoulder 13 as shown.

In the interior of the cylindrical shell 11 are held a segmentally-shaped permanent magnet block 17 and a pole member 18 having an eccentrically arranged pole piece 19 projecting into the open side of the shell 11 so as to concentrate a strong permanent magnet flux in the central space region between the outward end of the pole piece 19 and the adjacent edge region 19—1 of the permanent block segment 17, which serves as the other pole of the magnetic driving core structure. The permanent magnet block 17 and the pole member 18 are suitably secured, as by soldering, to each other and to the shell 11 so that the pole ends of the pole member 18 and permanent magnet block 17 are held in positions suitably aligned with respect to the surface elements of the aligning rim 12. A winding 20 in the form of a spool mounted on the pole piece 19 serves to actuate the receiver.

The aligning member 12 has an outwardly facing surface 16 which is provided with a continuous, generally-circular, outwardly-projecting seating ridge 21 against which a peripheral region of the inner side of a diaphragm 23 rests. The diaphragm 23 is self-supporting and may be made of a flat spring metal plate. The central part of the diaphragm 23 is arranged to serve as a magnetic armature for cooperation with the pole portions 19, 19—1 of the magnetic driving structure, so that the diaphragm shall vibrate over the principal audio-frequency range under the action of corresponding electric oscillatory currents send through the receiver windings 20. The cover seating shoulder 13 has height sufficiently greater than the diaphragm seating ridge so as to provide on the exterior side of the vibrating diaphragm an acoustic space predetermined acoustic characteristics and which serves to control the frequency response of the receiver.

In the arrangement shown, the central magnetic armature portion of the diaphragm is provided with the required magnetic cross-section by uniting to it, as by soldering, a central magnetic plate element 24. The permanent magnet block 17 is designed to produce a permanent flux strong enough to assure that the unidirectional magnetic forces, exerted by the flux in the pole region on the central portion of the diaphragm 23, will hold its periphery firmly pressed against and maintain

it in engagement with the underlying surface of the aligning rim 12.

In the past, earphone receivers of the type utilizing a floating diaphragm, the rim of which is held in its operative position solely by attractive forces exerted by the electro-mechanical driving structure on the central diaphram portion, have given a great deal of trouble because they exhibited disturbing and annoying buzzing due to assembly imperfections which have been found very difficult to eliminate. In accordance with the invention, these buzzing difficulties are eliminated by making the diaphragm support in the form of a continuous, raised ridge which engages a continuous region of the diaphragm spaced inwardly from its edge so that a free edge portion of the diaphragm projects beyond the region along which it engages the ridge.

Furthermore, the raised circular surface region 25 of the seating ridge 21 is adjoined by depressed inner and outer circular regions 26, 27, respectively, arranged so as to give the circular surface portion of the ridge facing the diaphragm a curved convex cross-section and assure that a raised circular region of the seating ridge shall at all times maintain seating engagement with a continuous inwardly-spaced peripheral region of the diaphragm in all of the vibratory positions to which it is brought by the varying forces exerted thereon.

The diaphragm seating arrangement of the invention is so designed as to assure that a peripheral region of the diaphragm, which is spaced from its outer edge, will engage a continuous circular region of the curved raised ridge surface in all the vibratory positions of the diaphragm throughout the normal range of its vibratory amplitudes. Such diaphragm seating arrangement of the invention makes it possible to operate a receiver diaphragm of only about ¾ inch diameter with very large amplitudes, as much as about .005 inch, without undue distortion, and to supply with a tiny receiver, using such small diaphragm, as much output as with a receiver which is a multiple of its size.

The receiver arrangement of the invention described above in connection with a specific exemplification thereof, has also the further advantage that it makes possible the manufacture of receivers with uniform predetermined desired response characteristics, notwithstanding the fact that the individual receivers have to be operated with diaphragms differing in their resonant frequencies.

In accordance with the invention, a series of receivers having acoustic sound-transmitting spaces of desired predetermined frequency response characteristics may be manufactured by determining the frequency response characteristics of the receiver diaphragms which are to be used in a given receiver, a machining the seating ridge projection of the given receiver with such diameter as to cause the diaphragm to operate with a resonant frequency at which the acoustic transmitting space formed between the cover wall with its sound outlet duct 15 and the vibratory diaphragm 23 exhibits the desired frequency response characteristics.

In other words, by making the circular ridge 21 of greater or smaller diameter, depending on the characteristics of the diaphragm which is to be used in a given receiver, the different receivers, although having diaphragms of different response characteristics, may be readily manufactured on a mass production basis so that they all operate with the same predetermined response characteristics.

The receiver assembly with its diaphragm supporting rim 12 is provided with an outwardly facing surface 16—1 extending along a higher level than the surface 16 on which the raised seating ridge 21 is formed, as indicated in Fig. 4. The receiver assembly shown in Fig. 4 has its circular surface 16—1 machined off as in a lathe operation, by a cutting tool 31 provided with a radially disposed cutting edge 32 extending over substantially the entire radial width of the surface 16—1 and having on its cutting edge 32 a notch 33 so as to reduce by a rotary cutting operation the height of the rim 12 and form on it the raised ridge 21 as well as the adjoining lower surface region 16. The cutting tool 31 is also shown provided along its radially inward edge region with a stop surface portion 32—1.

The stop surface portion 32—1 is designed to come into engagement with the flat pole faces of the pole piece end 19 and of the adjacent pole portion 19—1 for stopping the cutting action in a predetermined position at which the raised seating surface 25 of the seating ridge 21 is at such level with respect to the level of the pole faces as to assure the proper magnetic gap conditions between the pole faces and the facing central armature portion of the diaphragm 23 required for efficient operation of the receiver with the required frequency response characteristics.

The machining of the seating ridge 21 with different diameters so as to compensate for differences in the thickness of the diaphragms provides each diaphragm with a seating surface ridge of such diameter as to assure that it will operate with the desired resonance frequency which makes it possible to assure that all receivers having the same magnetic gap spacing will operate with the same desired frequency response characteristics.

By adjusting the radial position of the cutting tool 31 relatively to the aligning rim 12, in the manner indicated by arrows 31—2, the ridge may be formed on different radially-spaced peripheral regions of the rim 12, thus giving the raised seating surface of the seating ridge different diameters. Very minute differences in the diameter of the ridge, varying by only as little as .001 to .003 inch, are in most cases sufficient to compensate for differences in the resonant frequencies of the diaphragms resulting from slight variations in the thickness of the stock out of which the diaphragms are punched.

As shown in Figs. 1 and 2, the earphone is also provided with a casing shell member 41 which does not perform any functions except to serve as an enclosure for the parts of the driving structure which are secured to the aligning member 11. In order to secure the casing shell 41 to the driving structure, the inner wall of its annular rim 12 is provided with two inwardly extending ear portions 42 which serve as seats for the flat heads of two clamping screws 43, the shanks of which engage bushing portions 44 of the casing wall 41.

The winding ends of the coil 20 are connected to two terminal bushings 47 which extend through and are affixed to a side wall portion of the casing shell so that when a cord plug 48 of the connecting cord is inserted in the terminal bushings 44, the outwardly projecting plug portions shall not interfere with the insertion of the earphone into the space within the outer ear. As shown in Fig. 1, the portion of the cylindrical casing

shell in the region of the connector bushings 47 is cut away so as to expose the inner ends of the bushings 47 to the interior space of the shell 11 in which the coil 20 is mounted.

The principles underlying the invention as described above in connection with one specific exemplification thereof may be applied to other types of earphone receiver structures. Thus, as shown in Fig. 5, an earphone receiver having a diaphragm seating arrangement of the invention, such as described in connection with Figs. 1 to 3, may be provided with a driving structure formed of two straight T-shaped pole pieces 51 having their central pole arms aligned opposite the central region of the diaphragm 23, the wider rear portions 52 of the pole pieces 51 extending on opposite sides of a permanent magnet bar 17—1 and the pole piece portions 52 being united to the permanent magnet bar 17—1 and to the suitably deformed rear end portions of the aligning member shell 11—1, as by soldering.

The central raised circular seating region 25 of the seating ridge may be coated with a thin layer of flexible sealing material, such as synthetic resin or synthetic rubber material. The entire circular seating ridge projection 21 may be made as a unit either of metal or of a synthetic resin material, and suitably secured, as by soldering, fusion or cementing, in its proper position on the receiver structure.

Various other modifications of the invention will suggest themselves to those skilled in the art. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific details shown and described in connection with the exemplifications of the invention.

I claim:

1. In a telephone receiver: a vibratory diaphragm having a generally circular periphery; a cover wall including a sound outlet duct and extending over the outer side of the diaphragm and forming with it an acoustic transmitting space; a relatively massive driving structure comprising a substantially-rigid aligning member having a continuous, generally-circular, outwardly-projecting rigid seating ridge of curved cross-section against which a peripheral region of the inner side of said diaphragm rests and an electroacoustic transducing structure secured to said aligning member and located opposite the inner side of said diaphragm; said transducer structure embodying means for exerting unidirectional forces on the central region of said diaphragm and for inducing with electric oscillations of the principal audio-frequency range corresponding vibratory forces exerted on said central region of said diaphragm; said seating ridge having a raised circular surface region engaged by a peripheral region of said diaphragm spaced radially inwardly away from the outer edge thereof; said diaphragm being held pressed against said seating ridge and being maintained in an operative vibrating position thereon solely by the magnetic forces which are exerted on the central portion of said diaphragm; said raised circular surface region of said seating ridge being adjoined by depressed inner and outer circular regions thereof arranged to give the portion of said ridge facing said diaphragm a curved convex cross-section which is so shaped that a raised circular region of said seating ridge shall maintain engagement with a continuous peripheral region of the diaphragm throughout the normal range of the vibratory amplitudes thereof.

2. In a telephone receiver: a vibratory diaphragm having a generally circular periphery and a generally central magnetic armature portion; a cover wall including a sound outlet duct and extending over the outer side of the diaphragm and forming with it an acoustic transmitting space; a relatively massive driving structure comprising a substantially-rigid aligning member having a continuous, generally-circular, outwardly-projecting rigid seating ridge of curved cross-section against which a peripheral region of the inner side of said diaphragm rests and an electroacoustic transducing structure including magnetic core portions secured to said aligning member and located opposite the inner side of said diaphragm; said core structure embodying means for exerting unidirectional magnetic forces on the central region of said diaphragm; said transducer structure including windings for inducing with electric oscillations of the principal audio-frequency range corresponding vibratory magnetic forces exerted on said central region of said diaphragm; said seating ridge having a raised circular surface region engaged by a peripheral region of said diaphragm spaced radially inwardly away from the outer edge thereof; said diaphragm being held pressed against said seating ridge and being maintained in an operative vibrating position thereon solely by the magnetic forces which are exerted by said core structure on the central portion of said diaphragm; said raised circular surface region of said seating ridge being adjoined by depressed inner and outer circular regions thereof arranged to give the portion of said ridge facing said diaphragm a curved convex cross-section which is so shaped that a raised circular region of said seating ridge shall maintain engagement with a continuous peripheral region of the diaphragm throughout the normal range of the vibratory amplitudes thereof.

3. In a telephone receiver: a vibratory diaphragm having a generally circular periphery and a generally central magnetic armature portion; a cover wall including a sound outlet duct and extending over the outer side of the diaphragm and forming with it an acoustic transmitting space; a relatively massive driving structure comprising a substantially-rigid aligning member having a continuous, generally-circular, outwardly-projecting rigid seating ridge of curved cross section against which a peripheral region of the inner side of said diaphragm rests and an electroacoustic transducing structure including magnetic core portions secured to said aligning member and located opposite the inner side of said diaphragm; said core structure embodying pole elements for exerting unidirectional magnetic forces on the central region of said diaphragm; said transducer structure including windings for inducing with electric oscillations of the principal audio-frequency range corresponding vibratory magnetic forces exerted by said core structure on said central region of said diaphragm; said pole elements having fixed pole face portions spaced by a small gap from said armature portion; said seating ridge having a raised circular surface region engaged by a peripheral region of said diaphragm spaced radially inwardly away from the outer edge thereof so as to maintain said armature portion at a predetermined gap space range from said pole face portions; said diaphragm being held pressed against said seating ridge and being maintained in an operative vibrating position thereon solely by the magnetic forces which are

exerted on the central portion of said diaphragm; said raised circular surface region of said seating ridge being adjoined by depressed inner and outer circular regions thereof arranged to give the portion of said ridge facing said diaphragm a curved convex cross-section which is so shaped that a raised circular region of said seating ridge shall maintain engagement with a continuous peripheral region of the diaphragm throughout the normal range of the vibratory amplitudes thereof.

4. In a telephone receiver: a vibratory diaphragm having a generally circular periphery; a cover wall including a sound outlet duct and extending over the outer side of the diaphragm and forming with it an acoustic transmitting space; a relatively massive driving structure comprising a substantially-rigid aligning member having a continuous, generally-circular, outwardly-projecting rigid seating ridge of curved cross-section against which a peripheral region of the inner side of said diaphragm rests and an electro-acoustic transducing structure secured to said aligning member located opposite the inner side of said diaphragm, said transducer structure embodying means for exerting unidirectional forces on the central region of said diaphragm and for inducing with electric oscillations of the principal audio-frequency range corresponding vibratory forces exerted on said central region of said diaphragm; said seating ridge having a raised circular surface region engaged by a peripheral region of said diaphragm spaced radially inwardly away from the outer edge thereof; said diaphragm being held pressed against said seating ridge and being maintained in an operative vibrating position thereon solely by the magnetic forces which are exerted on the central portion of said diaphragm; the periphery of said aligning member having an outwardly projecting circular shoulder higher than said seating ridge and holding said cover at a desired spacing from said diaphragm and determining the acoustic characteristics of said transmitting space; said raised circular surface region of said seating ridge being adjoined by depressed inner and outer circular regions thereof arranged to give the portion of said ridge facing said diaphragm a curved convex cross-section which is so shaped that a raised circular region of said seating ridge shall maintain engagement with a continuous peripheral region of the diaphragm throughout the normal range of the vibratory amplitudes thereof.

5. In a telephone receiver: a vibratory diaphragm having a generally circular periphery and a generally central magnetic armature portion; a cover wall including a sound outlet duct and

extending over the outer side of the diaphragm and forming with it an acoustic transmitting space; a relatively massive driving structure comprising a substantially-rigid aligning member having a continuous, generally-circular, outwardly-projecting rigid seating ridge of curved cross-section against which a peripheral region of the inner side of said diaphragm rests and an electro-acoustic transducing structure including magnetic core portions secured to said aligning member and located opposite the inner side of said diaphragm; said core structure embodying means for exerting unidirectional magnetic forces on the central region of said diaphragm; said transducer structure including windings for inducing with electric oscillations of the principal audio-frequency range corresponding vibratory magnetic forces exerted by said core structure on said central region of said diaphragm; said seating ridge having a raised circular surface region engaged by a peripheral region of said diaphragm spaced radially inwardly away from the outer edge thereof; said diaphragm being held pressed against said seating ridge and being maintained in an operative vibrating position thereon solely by the magnetic forces which are exerted on the central portion of said diaphragm; the periphery of said aligning member having an outwardly projecting circular shoulder higher than said seating ridge and holding said cover at a desired spacing from said diaphragm and determining the acoustic characteristics of said transmitting space; said raised circular surface region of said seating ridge being adjoined by depressed inner and outer circular regions thereof arranged to give the portion of said ridge facing said diaphragm a curved convex cross-section which is so shaped that a raised circular region of said seating ridge shall maintain engagement with a continuous peripheral region of the diaphragm throughout the normal range of the vibratory amplitudes thereof.

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