FIG. 1.

[Diagram with various labeled parts]
Figure A.

Pressure response in decibels relative to 1000 cps.

Sea Level Response

4000 Ft. Response

FREQUENCY IN CYCLES PER SECOND

Sea Level Response

40,000 Ft. Response

FREQUENCY IN CYCLES PER SECOND

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This invention relates to telephones and more especially to a compensated receiver or the like for use at high altitudes.

An object of the invention is to improve telephone receivers and to provide a device for producing sound at the ear from electrical audio frequency current alternations, whose output can be adjusted so as to become greater as a function of altitude, and at the same time preserving a flat response curve characteristic at various altitudes. It is also an object of the invention to provide a simple, efficient and reliable compensating mechanism for a receiver. Other objects will appear from the following description of the invention.

In the accompanying drawings:

Fig. 1 is a vertical diametrical section of the receiver of the invention;

Fig. 2 is a diagrammatic view illustrating response curves of a conventional receiver; and

Fig. 3 is a diagrammatic view illustrating response curves of the receiver of the invention.

The normal response curve of a conventional receiver or headphone obtained by plotting frequency against sound pressure levels is a relatively flat curve of definite value, as illustrated by the curve denoted "sea level response" in Fig. 2. At higher altitudes, the response curve of the conventional receiver shows a drop in sound pressure values and is characterized by a pronounced peak at higher frequency values, as may be observed from an inspection of the "40,000 ft. response" curve in Fig. 2. Both of these changes appreciably lessen intelligibility.

The receiver of the invention maintains satisfactory sound pressure values at higher altitudes and substantially eliminates the high frequency peak. Fig. 3 illustrates its response curves at sea level and also at 40,000 ft. altitude.

Included in the improved receiver are means for moving the pole pieces and a covering toward the diaphragm, with such means being responsive to changing conditions resulting from variation in altitude and rarefied air. The receiver also includes means for limiting decrease in volume of air between the diaphragm and the covering surrounding the pole pieces resulting from the pole pieces moving closer to the diaphragm.

Considering the receiver of the invention in greater detail, numeral 10 indicates a casing member formed with a rim 12 which is provided along its inner periphery with threads 14. A cap 16 is adapted to be detachably engaged within the rim 12 by a threaded annular portion 18.

The base of the casing 10 is recessed to receive contact elements 20 and 22, through which extend screws 24 and 26 as illustrated at the right-hand side of Fig. 1. The contact elements 20 and 22 are preferably slotted in some convenient manner to permit the insertion of input terminals 28 and 30, the extremities of which are secured in place by means of the screws 24 and 26. The latter may be parts of binding posts or other external conventional circuit connections, not shown.

Secured in spaced relation to the base of the casing 10 is a cylindrical shell 32 which has received therein a stationary sleeve member 34 in which is slidably supported a ring member 36. The sleeve 34 is supported at the right-hand edge, as viewed in Fig. 1, against an insulating disc 38 to which are secured the extremities of the terminals 28 and 30. Numeral 40 denotes coils surrounding pole pieces 42 and 44 fixed in relation to the ring 36. Located in axially spaced relation to the polar extremities of the pole pieces is a diaphragm 50 held against the inner left-hand edge of the sleeve 34, as viewed in Fig. 1.

Numeral 56 indicates a protecting cap of rubberized cloth or other suitable material for excluding moisture from the diaphragm. 58 and 62 denote flexible connecting wires extending between the terminals 28 and 30 respectively and the ends of the coils. The diaphragm vibrates, producing sound, when an alternating current passes through the coils 40.

The ring 36, together with the coils and pole pieces, is adjustably secured to the sleeve 34 by means of a circular flexible covering 46 which is snugly fitted around the ends of the pole pieces and extends into overlapping relation with a flange 50 projecting inwardly from the sleeve 34. The covering 46 is preferably secured to the flange, as by means of an adhesive and is similarly attached to edges of the ring 36. As the latter ring is arranged in spaced relation to the flange 50, there is left an intermediate portion of the covering which is unattached. This unattached portions functions somewhat like a hinge allowing the ring 36 to move in and out of the sleeve 34.

The ring 36, pole pieces 42—44, covering 46, and coils 40 are normally held as a stationary magnetic unit in spaced apart position relative to the diaphragm 50 by means of a spring washer 48 which is interposed between the flange 50 and a shouldered portion of the ring 36. If advanced to an extreme position toward the right, the ring 36 may come to rest against the insulating disc 38. However, in a normal operating position, the ring member is spaced from the disc 38, and is
resiliently urged forward (toward the left) a slight distance against the action of the spring washer.

The last mentioned operating position is controlled by a aneroid barometric member 65 which may, for example, comprise a closed bellows cylinder provided with flexible corrugated sides 66 and a forward central plunger portion 68. By reason of this construction, the member 65 is sensitive to outside pressure fluctuations. The aneroid device is coaxial with the diaphragm and casing, and is loosely supported at some convenient point as in back of the insulating disc 38, and the plunger portion is allowed to project through an opening 70 in the disc 38 and to engage against a thin disk or plate member 64 at the back of the coil and pole pieces assembly. The cylindrical portion 68 of the aneroid 65 is held against the disc 64 with a light pressure by means of an adjustment screw 72 which is recessed in an external opening 74 formed in the base of the casing 10, and bears at its inner end against a wear plate set across the closed rear end of the aneroid member. This aneroid member then becomes the means resiliently urging the ring member 36 toward the left.

The aneroid member when properly adjusted maintains the pole pieces and covering 48 against the spring washer 49 in a position such that the polar faces of the pole pieces lie in a suitably spaced relation with respect to the diaphragm 54, to provide a flat response curve at sea level. In addition, the aneroid member is responsive to changing pressure conditions encountered at higher altitudes. With decrease in atmospheric pressure at such higher altitudes, air seated within the aneroid expands and advances the plunger 68 against the disc 64 which forces the ring member 36 against the spring 48 into a position in which the pole pieces are brought more closely adjacent to the diaphragm. This automatically compensates for rarefied air and lower sound pressure levels. By selecting a suitable distance through which the plunger moves during a known range of altitude values, there is obtained a means of providing a satisfactory response curve which compensates for variance in sound pressure levels at high altitudes. Good results have been obtained using a spacing or travel distance for the pole pieces, of .01 inch to .03 inch.

A screen piece 47 is provided in the covering 46 and back plate 41 which permits impeded passage of air from the space between the diaphragm and the back plate into the region enclosed by rings 36 and also reverse movement of the air. This screen piece permits limited movement of air from the space immediately behind the diaphragm to the space at 36, and the impendence of air by the screen and the small size of the clear- way through the covering and back plate 41 is necessary for the obtaining of a uniform response characteristic. At higher altitudes, the air in the space between the diaphragm and the covering 46 becomes rarefied and much more compressible, resulting in a condition where the air fails to go through the screen piece in sufficient quantity and a frequency peak develops. To increase the flow of air through the screen it is necessary to decrease the spacing between the pole pieces and the diaphragm, and the volume of the air space. The decrease of spacing last mentioned results in a greater movement of the diaphragm in response to a given alternation in current and consequent movement of a greater volume of air, so that impedance of the air at 47 becomes more pronounced, especially at high frequencies. Such decrease must be limited in degree, however, or an ideal response characteristic will not be obtained.

I have designed the covering 46 and back plate 41 to provide for a limited decrease in volume of the space between the diaphragm and covering as the pole pieces move closer. It will be noted that the flange 54 is characterized by an appreciable radial width, and as a result, when the covering 46 is attached to it, there occurs a substantial reduction in area of that portion of the covering which is free to move. The reduction in area is so chosen that, having regard to the actual extent of movement of the covering, there will always be preserved a sufficiently large volume of air for the screen piece 47 to function in a satisfactory manner. The result of this is to smooth out the frequency peak and provide for high intelligibility at all altitudes.

The number of turns of the screw 72 required for a given adjustment may be used as a calibration of the spacing of the pole pieces from the diaphragm. Also, other types of air chamber controls and other devices may be resorted to. Similarly, the covering means may be modified in various ways to provide a limit on decrease of volume.

It will be seen that the invention provides means for maintaining uniform performance of a headphone at varying altitudes, thus protecting intelligibility of speech and eliminating difficulties arising at higher frequencies. The device may or may not be self-regulatory, according to the requirements which the unit is put to. The construction described as the preferred embodiment of the invention is simple, cheap, and readily carried out with current forms of receiver assembly.

While I have shown a preferred embodiment of my invention, it should be understood that various changes and modifications may be resorted to, in keeping with the spirit of the Invention as defined by the appended claims.

Having thus described my invention, what I claim is:

1. A headphone for use at varying altitudes comprising a casing, an air-impermeable diaphragm received in the casing, pole pieces arranged in spaced relation to the diaphragm, coils surrounding the pole pieces, a flexible air-containing covering member surrounding the pole pieces and means connecting said covering member and diaphragm to form therebetween an air containing space co-extensive with the major area of the diaphragm, altitude-responsive means for causing relative movement of the pole pieces and the diaphragm, and means for venting air from and impeding movement of air from and to the space between the diaphragm and said flexible covering when relative movement between the pole pieces and diaphragm takes place.

2. A headphone compensated for use at varying altitudes comprising a casing, a diaphragm secured in the casing, pole pieces arranged in spaced relation to the diaphragm, coils surrounding the pole pieces, ring means for supporting the pole pieces and coils, said ring means being slidable received in the casing, a covering member secured to the coils and pole pieces, said covering extending into overlapping relation with a flange on the said casing and fixed thereto, spring means interposed between the flange and the ring member adapted to maintain the pole pieces in spaced relation to the diaphragm, and means re-
A headphone compensated for use at varying altitudes comprising a casing, a diaphragm secured in the casing, pole pieces arranged in spaced relation to the diaphragm, coils surrounding the pole pieces, ring means for supporting the pole pieces and coils, said ring means being slidably received in the casing, a covering member secured to the coils and pole pieces, said covering extending into overlapping relation with a flange on the said casing and fixed thereto, spring means interposed between the flange and the ring member adapted to maintain the pole pieces in spaced relation to the diaphragm, means responsive to atmospheric pressure change for resiliently urging the pole pieces toward the diaphragm against the said spring means, and an adjustment means for regulating the spacing of the pole pieces and diaphragm.

An earphone comprising an earpiece having a diaphragm closely adjacent a face thereof; and means for moving the diaphragm consisting of the following parts, which parts are located further from said face than is said diaphragm: electromagnetic means for vibrating said diaphragm, and means responsive to changes in atmospheric pressure for bodily moving said electromagnetic means toward said diaphragm in response to decrease in atmospheric pressure and away from said diaphragm in response to an increase in atmospheric pressure.

5. The device of claim 4 wherein the last-named means at least partially supports said electromagnetic means.

6. A pressure compensated telephone unit having opposed spaced electrical reactance elements, at least one being a diaphragm capable of vibration relative to the other at voice frequencies, and being constructed to form a closed chamber therebetween, a limited vent in communication with the said chamber, a resilient support for the other said reactance element adjacent the diaphragm, and an expandable and contractible barometric device on said support having a fixed base, and oppositely in hearing with said other reactance element in a relation to move the same in response to change in ambient air pressure against the action of said resilient support to vary the spacing of the reactance elements inversely as the pressure varies.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Number</th>
<th>Name</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>977,961</td>
<td>Stuart</td>
<td>Dec. 6, 1910</td>
</tr>
<tr>
<td>1,414,105</td>
<td>Timmons</td>
<td>Apr. 25, 1922</td>
</tr>
<tr>
<td>1,602,696</td>
<td>Midsley</td>
<td>Oct. 13, 1926</td>
</tr>
<tr>
<td>1,743,453</td>
<td>Hillhouse</td>
<td>Jan. 14, 1940</td>
</tr>
<tr>
<td>2,364,485</td>
<td>Spencer</td>
<td>Dec. 5, 1944</td>
</tr>
</tbody>
</table>