

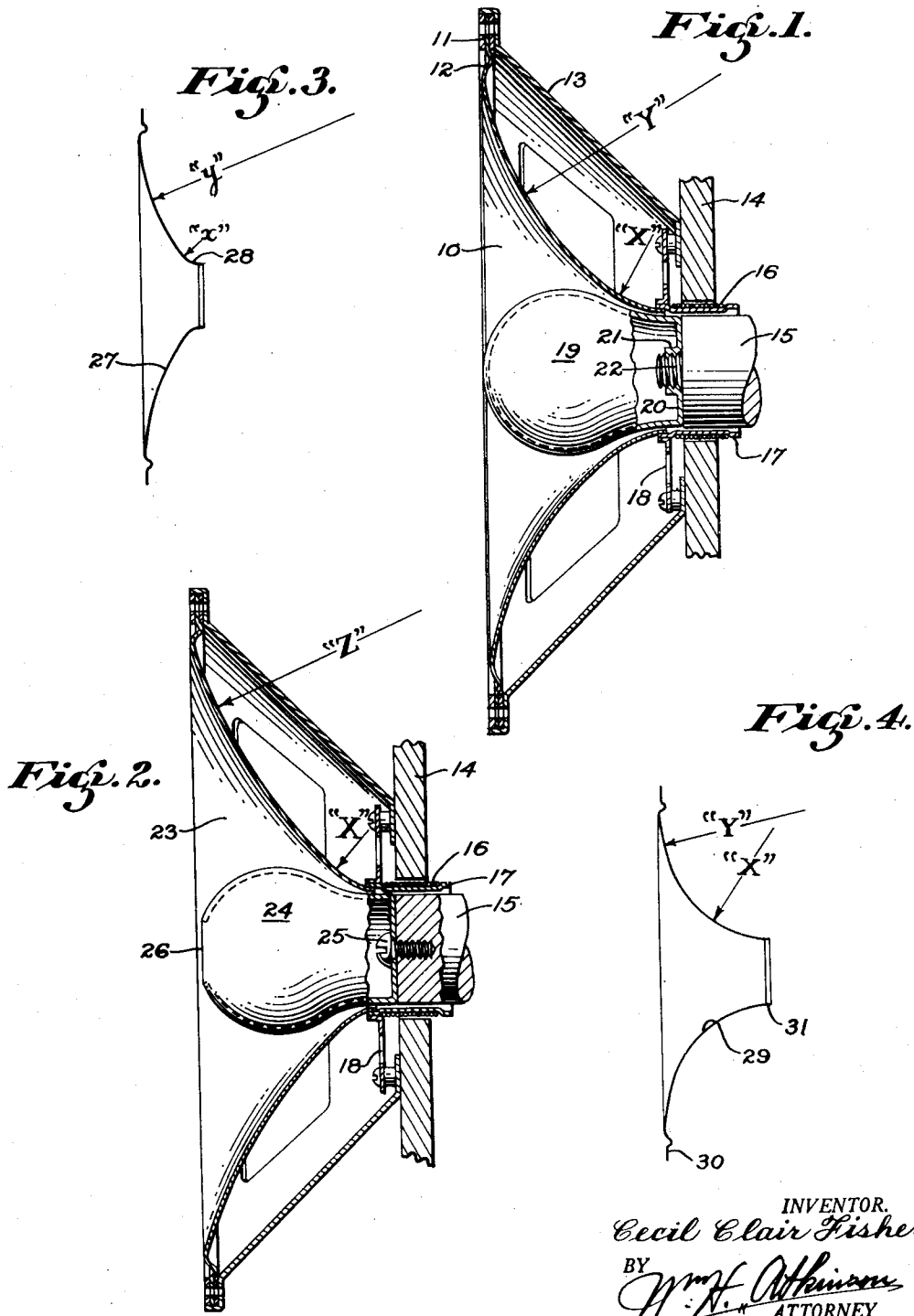
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ACOUSTIC APPARATUS

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ACOUSTIC APPARATUS

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This invention relates to acoustic apparatus and more particularly to a new and improved sound reproducing diaphragm for loud speakers of the electrodynamic type.

Electrodynamic loud speakers as is well known consist essentially of an electromagnetic field structure, having an air gap, and a flexibly supported diaphragm with a driving coil secured thereto and supported to vibrate within the air gap. Such loud speakers have proven very satisfactory in reproducing sound over a relatively wide frequency range, but attempts to increase this frequency range, especially at the high frequency end of the range, have not been entirely successful for several reasons, the principal reason being due to high inertia of the moving parts which prevents the apparatus from responding to the impressed currents of higher frequencies. At the lower frequencies the inertia of the moving parts is sufficiently low so that it does not have any material effect on the fidelity of reproduction, whereas at the higher frequencies, i. e. frequencies above six thousand cycles per second, the mechanical inertia of the moving parts, and particularly of the diaphragm, becomes relatively high and seriously affects the fidelity of the reproduction.

It is an object of the present invention to provide an improved acoustic diaphragm which will respond with a high degree of fidelity over a broader range of frequencies than that accomplished by electrodynamic loud speakers of present commercial construction.

Another object of the invention is to provide a new and novel form of diaphragm for electrodynamic loud speakers, having more uniform sound pressure frequency characteristics than have heretofore been provided and in which parasitic frequencies either harmonic or inharmonic relative to the applied fundamental are reduced to a minimum, and wherein cross modulation effects, whereby high frequencies are chopped or modulated by simultaneously applied lower frequencies, are also reduced to a minimum.

Another object of the invention is to provide a diaphragm having an increased range of operation in both the high and low frequency registers and in which distortion is reduced to a minimum.

Another object of the invention is to provide a diaphragm which is capable of reproducing sounds over a frequency range which is increased at both extremes and which is capable of handling larger power output without surface break-

up and the resultant distortion than is possible with diaphragms of the so-called cone type.

These objects are attained in accordance with the present invention by constructing the diaphragm so that it may be said to have at least two zones, one which is responsive to the higher frequency oscillations impressed thereupon, the other of which is responsive only to the lower frequency oscillations impressed thereupon.

In its broadest aspect the invention consists in providing the diaphragm with a non-developable seamless curvilinear configuration, in which the curvature of the inner portion follows a radius which is substantially less than the curvature of the remaining portion of the diaphragm.

In Patent No. 2,007,747, issued July 9, 1935, to Abraham Ringel, there is illustrated an arrangement which approaches a solution of the above problems. In this disclosure there is shown a diaphragm system in which a conical diaphragm is divided up into two distinct parts with a compliant connecting means interposed between the two parts. In this arrangement the inner part of the diaphragm which is connected directly to the driving coil serves to reproduce the higher frequency tones and the other part, due to the compliant connection, serves to reproduce only the tones of lower frequency. In such an arrangement it will be readily appreciated that if the frequency ranges of the two parts of the diaphragm are not properly designed so that one will take up where the other leaves off, there will either be an overlapping or a gap in the two frequency range curves of the complete diaphragm, and as a result the reproduction of sound throughout the complete range for which the speaker is designed will not be uniform.

As distinguished from the above, the diaphragm of the present invention will give a substantially uniform response throughout the entire range of frequencies, and at the same time reproduce sounds over a greater frequency range than is possible with a single diaphragm of the conical type. For example, with a diaphragm constructed in accordance with this invention, it has been found that the frequency range may be extended from the lowest important voice frequency to a frequency of eight thousand cycles per second, with a marked improvement in the smoothness of the response. This improvement in response is attributed to the fact that because of the increased radius of the outer portion of the diaphragm the inner portion thereof is gradually unloaded as the frequency increases and its impedance is thereby gradually decreased so

that the central portion can respond with substantial fidelity to the movements impressed thereupon by the driving coil.

In the above referred to patent the lower frequency part of the diaphragm is shown in two modifications as of the so-called "Morning Glory" configuration which, as is stated, functions as a horn with respect to the central or the higher frequency portion of the diaphragm. At this point attention is called to the fact that this so-called "Morning Glory" portion of the diaphragm of this patent is curved in a manner which is the reverse of that contemplated by the present invention, and as a result it will move substantially as a unit rather than yield, as is the case with the applicant's diaphragm, to unload the higher frequency portion of the diaphragm. In other words, the diaphragm of the present invention, as distinguished from the "Morning Glory" type of diaphragm, functions as a single unit to reproduce both the high and low frequency tones with substantially perfect fidelity. In operation the inner portion of the diaphragm, because of its direct connection to the driving means and the curvature thereof, which follows the shorter radius, operates as a true piston in response to the higher frequency impulses, and the outer portion, because of its curvature along the larger radius and its remoteness from the driven end, flexes or yields sufficiently to unload the central or higher frequency portion of the diaphragm and at the same time reproduces with substantially perfect fidelity the lower frequency impulses.

It is well known that the fidelity with which a diaphragm will reproduce sound in response to electrical impulses is determined largely by its mass and as a result, in the past, it has been the practice where high frequency tones are to be produced to make the diaphragm as small as possible. It is also well known that where a flat diaphragm or a comparatively shallow diaphragm is used, there is a tendency for parasitic vibrations to be set up in the diaphragm, particularly where the sound frequency range is of a high order. On the other hand where the sound frequencies of a low order are to be reproduced, these parasitic vibrations are not so prevalent in the diaphragm structure. Having the two above characteristics in mind, I have, by constructing my diaphragm in the manner above described, provided in a single diaphragm a surface which will reproduce both the high and low frequency tones simultaneously and with improved fidelity.

At this point it should be stated that the expression "curvilinear", as used in this description, is to be understood as defining any non-developable curved surface which follows a curve of successive arcs of different radii, the radii increasing from the driven end of the diaphragm outwardly.

In a conventional straight-sided diaphragm of the cone type, considerable distortion has been found to take place in the frequency response range above fifteen hundred cycles, or at the point where the cone departs from its true piston action. This high frequency distortion gives the illusion of a high frequency response, and is sometimes used to compensate for the deficiency in the higher frequency response of the amplifier system in which the speaker is used.

With a curvilinear diaphragm of the type contemplated by the present invention, the above distortion is not present and therefore the listener may obtain the impression of less high frequency response or the impression that the curvilinear

cone has a more pronounced beam effect. In order to overcome this characteristic a resort may be had, if desired, to what will be herein termed a high frequency diffuser or beam spreader. Such a diffuser or beam spreader in its simplest form may comprise a stationary outwardly projecting surface, either cylindrical, bell-shaped or of a spheroidal configuration, disposed centrally at the front side of the diaphragm.

For a more detailed description of the invention reference is now made to the accompanying drawing, wherein there is shown by way of illustration and not of limitation, apparatus embodying the invention.

In the drawing—

Figure 1 is a fragmentary sectional view showing one form of a curvilinear diaphragm contemplated by this invention, with a diffuser of preferred form disposed centrally thereof,

Figure 2 is a view similar to Figure 1, showing a modified form of diaphragm and diffuser,

Figure 3 is a diagrammatic illustration of an extreme modification of the present invention, and

Figure 4 is a view similar to Figure 3, showing a diaphragm embodying another extreme modification of the invention.

In Figure 1 of the drawing, the diaphragm embodying the present invention, designated by the numeral 10, is shown as having a flat annular support engaging portion 11 at its outer periphery and a reverse curved or ridged portion 12 there adjacent to provide for flexibility between the diaphragm surface and the annular rim portion 11. As shown, the rim portion 11 of the diaphragm 10 is secured in any suitable manner upon a supporting frame 13 that extends outwardly from the magnetic field structure of a loud speaker. The field structure of the loud speaker is here illustrated as having an outer annular pole piece 14, in which there is centrally disposed in spaced relation an inner pole piece 15, that in conjunction with the outer annular pole piece 14 provides an annular air gap into which a diaphragm driving coil 16 may be disposed. The driving coil 16 is wound upon a cylindrical form 17 which is secured to the small end of the diaphragm 10. As a means for centering the coil 16 within the air gap, there is also provided an outwardly extending spider-like centering means 18, which is sufficiently flexible to permit a substantially free axial movement of the coil 16 within the air gap throughout its operating range. Upon referring now to the configuration of the diaphragm 10, it will be noted that its curvature, as here illustrated, follows arcs of two distinct radii. The curvature of the inner portion of the diaphragm follows the arc of a radius "X" and the curvature of the outer portion of the diaphragm follows the arc of a radius "Y". It will also be noted that the radius "Y" is substantially twice that of the radius "X" and that the centers of these arcs are disposed at the rear of the normal plane of the diaphragm 10. In this figure of the drawing there is also illustrated, as disposed centrally within the diaphragm 10, a high frequency diffuser or beam spreader 19, that is secured in a stationary position upon the end of the inner pole piece 15 of the magnetic field structure. The diffuser 19, as has been previously stated, may be of any desired configuration. In the drawing it is shown as a spheroid, and as of hollow construction. In this specific embodiment the diffuser 19 has a flat end 20 with an inwardly turned flange 21 that is adapted to be threaded upon an extension 22 carried by the inner pole piece 15. If desired, the diffuser

19 may be of solid construction and is preferably of a non-magnetic material. It should also be pointed out that the surface of the diffuser may be polished or provided with any acoustically proper surfacing.

In Figure 2 of the drawing there is shown a diaphragm 23, constructed in accordance with the present invention, wherein the radius of the outer arc of curvature is of a considerably larger dimension and disposed at a greater distance to the rear of the normal plane of the diaphragm 23. In this embodiment the outer radius, designated by the letter "Z", is approximately four times that of the radius "X", and as a result, the diaphragm 23 has a somewhat flatter line of curvature. The diaphragm 10 also has a driving coil 16, which is mounted upon a cylindrical form 17 in the manner above described. In this figure of the drawing there is shown a diffuser 24 which is secured upon the end of the inner pole piece 15 by means of a screw 25. To provide for the insertion of the screw 25, the outer end of the diffuser 24 is left open as at 26 so that the screwdriver may be inserted therein with the screw 25.

Figure 3 of the drawing diagrammatically shows an extreme embodiment of a diaphragm employing the present invention. In this figure of the drawing the magnetic field structure and the diaphragm actuating coil is omitted and the diaphragm, designated by the numeral 27, is shown as having a short collar or cylindrical portion 28, to which the coil supporting cylinder 17 may be attached. In this embodiment the diaphragm is shown as having a curvature at its small end that follows a relatively short radius "x" and a curvature throughout the major and outer portion thereof which follows a considerably larger radius "y".

In Figure 4 of the drawing there is shown a further modified form of diaphragm in which the shorter radius of curvature "X" covers a wider portion of the diaphragm and the curvature of the radius "Y" comprises a relatively smaller portion of the total diaphragm surface. In this embodiment the diaphragm designated by the numeral 29, like those above described, is provided with a flat annular support engaging portion 30 and a driving coil support engaging collar 31.

Because of the non-developable character of the diaphragms contemplated by the present invention, it is necessary that they be formed of pulp or like material which can be molded into the proper shape without imposing any stress or strain in the sound reproducing surface during the process of manufacture. A process of manufacture which is admirably adapted to the production of diaphragms in accordance with the present invention, is disclosed in the Jesse B. Hawley Patent No. 1,984,019, dated December 11, 1934. In this patent there is disclosed a process for manufacturing diaphragms in which the diaphragm is built up on a suitable form by accreted and integrated fibrous material and then pressed to desired thickness. Such a process, with the dies of proper curvature, as disclosed above, will provide a diaphragm of light weight and of desired thickness, and one which will be free of inherent strains and stresses, which might tend to develop a change in shape or contour or become distorted during use. A further advantage in forming the diaphragm in this manner is that the diaphragm may be made lighter in weight and consequently with little inertia of mass.

When the diaphragm is formed in this manner,

and the fibrous material has taken a permanent set, the sound reproducing surface thereof will retain its curvature and as a result a diaphragm of greater mechanical strength and rigidity will be produced. Such a diaphragm will also be free of surface breakup, such as usually found in straight-sided diaphragms at the frequency where the diaphragm ceases to act as a true piston.

In conclusion it is to be understood that in addition to the curvature of the diaphragm, resort may also be had to lacquering or similar impregnations throughout any desired area of the diaphragm in order to produce a definite response over any portion of the total frequency range of the diaphragm.

While I have, for the sake of clearness and in order to disclose my invention so that the same can be readily understood, described and illustrated specific devices and arrangements, I desire to have it understood that this invention is not limited to the specific means disclosed, but may be embodied in other ways that will suggest themselves to persons skilled in the art. It is believed that this invention is new and it is desired to claim it so that all such changes as come within the scope of the appended claims are to be considered as part of this invention.

Having thus described my invention, what I claim and desire to secure by Letters Patent is—

1. A seamless diaphragm for sound reproducing devices, comprising a non-developable surface having a curvature of section in any radial plane extending through its axis, which follows in its entirety two distinct radii.

2. A seamless diaphragm for sound reproducing devices, comprising a non-developable seamless surface having a curvature of section in any radial plane, which follows two distinct radii.

3. A sound reproducing diaphragm for sound reproducing devices having an outside diameter at least twice as great as its depth and a non-developable curvilinear surface which in any section follows a series of increasing radii each one of which forms a substantial area of the diaphragm between its apex and the outer edge thereof.

4. A diaphragm for sound reproducing devices, comprising a non-developable surface of curvilinear configuration, the curvilinear surface of the diaphragm following the curvature of two arcs of circles of increasing radii from the small end of the diaphragm to the outer portion thereof.

5. A sound reproducing diaphragm for sound reproducing devices having an outside diameter greater than its depth and a non-developable curvilinear surface which in any radial plane follows the arcs of two circles of increasing radii which extend from the apex to the outer edge thereof.

6. A diaphragm for sound reproducing devices having a non-developable surface of curvilinear configuration with two concentric zones of definite uniform curvature responsive to axial vibrations of different sound reproducing frequencies.

7. A diaphragm for sound reproducing devices having a non-developable surface of curvilinear configuration with concentric zones therein the curvature of which throughout the width of each zone follows a definite radius.

8. A diaphragm for sound reproducing devices, comprising a non-developable surface having a cylindrical coil engaging collar at its small end and a transversely disposed annular flange at its

- large end, the curvature of said non-developable surface in any plane including the axis of the diaphragm following two different and increasing radii from the small end to the large end thereof.
- 5 9. A diaphragm for sound reproducing devices having a non-developable curvilinear surface in which throughout its active area there are no straight line surfaces either parallel to or perpendicular to the axis of the diaphragm.
- 10 10. A diaphragm for sound reproducing apparatus having a curvilinear surface the curvature of which follows the arcs of successive circles the radii of which more than doubles as the outer diameter thereof is approached, whereby the diaphragm will have definite zones of decreasing stiffness from the small end to the large end thereof so that the central portion will respond to the higher frequency impulses impressed thereupon and the outer portion thereof will respond only to the impulses of lower frequencies.
- 15 11. A diaphragm for sound reproducing apparatus having a curvilinear surface which is generated by two radii having a transversely extending flange flexibly incorporated therewith at its large end and a cylindrical driving coil mounting at its small end, the curvature of said surface adjacent the driving coil end of the diaphragm being of a radius substantially less than the radius of the remaining portion of the curvilinear surface.
- 20 12. In a sound reproducing device, the combination of a diaphragm having a surface of curvilinear configuration with concentric zones of uniform curvature therein, the curvature of which throughout the width of each zone follows a definite radius, and a sound wave deflector of spheriodal configuration mounted centrally in front of the diaphragm.
- 25 13. In a sound reproducing device, the combination of a diaphragm having a surface of curvilinear configuration with concentric zones of uniform curvature therein, the curvature of which throughout the width of each zone follows a definite radius, a sound deflector supported at the apex of said diaphragm and extending outwardly in relation thereto in a centrally disposed position, said deflector having a circular cross section of increasing diameter throughout the inner portion of its length and a cross section of decreasing diameter as its outer end is approached.
- 30 14. In a sound reproducing device, the combination of a diaphragm having concentric zones adapted to vibrate at different frequencies, the inner zone of which will propagate sound waves in the higher frequency register and the outer zone of which will propagate sound waves in the lower frequency register, and a sound wave diffuser mounted centrally of the diaphragm and in front of the inner concentric zone for deflecting the high frequency sound waves and reducing beam effect.
- 35 15. In a sound reproducing device of the electrodynamic type, the combination of a conical diaphragm having an opening at the apex thereof, a sound wave diffuser disposed centrally in front of said diaphragm, and means extending through the open apex of said diaphragm for supporting said sound wave diffuser free of the diaphragm and in a position to deflect the high frequency sound waves emanating from said diaphragm and thus reduce the beam effect produced when high frequency sound waves are reproduced by said diaphragm.
- 40 16. In a sound reproducing device of the electrodynamic type, the combination of an open apex conical diaphragm of the type having high and low frequency sound wave reproducing areas, a sound wave diffuser disposed centrally in front of the high frequency sound wave reproducing area of said diaphragm, and means extending through the open apex of said diaphragm for supporting said sound wave deflector free of the diaphragm and in a position to deflect the high frequency sound waves and thus reduce the beam effect produced by the high frequency sound wave reproducing area of said diaphragm.

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DISCLAIMER

2,115,924.—*Cecil Clair Fisher*, Fort Wayne, Ind. ACOUSTIC APPARATUS. Patent dated May 3, 1938. Disclaimer filed February 3, 1939, by the assignee, *The Magnavox Company, Incorporated*.

Hereby enters this disclaimer to claim 15 of said Letters Patent.
[*Official Gazette February 28, 1939.*]