Nov. 26, 1935. A. E. SWICKARD 2,022,060

ACOUSTIC DEVICE

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FIG. 1

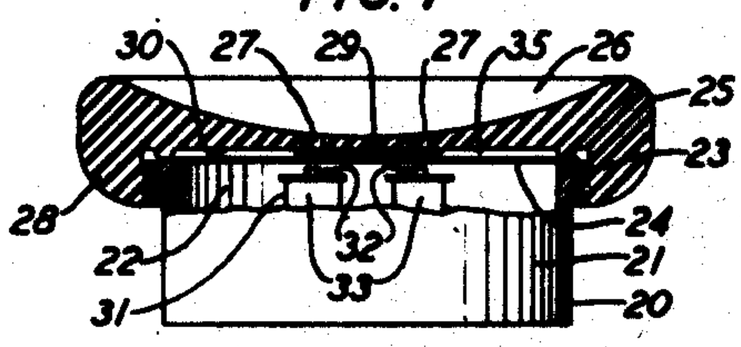


FIG. 2

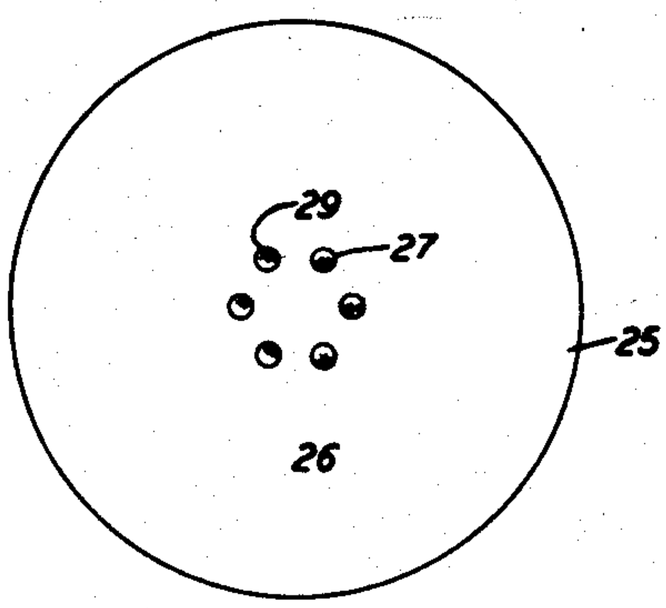


FIG. 3

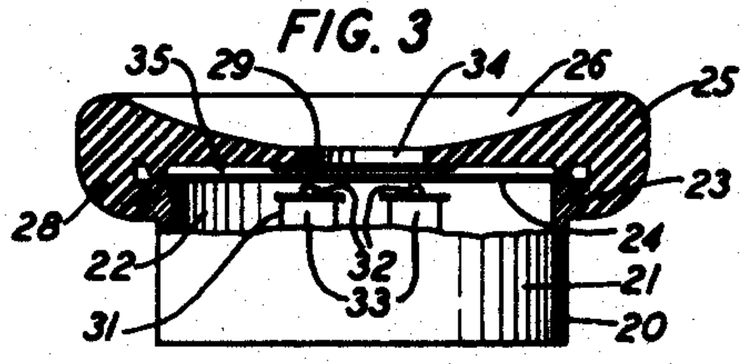


FIG. 4

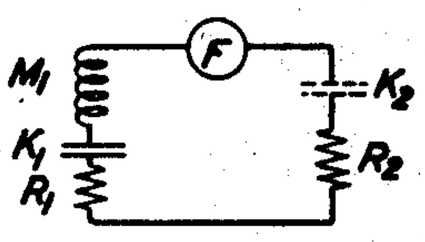


FIG. 5

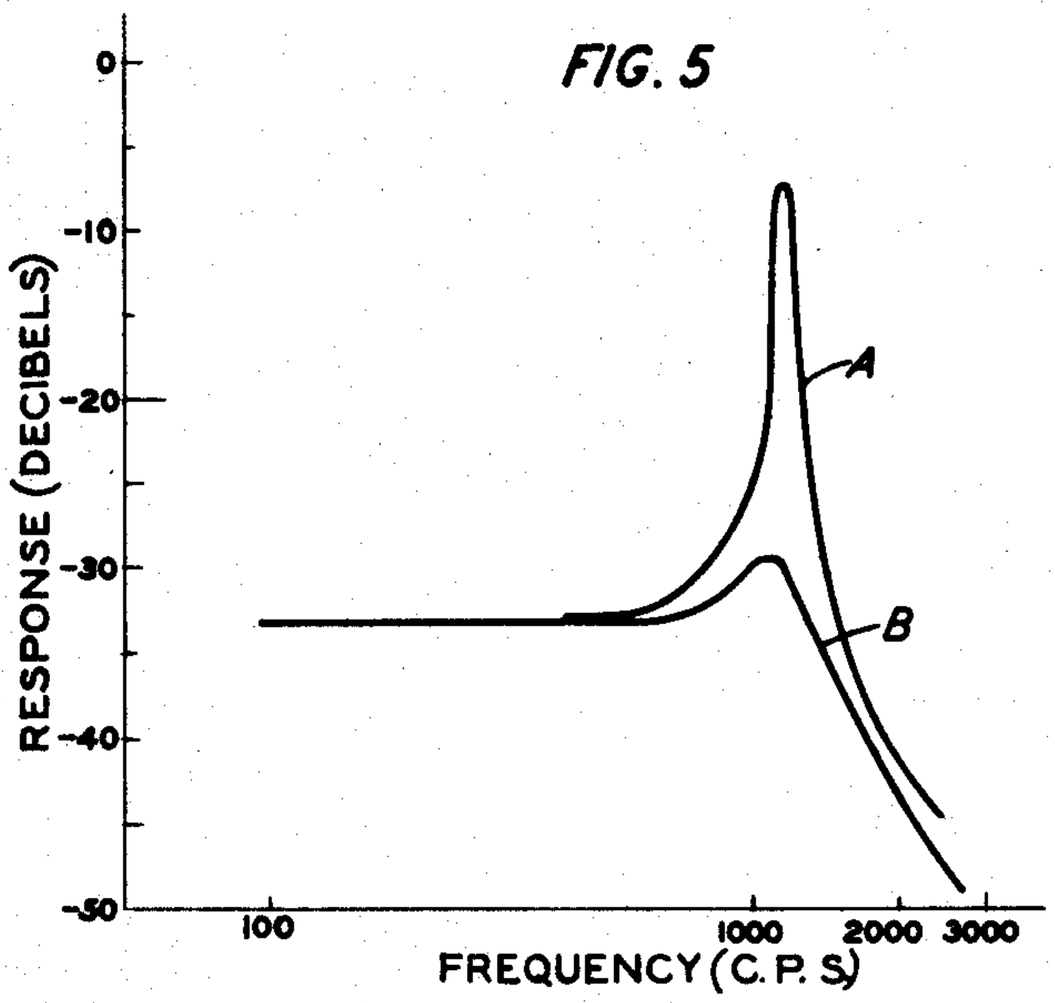


FIG. 6

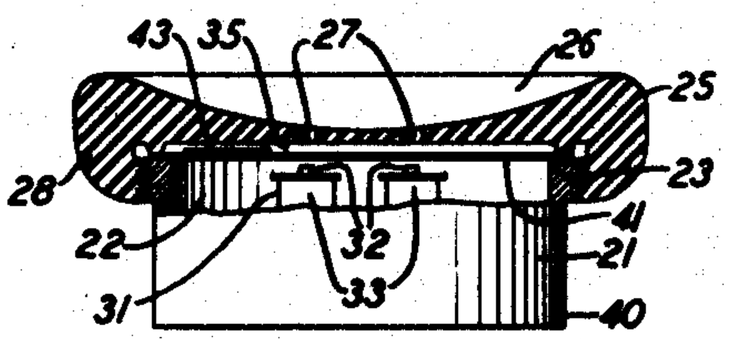


FIG. 7

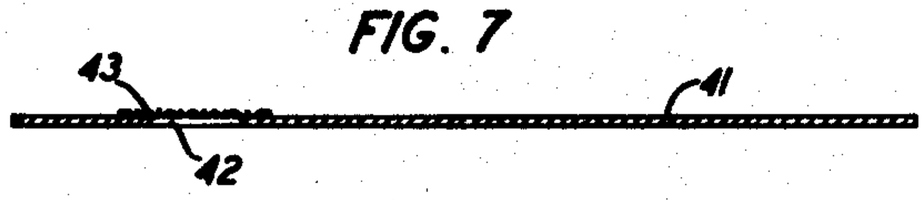


FIG. 8

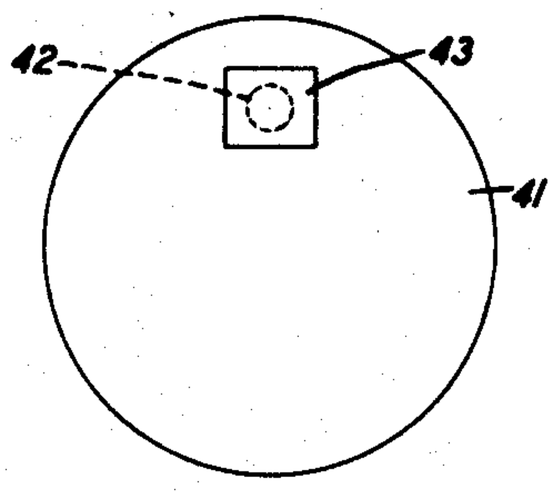


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FIG. 9

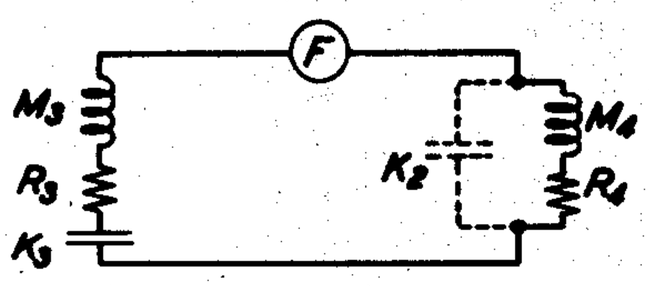



FIG. 10

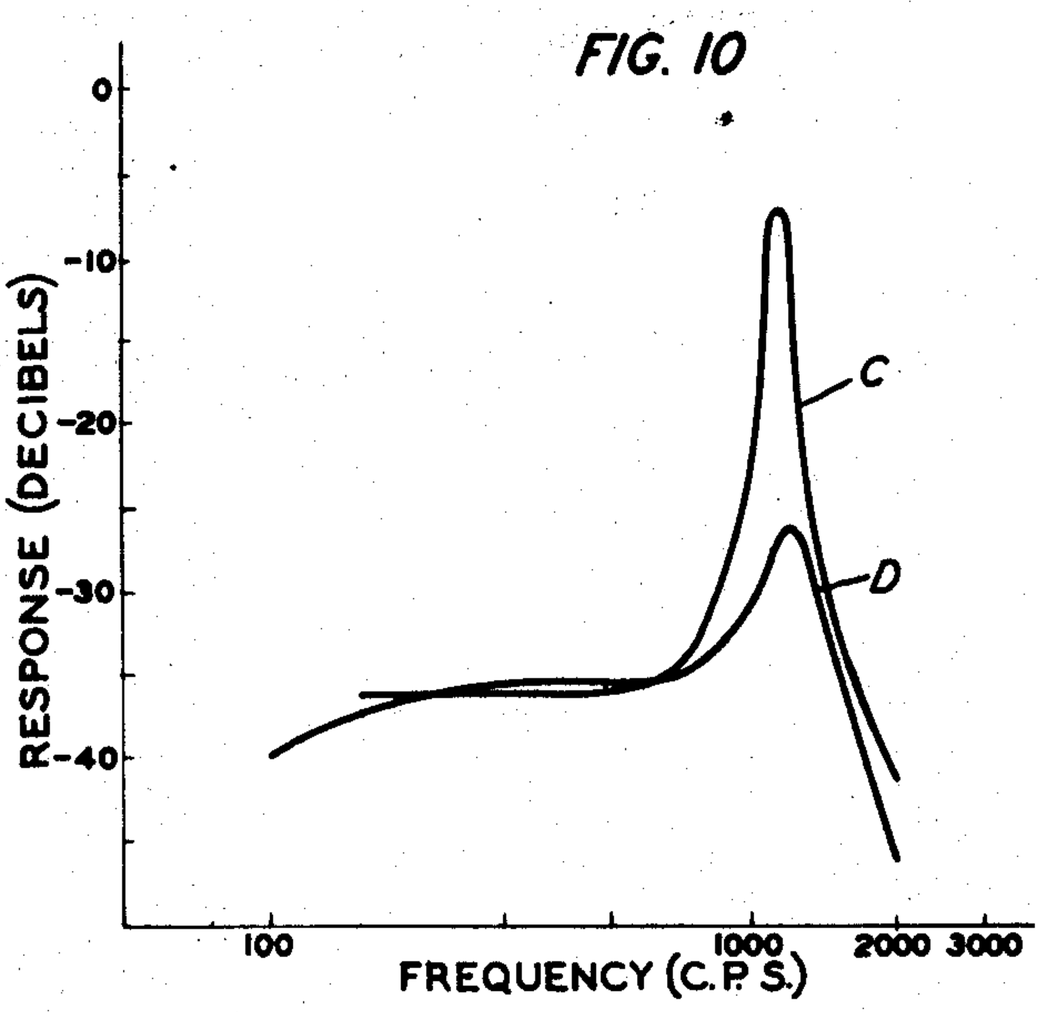



FIG. 11

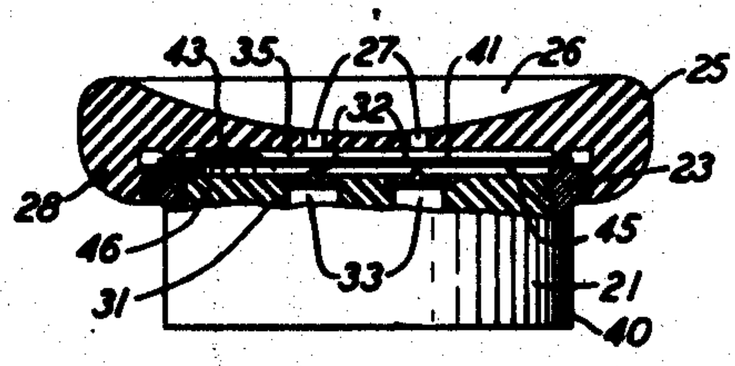



FIG. 12

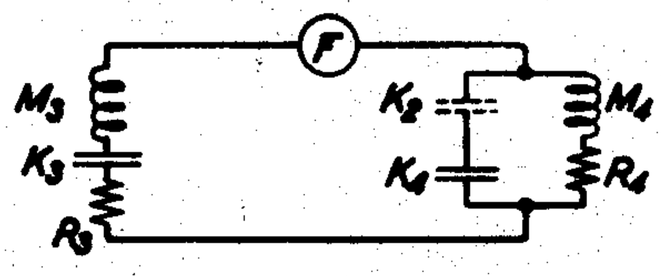



FIG. 13

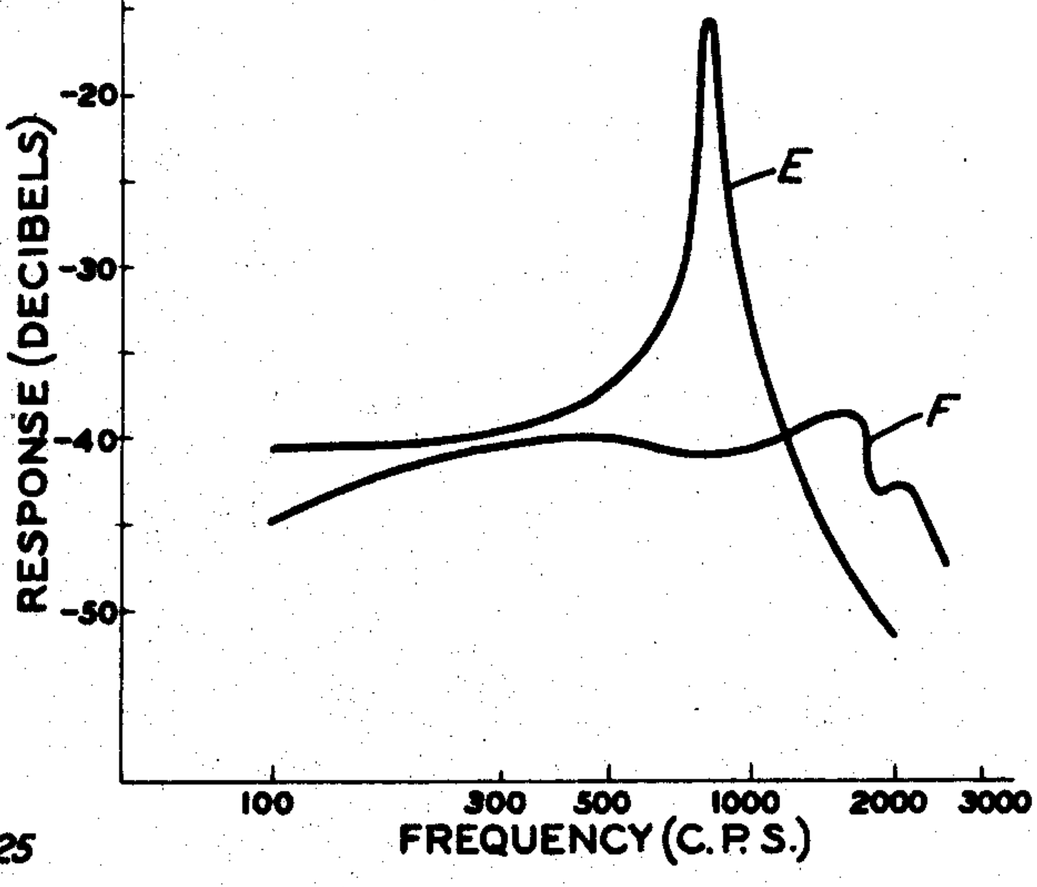
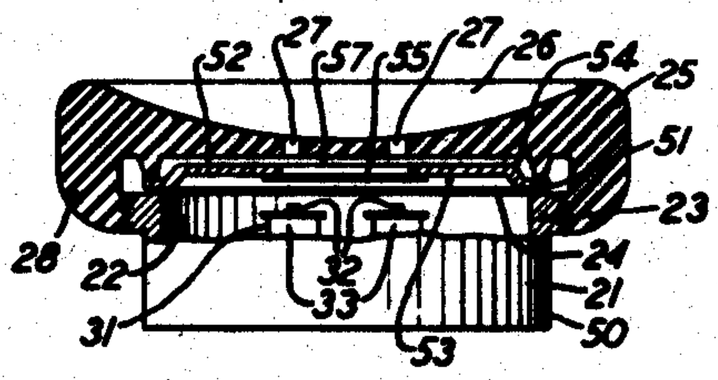



FIG. 14

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Patented Nov. 26, 1935 2,022,060

# UNITED STATES PATENT OFFICE

2,022,060

## ACOUSTIC DEVICE

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Application August 29, 1934, Serial No. 741,881

11 Claims. (Cl. 181—32)

This invention relates to acoustic devices, and, more particularly, to a telephone receiver and a diaphragm therefor.

An object of this invention is to improve the response characteristic of an acoustic device, particularly of a telephone receiver.

A further object is to extend the frequency range of an acoustic device, particularly of a telephone receiver.

A feature of this invention comprises providing a diaphragm with an aperture forming an air passage between the sides of the diaphragm and placing acoustic resistance or damping material in or over the aperture.

Another feature comprises associating such a diaphragm with a telephone receiver casing defining a shallow air chamber on one side of the diaphragm for extending the frequency range of the receiver.

Still another feature comprises providing a telephone receiver with a damping plate between its diaphragm and earpiece, the damping plate having a sound wave passage in or over which acoustic resistance or damping material is disposed.

A preferred embodiment of this invention comprises a telephone receiver including a hollow casing having an open end portion defined by a rim, and a diaphragm supported on the rim and having an aperture therein providing an air passage between opposite sides of the diaphragm, acoustic resistance material being secured to the diaphragm and over the aperture therein. This material comprises, preferably, a strip of cloth, for instance, silk. The casing contains means for actuating the diaphargm, and defines a shallow air chamber adjacent the rear side of the diaphragm. The cloth serves to damp the diaphragm in the region of its resonant frequency and the shallow air chamber aids in extending the frequency range of the receiver.

A more complete understanding of this invention will be obtained from the detailed description which follows, taken in conjunction with the appended drawings, wherein:

Fig. 1 is a side elevational view, partly broken away and partly in section, of an acoustic device embodying this invention;

Fig. 2 is a plan view of the device of Fig. 1;

Fig. 3 is a modification of the device of Fig. 1;

Fig. 4 is an electrical circuit analogy of the acoustical elements of the devices of Figs. 1–3;

Fig. 5 shows typical frequency response curves that demonstrate the improvement in the response of an acoustic device, made possible by this invention;

Fig. 6 is a side elevational view, partly broken away and partly in section, of another acoustic device embodying this invention;

Fig. 7 is a sectional view, to an enlarged scale, of the diaphragm of the device of Fig. 6;

Fig. 8 is a plan view of the diaphragm of the device of Fig. 6;

Fig. 9 is an electrical circuit analogy of the acoustical elements of the device of Fig. 6;

Fig. 10 shows typical frequency response curves demonstrating the improvement in the response of an acoustic device made possible by this invention;

Fig. 11 is a side elevational view, partly broken away and partly in section, of another device embodying this invention;

Fig. 12 is an electrical circuit analogy of the acoustical elements of the device of Fig. 11;

Fig. 13 shows typical frequency response curves evidencing the improved response of the device of Fig. 11 over a typical telephone receiver; and

Fig. 14 is a side elevational view, partly broken away and partly in section, of another acoustic device embodying this invention.

The acoustic device of Figs. 1 and 2 comprises a telephone receiver, designated generally, **20**. The receiver comprises a case **21**, preferably of insulating material, for instance, a phenolic condensation product, containing a chamber **22** and having an open end defined by an exteriorly threaded rim portion **23**. A diaphragm **24** of magnetic material, for instance, an imperforate, circular steel or iron disc, rests at its peripheral portion on the rim portion and is clamped thereagainst by an earpiece or cap **25**, preferably of the same material as the case. The cap has a concave or dished surface **26** to be placed against the ear of a user of the receiver, contains a plurality of centrally disposed, spaced sound wave passages or apertures **27**, and has a depending, peripheral flange portion **28**, interiorly threaded for engagement with the threaded portion of the case. Acoustic resistance or damping means, member, or element **29**, preferably a cloth strip, for instance, of silk, is secured in any suitable manner, for instance, by an adhesive, to the inner or under surface **30** of the earpiece which forms a shallow air chamber **35** with the diaphragm, the strip extending across the inner or diaphragm ends of the apertures **27**. Diaphragm actuating means **31**, for instance, of the electromagnetic type and including a pair of pole pieces **32** and an energizing winding comprising coils

33, is disposed within the case on the rear or inner side of the diaphragm.

Telephone receivers similar to that described hereinabove but not embodying the acoustic resistance material 29, are known, and have a decided or pronounced diaphragm resonance, as indicated by the typical response curve A of Fig. 5. In a resonant system, the amount of mechanical resistance or damping present, determines the magnitude of the resonant peak. It has been discovered that if resistance or damping can be introduced in series with the diaphragm of the receiver, the resonant condition can be effectively minimized. The material 29 provides this resistance, the resultant substantially uniform response of the receiver being evidenced by the typical response curve B of Fig. 5, curves A and B being that of a single receiver without and with, respectively, the means 29. In Fig. 4, $M_1$, $K_1$, and $R_1$ are the mass, stiffness and resistance, respectively of the diaphragm, $R_2$ is the resistance of the damping means, and F represents the electromagnetic actuating means. When the receiver is in use, the ear chamber provides an additional stiffness represented by $K_2$.

The device of Fig. 3 is the same as that of Figs. 1 and 2 except that the earpiece is provided with a single, enlarged sound wave passage or aperture 34.

The acoustic device of Fig. 6 comprises a telephone receiver, designated generally, 40, similar in some respects to the devices of Figs. 1–3, like parts being identified by the same reference characters. The diaphragm 41, comprising a circular disc of steel or iron, contains an aperture 42 intermediate its center and periphery. This aperture provides a passage between the opposite or front and rear sides of the diaphragm. Acoustic resistance or damping means, member or element 43, preferably a cloth strip, for instance, of silk, is secured to the front side of the diaphragm, for instance, by an adhesive, and extends across the aperture 42. As shown by Fig. 9, the aperture in the diaphragm and the damping means provide a mass, $M_4$, and resistance, $R_4$, in series, which are in shunt with the stiffness, $K_2$, of the ear chamber of a user when the receiver is in use. $M_3$, $K_3$, and $R_3$ are the mass, stiffness, and resistance of the diaphragm 41. It is well known in electrical circuit theory that a capacity shunted by an inductance and a resistance has an impedance characteristic that has a resistance component. By adjusting the values of $M_4$ and $R_4$, the resistance component of the impedance can be made a maximum at any desired frequency. In the device of Fig. 6, the resistance component is made to be a maximum in the region of resonance of the diaphragm. Curve C of Fig. 10 is a typical response curve for a typical receiver of the type shown in Fig. 6, except that an imperforate diaphragm, such as that of Figs. 1 and 3 was used. Curve D of Fig. 10 is a typical response curve for a device such as is shown in Fig. 6 and indicates the more uniform response attainable therewith.

The frequency range of a telephone receiver may be extended by increasing the stiffness of its diaphragm, or, by what is the same thing, placing an acoustical stiffness in series with the diaphragm. The response of the receiver below diaphragm resonance, however, will be decreased. If, however, the added stiffness is shunted by an acoustical mass, the increased stiffness will not become effective until a fairly high frequency is attained, and the receiver range is extended without sacrificing its low end response. By modifying the device of Fig. 6 in accordance with Fig. 11, this advantageous result may be attained in a convenient, inexpensive manner. A shallow air chamber 45 on the rear side of the diaphragm 41 is defined by the diaphragm and a filler or body 46 of suitable material, for instance, wax or an insulating material such as a phenolic condensation product, within the case 21. As will be apparent from Fig. 12, the stiffness $K_4$, of the chamber 45 is in series with the stiffness, $K_3$, of the diaphragm, and, when the receiver is in use, with the stiffness, $K_2$, of the user's ear chamber, and, also, in shunt to the mass, $M_4$, and resistance, $R_4$, of the diaphragm aperture and damping means, respectively. The shunting action of $M_3$ and $R_3$ results in the network comprising $M_3$, $R_3$, $K_3$, and $K_4$ having a reactive impedance at low frequencies, and a capacitative impedance at high frequencies, there being, of course, a resistance component which functions to damp the diaphragm particularly in the region of its resonant frequency.

Curve E of Fig. 13 is a typical response curve for a receiver such as is shown in Fig. 1, except that the damping means 29 is not embodied therein. Curve F of Fig. 13 evidences the substantially uniform and extended response of such a receiver when modified to accord with the device of Fig. 11.

The acoustic device of Fig. 14 comprises a telephone receiver, designated generally, 50, comprising a case 21, earpiece 25, diaphragm 24, and actuating means 31. Clamped at its peripheral portion 51 between the earpiece and the diaphragm, and having a central raised centrally apertured portion 52 spaced from the diaphragm to form a shallow air chamber 53 therewith, is a damping plate or member 54 preferably of non-magnetic material, such as brass. Acoustic resistance or damping material 55, preferably a cloth strip, for instance, of silk, is secured, for instance, by an adhesive, to the inner surface of the plate, and extends across the central sound wave passage or aperture 57 therein. The damping means functions to render the receiver response more uniform by damping the diaphragm in the region of the resonant frequency thereof.

While this invention has been disclosed with reference to several specific embodiments, it will be understood that they are illustrative of the invention which is to be considered as limited in scope only by the appended claims.

What is claimed is:

1. An acoustic device comprising a diaphragm having an aperture therein, and damping cloth extending across said aperture.

2. An acoustic device comprising a diaphragm having an aperture therein, and a strip of damping cloth secured to one side of said diaphragm and over said aperture.

3. An acoustic device comprising a hollow casing having an open end, a diaphragm supported on said open end and having an opening therein providing an air passage between opposite sides of the diaphragm, and acoustic resistance material extending across the air passage.

4. An acoustic device as claimed in claim 3 in which said material is acoustic damping cloth.

5. An acoustic device comprising a diaphragm resonant within the audio-frequency range, said diaphragm having an opening therein, and means secured to said diaphragm and forming a closure for said opening for damping the diaphragm in the resonant range thereof.

6. An acoustic device comprising a diaphragm

resonant within the audio-frequency range, having an aperture therein intermediate its center and periphery and providing a passage between the sides thereof, and means secured to said diaphragm and closing said passage for damping the diaphragm in the resonant range thereof.

7. An acoustic device comprising a diaphragm resonant in the audio-frequency range and having an aperture therein, and acoustic resistance material providing a closure for said aperture, the mass of said aperture and the resistance of said material constituting an impedance for damping the diaphragm in its resonant region.

8. An acoustic device comprising a diaphragm resonant within the audio-frequency range, means attached to said diaphragm for damping said diaphragm in its resonant range, and means providing a shallow air chamber for extending the frequency response range of said device.

9. An acoustic device comprising a diaphragm having an aperture therein, acoustic resistance material providing a closure for said aperture, a case providing a shallow air chamber on one side of said diaphragm, and an earpiece clamping the diaphragm to the case and providing a shallow air chamber on the other side of the diaphragm.

10. A telephone receiver comprising a case having an open end defined by a rim portion, a diaphragm resonant in the audio-frequency range supported on said rim portion, an earpiece engaging said case, clamping said diaphragm against said rim portion, and defining a shallow air chamber with the front side of the diaphragm, means in said case defining a shallow air chamber on the rear side of the diaphragm, said diaphragm having an aperture therein, and acoustic resistance material over said aperture for damping the diaphragm in the resonant range thereof, said chambers being interconnected through said aperture and acoustic resistance material.

11. An acoustic device comprising a diaphragm resonant in the audio-frequency range and having an aperture therein, and acoustic resistance material over said aperture, the opposite sides of the diaphragm being acoustically connected through said aperture and resistance material.

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