Oct. 26, 1926. 1,604,149

H. W. DIX

ELECTRICAL APPARATUS

Filed Nov. 3, 1922

Fig. 1.

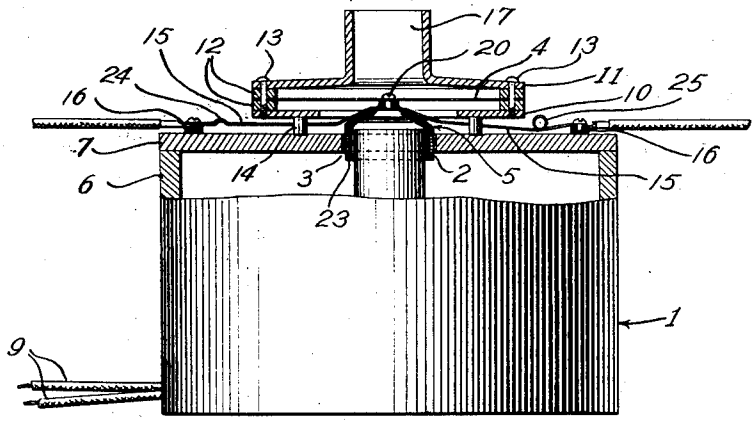


Fig. 2.

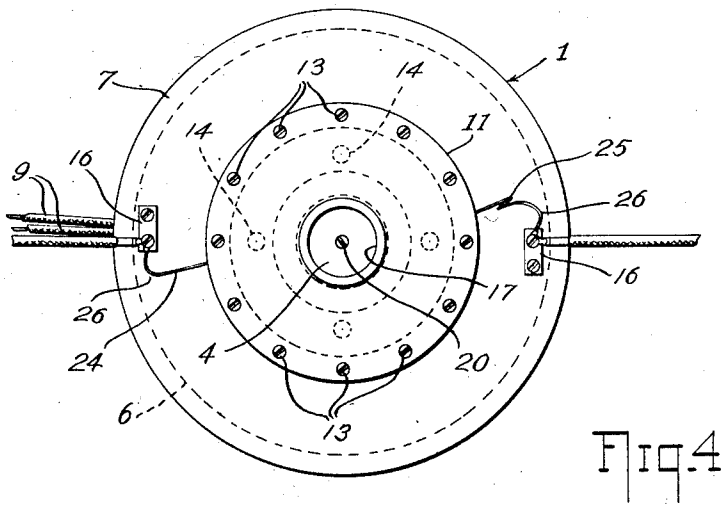


Fig. 3.

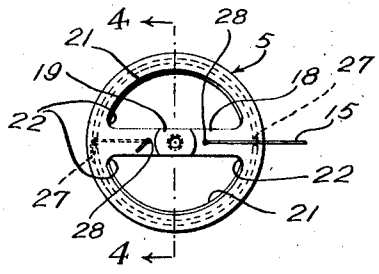
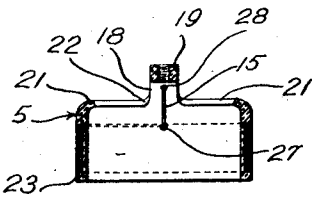


Fig. 4.



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UNITED STATES PATENT OFFICE.

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ELECTRICAL APPARATUS.

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This invention has to do with electrical apparatus and more in particular it has to do with apparatus which includes magnetic circuits, small coils movable in the magnetic circuit and flexible means such as diaphragms which are set into vibration by the movements of the small coils.

It is well known in the field of electrical industry that when an electrical conductor is suspended in a magnetic circuit and a certain mechanical force is exerted to move the conductor that an electromotive force is generated in the conductor. It is also well established that when the conductor is suspended in a magnetic field and an electromotive force is passed through the conductor that there is a reaction which moves the conductor. Most of the present electrical measuring instruments and other apparatus employed to indicate certain electrical phenomena are constructed upon these principles. Further, many parts of telephones for the transmission of speech are based upon these principles but instead of having a needle move to make an indication which is perceptive to the eye, the reaction operates in the telephone to move a diaphragm which creates an indication that is perceptible to the sense of hearing. The present invention relates to apparatus which requires the movement of diaphragms so that the transmission of speech and other sounds may be accomplished with the greatest efficiency and with the best quality.

In the rapid development of the wireless art many different types of apparatus have been evolved to create sound waves which may be readily heard by many persons. Most of these amplifiers or loud speakers as they are sometimes called are based upon the principle of mechanical amplification of the sound waves, while many of the other types are based upon the above outlined electrical principles. The electrical amplifiers emit great volumes of sound but heretofore these sounds have been greatly distorted and have not been at all pleasing to the ear. My invention aims to so construct an electrical amplifier that the amount of distortion is reduced to a minimum thus making the sounds pleasing to the ear and thereby creating a reproduction of the original sound that is more nearly perfect.

The usual construction of an electrical amplifier provides for an electromagnet or sometimes a permanent magnet, a small coil which is suspended between the pole pieces of the magnet so that the coil may be free to move, a diaphragm, and some means for supporting the coil and connecting it to the diaphragm so that the movements of the coil will vibrate the diaphragm. Theoretically, the maximum effect and the highest efficiency of such an amplifier is obtained when the maximum effect of the magnetic circuit is taken advantage of and when the weight of the member which supports the small coil and connects it to the diaphragm is nil. Much of the energy developed by the passing of the electromotive force through the small coil while the latter is suspended in a magnet circuit, is required to move the weight of the member which supports the coil. Also considerable of this reactive energy is required to bend the leads which conduct the electromotive force from terminals mounted on a nonmoving part of the apparatus to the small coil which is constantly moving.

My invention further aims to so constitute a support for the small coil that the maximum strength and rigidity will be obtained with minimum weight, thus making it possible to direct more of the reactive energy to the actual movement of the diaphragm. Further I have provided a novel manner of arranging the leads extending from the small coil to the nonmoving terminals so that the energy required to move the leads will be reduced. By so diverting more of the reactive energy to its desired use, that is, in vibrating the diaphragm, it is found that the sounds emitted from the amplifier are much clearer and pleasing to the ear while the volume thereof appears to be materially increased.

While I have set forth the aims of my invention in connection with one of its adaptations, it is desired to be understood that the advantages to be obtained by my construction are appreciable when the apparatus is employed for other purposes. For instance, a force may be applied to move a needle, arm or diaphragm connected to the small coil and the intensity of the electromotive force generated in the small coil by its movement in the magnetic circuit will give an indication of the intensity of the

force applied. Other advantages of my invention will be appreciated by a reading of the detailed description which follows.

A selected embodiment of my invention is illustrated in the accompanying drawing wherein:

Fig. 1 is a view in elevation of the apparatus as assembled and shows many of the parts in section to more clearly illustrate their constructions and their relative positions;

Fig. 2 is a top plan view of the apparatus showing, in particular, flexible leads and nonmoving terminals;

Fig. 3 is a top plan view of a support for a small coil showing in addition the manner of attaching the leads; and

Fig. 4 is a sectional view of the support taken on the line 4—4 of Fig. 3.

Referring now to this drawing, the amplifier consists, in general, of an electromagnet 1, a small coil 2 suspended in an air gap 3, a vibrating diaphragm 4, and a support 5 for holding the coil 2. This support also functions to form a rigid connection between the coil and the diaphragm 4. The small coil 2 is so suspended in the air gap that it is free to move without engaging parts of the electromagnet.

The magnet proper is constructed in the ordinary manner of iron-clad magnets and has an outer casing 6, a cover 7 adapted to fit over the casing, a core or spindle 8, and a winding (not shown) located within the casing. The leads 9 are provided to conduct electrical energy to the magnet winding. The cover is provided with an opening through which the spindle 8 extends and the width of the opening is greater than the thickness of the spindle thus providing the air gap 3. For purposes of reducing the cost of manufacture, the spindle is of round bar material and the opening may be readily drilled to accommodate the spindle. With this type of construction it will be readily noted that the air gap is annular and I prefer to have the width thereof as small as possible without injuring the small coil 2. It will readily be seen by this explanation that the magnetic circuit is closed except for the gap 3, and since it is well known that the magnetic lines of force spread in passing across an air gap, I have constructed the spindle so that it extends a trifle above the top surface of the cover 7 so as to collect and make effective as many of the stray or outlying lines of force as possible.

The diaphragm 4 may be of any suitable material and formation and may be supported in any desired manner that will permit it to be most efficiently vibrated under certain conditions. Although I have shown the diaphragm flat, it is to be understood that it may have any contour desired to give it proper strength and flexibility. In supporting the diaphragm I prefer to position it between frames 10 and 11 as shown with holding washers 12 acting to space it apart from the frames so that it has free movement. Suitable screws 13 or other preferred means may be employed to hold these several parts together as a unit. It is desirable to have the external edge of the diaphragm firmly supported so that the main part of the diaphragm will vibrate in its proper and most efficient manner, and I have therefore shown the washers of effective size and width. The frame 10 is preferably provided with feet 14 so that free spaces may be provided between the cover and the frame to allow the exit of leads 15 which conduct electromotive force from terminals 16 to the small coil 2. These feet are firmly attached to the cover 7 in a suitable manner that prevents the frames from having a relative movement to the magnet, thus the small coil 2 is properly held in the air gap so that sidewise movement thereof is prevented. The frame 11 is so shaped and the contour of its inner surface is such that the best and most efficient sound transmission is obtained. On the top of this frame I have provided a suitable extension or exit 17 for the reception of a horn or a sound conduit which leads to a suitable mechanical amplifier.

The constructions of the small coil 2 and of the support 5 will next be considered. It is desirable, in order to obtain the best efficiency of the apparatus, to construct the coil so that there will be maximum reaction between the electromotive force passed through the coil and the magnetic influence developed by the electromagnet. Also as has been noted, the efficiency is increased by reducing the weight of the moving parts, therefore it is desirable to have the support of the lightest possible weight consistent with its strength as it functions to transmit the movement of the small coil to the diaphragm. By experiments along these lines it is found that improved and satisfactory results have been obtained with the apparatus herein disclosed.

The support, although it may be constructed of several parts of different materials, is found to be very satisfactory when constructed as a unit of a single piece of material. I prefer to make the support of an insulating material which offers a very small resistance to the passage of the magnetic lines of force. The best perception of the one piece or unit construction may be obtained by referring to Figs. 1, 3 and 4. The construction is preferably of bell shape to provide a single point of contact with the diaphragm while the lower or wide part is arranged to be suspended in the annular air gap. The assembly of the support with the other parts of the apparatus is clearly shown in Fig. 1. Most of the top part of the sup-

port is cut away so as to reduce the weight but I have retained a bridge portion 18 which has a thickened part 19 adapted to contact with the diaphragm and to receive an attaching means such as a screw 20. In reducing the weight by removing some of the material, I have provided against the loss of strength by reinforcing certain portions. In accomplishing this reinforcement and still maintaining the unit construction, there is provided a flange 21 in each of the open parts of the top portion, the openings are easily noted by referring to Fig. 3. These flanges extend inwardly and usually at an angle greater than 90° with the vertical portion of the wide part of the support. The flanges may, however, be at 90° and may be of other construction than that illustrated in the drawing, their main function is however, to increase the rigidity of the support thereby permitting the support to be of lighter weight. As the upper part of the support does not pass into the air gap the flanges may extend outwardly if desired. It is preferred also to provide curved corners 22 at the junction points of the bridge with the remainder of the support, thus the strength of this portion of the support is increased.

The lower part of the support is provided with a groove in which the electrical conductor or coil is wound. The edges of the groove operate to maintain the winding in its proper position so that it will not have relative movement with said support. These edges also operate to protect the winding from injury. In forming the groove a flange 23 is created at the lower edge of the support and as the thickness of the wall at the grooved portion is very thin this flange also functions to add to the strength of the support. While I have shown the reinforcing means as formed integral with the support, it is to be understood that another material of light weight may be efficiently attached to perform the same function. By properly designing this support with correct attention to the positions and sizes of the flanges, the weight may be materially reduced while the strength is satisfactorily maintained to transmit the forces.

Preferably the width of the groove is such that when the wire is properly wound therein and the coil positioned in the air gap, the winding extends a trifle above and below the top and under surfaces of the cover. By this arrangement I convert many of the otherwise noneffective lines of force into effective ones which add to the value of the reactive energy.

In electrically connecting the small coil 2 to the terminals 16, mounted on the non-moving part of the apparatus it is possible to employ the wire used in forming the coil, but this is not feasible as a heavier wire is more advantageous to withstand the continued flexing due to the movement of the small coil support. I have therefore found it desirable to use a very flexible wire that is relatively heavy and one that is properly insulated usually by means of a cloth or silk covering. Great flexibility in this wire used for the leads is found to be desirable as less energy is required to move it and as has been noted the energy thus saved adds to the energy available to move the diaphragm.

The leads may extend from the support to the terminals in any desired manner so that they do not tend to twist the support or to push it to one side or in any other way tend to move the support out of its normal suspended position. It has been found by experiment that it is desirable to have the leads firmly attached to the support to prevent rattling or other undesirable noises, and to form a bend in each lead at some place between the points of attachment at the support and the terminals. This bending adds to the freedom of movement of the support and prevents any twisting or pushing of the support. I have shown in the drawing three different types of bends, all of which have proven successful for the purposes for which they are intended. An ordinary semi-circular bend 24 is shown in the lead on the left of Fig. 1. The right hand lead in the same figure shows the formation of a "pig tail" 25. The third type of bend is shown in Fig. 2 wherein a sweeping bend 26 is formed. By having the leads provided with one or more of these bends it is found that there is a considerable improvement over the straight leads which have been heretofore employed, as the moving coil is not restrained in a certain unnatural position and it thus has more freedom of movement. I have also found it advisable to have the leads extend from opposite sides of the support so that the weights of the leads will be balanced on each side of the point of support. For this reason the leads 15 are arranged to extend in diagonally opposite directions on the outer surface of the bridge 18.

My preferred manner of attaching the leads to the support is as follows: One end of the small coil winding is adapted to extend through a hole 27 to the inner surface of the support. Here the flexible lead is soldered to one of the coil ends and the lead then passes along the under side of the bridge as shown in full lines in Fig. 4, it then passes through hole 28 and extends downward along the outer surface of the bridge and then to the terminals as shown in full lines on the right of Fig. 3. On the left it is positioned as shown only to allow the showing of the lead in dotted lines as it is positioned on the under side of the bridge.

On the outside of the bridge the lead takes a normal position represented by the lead on the right of the figure. The other lead is also attached in like manner and a small drop of glue or like material serve to properly hold the leads to the support so there is no rattling. The wire of the small coil is firmly wound in the groove so that any turn thereof will not be free to rattle. However, to guard against any rattling a light coat of an adhesive solution or the like may be painted over the outside of the coil, or if desired such a solution may be applied to each layer of the winding if the construction is such that the desired length of wire may be more readily positioned by winding it in layers.

From the foregoing descriptions of the several elements of the apparatus and of their cooperation, it is readily seen that much of the heretofore wasted energy has been converted into useful energy which has resulted in materially increasing the efficiency of the apparatus and has also given a reproduction of speech of fine quality that is pleasing to the ear and may be heard by many people.

It is appreciated that modifications, changes and substitutions may be made in my apparatus, but any of these are considered as being within the scope of my invention as outlined in the following claims.

I claim:

1. In combination a magnet having its pole pieces arranged to form a relatively small air gap there-between, an electrical conductor so suspended in said air gap that it is free to move therein, a diaphragm capable of being vibrated held above said air gap, a unit support for holding the electrical conductor and constructed as to be attached to said diaphragm, and leads from said electrical conductor extending from said support to nonmoving parts of said apparatus, the leads being so attached that their weights will be balanced in respect to a tipping effect on the support.

2. In combination a magnet having its pole pieces arranged to form a relatively small air gap there-between, an electrical winding adapted to be suspended in said air gap in a manner to have movement therein, a diaphragm capable of being vibrated held above said air gap, a support for receiving said winding and being arranged to be attached to said diaphragm, and leads from said winding extending from opposite sides of said support and leading from the top thereof to nonmoving parts of the magnet.

3. In combination a magnet having its pole pieces arranged to form a relatively small air gap there-between, an electrical winding adapted to be suspended in said air gap in a manner to have movement therein, a diaphragm capable of being vibrated held above said air gap, a support for receiving said winding and being arranged to be attached to said diaphragm, and light weight leads of great flexibility for electrically connecting said winding to nonmovable terminals, each of said leads being bent so that its resistance to the movement of the support is decreased.

4. In combination a magnet having its pole pieces arranged to form a relatively small air gap there-between, an electrical winding so suspended in said air gap that it is free to move therein, a diaphragm capable of being vibrated held near said air gap, a support for holding said winding and being so constructed as to be attached to said diaphragm so that movements of said winding will cause said diaphragm to be vibrated, and curved flexible leads for electrically connecting said winding to nonmovable terminals, each of said leads being firmly held at its juncture points with said support and with said terminal and being free to move between these points, the curvature in each lead adding to the freedom of movement.

5. In combination a magnet having its pole pieces arranged to form a relatively small air gap there-between, an electrical winding so suspended in said air gap that it is free to move therein, a diaphragm capable of being vibrated held near said air gap, a support for holding said winding and being so constructed as to be attached to said diaphragm so that movements of said winding will cause said diaphragm to be vibrated, and leads for electrically connecting said winding to nonmovable terminals, said leads being in firm contact with said support and on opposite sides thereof at the top of the support to thereby balance their weights on each side of the center of said support, said leads extending from the sides of said support and being so arranged that they have freedom of movement for a portion of their lengths between said support and said terminals and also being so positioned that they offer substantially no resistance to the movement of said support.

6. In combination a magnet having its pole pieces arranged to form a relatively small air gap, an electrical winding held in said air gap so as to have movement therein, a diaphragm capable of being vibrated when firmly held in position near said air gap, an insulating support arranged to have said winding wound thereon and adapted to be affixed to said diaphragm so that said winding will be held in said air gap in the paths of substantially all of the effective magnetic lines of force passing between said pole pieces, said support having a portion of its body tapered, and leads for electrically connecting said winding to terminals, said leads adapted to contact with the tapered portion

of said support and each lead having a bend formed therein between its point of contact with said support and its terminal thereby permitting a greater freedom of movement of said support.

7. In combination a magnet having a closed magnetic circuit except for a small annular air gap, a vibrating diaphragm associated with said magnet, an electrical winding disposed in said air gap, an annular unit support attached to said diaphragm and having a portion extending into said air gap, said support being so constructed that it has an annular groove in which said winding is wound and has its top portion cut away to form a bridge, a portion of which contacts with said diaphragm, and electrical conductors for joining said winding with nonmoving terminals.

8. In combination a magnet having a closed magnetic circuit except for a small annular air gap, a vibrating diaphragm associated with said magnet, an electrical conductor adapted to be held in said air gap in the path of the magnetic lines of force passing between the pole pieces of said magnet, an annular unit support of minimum weight adapted to have said conductor wound thereon and to be attached to said diaphragm so that movements of said conductor when positioned in said air gap will be transmitted to said diaphragm, said support being cut away to reduce its weight but being reinforced to increase the rigidity of the portion between said conductor and said diaphragm, and electrical leads extending from said conductor to nonmoving parts of said magnet.

9. In combination an electromagnet having a closed magnetic circuit except for a small annular air gap, a diaphragm firmly held above said air gap, an electrical conductor adapted to be held in said air gap, a light weight rigid one piece annular support adapted to have said electrical conductor wound thereon and adapted to be so affixed to said diaphragm so that said conductor will be suspended in said air gap, said support having some of its upper part cut away to reduce its weight and having internally extending flanges to increase its rigidity, and flexible electrical leads extending from said conductor.

10. A support for holding an electrical conductor in an air gap of a magnet being an insulator of unit construction provided with a groove in which said conductor may be wound, the walls adjacent the groove acting to position and protect said conductor and to increase the strength of said support, the top of said support being cut away except for a bridge extending there-across, said bridge acting as a means to connect said support to another member and also acting as a support for leads extending from said conductor, said support being reinforced at the openings by having flanges formed of the material.

11. A support for holding an electrical conductor in an annular air gap of a magnet being a unit piece of insulating material formed in the shape of a bell with a groove in the external circumference of the lower part of said support for having said conductor wound therein and having its upper part cut away except for a bridge extending straight across, a thickened portion in the center of said bridge adapted to receive an attaching means, said support having flanges extending inwardly at one edge of each opening in said upper part and having the juncture points of said bridge with the remainder of the support reinforced by having the edges of the bridge curve into the body portion instead of making right angle corners.

12. In combination an electromagnet having a closed magnetic circuit except for a small annular air gap, a diaphragm capable of being vibrated firmly supported above said air gap, a light weight annular unit support of insulating material fastened to the center of said diaphragm and extending into said air gap, said support being cut away at the top except for a bridge extending straight across and having internally extending flanges at one edge of each opening in the top of said support to increase the strength of the support, an electrical conductor wound in a groove formed in the portion of said support which is positioned in said air gap, the width of the winding being such that it extends somewhat above and below one of the pole pieces of said magnet, and electrical leads for joining said conductor with nonmoving terminals mounted on said magnet, said leads adapted to pass to the interior of said support and along the under side of said bridge and then pass to the outside of said bridge then to said terminals, each of said leads being so bent that the freedom of movement of said support is increased.

In testimony whereof, I have signed my name to this specification this 2nd day of November 1922.

HOWARD W. DIX.