Jan. 18, 1938. C. E. STEVENS 2,105,934

ELECTROACOUSTIC DEVICE

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Fig. 1.

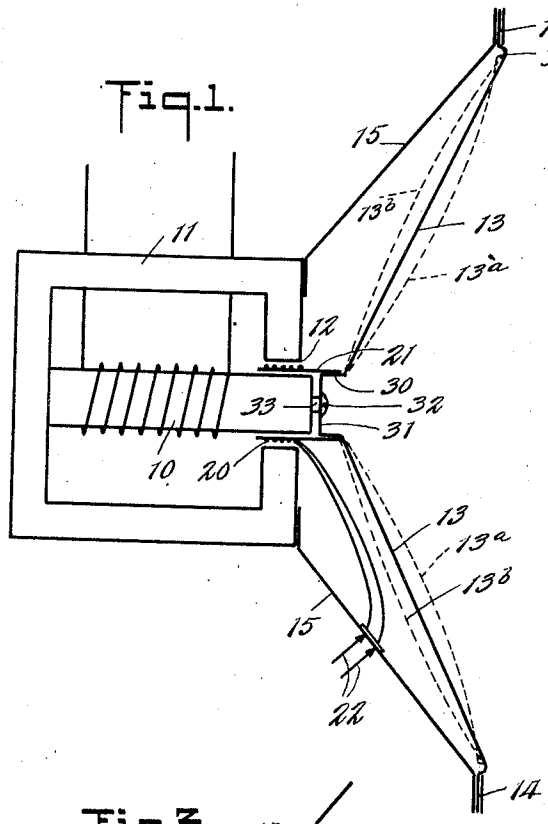


Fig. 2.

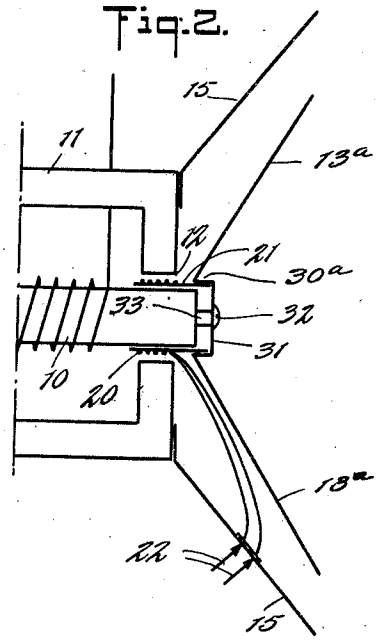
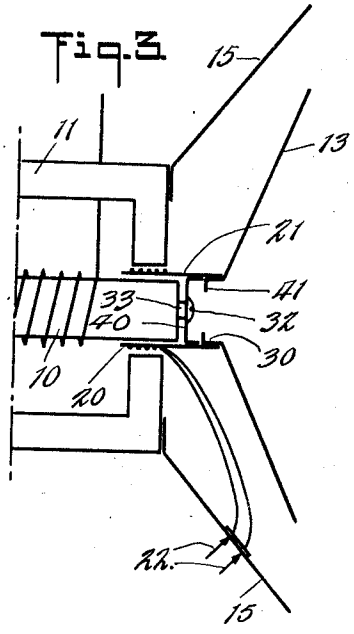


Fig. 3.



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Fig. 4.

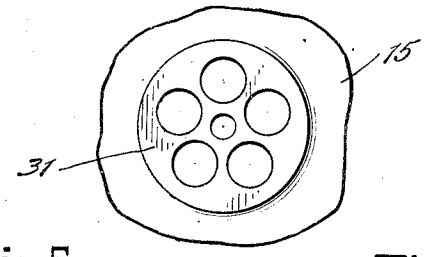


Fig. 5.

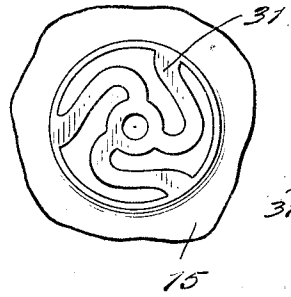
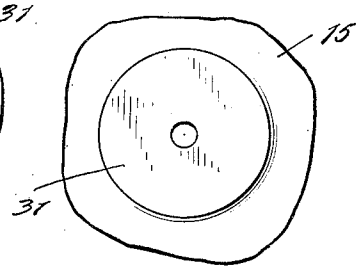


Fig. 6.



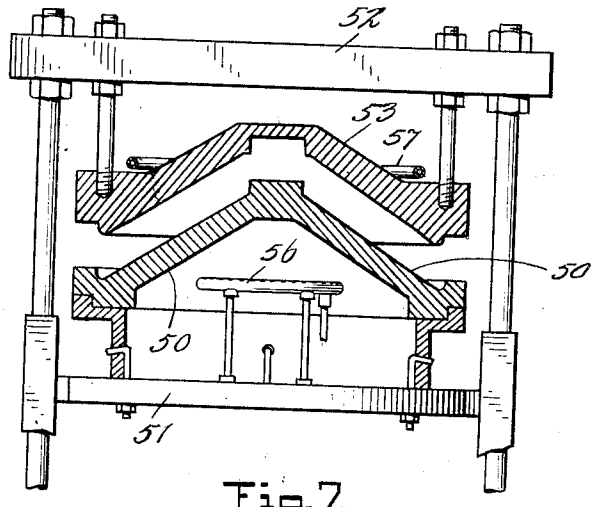


Fig. 7.

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UNITED STATES PATENT OFFICE

2,105,934

ELECTROACOUSTIC DEVICE

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Application November 23, 1929, Serial No. 409,212

22 Claims. (Cl. 179—115.5)

This invention relates to electro-acoustic devices of the moving coil or dynamic type for converting electrical oscillations into sound waves or vice versa, that is, telephone receivers or transmitters, and to diaphragms for use in such devices. The invention relates more especially to the connection of the moving coil carrier tube to the diaphragm and to the positioning of the diaphragm and moving coil carrier tube with respect to the magnet, and to a diaphragm formed to facilitate such connection and positioning. The invention aims to improve, simplify and cheapen devices of the kind referred to.

It is desirable that the annular air gap in the magnetic circuit of a dynamic receiver or transmitter shall be as narrow as possible, but the narrower the gap the more necessary it becomes to have the moving, or "voice", coil and its carrier tube, which are mounted free to move axially in the magnetic gap, accurately positioned and held against transverse movement so as to avoid contact with either the inner or outer pole pieces. The position of the carrier tube in the magnetic gap is affected by the position of the tube with relation to the diaphragm, and considerable difficulty has been experienced in securing the voice coil carrier tubes to the diaphragms with the desired accuracy, and in providing a connection which will have the necessary lasting strength to withstand the severe vibratory strains to which it is subjected and which will be efficient in transmitting all the sound vibrations between the diaphragm and the carrier tube without overloading or otherwise affecting the diaphragm. The present invention provides improved means for securing the voice coil carrier tube to the diaphragm and for positioning it in the magnetic gap with a maximum of simplicity of construction and a minimum of construction and assembly costs.

According to the invention, I form the diaphragm, which is usually of dished shape and most desirably conical, either true cone-shape or conoidal, that is, with its wall somewhat curved from the central portion radially outward, with a cylindrical collar formed by displacing a part of the central portion of the diaphragm material. This collar is usually made relatively short and serves as a means for attaching by cement or otherwise the voice coil carrier tube. The carrier tube may be held against transverse movement in the annular magnetic gap by any suitable means. Most desirably, however, I form the diaphragm with a positioning disc extending across the end of the collar and integral therewith, such disc in the complete apparatus being secured to the end of the magnet core. The diaphragm is most desirably made of a continuous piece of woven fabric impregnated with stiffening material as described and claimed in the patent of Leslie Stevens, No. 1,729,407, dated September 24, 1929, but the invention is not limited to such one-piece diaphragms or diaphragms of such material. Making the positioning disc integral with a coil-carrier-attaching collar carried by the diaphragm constitutes a feature of the invention apart from the feature of having the collar formed integral with the diaphragm.

A full understanding of the invention can best be given by a detailed description of devices embodying the features of the invention in preferred forms, and such a description will now be given in connection with the accompanying drawings, in which:

Fig. 1 shows diagrammatically a dynamic speaker according to the invention;

Fig. 2 is a fragmentary diagrammatic view of a similar speaker, but illustrating a modification in the shape of the small end of the diaphragm;

Fig. 3 is a similar fragmentary view showing another modified construction embodying features of the invention;

Figs. 4, 5 and 6 are views of the small end of the diaphragm showing different positioning discs; and

Fig. 7 is a sectional view of an apparatus for use in shaping the diaphragms.

Referring to the drawings, and first to Fig. 1, the dynamic speaker illustrated includes the usual magnetic circuit, shown as formed by a magnet of usual form having a central core 10 provided with a field winding and an outer pot-shaped member 11 connected at one end to one end of the core 10 and extended inwardly at its other end to form an outer pole piece spaced from the pole piece formed by the other end of the core to leave an annular air gap 12. A dished diaphragm 13 is mounted in front of the magnet, the large end of the diaphragm being secured through a flexible portion 14 to the edge of a support or cage 15. The voice coil 20 is mounted on a carrier tube 21 which is secured to the small or apex end of the diaphragm and extends into the annular air gap 12 with the coil located between the magnet poles. The voice coil is fed through leads 22 with an audio-frequency varying current as usual.

The diaphragm 13 is a frusto-conical form and is provided at its small end with a collar 30 which serves as a means for attaching the coil carrier

tube 21 to the diaphragm, the collar and the carrier tube being of such size that the tube fits on the collar, and the tube being secured to the collar in any usual manner, usually and most desirably by being cemented thereto. The collar 30 carries at its outer end a flexible disc 31 which is secured by means of a screw 32 and spacing washer 33 to the end of the core, or inner pole piece, 10. The disc 31 serves as the usual positioning disc, holding the diaphragm and coil carrier tube against transverse movement and insuring accurate positioning of the coil in the air gap, while permitting the necessary axial movement of the diaphragm and carrier tube. The coil carrier tube and coil may be of any suitable construction. The tube will usually be made of paper board.

The disc 31 and the collar 30 and the diaphragm are most desirably made of a single piece of sheet material. While the invention is not limited to diaphragms of any particular material or shape, the invention has been made especially with the idea of using one-piece fabric diaphragms such as are described and claimed in the said Stevens Patent No. 1,729,407, and I believe that the invention has its greatest value when embodied in diaphragms of that kind or in apparatus including such diaphragms. Such a diaphragm, as more particularly described in said patent, is made of a continuous piece of one or more layers or plies of woven fabric impregnated with stiffening material stretched to the desired shape. In shaping such a diaphragm according to the present invention with a collar 30 and disc 31 as shown in Fig. 1, the central portion of the fabric is displaced to form the collar and positioning disc, the collar and disc being thus integral with the truncated conical diaphragm. The diaphragm is most desirably of truncated conical form and may have the form of a true cone as shown in full lines in Fig. 1, or it may be of conoidal form curved in all radial directions from the center outward, either concavely, as indicated by the dotted lines 13*a* in Fig. 1, or convexly, as indicated by dotted lines 13*b* in Fig. 1. For convenience, I have shown true cone-shaped diaphragms in the drawings, but the particular form of the diaphragm is not of special importance so far as the present invention is concerned. As stated, however, it will usually be conical, having the shape either of a true cone or being conoidal.

Instead of having the collar 30 for attachment of the voice coil carrier tube extend outward from the small end of the conical diaphragm, the collar may be formed to extend inward as shown at 30*a* in Fig. 2. In this case, the end of the voice coil carrier tube 21 will extend inside the collar, and the positioning disc 31 extending across the end of the collar will be located within the cone.

Instead of having a positioning disc formed integral with or otherwise carried by the collar 30, the voice coil carrier tube may be otherwise transversely positioned, as by means of a flexible positioning disc secured within the carrier tube 21. Fig. 3 shows such a construction, in which a flexible positioning disc 40 secured within the tube 21 is connected to the end of the pole piece 10. With this arrangement the disc at the end of the collar 30 may be dispensed with, and it is more desirable not to have it, in order that convenient access may be had to the connecting screw 32. A narrow stiffening flange 41 at the outer edge of the collar 30 has been found desirable in such a construction.

In each of the arrangements shown, the construction has the advantages of simplicity and of economy both of construction and of assembly over the devices heretofore used, but constructions such as shown by Figs. 1 and 2, in which both an attaching collar and a positioning disc are formed integral with the diaphragm, have, of course, the greatest advantage and will usually be found most desirable.

The positioning disc 31 should be sufficiently flexible to give the desired freedom of axial movement of the voice coil carrier tube and diaphragm, and to have such sufficient flexibility the disc may be partly cut away between its central and peripheral portions, as, for example, as illustrated by Figs. 4 and 5. If the material is sufficiently flexible, and especially if the disc is of sufficient size, the disc may be without openings. Such an imperforate disc is illustrated by Fig. 6. The use of an imperforate disc closing the small end of the diaphragm serves to prevent air leak at this place, and this is in some cases apparently of advantage.

In making the diaphragms of woven fabric, I shape the fabric against a suitable shaping form, using an apparatus such as is illustrated in Fig. 7. The particular forms used will vary somewhat according to the shape of the diaphragms. The apparatus shown in Fig. 7 is provided with forming devices for shaping a diaphragm such as shown by full lines in Fig. 1. The apparatus shown comprises a metal form 50 against which the diaphragm is shaped and which is mounted on a bedplate 51 of a suitable press having an upper member 52 and means for causing an approaching movement between the bedplate and such upper member, usually by downward movement of the upper member. The upper member or crosshead 52 of the press carries depending therefrom an upper shaping member 53 formed to cooperate with the form 50. The two shaping members are shaped to displace the diaphragm fabric at the center of the piece to form the collar 30 and flat central portion or disc 31 and to form a suitable circumferential corrugation 35 near the edge of the diaphragm with a flat peripheral flange extending around the corrugation and with the intermediate portion of the diaphragm between the corrugation 35 and the collar 30 extending at an angle to the plane of the peripheral portion of the diaphragm. The surface of the upper member 53 between the portions which form the collar 30 and the circumferential corrugation 35, for shaping a diaphragm of true cone form or a convexly conoidal diaphragm, need not be shaped to press the material against the form 50, and this portion of the surface of the upper member is usually set back slightly so that the pressure on the material may be more surely effective at the base of the collar 30 and at the circumferential corrugation. In shaping a conoidal diaphragm which is concavely curved radially, as indicated by the dotted lines 13*a* in Fig. 1, the diaphragm may be shaped against the upper form member, and the lower form 50 need not press against the sloping intermediate portion of the diaphragm. The form members are most desirably heated, as by means of a ring burner 56 for heating the form 50 and a ring burner 57 for heating the upper form 53.

In making a fabric diaphragm using shaping apparatus such as shown in Fig. 7, the piece of woven fabric, this term being used to include

fabric known as knitted or crocheted fabric, and the piece being a continuous piece of a single sheet or layer or of several sheets or layers laid together, usually a piece of two plies or layers, and having had applied thereto suitable sizing or stiffening material, is, while in a dampened condition, placed on the heated shaping form 50 and pulled out smoothly over the form. While the fabric is held stretched over the form, the press is operated to lower the upper shaping member to clamp the edge of the material against the peripheral portion of the form 50 and to shape the circumferential corrugation and the central portion forming the collar 30 and the disc 31. The diaphragm is then left clamped on the form until the moisture has dried out and the stiffening material has set. It is then removed from the form, and may have applied to it material to further stiffen it and to fill the interstices of the fabric and to render it waterproof as described in said Stevens Patent No. 1,729,407.

It will be understood that the invention is not limited to diaphragms made of woven fabric or to diaphragms of the particular shapes shown, and that the invention includes changes and modifications in the devices and apparatus shown which come within the claims.

What is claimed is:

1. A large direct-acting acoustic diaphragm of truncated conical form, provided at its small end with a cylindrical collar for attachment of a voice coil carrier tube, and a flexible positioning disc, the conical portion of the diaphragm, the collar and the disc comprising parts of a continuous piece of material.

2. A large direct-acting acoustic diaphragm of truncated conical form, consisting of a continuous piece of woven fabric impregnated with stiffening material, the fabric at the small end of the diaphragm being shaped to form a cylindrical collar for attachment of a voice coil carrier tube and a flexible positioning disc at the end of the collar.

3. A large direct-acting acoustic diaphragm of truncated conical form, consisting of a continuous piece of woven fabric impregnated with stiffening material, the fabric at the small end of the diaphragm being shaped to form an outwardly extending cylindrical collar for attachment of a voice coil carrier tube and a flexible positioning disc at the outer end of the collar.

4. A large direct-acting acoustic diaphragm of truncated conical form, consisting of a continuous piece of woven fabric impregnated with stiffening material the central portion of which is shaped to form a flexible positioning disc.

5. A large direct-acting acoustic diaphragm of truncated conical form, having at its small end an imperforate flexible positioning disc connected peripherally to the adjacent portion of the diaphragm, the conical portion of the diaphragm and the disc comprising parts of a continuous piece of material.

6. Acoustic apparatus of the electro-dynamic type comprising a large direct acting diaphragm of truncated, conical form, a cylindrical voice coil form and a member for connecting the truncated diaphragm with the voice coil form having a cylindrical portion and a closed end portion, said closed end portion comprising means for flexibly maintaining the voice coil form in position and said cylindrical portion comprising the support for said voice coil form.

7. Acoustic apparatus of the electro-dynamic type comprising a large direct-acting diaphragm of truncated, conical form, a voice coil carrier tube and a re-entrant cylinder portion at the smaller base of said truncated diaphragm for securing said voice coil carrier tube to said diaphragm.

8. Acoustic apparatus of the electro-dynamic type comprising a large direct-acting truncated diaphragm, a voice coil carrier tube, a cylindrical portion at the smaller base of said truncated diaphragm extending into said voice coil carrier tube for supporting the same, and a member having a cylindrical portion and a closed end portion for flexibly maintaining the voice coil carrier tube in position, the cylindrical portion of said member being arranged within said voice coil carrier tube and secured thereto and the closed portion of said member being suitably supported.

9. An acoustic diaphragm comprising a conical wall, an annular flange surrounding the base of the cone, an axial cylindrical tube at the apex thereof, and a circular disc at one end of said tube, the entire diaphragm being integrally molded, homogeneous, and of unbroken continuity, and of substantially uniform thickness throughout.

10. An acoustic diaphragm comprising a conical wall, an annular flange surrounding the base of the cone, an axial cylindrical tube at the apex thereof, and a circular disc at one end of said tube, the entire diaphragm being integrally molded, homogeneous, and of unbroken continuity.

11. An acoustic diaphragm in the form of a seamless one piece frustum of a cone, a flat flexible centering surface located in a plane normal to the axis of said cone, and an actuating coil-locating and supporting flange secured to said centering surface.

12. A seamless acoustic diaphragm of generally frusto-conical configuration wherein the smaller base thereof is closed to form a flat flexible centering disc and a cylindrical extension integral with said cone, said extension being formed therefrom between said centering disc and the adjacent conical portion of said diaphragm, said diaphragm being attached to a stationary support at the center of said disc and being driven at a portion around the edge of said disc.

13. In a sound reproducing device, a conical seamless one piece fabric diaphragm having its smaller end terminating in a coil supporting annulus, said annulus having a centering surface integral therewith and disposed in a plane normal to the axis of said annulus, and a driving coil structure carried by said annulus.

14. A unitary sound reproducing diaphragm comprising a frusto-conical surface and a cylindrical surface, the smaller base of said frusto-conical surface merging into said cylindrical surface, said cylindrical surface having a flat flexible centering disc in a plane normal to the axis of said diaphragm.

15. A unitary sound reproducing diaphragm comprising a frusto-conical surface and a cylindrical surface, the smaller base of said conical surface merging into said cylindrical surface, said cylindrical surface having a perforated flexible centering disc in a plane normal to the axis of said diaphragm.

16. In a dynamic loudspeaker having a fixed field pole structure forming an annular air gap,

a frusto conical diaphragm, a cylindrical actuating coil structure, means for securing said coil structure to said diaphragm comprising a formed flange on the small end of said diaphragm, and means for centering said coil in said air gap comprising a flexible element integral with said flange, said element being rigidly secured to said pole structure.

17. In a dynamic loudspeaker having a fixed field pole structure forming an annular air gap, a frusto conical diaphragm, a cylindrical actuating coil structure, means for securing said coil structure to said diaphragm comprising a formed cylindrical flange on the small end of said diaphragm, said flange being secured to the inner face of said coil structure, and means for centering said coil in said gap comprising a flexible disc integral with said flange and extending across the small end of said diaphragm, said disc being rigidly fastened at its center to said pole structure.

18. In an electrodynamic sound reproducer, an acoustic diaphragm, a cylindrical coil structure for driving said diaphragm, a centering means for said coil structure comprising a relatively flexible disc-like element, means for locating and securing said element with respect to said coil structure comprising a flange portion formed at the periphery of said element and adapted to intimately engage one end of said coil structure.

19. In an electrodynamic sound reproducer, pole pieces defining an annular air gap, an acoustic diaphragm, a cylindrical coil structure for driving said diaphragm, unitary non-metallic means for attaching said coil structure to said diaphragm and for flexibly supporting said coil structure in said air gap comprising a flexible disc-like element having a peripheral cylindrical flange, said flange being connected to said diaphragm and secured at its outer periphery to said coil structure.

20. A sound reproducing diaphragm for an electro-dynamic speaker, formed integrally throughout of fibrous material, comprising a cone shaped body whose apex portion is constituted by a relatively flexible centering surface bounded by a flange, said flange being adapted to support a driving coil.

21. A diaphragm comprising a seamless truncated conical portion and an integral web extending across the apex end thereof, said web being relatively flexible as compared to the conical portion.

22. A conoid sound diaphragm of porous molded material having a cylindrical collar molded integral with it, near its apex, and a perforated disc molded integral with said collar on its rim.

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