Oct. 28, 1952 T. LINDENBERG ET AL 2,615,994

DIAPHRAGM FOR ELECTROSTATIC LOUD-SPEAKERS

Filed Dec. 14, 1948

2 SHEETS—SHEET 1

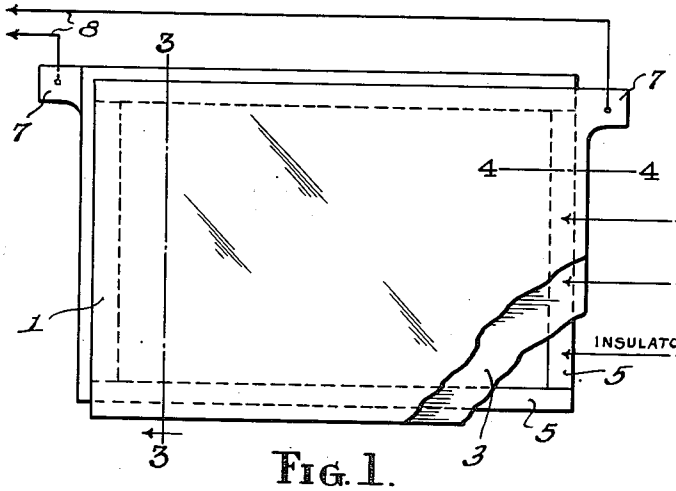


FIG. 1.

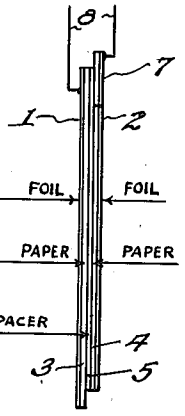


FIG. 2.

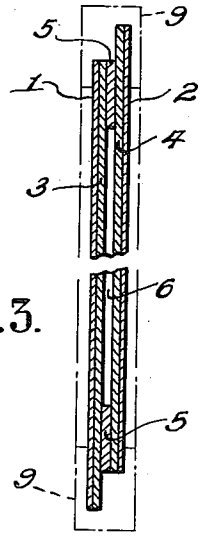


FIG. 3.

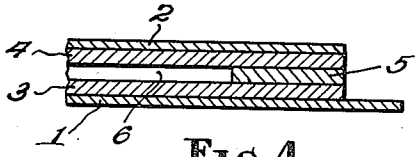


FIG. 4.

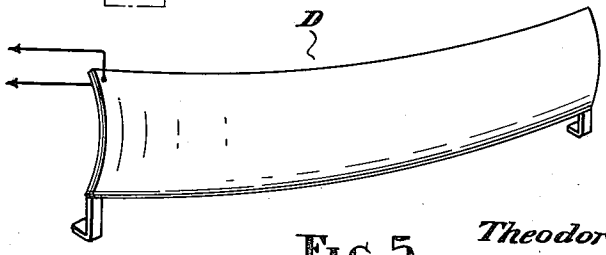


FIG. 5.

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DIAPHRAGM FOR ELECTROSTATIC LOUD-SPEAKERS

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2 SHEETS—SHEET 2

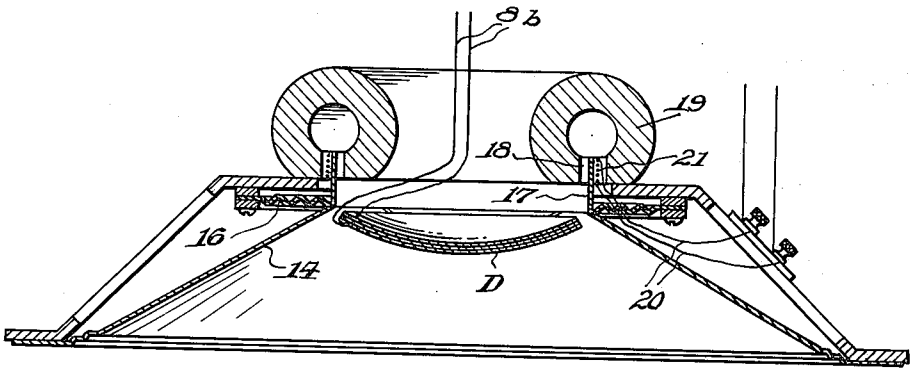


FIG. 6.

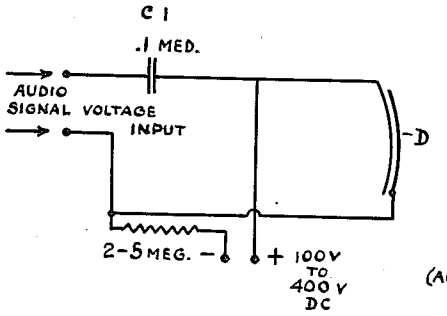


FIG. 7.

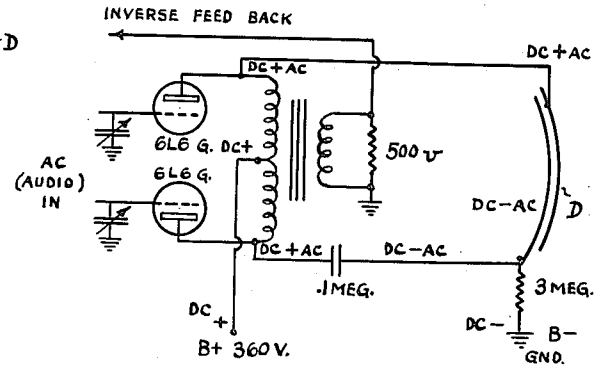


FIG. 8.

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UNITED STATES PATENT OFFICE

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DIAPHRAGM FOR ELECTROSTATIC LOUD-SPEAKERS

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Application December 14, 1948, Serial No. 65,236

3 Claims. (Cl. 179—111)

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The present invention relates to sound producers and reproducers, such as those used in radio reception, and has reference to the type known as electrostatic sound reproducers or loud speakers.

The ability to reproduce the higher tonal range of recorded or radio music is most difficult in the final electro-acoustic step of moving reasonable volumes of air in exact accord with the audio frequency input to the reproducer. It is known that the smaller, lighter and stiffer diaphragms are most efficient and produce the lowest distortion. The conventional loud speaker (a paper cone, driven from a coil at its apex) has evolved as the natural commercial design incorporating the above qualities.

This cone actually moves the body of air on both its sides, after the manner of a piston, for low frequencies, but at higher frequencies, the load of air upon it becomes too great and, under the driving force from the voice coil, the paper gives and the area of the cone moves in sections. This is known as "break up" and causes a loss of efficiency as less air is modulated. More important, distortion is introduced because listeners hear this breaking up as added harmonics, or partials, introduced by the paper along with the pure tone that, of course, is reduced in volume. This fact is known and it is customary in the construction of such loud speakers to put a few annular embossed rings in the cone paper as a partial control in minimizing the distortion.

The highest sound frequencies normally radiate only from the very center of the cone within a half inch or so of the voice coil, and are not only weak and distorted but are highly directional, that is, can be heard well only when the listener occupies the principal axis of the speaker.

Loud speakers or sound reproducers of this type start to introduce distortion above 1000 cycles per second and usually fall off rapidly in efficiency above 3000 cycles per second. Together with these losses, the distortion takes the form of a "papery" quality which modifies objectionably the reproduction.

The best commercially available loud speakers today, which are used for listening standards in broadcast and recording studios, operate on a different principle. The audio signal is divided and a specially designed speaker produces high frequencies only. The diaphragm thereof is made very small and light to gain efficiency and attempt to hold the piston action to a higher frequency before break-up occurs.

In one of such speakers, the high frequency

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cone is very small and is placed within the apex of the larger low-frequency speaker. In another commercially used speaker, the diaphragm is composed of thin sheet metal and is dome-shaped for stiffness. This dome-shaped diaphragm is quite small and is connected by an acoustic loading throat to a plurality of small exponential horns to achieve a non-directional effect by projecting the sound over considerable angular area. This arrangement has also been designed to occupy the center of a conventional low-frequency cone speaker; although in larger size, the nest of exponential horns is usually placed above a low-frequency baffle.

In these loud speakers, the attempts to reproduce accurately high frequency sound depend on translating the electromotive force of the voice coil to a body of air by means of stiff diaphragms. Such diaphragms must also be of negligible mass to prevent losses at high frequencies attributable to inertia. This compromise still leaves a gap between natural true reproduction and the original sound. The trained ear can distinguish easily between the metallic diaphragm and the paper cone when the speakers are concealed behind a thin curtain, and even the untrained ear objects, as it were, to such so-called "high fidelity," particularly when the speakers operate at high volume.

It is an object of the invention to provide an electrostatic or condenser-type loud speaker utilizing a flexible sheet-type diaphragm.

Another object of the invention is to provide an electrostatic loud speaker adapted for the true reproduction of the higher acoustic range, covering frequencies above 1000 cycles per second up to the upper limit of human audibility.

It is another object of the invention to provide an electrostatic loud speaker adapted to be employed as a supplement to existing loud speakers suitable for relatively low frequency sound reproduction, whereby to provide true tonal effects or characteristics throughout the entire range of frequencies audible to the human sense of hearing.

A further object is to provide an electrostatic loud speaker having a diaphragm especially adapted for the clear reproduction of sound found in the upper frequency spectrum and embodying thin sheets of a metallic foil separated by a thin flexible dielectric, such as paper or rubber.

Another object is to provide a loud speaker diaphragm of this character which is capable of being driven evenly and in phase over its entire area.

Still a further object is to provide a structurally simple and inexpensive diaphragm for electrostatic loud speakers which will generate undistorted acoustic output in the upper frequencies of audible sound and wherein the diaphragm comprises two thin flexible sheets of a metallic foil which are secured together and separated electrically by paper sheets arranged at their edges.

For a further understanding of the invention, including additional objects and advantages thereof, reference is to be had to the following description and the accompanying drawings, wherein:

Fig. 1 is a front elevational view of my improved sheet-type diaphragm for use in electrostatic loud speakers;

Fig. 2 is an edge elevational view thereof. In this figure, the thicknesses of the several parts of the diaphragm have been exaggerated for clarity of illustration.

Fig. 3 is a transverse vertical sectional view taken on the line 3—3 of Fig. 1;

Fig. 4 is a fragmentary detail horizontal sectional view taken on the line 4—4 of Fig. 1;

Fig. 5 is a perspective view disclosing my improved diaphragm in a somewhat curved arcuate state to widen the angles of sound propagation therefrom;

Fig. 6 is a transverse horizontal sectional view disclosing the manner in which my improved diaphragm, which is adapted for high frequency sound reproduction, may be incorporated in the cone diaphragm of a low frequency reproducer;

Fig. 7 is a wiring diagram showing one method of connecting the speaker of the present invention with an output circuit;

Fig. 8 is a similar view of another method of connecting the speaker of the present invention with an output circuit in which is involved a low-frequency sound reproducer.

Referring to the drawings, and especially Figs. 1 and 2 thereof, my improved diaphragm has been shown as being composed of thin capacitative sheet of metallic foil, as indicated at 1 and 2. In this regard, aluminum foil may be employed having a thickness of the order of .0002 of an inch, although other conducting materials may be employed in sheets of different thicknesses. The foil sheets 1 and 2 are flatly and adhesively mounted on paper backing sheets indicated at 3 and 4, and the adjoining surfaces of the sheets 3 and 4 are united and maintained in spaced relationship from each other by the employment of insulating spacer strips 5 around the edges only of the sheets. The latter produce an air chamber 6 between the capacitative sheets 3 and 4 to separate the latter primarily for damping purposes. These strips and sheets are adhesively joined together in fixed unitary relationship, providing a thin flexible diaphragm. If desired, the sheets 1 and 2 may be provided with laterally projecting tabs 7 for the attachment of conductor wires 8 of a circuit from which sound may be reproduced from electrical energy. Due to rapid differences in potential levels of the charges on the metallic sheets 1 and 2, and as induced into the material or surfaces of the paper dielectric sheets 3 and 4, the diaphragm will vibrate to produce sound. The vibrations are accurate facsimiles of the changes in potential and the noise normally parasitic upon the sound of the ordinary loud speaker when reproducing high frequencies is absent when our improved diaphragm is utilized. The diaphragm may be suitably supported by having its marginal edges disposed in a supporting frame indicated at 9.

The diaphragm is, of course, subject to certain variation. As shown in Fig. 5, our improved diaphragm, which is indicated in its entirety by the letter D, may be curved both longitudinally and transversely, whereby to widen its directional characteristics for room propagation of sound.

In Fig. 6, we have shown our improved diaphragm as being arranged in combination with a low frequency loud speaker. In this arrangement, the diaphragm D functions to reproduce high frequency sound, particularly sound above 1000 cycles per second, and is employed in conjunction with a low frequency cone 14 of conventional construction and operation. As shown, the combined loud speaker unit is provided with the usual rigid perforated outer cone ring, which carries a flexible annular suspension 16 for the apex region of the cone 14. The apex of the cone is formed with the conventional tubular extension 17 which is located in a circular slot 18 provided in an annular magnet 19. Circuit conductors are shown at 20 and these conductors lead to the voice coil 21 on the cone extension 17. It will be observed that the diaphragm D is disposed in the center at the front of the cone 14 and is stationarily mounted in any suitable manner in this position. Conductors 8b are disclosed as leading to the metallic plates or elements of the diaphragm D.

In the operation of the diaphragm D, it is desirable to permit only the frequency spectrum above 1000 cycles per second to enter the diaphragm. This may be accomplished by the circuit disclosed in Fig. 7 in which by reducing the fixed condenser 61 to a small value, or by filtering the low frequencies out in the amplifier used to drive the diaphragm, the latter will respond to the desired high frequencies. The wiring diagram of Fig. 7 is applicable to the diagram of Fig. 1, whereas in Fig. 8, a wiring diagram has been illustrated suitable for use in connection with the apparatus of Fig. 6 in which my improved high frequency sound reproducer is combined with a conventional sound reproducer of a relatively low-frequency type.

While we have herein described and shown various illustrative embodiments of the invention, it is to be understood that the latter is not limited thereto, but may comprehend other parts, details and arrangements of features without departing from the spirit of the invention.

We claim:

1. An electrostatic sound reproducer comprising a diaphragm embodying a pair of spaced flexible base sheets of dielectric composition, flexible metal foil plates directly applied to the outer surfaces only of said base sheets to form component parts thereof, and spacing strips of flexible material positioned between and uniting the marginal edge portions only of said base sheets, said spacing strips serving to physically separate said base sheets from each other and producing a shallow air chamber therebetween.

2. A composite diaphragm for electrostatic sound reproducers, comprising a pair of juxtaposed relatively spaced thin flexible base sheets of dielectric composition, correspondingly thin and flexible metal foil plates directly applied and adhesively secured to the outer surfaces only of said base sheets to form component parts thereof, and spacing strips positioned between and adhesively secured to the inner adjoining marginal

edge portions of said base sheets to unite the latter in assembled relationship and to form between said base sheets a shallow air chamber, the latter possessing a thickness corresponding with that of the spacing strips.

3. A composite sound-wave generating diaphragm for electrostatic sound reproducers, comprising a pair of parallel closely spaced relatively thin flexible base sheets of paper, correspondingly thin flexible metallic foil plates applied to the outer surfaces of said base sheets to form component synchronously flexing parts thereof, and flexible spacing means positioned between and uniting the inner adjoining marginal edge portions of said base sheets in a manner forming between said sheets a shallow air chamber.

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