

July 4, 1933.

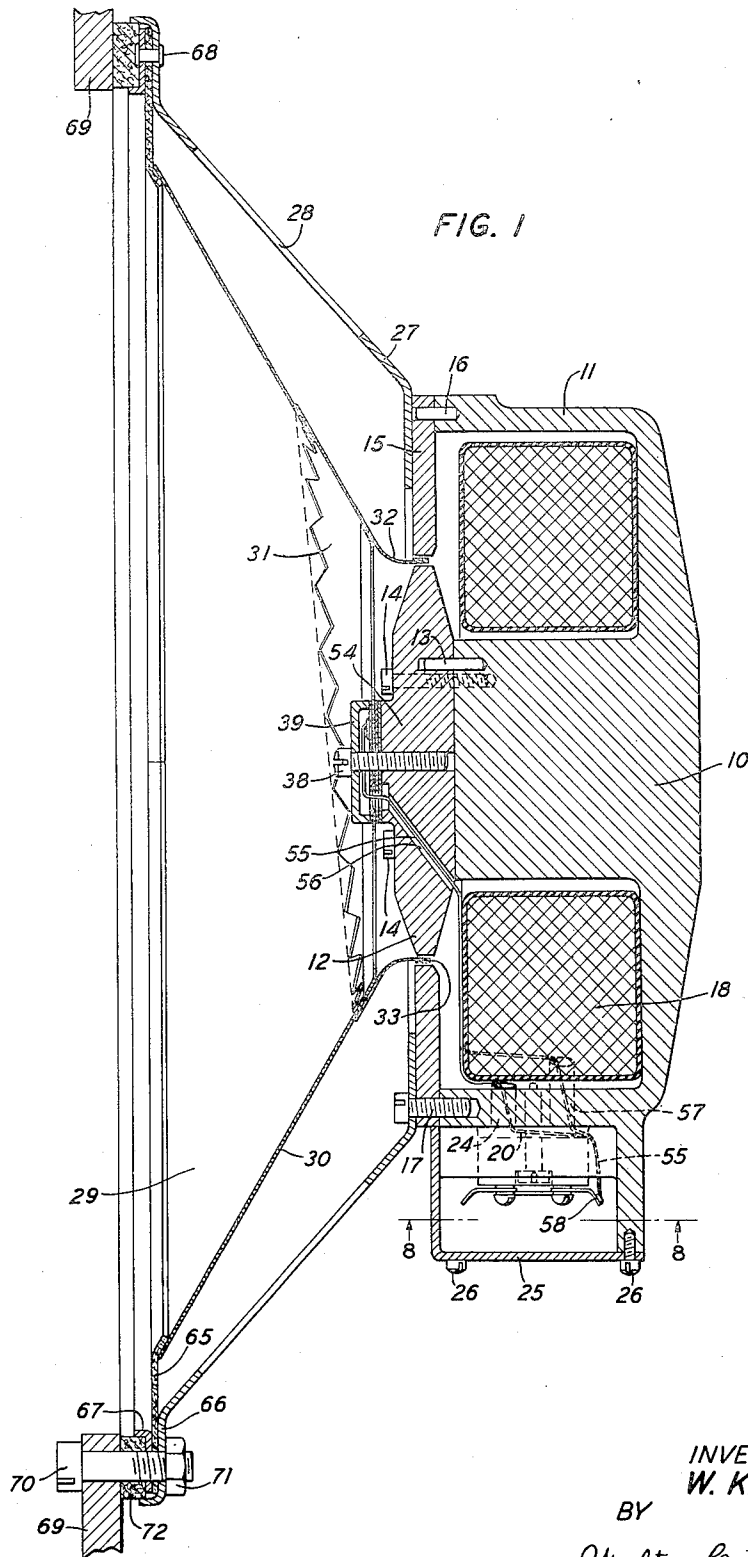
W. KALIN

1,916,223

SOUND TRANSLATING DEVICE

Filed Feb. 12, 1932

4 Sheets-Sheet 1



INVENTOR
W. KALIN
BY
Walter C. Kiesel
ATTORNEY

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W. KALIN

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4 Sheets-Sheet 2

FIG. 2

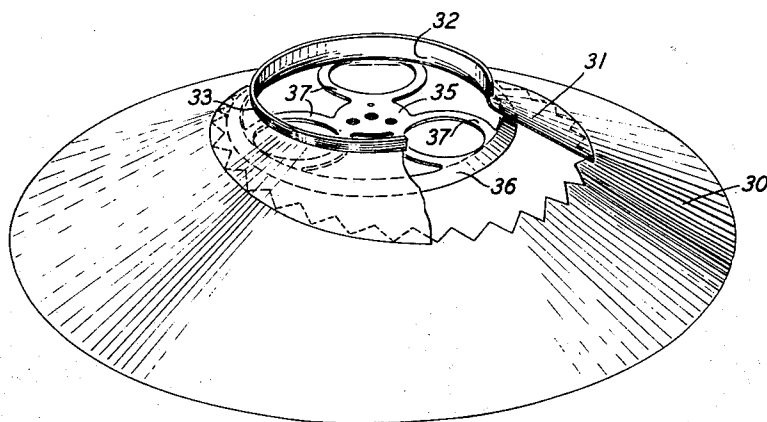
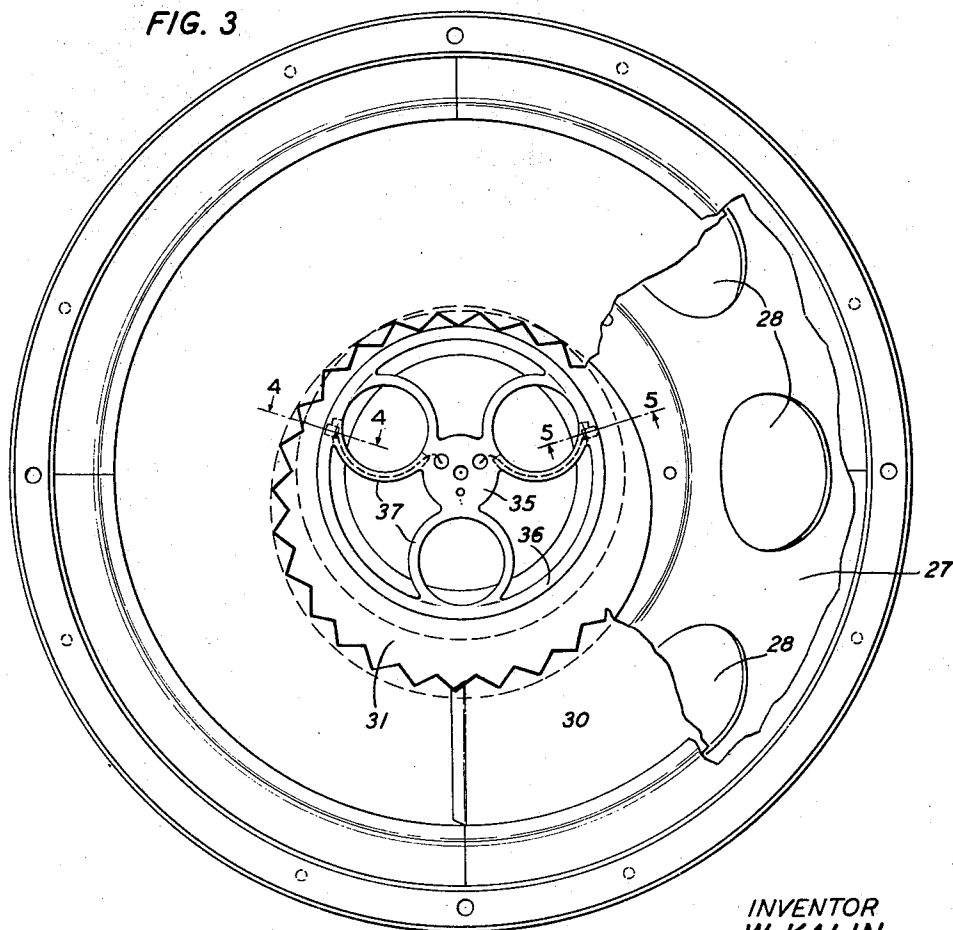


FIG. 3



INVENTOR
W. KALIN

BY

Walter C. Kiesel

ATTORNEY

July 4, 1933.

W. KALIN

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4 Sheets-Sheet 3

FIG. 4

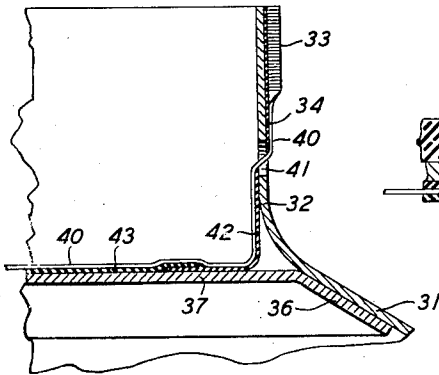


FIG. 6

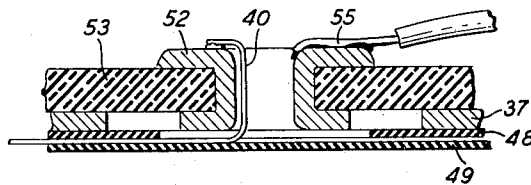


FIG. 7

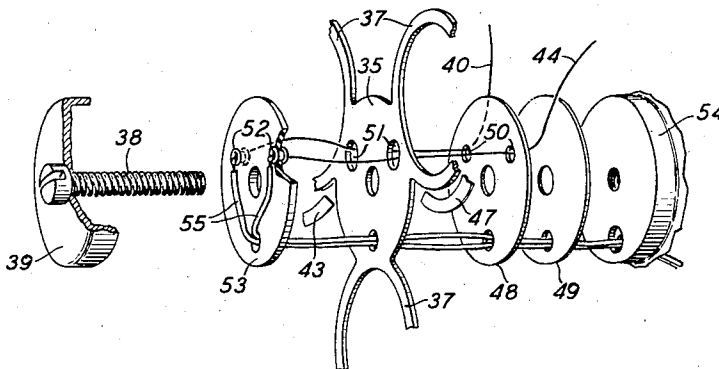


FIG. 5

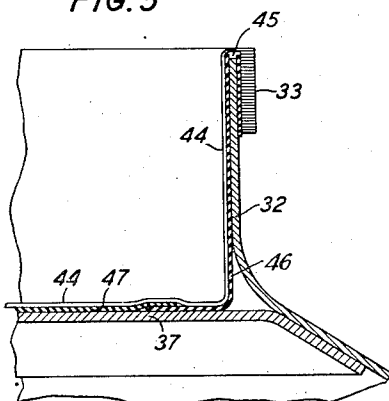
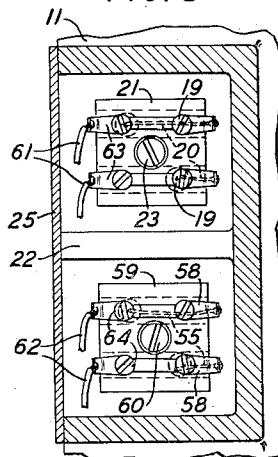


FIG. 8



INVENTOR
W. KALIN

BY

Walter C. Kiesel

ATTORNEY

July 4, 1933.

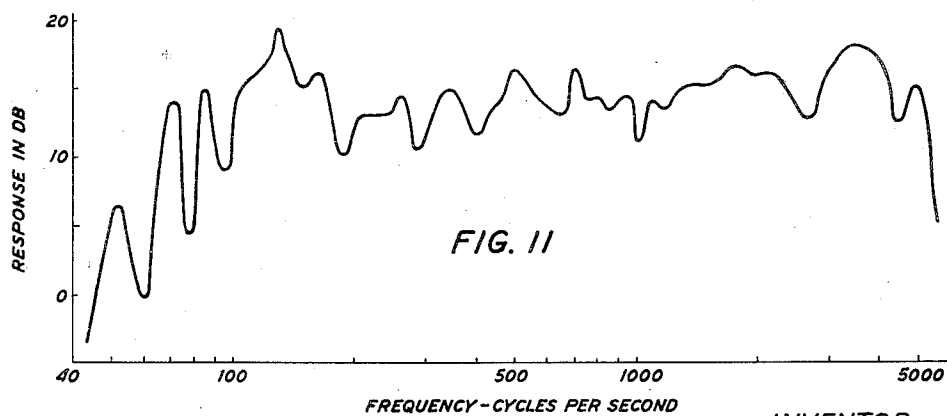
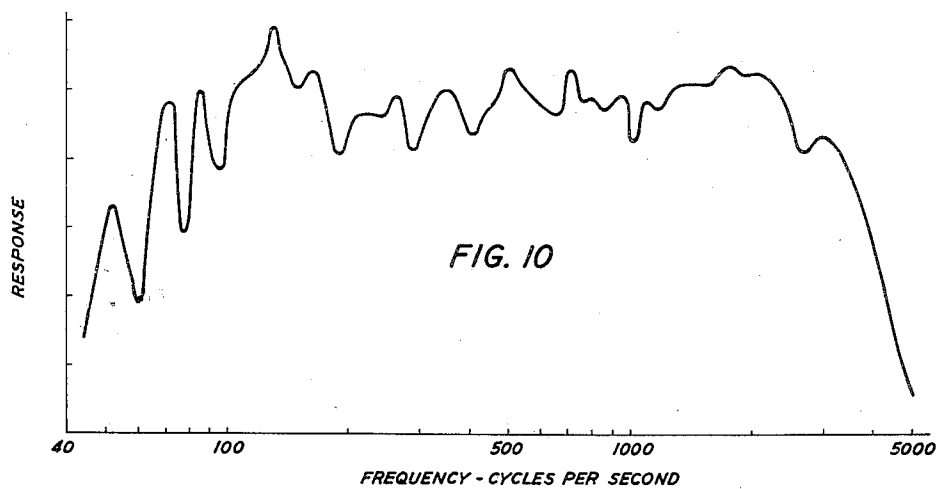
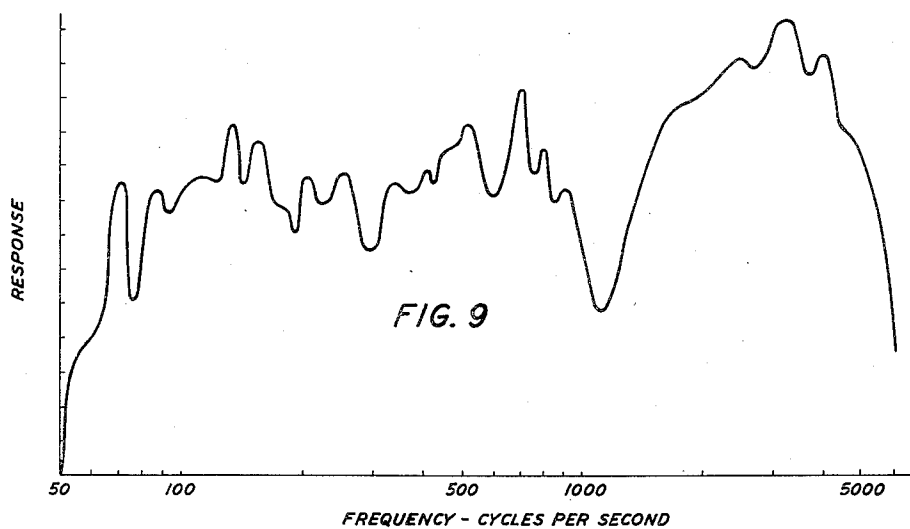
W. KALIN

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4 Sheets-Sheet 4



INVENTOR
W. KALIN

BY

Walter E. Kiesel

ATTORNEY

UNITED STATES PATENT OFFICE

WALTER KALIN, OF BROOKLYN, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SOUND TRANSLATING DEVICE

Application filed February 12, 1932. Serial No. 592,498.

This invention relates to sound translating devices and more particularly to such devices known as loud speakers and employing direct-acting diaphragms.

5 Large direct-acting diaphragms embodied in present day loud speakers are usually adapted to vibrate as a whole analogous to a piston over the lower portion of the audio-frequency spectrum, say up to about 800 or 1000 cycles. Above this frequency and throughout the upper portion of the audio-spectrum, these diaphragms break up and vibrate locally analogous to a wave transmission device. The character of the response, and hence the fidelity and uniformity with which speech and music are translated by a device embodying such diaphragms is dependent among other factors upon the manner in which the diaphragm breaks up at the higher frequencies.

10 In devices incorporating a large direct-acting single piece diaphragm, such as of paper and having a central angle of the order of 90°, the response is irregular and an objectionable peak is present at the higher frequencies. The undesirable irregularity and peak may be overcome to some extent by increasing the central angle of the diaphragm. However, so varying the angle materially decreases the range of frequencies which the diaphragm will reproduce satisfactorily, that is, a low upper cut-off effect is produced.

15 This cut-off effect and the resultant deficiency at the higher frequencies may be overcome in part by forming the diaphragm of several sections of different materials, one of which is particularly adapted to reproduce the higher frequencies. For example, a diaphragm may be composed of two joined right frusto-conical sections, one of paper and one of a suitable light-weight metal, such as duralumin, the latter of which is particularly effective at the higher frequencies. It has been found, however, that a diaphragm of such construction introduces subharmonics in the response, particularly at the higher power levels, with a resultant unfaithful reproduction of speech and music.

20 One object of this invention is to improve

the acoustic characteristics of diaphragms for sound translating devices, whereby sound energy may be translated efficiently and with fidelity over a wide range of frequencies.

25 In one embodiment of this invention a large direct-acting diaphragm comprises a plurality of obliquely truncated conoidal sections of different materials which are secured together at the oblique edges to form a right frustum of a conoid. The several sections may have different acoustic characteristics; for example, one section may be of paper and another section may be of a suitable lightweight metal, such as duralumin. The free edge of one of the sections is provided with an integral cylindrical flange which carries a driving coil for use in actuating the diaphragm, the coil and the flange being disposed within a conforming air gap in a magnet assembly.

30 In a diaphragm constructed in accordance with this invention the entire diaphragm, which is flexibly supported at its outer edge, is adapted to reproduce the lower frequencies of the audio-range, and one section is adapted particularly to reproduce the higher frequencies. The diaphragm vibrates as a whole analogous to a piston over a portion of the lower frequency range and breaks up to vibrate locally at the higher frequencies. The oblique truncation of the several sections provides a non-uniform radial transmission through the diaphragm along the elements thereof and insures desirable breaking up of the diaphragm whereby speech and music may be translated faithfully and efficiently over a large portion of the audio-frequency spectrum.

35 The invention will be understood more fully and clearly from the following detailed description with reference to the accompanying drawings in which:

40 Fig. 1 is a side elevational view in cross-section of a moving coil actuated loud speaker illustrating one embodiment of this invention;

45 Fig. 2 is a perspective view of the diaphragm of the loud speaker shown in Fig. 1, with a portion broken away to show the construction more clearly;

Fig. 3 is a front elevational view of the diaphragm and mounting therefor, with a portion of the diaphragm broken away to show the form of the mounting more clearly;

Figs. 4 and 5 are enlarged detail views in cross-section along lines 4—4 and 5—5 of Fig. 3 showing the association of the diaphragm, the driving coil therefor, and the driving coil leading-in wires;

10 Fig. 6 is an enlarged detail view in cross-section showing the manner in which the driving coil is associated with terminals therefor;

Fig. 7 is an exploded view showing the relation of the spider for supporting the diaphragm at one end and the mounting therefor, and the current supply wires for the driving coil, in the loud speaker shown in Fig. 1:

Fig. 8 is a detail view partly in cross-section of the external terminal and mounting assembly for the driving coil and for the field coil of the magnet; and

25 Figs. 9 and 10 show comparative response characteristics for loud speakers embodying diaphragms of forms known heretofore and Fig. 11 a response characteristic for a loud speaker embodying a diaphragm constructed in accordance with features of this invention.

30 In accordance with the features of this invention,
Referring now to the drawings, in one em-
bodiment of this invention the loud speaker
comprises a casting of magnetic material
having a central pole 10 and an outer pole 11
disposed about the pole 10. A circular pole
35 piece 12 is positioned on the central pole 10
by dowel pins 13, only one of which is shown,
and is secured in position by bolts 14 extend-
ing through the pole piece 12 and threaded
into the central pole 10. A pole piece 15
40 having a circular opening is concentrically
positioned about the pole piece 12 by dowel
pins 16, only one of which is shown, to form
a narrow annular air gap and is secured to the
outer pole 11 by a plurality of bolts 17
45 threaded into the pole 11. The dowel pins 13
and 16 accurately position the pole pieces 12
and 15 with respect to each other and insure
the proper relation thereof if the pole pieces
are removed and then replaced upon the poles
50 10 and 11; for example to allow repair or
replacement of a field or magnetizing coil 18,
which encircles the center pole 10. The coil
18 is electrically connected to terminals 19
by leading-in conductors 20. The terminals
55 19 are mounted upon an insulating block 21
which is disposed in a pocket or chamber
formed in the magnetic casting and divided
by a partition 22 and is secured to the outer
pole 11 by a single bolt 23. The conductors
60 20 extend through a bore 24 in the pole 11
and are connected to the terminals 19 as
shown more clearly in Fig. 8. The pocket in
which the terminal block 21 is disposed may
be closed by a plate 25 having a suitable aper-
65 ture therein for passage of leading-in wires

for the terminals, and secured to the casting by screws 26.

A dashed metallic member 27 having a plurality of spaced apertures 28, as shown more clearly in Fig. 3, is mounted upon the annular pole piece 15 by the bolts 17 and houses and supports a large direct-acting diaphragm 29, to be described in detail hereinafter. The area of the apertures 28 is preferably such that free outward and inward flow of the air adjacent the face of the diaphragm 29 contiguous with the member 27 is allowed so that substantially no air damping of the diaphragm 29 is effected.

The diaphragm 29, as shown more clearly in Fig. 2, comprises two obliquely truncated frusto-conical sections 30 and 31 which are suitably secured together, as by cement, at the oblique edges to form a right frustum of a cone. One of the sections, for example the section 30, as shown in Fig. 3 may have a serrated edge. Although but two sections are shown, it is of course to be understood that more than two sections may be used. It is desirable that the several sections of the diaphragm be of materials having different acoustic properties. For example, in the diaphragm shown in Figs. 1 and 2, the section 30 may be of paper and the section 31 may be of a suitable lightweight metal such as duralumin.

The section 31 is provided with a cylindrical flange 32 which may be integral therewith. The flange 32 extends into the air gap between the pole pieces 12 and 15 and carries a cylindrical driving coil 33. The driving coil 33, as shown more clearly in Figs. 4 and 5, may comprise a plurality of edge-wound turns of insulated metallic ribbon, such as disclosed in A. L. Thuras Patent 1,707,544, April 2, 1929 and is suitably attached, as by cementing to an insulating sleeve 34 secured to the flange 32.

The spider, which may be of a suitable lightweight, metal such as duralumin, includes a hub portion 35, an annular flange portion 36 which is secured to the section 31 of the diaphragm, and a plurality of flexible radially extending arcuate arms 37 connected to the hub and flange portions 35 and 36, respectively, and integral therewith. The spider is mounted upon the pole piece 12 by a bolt 38 extending through a metallic cap 39 and threaded into the pole piece 12 and accurately locates the driving coil 33 within the air gap between the pole pieces 12 and 15. The arcuate arms 37 are flexible radially of the spider so that the coil 33 may execute rectilinear movement within the air gap.

An extension 40 of the driving coil 33, as shown in Fig. 4, passes through an aperture 41 in the flange 32 and is secured as by cementing, to overlapping insulating strips 42 and 43 attached to the flange 32 and to one of the arms 37 of the spider. Another exten-

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sion 44 of the driving coil 33, as shown in Fig. 5, passes through a slot 45 in the flange 32 and is secured to overlapping insulating strips 46 and 47 likewise attached to the flange 32 and to one of the arms 37, respectively. The extensions 40 and 44 pass between insulating washers 48 and 49, as shown clearly in Fig. 7, and through corresponding apertures 50 and 51 in the washers 48 and hub 35, respectively, and are attached to terminal eyelets 52 mounted upon an insulating disc 53, which is seated upon the hub 35 of the spider. The disc 53, hub 35, and washers 48 and 49 are clamped as a unitary pile-up upon a raised hub 54 of the pole piece 12 by the cap 39 through the bolt 38.

Insulated leading-in conductors 55 are attached at one end to the eyelets 52 and pass through aligned apertures in the disc 53, hub 35 and washers 48 and 49, through an oblique bore 56 in the pole piece 12, and through a bore 57 in the pole 11. The conductors 55 are attached at their other ends to terminal clips 58 mounted upon an insulating block 59 secured to the pole 11 adjacent the partition 22 by a single bolt 60.

The driving coil 33 and field coil 18 may be connected in external circuits through conductors 61 and 62, respectively which are connected to terminal clips 63 and 64 associated with the terminals 19 and 58, respectively.

The circumferential edge of the section 30 of the diaphragm 29 is supported in the housing member 27 by an aperiodic annulus 65 of vibration absorbing material, such as felt, which is clamped between a peripheral flange 66 of the member 27 and a ring 67 by eyelets 68. The member 27 may be mounted on a baffle board or wall 69 by bolts and nuts 70 and 71, a sealing and buffer ring 72 of felt or the like being disposed between the clamping ring 67 and the baffle or wall 69.

The diaphragm is freely vibratile substantially as a whole in response to impulses produced by currents of speech and music frequencies flowing in the driving coil 33. The sections 30 and 31 of the diaphragm are effective for frequencies in the lower portion of the audio-frequency range, while the section 31 is particularly effective at the higher frequencies. Because of the oblique truncation of the sections 30 and 31 the time of propagation of waves along different radial elements of the diaphragm is unequal in contrast with a single piece diaphragm or one composed of joined right frustums of conoids. Furthermore, a diaphragm constructed in accordance with this invention is capable of effectively reproducing speech and music with uniformity and fidelity over a wide range of frequencies without the introduction of objectionable subharmonics.

Some of the features of a diaphragm constructed in accordance with this invention,

may be seen from a comparison of the curves shown in Figs. 9, 10 and 11. In Figs. 9 and 10 curves representing response characteristics for devices embodying diaphragms of substantially similar overall dimensions, but of different construction, are shown, the curves being plotted from data obtained by operating several of said diaphragms under substantially identical conditions.

The curve shown in Fig. 9 illustrates the response and frequency relation for a device embodying a large direct-acting frusto-conical diaphragm having a solid angle of approximately 90° formed of a single piece of paper and actuated at its smaller base. It will be seen that a pronounced peak occurs in the response at about 3000 cycles and that the response between approximately 1000 and 2000 cycles varies greatly from the mean response between 60 and 1000 cycles. It will be evident that a device having a characteristic of the general form shown in Fig. 9 will reproduce the frequencies in the upper portion of the audio-frequency range with greater effect than the lower frequencies and that an unfaithful and non-uniform transmission of speech and music will necessarily result.

Fig. 10 illustrates the response characteristic of a device embodying a diaphragm of a greater solid angle than that of the diaphragm of the device corresponding to Fig. 9. It will be seen that although the response curve shown in Fig. 10 is less irregular than that shown in Fig. 9, a sharp cut-off effect occurs at about 3000 cycles and that the diaphragm is satisfactorily effective only between about 60 and 3000 cycles.

Fig. 11 illustrates the response characteristic of a loud speaker of the general construction shown in Fig. 1, embodying a diaphragm in accordance with this invention. From this characteristic it will be evident that a very uniform response is obtained between substantially 60 and 5000 cycles and that the mean response for the upper portion of the translated range, say between 1000 and 5000 cycles is substantially equal to the mean response between say 60 and 1000 cycles. The mean attenuation between say 100 and 5000 cycles is substantially negligible and the maximum variation between 100 and 5000 cycles is less than 10 decibels. (The term "decibel" is a unit for expressing telephone transmission efficiencies and levels and is discussed and defined in an article entitled, "Decibel—The Name for the Transmission Unit" by W. H. Martin, Bell System Technical Journal for January 1929, page 1). A loud speaker incorporating a diaphragm constructed in accordance with this invention will, therefore, reproduce speech and music uniformly and with fidelity over a wide range of frequencies.

The acoustic characteristics of the diaphragm are dependent to some degree upon

the relative dimensions of the sections 30 and 31 and upon the angle of the frusto-cone. It has been found that a diaphragm having an angle of approximately 120° between diametrically opposite elements thereof, and in which the average major axis of the elliptical edges of the sections 30 and 31 is substantially one half the diameter of the base of the section 30 gives a particularly good response.

10 In a specific embodiment, the diaphragm 29 may have an overall height of $2\frac{3}{4}$ ", with bases of 4" and 12", the average major axis of the joined edges of the sections being approximately 6".

15 The mechanical motional resistance of the driving coil 33 and the mechanical impedance of the vibrating element, i. e. the diaphragm 29, driving coil 33, the spider, and the annulus 65, may be made substantially equal at a frequency in the lower portion of the audio range, whereby the diaphragm is substantially resistance-controlled at the lower frequencies and is substantially mass-controlled at the higher frequencies.

25 What is claimed is:

1. An acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges.

2. An acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges, said sections tapering in the same direction.

3. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges to form a right frustum of a conoid.

4. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated sections of circular cones, said sections being joined at the oblique edges to form a right frusto-cone having concentric bases.

5. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges to form a right frustum of a conoid; said sections having different acoustic characteristics.

6. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges to form a right frustum of a conoid, one of said sections being of paper, and another of said sections being of a lightweight metal.

7. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections secured together at the oblique edges to form a right frustum of a conoid, having concentric bases, the angle between diametrically opposed elements of said frustum being substantially 120° .

8. A large direct-acting acoustic dia-

phragm comprising a pair of obliquely truncated sections of right circular cones, said sections being joined at the oblique edges to form a right frustum of a right circular cone, the angle between diametrically opposite elements of said frustum being substantially 120° , one of said sections being of paper, and the other of said sections being of a lightweight metal, the mean major axis of the joined edges being substantially one half the diameter of the larger base of said frustum.

9. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges, one of said sections having a cylindrical flange extending from the free edge thereof for attachment to an actuating device.

10. A sound translating device including a large direct-acting diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges to form a frustum of a conoid, aperiodic mounting means secured to the base of said frustum, and actuating means attached to the other end of said frustum.

11. A sound translating device including a diaphragm comprising a plurality of obliquely truncated conoidal sections joined at the oblique edges to form a right frustum of a conoid, one end section having an integral cylindrical flange extending from the free edge thereof, actuating means secured to said flange, a support, and an aperiodic mounting member connecting the free edge of the other end section and said support.

12. A sound translating device comprising a large direct-acting diaphragm consisting of a pair of obliquely truncated sections of right circular cones, said sections being joined at the oblique edges to form a right frustum of a right circular cone, the larger of said sections being of paper and the other of said sections being of lightweight metal, said other section having an integral cylindrical flange extending from the free edge thereof, means for applying an actuating force to said flange, a support adjacent the larger base of said frustum, and an aperiodic annulus of vibration absorbing material connecting said support and said larger base.

13. A large direct-acting acoustic diaphragm comprising a plurality of obliquely truncated frusto-conoidal sections, said sections being joined at the oblique edges to form a continuous surface in which the stiffness along diametrically opposite elements is unequal.

14. A sound translating device including a large direct-acting diaphragm comprising a plurality of truncated sections of right cones, said sections being joined to form a right frustum of a right cone, in which the stiffness along diametrically opposite elements is unequal, means for applying an actu-

ating force to the smaller edge of said diaphragm, and aperiodic vibration absorbing means engaging the larger edge of said diaphragm.

- 5 15. An acoustic device including a large direct-acting diaphragm comprising a plurality of obliquely truncated frusto-conoidal sections joined at the oblique edges to form a right frustum of a conoid, means for supporting said diaphragm so that it is vibratile
10 substantially as a whole, actuating means connected to said diaphragm, the mechanical motional resistance at said actuating means and the mechanical impedance of said diaphragm and said means being substantially
15 equal at a frequency in the lower portion of the audio range, the acoustic characteristics of said sections being proportioned so that said diaphragm will reproduce sound energy
20 with substantially negligible mean attenuation between 100 and 5000 cycles.

16. A loud speaker including a large direct-acting diaphragm comprising a plurality of obliquely truncated frusto-conoidal sections joined at the oblique edges to form a right frustum of a conoid, said sections
70 being of materials having different mechanical and acoustic properties, means supporting said diaphragm so that it is vibratile as a whole, actuating means connected to one
75 end of said diaphragm, the mechanical motional resistance at said actuating means and the mechanical impedance of said diaphragm and said first means being substantially equal
80 at a frequency between 100 and 400 cycles, said diaphragm being adapted to propagate sound energy between 100 and 5000 cycles with a maximum variation less than ten decibels.

In witness whereof I hereunto subscribe my name this 11th day of February, 1932.
85 WALTER KALIN.

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