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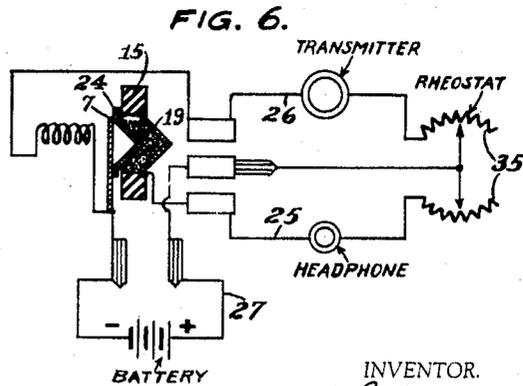
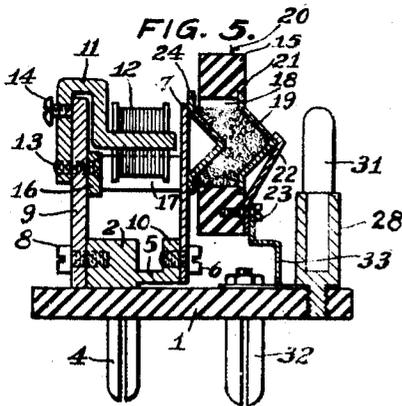
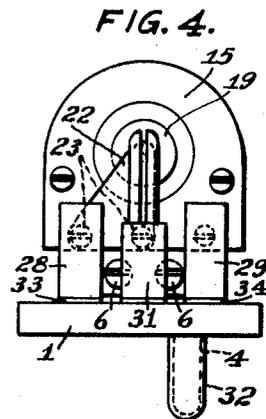
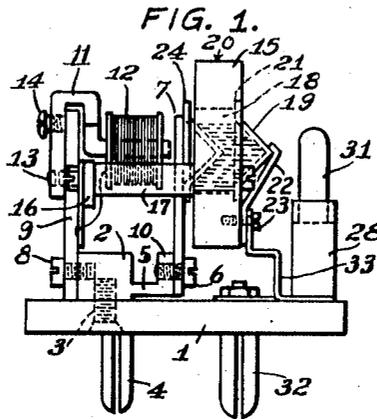
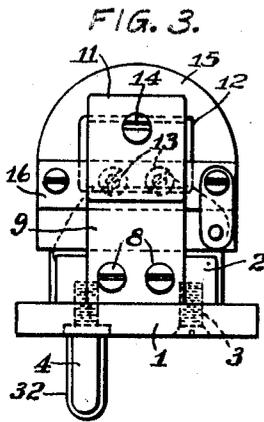
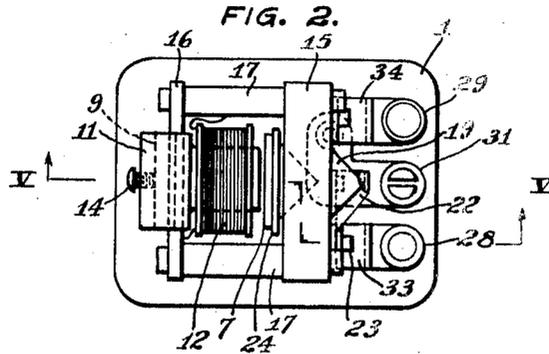
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2,145,603

MICROPHONIC RELAY

Filed April 26, 1935

2 Sheets-Sheet 1



WITNESSES

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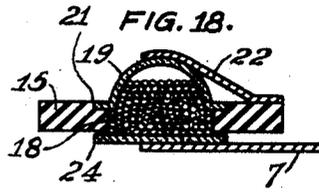
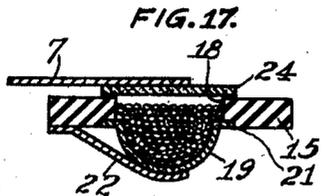
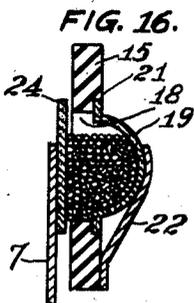
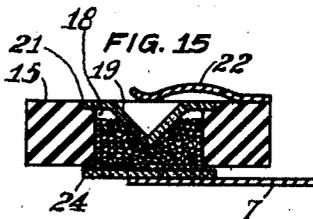
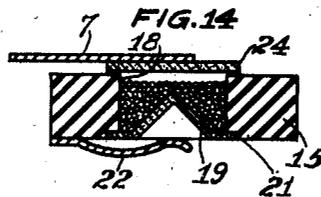
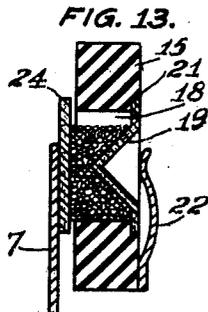
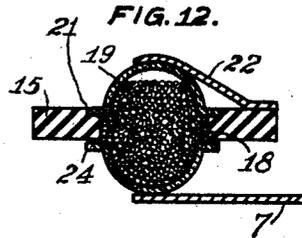
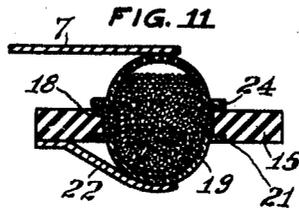
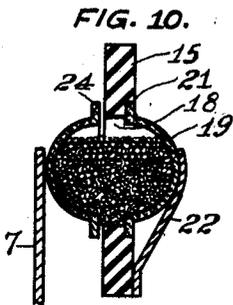
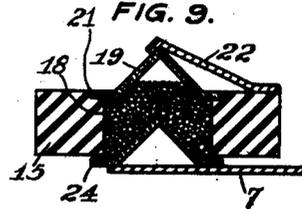
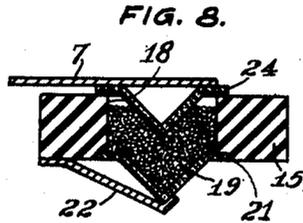
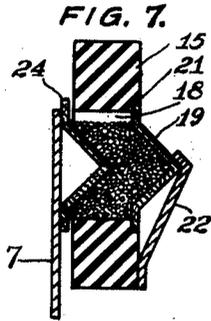
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2,145,603

MICROPHONIC RELAY

Filed April 26, 1935

2 Sheets-Sheet 2



WITNESSES  
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## UNITED STATES PATENT OFFICE

2,145,603

## MICROPHONIC RELAY

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Application April 26, 1935, Serial No. 18,385

4 Claims. (Cl. 175—336)

This invention relates to an improvement in microphonic relays, and more particularly to a relay of the amplifier type such as is employed to increase the amplification in telephonic type hearing aid sets used by people with defective hearing.

To satisfy the demands of users of portable hearing aid sets of this nature it is necessary to make the parts thereof, including the amplifiers, as small and as inconspicuous as possible, and also in such a way that they will require a minimum of attention. Because of this and the fact that they must be capable of standing up under continuous and rather strenuous use their construction becomes considerable of a problem. As heretofore made the amplifiers employed in these sets have embodied several objectionable features. Among the more pronounced of these is the tendency of their operating characteristics to change with changes in temperature. Another is their tendency to cut out and lose efficiency when oriented to certain positions of rest. Others are their lack of convenient and satisfactory means for adjusting the air gap between the pole piece and armature of the electromagnet employed in them and also their inability to respond to a very wide range of frequency impulses as well as their relatively low efficiency.

With the foregoing in mind it is an object of this invention to provide an improved amplifier of the character referred to which while small and inconspicuous is exceedingly sturdy and simple of construction, dependable and highly sensitive, as well as efficient in operation and susceptible of being manufactured at a low cost.

A more particular object is to provide an amplifier of this type which will not cut out in service irrespective of its position of rest.

Another particular object is to provide a relay of this kind with a continuously adjustable air gap and one in which variations in spacing thereof, due to temperature changes in its armature, are substantially eliminated.

A further object is to improve frequency response and flexibility characteristics of such a relay.

These and various other objects, as well as the other various novel features and advantages of the invention, will be apparent when the following detailed description is read in conjunction with the accompanying drawings, of which Fig. 1 is a side elevation; Fig. 2 a plan view; Fig. 3 a front view; Fig. 4 a rear view; Fig. 5 a sectional view taken on the line V—V of Fig. 2 of a microphonic amplifier designed in accordance with

this invention for use in a hearing aid set; Fig. 6 a typical schematic wiring diagram of a hearing aid set showing the amplifier circuit; Fig. 7 an enlarged fragmentary sectional view of the microphone cell in the amplifier showing the disposition of its carbon spheres when the amplifier is in a vertical position; Fig. 8 a view similar to Fig. 7 but showing the cell disposed in a horizontal position; Fig. 9 another view similar to Fig. 7 but showing the cell rotated 180° from the position shown in Fig. 8; Figs. 10, 11 and 12 views similar to Figs. 7, 8 and 9 of a modified form of microphone cell; Figs. 13, 14 and 15 views also similar to Figs. 7, 8 and 9 of another modified form of the microphone cell; and Figs. 16, 17 and 18 like views of a still further modification of the microphone cell.

Referring in detail to the embodiment of the invention illustrated in Figs. 1 to 5, the numeral 1 designates a base plate on which the other parts of the amplifier are mounted and which is preferably made of some suitable insulating composition. On the upper surface of this base at one end thereof there is mounted a block 2 of cold rolled steel or similar material which is employed to function as a part of the magnetic circuit of the electromagnet in the amplifier and also as a support for various of the other amplifier parts. As shown, this block is secured to the base 1 from the under side thereof by a screw 3 and a threaded circuit connecting jack plug 4, and has secured to a projection 5 on one of its faces by screws 6 an upwardly extending armature 7 and on its other face by screws 8 a similarly disposed high-grade bar-type permanent magnet 9.

At the top of the permanent magnet 9, which is preferably made of cobalt steel or like material having a high coercive force, there is mounted a pole piece 11. The latter is made of soft iron or other highly permeable material and is employed as a core for a magnetic coil 12. As shown it is formed in substantially the shape of, or similar to the shape of, a question mark, and is mounted with its curved end fitted over the upper end of the magnet and its stem portion on which the coil 12 is mounted projected toward the armature 7 in parallel relation with the base plate 1. To hold it in place it is secured by screws 13 to the magnet 9 at a point spaced from the upper end of the magnet.

The projection 5 on the block 2 to which the armature 7 is mounted is made in the shape of the letter L, for a purpose which will presently appear, and is disposed with its stem portion

parallel with and slightly above the base 1. The armature 7 which is preferably made of soft iron, silicon steel, or like material having a high permeability combined with high magnetic saturation point, and in the shape of a flat bar, is secured to the base 10 of this L-shaped projection 5 and spaced sufficiently from the pole piece 11 to provide an adequate air gap therebetween to permit its necessary vibratory operation. To readily and effectively, as well as accurately, adjust this air gap an adjustment screw 14 is threadably extended through the pole piece 11 near the upper end of the permanent magnet 9 with its inner end bearing against such magnet. Through the use of this arrangement when the screw 14 is turned in one direction it causes the curved portion of the pole piece 11, which is weaker than the bar magnet 9, to be flexed and in such a way that the outer end of the pole piece is drawn away from the armature 7 to thereby increase the spacing of the air gap. When it is turned in the opposite direction it permits the pole piece, due to the latter's resiliency, to move toward the armature and reduce the spacing of the air gap.

The advantage of this adjustment will be appreciated when it is considered that normally this air gap in devices of this type is maintained at from .002 to .003 of an inch and is customarily obtained by machining the various elements and that their machining to such accuracy is extremely difficult. An error of .0005 of an inch in the machining of any one piece causes an error in spacing of 25 per cent. Furthermore, there is always some variation in the strength of the permanent magnet 9, in the amount of bending in the armature 7, and in the spring portion of the armature supporting projection 5. Through the use of this adjustment the pole piece 11 may be readily adjusted with respect to the armature over a range of several thousandths of an inch, which makes accurate machining of the parts involved unnecessary, and at the same time accurate and sensitive adjustment of the air gap is provided.

At the side of the armature 7 opposite to the magnetic coil 12 a microphone cell 20 is provided. As shown this comprises a housing 15 formed of insulating material which is held in place by a bar 16 secured to the permanent magnet 9 by the same screws that hold the pole piece 11 in place, and a pair of rods 17 which are connected between the ends of the bar and the adjacent face of the housing 15. This bar and these rods are made of some non-magnetic material, such as brass, so as to not impair the operation of the electromagnet. Through the center of the housing 15 there is provided a circular chamber forming a hole 18. The outer end of this hole is enclosed by a removable electrode 19 which is made of carbon or other suitable material and seated in an enlargement 21 provided for such purpose at the outer edge of the hole. To hold such electrode in place a resilient current conducting terminal and clamping plate 22 is employed being connected by screws 23 to the housing 15 with its free end bearing against the electrode.

The inner end of the chamber forming hole 18 in the housing 15 is covered by a second electrode 24 which is also formed of carbon or similar material and soldered or otherwise secured to the adjacent face of the armature 7. Between the latter electrode and the housing 15 there is allowed a sufficient space to permit the necessary

vibration of the armature but at the same time insufficient to permit the escape of the current flow regulating material which is placed in the chamber 18. The material that is preferably used for this latter purpose is small carbon spheres having a diameter below 1 millimeter and to prevent their escape the electrode 24 is spaced from the housing 15 a distance which is not greater than one-half of the diameter of the spheres. If granular carbon is used in place of the spheres, as it may be, as well as other suitable material, a loose felt ring or the like, not shown, may be inserted between the housing and electrode to prevent its escape.

For connecting the amplifier in a headphone and transmitter circuit 25 and 26, as well as in a current-supplying battery circuit 27 as shown in Fig. 6, four additional jack plugs, 28, 29, 31 and 32 are provided. Three of these, 28, 29 and 31, are mounted in spaced relation on the upper surface of the base 1 adjacent the microphone housing 15 and the fourth, 32, is mounted on the bottom of the base adjacent the previously-mentioned jack plug 4. Of these, the jack plugs 28 and 29 into which the transmitter and headphone circuits 25 and 26 are adapted to be plugged, are preferably of the female type and are connected respectively to one end of the electromagnet coil 12 and to the stationary electrode 19 by current-conducting metallic strips 33 and 34. To secure such strips rigidly in place they are mounted with one end disposed between the lower end of the plug 28 or 29 and the base 1 and the other attached by a screw to the microphone housing 15.

The two lower jack plugs 4 and 32, which are of the male type and adapted to be plugged into a casing in which the battery circuit 27 is customarily housed, are connected respectively to the other end of the coil 12 and to the intermediary jack plug 31 which is also of the male type and used to connect the batteries to the headphone and transmitter circuits 25 and 26 by way of a current regulating rheostat 35.

As previously stated one of the faults of the prior amplifiers of this character is that they cut out in service and lose their efficiency when they are oriented to different positions. This is due to the falling of the carbon granules or spheres in the microphone cell away from one of the electrodes when they are so oriented. To completely overcome this difficulty irrespective of the position of the amplifier and to greatly reduce the loss of efficiency when the amplifier is inclined at an angle to the vertical, the electrodes 19 and 24 at the two ends of the microphone, in accordance with this invention, are made in shapes such as illustrated in Figs. 7 to 9 and 10 to 12, or, in shapes of this character which give the desired result. As shown in Figs. 7 to 9 this result is obtained by providing the electrodes 19 and 24 with similarly projecting centrally disposed cone-shaped indents which insure continuous contact between the carbon spheres of the microphone cell and the electrodes at all times and also a very substantial area of contact in all positions of the amplifier which makes for efficiency in the operation of the cell. This is also true of the cell construction shown in Figs. 10 to 12 where instead of being provided with like disposed conical indents the electrodes are made in the shapes of flanged hemispheres mounted with their convex portions projecting from the opposite ends of the cell housing.

The customary prior practice has been to make

the microphone cell electrodes in the shapes of discs, which, as is obvious, allows the circuit therethrough to cut out gradually as the cell is canted at an angle to the vertical and completely when the cell is disposed in a horizontal position as in such position the upper plate is completely out of contact with the carbon spheres. As an improvement upon such practice only one of the electrodes may be made as shown in Figs. 13 to 15 and 16 to 18 in the shape of the electrodes illustrated in Figs. 7 to 9, and 10 to 12, respectively. While with the latter constructions the cells will cut out gradually when canted in one direction and completely when disposed on one side they do so only under such conditions and accordingly represent a decided improvement over the older type of construction.

As also previously stated, another objectionable tendency of the prior amplifiers is that they change their operating characteristics with temperature changes. In this respect the armatures have been the chief source of evil and such is brought about by the heat generated by the current flowing through the carbon cell and the electromagnet coil both of which are adjacent the armature and communicate such heat either directly or indirectly to the armature. In the prior amplifiers as the armature is heated up by this generated heat it usually moves towards the pole piece of the electromagnet and as a result the air gap is made continuously smaller the longer the current is on. This of course causes a variation in the sensitivity of the amplifier and under extreme conditions, which are not infrequent, the armature actually touches the pole piece. More frequently, however, it is moved to such an extent that while not in actual contact with the pole pieces it strikes the latter when it is vibrated by the voice current passed through the electromagnetic coil 12, and bad distortions are developed in the amplification produced. Such change in spacing of the air gap occurs in all devices where the armatures are held at two or more positions, as they customarily have been in the past. In most of the devices the heating of the armature is usually greatest at the point closest to the carbon cell where the most heat is generated and as a result its length is increased most at such point. If the armature is of the strip type clamped at both ends there is considerable movement, due to heat, at the center thereof perpendicular to its plane, and as its central portion is normally displaced slightly from a common plane in which its ends lie by the permanent magnet as the motion increases the armature moves toward the pole piece. This is also true of a circular diaphragm having the armature attached to it.

In accordance with this invention the aforementioned difficulty is overcome by clamping the armature 7 at only one end. As a result there is no bending in the armature due to heating since all of its expansion takes place in the direction of its length and such expansion in no way affects the air gap. While there may be a slight change in thickness of the armature due to increases in its temperature this effect is infinitesimal in comparison to the deleterious effects referred to in the prior devices. The importance of this phase of the invention will be best appreciated when it is considered that it insures practically constant sensitivity in the armature regardless of the temperature of the armature, or the changes in temperature of the rest of the structure, as the latter does not appreciably affect the air gap spacing

because the horizontal expansion in the mounting block is very nearly the same as the horizontal expansion in the coil. Thus the air gap spacing due to these variables is kept constant.

Another outstanding feature of the invention resides in the construction of the armature mounting, the chief advantages of which are that it renders the amplifier responsive to a wider range of frequencies and adapts it to be readily varied to respond to different frequencies. Another advantage is that by making the armature support capable of allowing the armature to vibrate and making the armature long to function as a lever on its support the armature can be made heavy enough to properly carry the magnet flux of the magnetic circuit. Through the use of the projection 5 on the block 2 as a support for the armature 7 and the armature being secured at only one end, as well as the base 10 of the projection 5 having some considerable weight, the mounting of the armature is not unlike two weights being suspended in series by separate springs. By reason of this, a mounting is provided which has a plurality of natural frequencies which give a maximum of amplification. With a mechanical structure such as this it can be shown experimentally and theoretically that as the frequency of the alternating force on the armature, which is produced by the action of the current in the electromagnet, is increased, the amplitude of vibration of the armature will remain reasonably constant then rise to a point of maximum vibration or resonance, then decrease until a certain point is reached and then increase again to another point of maximum response. Thus the system has two frequencies at which maximum vibration occurs and between which there lies a point of less vibration.

The construction as is apparent is one in which the characteristics referred to can be readily changed by changing the values of the various elements comprising the mounting, such as changing the length, thickness and width of the armature, changing the weight of the screws 6, adding or subtracting weight from the base 10 of the projection 5, or removing some of the material from the stem of the projection. A very easy and recommended method of changing these characteristics is to machine the stem of the projection 5. By doing this, spring action of the projection is changed and the thinner it is the weaker its spring action becomes, which makes for a lower first resonant frequency which is desirable.

In general it is desirable to keep the mass of the armature small to insure good high frequency response, and to so proportion the elements of the mounting that the first resonance or point of maximum vibration only is used so that the frequency of minimum vibration is very much higher than the highest frequency which it is desired to transmit through the amplifier. The construction recommended is one in which the first frequency of maximum response is between two-thirds and three-fourths of the maximum frequency which it is desired to transmit through the amplifier. The actual choice of this frequency, of course, will depend upon the apparatus with which this amplifier is used. The invention contemplates that a number of different types of construction will be provided which have different frequencies of maximum vibration between 1500 and 4000 cycles so that the most suitable amplification characteristics can be chosen to satisfy the demands of different in-

dividuals and as will be obvious and as has been pointed out the construction provided is such that it lends itself readily to the provision of such a range of devices.

5 It will also be appreciated that the characteristics of this construction afford other advantages. For example, in many cases in actual practice it is found that other parts of the apparatus with which it is used, such as the transmitter and headphones, have pronounced resonances or  
10 peaks of response. By utilizing the fact that a point of minimum response followed by another frequency of maximum response is objectionable with this invention, the invention can be used to advantage to smooth out the over-all amplification curve of the joint apparatus by making the  
15 frequency of minimum response of the amplifier coincide with a resonance peak in the associated apparatus. The over-all response can in this way be made nearly uniform over a considerably wider range than is otherwise possible.

According to the provisions of the patent statutes, I have explained the principle and construction of my invention and have illustrated and described what I now consider to represent  
25 its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

30 I claim:

1. In a microphonic amplifier, a supporting base, a block of magnetic material secured to said base, a permanent magnet secured at one end to one side of said block, a pole piece adjustably  
35 secured to the free end of said magnet, an electromagnetic coil mounted on said pole piece, a flexible projection on the side of said magnetic block opposite to said permanent magnet extended in spaced parallel relation to said base, an elongate armature secured at one end to said  
40 projection with its free end disposed in spaced relation thereto opposite the free end of said pole piece.

2. In a microphonic amplifier, a support, an elongate pole piece disposed with an end portion in overlapping engagement with one side of said support, means for rigidly connecting the end  
45 of the pole piece to the support, the projecting portion of the pole piece being provided with a reverse bend to provide a portion extending along the opposite side of the support and terminating

in a portion extending substantially perpendicular to the support, an actuating coil mounted on said last portion of the pole piece, a movable armature disposed adjacent the free end of the pole piece with an air gap normally between,  
5 and an adjusting screw mounted in said overlapping portion of the pole piece and bearing against the adjoining support for springing the pole piece away from the support to widen said air gap.

3. In a microphonic amplifier, a support, an elongate pole piece disposed with an end portion in overlapping engagement with one side of said support, means for rigidly connecting the end  
15 of the pole piece to the support, the projecting portion of the pole piece being provided with a reverse bend to provide a portion extending along the opposite side of the support and terminating in a portion extending substantially perpendicular to the support, an actuating coil mounted on  
20 said last portion of the pole piece, a block mounted at one side of said coil and provided with a flexible extension substantially parallel to the coil supporting portion of said pole piece, a movable armature rigidly connected at one end  
25 to the free end of said flexible extension, the opposite end of the armature being disposed adjacent the free end of the pole piece with an air gap normally between, and means for springing the pole piece away from its support to vary  
30 said air gap.

4. In an electromagnetic vibrating device for hearing aids, a substantially straight bar magnet, an elongate pole piece disposed near one end of the bar magnet with an end portion in overlapping  
35 engagement with one side of said magnet, means for securing the end of the pole piece to the magnet, the projecting portion of the pole piece extending substantially at right angles across said end of the magnet in very close proximity thereto and substantially at right angles  
40 away from the opposite side of the magnet, an electromagnetic coil mounted on the free end of the pole piece, a movable armature disposed adjacent said free end with an air gap between them, and an adjusting screw threadedly mounted  
45 in said overlapping portion of the pole piece in very close proximity to said end of the magnet against which it bears for springing the pole piece away from the magnet to widen said air gap.  
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