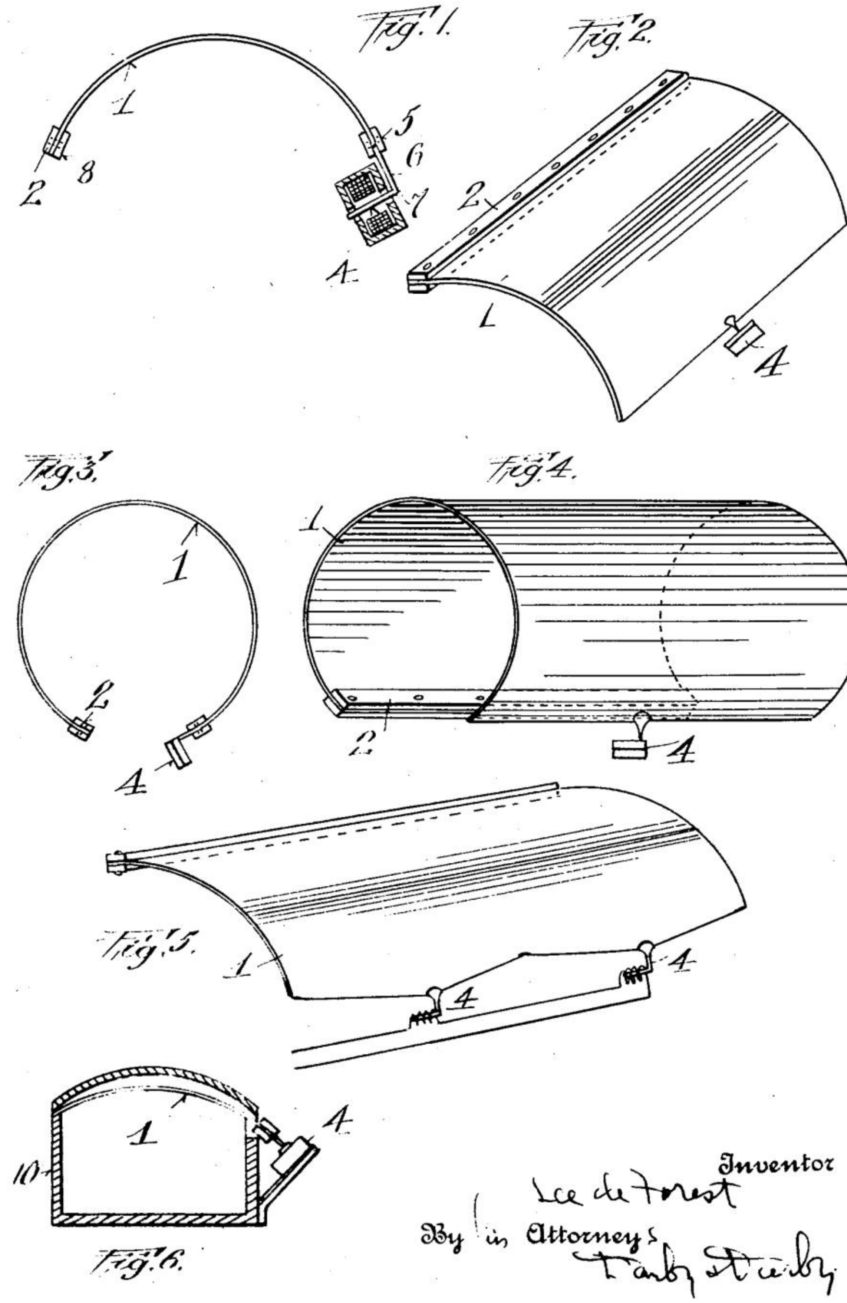
Les ancêtres du Janus-like

Nov. 3, 1925. **1,560,502**

L. DE FOREST

SOUND REPRODUCING DEVICE

Filed Jan. 15, 1925 **2 Sheets-Sheet 1**

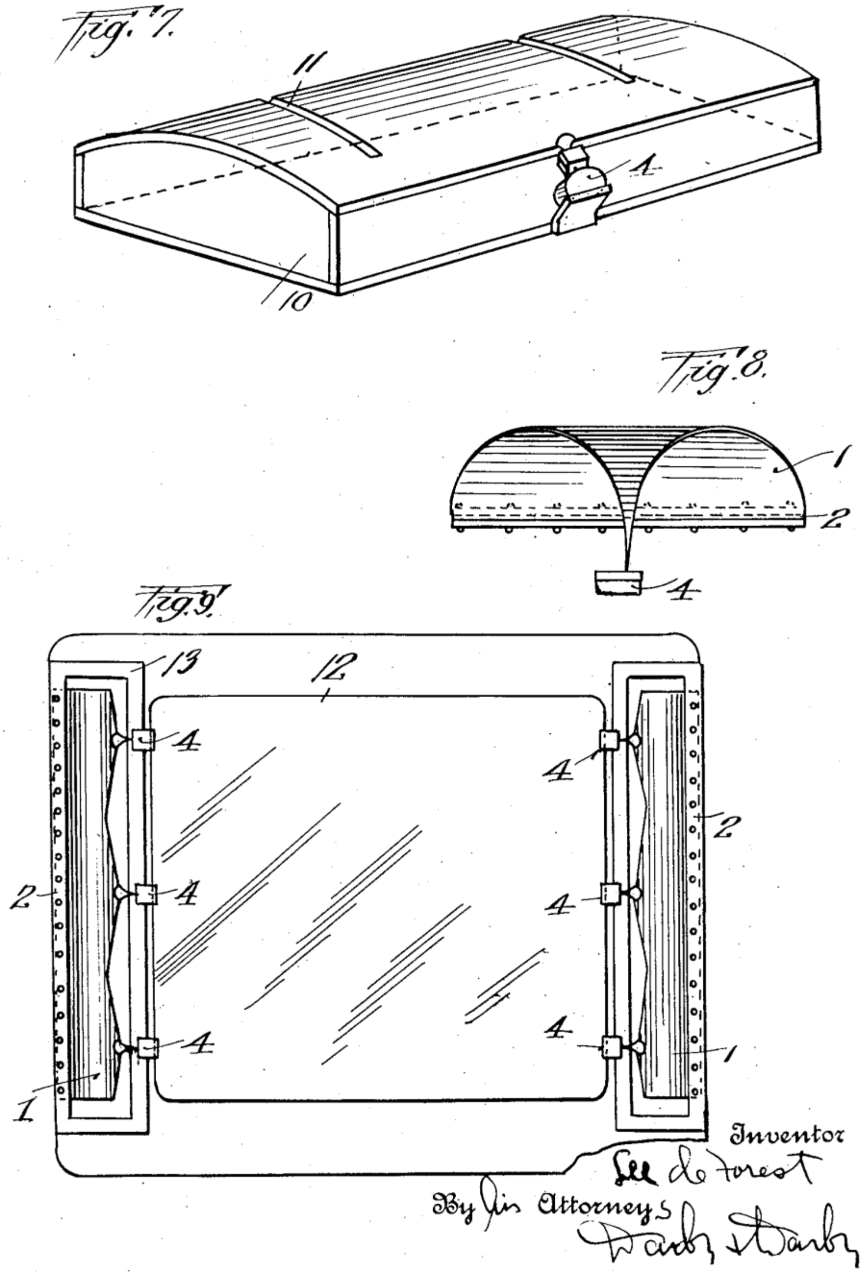


Nov. 3, 1925. 1,560,502

L. DE FOREST

SOUND REPRODUCING DEVICE

Filed Jan. 15, 1925 2 Sheets-Sheet 2



DESCRIPTION (Le texte OCR peut contenir des erreurs.)

Nov. 3, 1925.

L. DE FOREST SOUND REPRODUCING DEVICE Filed Jan. 15, 1925 2 Sheets-$heot 1 anoento \LK 1 $51 n Gum/mt a, LA w Nov. 3, 1925. 1,560,502

. L. DE FOREST 5 OUND REPRCDUC ING DEVICE Filed Jan. 15, 1925 2 Shoots-Sheet 2 Patented Nov. 3, 1925.

UNI-TED STATES PATENT OFFICE.

LEE m: FOREST, NEW YORK, N. Y.

SOUND-REPRODUCING- DEVICE.

Application filed January 15, 1925. Serial No. 2,548.

To all whom it may concern:

Be it known that I,,Lnn on Fonns'r, a citizen of the United States, residing at New York, in the county and State of New York, have made a certain new and useful Invenspeakers, radio receiving sets, etc., and has for its principal object the production of a'simple, efiicient and economical unit for the reproduction of sound'waves from an electrical or similar type'of source.

A further object of the invention is to provide a unit of this character which, due to its simplicity of construction, affords an exceptionally advantageous commercial device for the uses hereinabove set forth.-

A further object of the invention is to provide a device of this character wherein faithful reproduction of speech, music or other sounds, is secured with maximum volume and clarity and minimum distortion.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative arrangement of parts, all as will be more fully hereinafter set forth, as shown by the accompanying drawings and finally pointed out in the appended claims.

Referring to the drawings: Figure l is a view in side elevation of a sound reproducing device embodying my lll' ther modification as applied to a motionpicture screen. 7 I

. The same part is designated by the same reference character wherever it occurs throughout the several views.

I have discovered that if vibratlons occasioned by sound are imparted to the marginal edges or corner of a substantially rigid membrane and in the direction of the plane thereof, exceptionally clear, loud, distortionless and accurate sound wave reproduction is obtained and, in essence, this is what constitutes, in its broadest scope, the subject-mattor of my present invention.

While I have shown and will now describe my invention as applied to an electrically actuated sound reproduction device, I do notwish it to be limited or restricted thereto as this form of sound reproducer has been selected solely for the purpose of illustration.

The principle may be equally advantageousof in any suitable manner; for example, by

means of a clamp 2. he membrane is flexed and preferably maintainedunder tension. A sound reproducing devicein the form shown, an electrical telephone receiver of the balanced armature typeis diagrammatically illustrated at 4, with the armature thereof adapted to bear against the marginal edge of the membrane 1 in any *suitable manner. In the arrangement selected for illustration, I employ a yoke 5 adapted to fit on opposite sides of the marginal edge of the membrane 1, which affords a connection between the mechanical link 6 and the end of the armature 7 of the reproducer. The opposite edge of the device may be secured in any desired manner; e. g., and as shown, by means of two clamping members 2 and 8, or it may be flexibly supported on rubber or string lacings, or held between soft clamps of rubber, felt, or other yielding material.

I do not desire to be limited or restricted to any particular material employed for the membrane 1, as it may consist of cardboard, parchment, fiber board, paper, sheet metal,

and in fact, may be of any material which membrane is rectangular; or as s own in Figs. 5 and 9, it may be of modified rectangular shape; or as shown in Fig. 8 it may be of triangular shape. I therefore wish it to be understood that the shape of the mem brane may be of any geometrical shape,

as it may be ofconstant thickness, or gradually increasing or decreasing thickness, or of irregular thickness; all in accordance with the particular design and the use to which the device is to be put. Also, it may obe ribbed or corrugated. Likewise, I do not desire to be limited or restricted to the degree of flexiure or the geometrical degree of curvature imparted to the membrane. For. example, it may be slightly flexed, as shown in Figs. 1 and 2; or it ,may be substantially cylindrical, as shown in Figs. 3 and 4; or it may be flexed as shown in Figs. 5, 6 and 7; or in a spiral formation, the fundamental feature being that the mechanical sound reproducing vibration is imparted to the n1ar-- ginal edge of the membrane, preferably in the plane of the membrane at that point, or tangentially thereto.

Likewise, I do not desire to be limited or restricted to the point of application of the sound record reproductions on the membrane. As shown in Figs. 1 and 2, these may be imparted at the approximate center thereof; or they may be imparted, as in the case of Fig. 8, at the apex of the triangle; or a pluralityof sound reproducing devices may be connected, either in series or parallel, and applied at different pointson the marginal edge of the membrane 1, as shown in Figs. 5 and 9'.

Likewise, if desired, the membrane may be encased, as illustrated in Figs. 6 and 7 with the' sound reproducingdevice 4 applied to the marginal edge thereof, as shown. In such instance, I prefer to provide the case 10 with one or more slots 11 to allow the sound waves caused by the vibration of the membrane 1 to escape therefrom. The-casmg acts like a sounding box or board, to

. enhance the, vibrations of the air therein contained.

In Fig. 9 I have shown a simple application of the invention to a motion picture screen for special adaptation to talking mo-v tion pictures. The motion picture screen is illustrated at 12, and on both sides thereof I mount a frame 13, the frame in this instance serving as a clamp 2 for one edge of the membrane, and the sound reproducing device 4 operating on the marginal edge of the membrane-1 as hereinbefore described.

Many other modifications and chan es in details of construction,- shape, size an material, as well as applications of the invention, will readily occur to those skilled in the art without departing from the spirit and scope of my invention as defined in theappended claims. Therefore, what I claim as new and useful, of my own invention,

and desire to secure by Letters Patent is:

1. A sound reproducing device comprising a membrane and a. sound reproducing member attached tangentially thereto to im part vibrations tangentially to the plane thereof. Y

2. A. sound reproducing device comprising a membrane and a sound reproducing member attached tangentially thereto to impart vibrations to the marginal edge thereof.

3. A sound reproducing device comprising a flexed membrane and a sound repro-' ducing member attached tangentially to the marginal edge thereof.

4. A sound reproducing device comprising a membrane flexed to form a portion of a cylinder and a sound reproducing member attached tangentially to the marginal edge thereof. 3 i

5. A sound reproducing device comprising a membrane flexed to. form a portion of. a cylinder and a sound reproducing member attached tangentially thereto to impart Vibrationstangentially to the plane thereof. I

6. A sound reproducing device comprising a membrane fixed at at least one edge thereof, and a sound reproducing member attached tangentially to the marginal edgethereof. v

7. A sound reproducing device compris-' ing a membrane fixed at at least'one edge thereof, and a sound reproducing memberattached tangentially thereto to impart vibrations tangentially to the .plane thereof.

8. A sound reproducing device comprising a membrane fixed at at least one edge thereof and flexed to form a portion of a cylinder, and a sound reproducing member attached tangentially to the marginal edge thereof.

9. A sound reproducing 'device comprising a membrane fixed at at least one edge thereof and flexed to form a portion of a cylinder, and a sound reproducing member attached tangentially thereto to impart vibrations tangentiallyto the .plane thereof.

10. A sound reproducing device comprising a membrane and an electro-magnetically operated sound reproducing member at-. tached tangentially to the marginal edge thereof.

11. A sound reproducing device comprising a membrane and an electro-magnetically operated sound reproducing member attached tangentially thereto to impart vibrations tangentially to the plane thereof.

12. A sound re roducing device eompris-- ing a flexed gnem rane and an electro-magnetically operated sound reproducing member attached tangentially to the marginal edge thereof.

13. A sound reproducing device comprising a flexed membrane and an electro-magnetically operated sound reproducing member attached tangentially-thereto to impart vibrations tangentially to the plane thereof.

14. A sound reproducing device comprising a membrane and a sound reproducing member attached tangentially to the marginal edge thereof, and a f ame for supportmg and membrane and member.

15. A sound reproducing device comprising-a membrane and a sound reproducing member attached tangentially to thema'rginal edge thereof, and a frame for supporting said membrane and member, said frame also serving to act as a sounding board to reinforce the air vibrations set up by the membrane.

16. A sound reproducing device comprising a flexed membrane and asound reproducing member attached tangentially there'- to to impart vibrations tangentially to the plane'thereof, and a frame for supporting said membrane and member.

17. Asound reproducing device comprising a flexed membrane and a sound reproducing member attached tangentially thereto to impart vibrations tangentially to the plane thereof, and a frame for supporting said membrane and member, said frame also serving to act as a sounding board to reinforce the air vibrations set up by the membrane.

' 18. A sound reproducing device comprising a membrane fixed at at least one edge thereof and a sound reproducing member attached tangentially to the marginal edge thereof, and a frame for supporting said membrane and member, said frame also serving to act as a sounding board to reinforce the air vibrations set up by the membrane.

19. A sound reproducing device com rising a flexed membrane fixed at at east one edge thereof, and a sound reproducing member attached tangentially to the marginal edge thereof, and porting said membrane and member.

20. A sound reproducing device comprising a flexed membrane fixed at at least one edge thereof, and a sound reproducing member attached tangentially to the marginal edge thereof, and a frame for supporting said membrane and member, said frame also serving to act as a sounding board to reinforce the air vibrations set up by the membrane.

In testimony I have hereunto set my hand on this 12th day of January A. 1)., 1925.

LEE DE. FOREST.

a frame for sup-

RÉFÉRENCÉ PAR

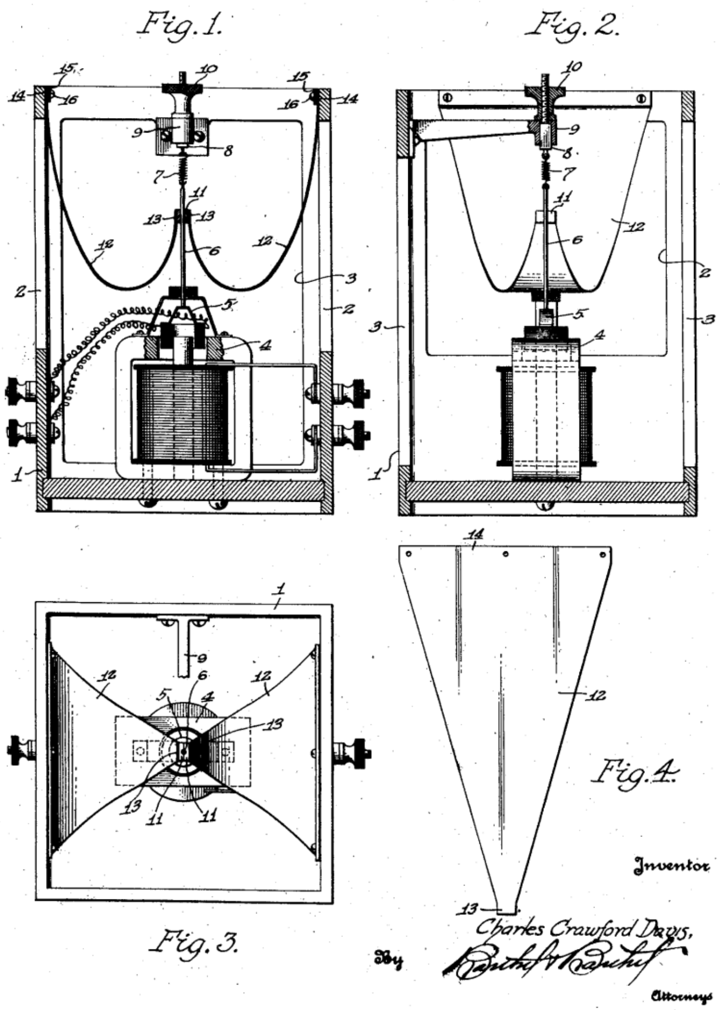
Brevet citant	Date de dépôt	Date de publication	Déposant	Titre
US3107746 *	29 avr. 1960	22 oct. 1963	Richard Namon	Speaker design
US3239029 *	19 août 1963	8 mars 1966	Richard Namon	Speaker design
US4700396 *	11 juil. 1984	13 oct. 1987	Bolin Gustav G A	Sound-wave receiving appliance
US4903308 *	10 févr. 1988	20 févr. 1990	Linaeum Corporation	Audio transducer with controlled flexibility diaphragm
US5198624 *	14 nov. 1989	30 mars 1993	Linaeum Corporation	Audio transducer with controlled flexibility diaphragm

Brevet citant	Date de dépôt	Date de publication	Déposant	Titre
US6061461 *	8 mai 1998	9 mai 2000	Paddock; Paul W.	Audio transducer
WO2002056636A2 *	14 janv. 2002	18 juil. 2002	Paddock Paul W	Loudspeaker transducer

* Cité par l'examinateur

Aug. 9 1927. 1.638,245
C. C. DAVIS LOUD SPEAKER Filed Ju1.v1' 7. 1925 Panarea Aug. 9, 1927.
CHARLES onawroan Davis, Aor rENToN, `iiirciazelusr.
ECE.y
LOUD arianna.
'y Application filed July 17, 192,5.- Serial No. 44,207.

Aug. 9, 1927. C. C. DAVIS **1.638,245**
LOUD SPEAKER
Filed July 17, 1925



DESCRIPTION (Le texte OCR peut contenir des erreurs.)

This/'inventionfrelates to devices for the reproduction of sound and more particularly loud speakers such as are used in connection Withvradioreceivers wherein it is desirable that quality of tone-should be preserved to the exclusion of noises or vibrations tending to interfere with the'proper reproduction of sound, and especially is it desirable that such reproducers or loud speakers be free from periods of resonance such as will Iresult in the setting up of sympathetic vibrations in the material of the reproducing medium or diaphragm which will be of an audible degree or frequency and consequently, be the cause of objectionable distortion of or interference, with the required sound reproduction.

AIt is, therefore, the object of this invention to produce a diaphragm construction which will practically eliminate the aforesaid 'ob-v jectionable features hitherto so common in sound amplifyingforms'for loud speakers in a very simple and highly eiiicient manner', the

said invention further aiming to provide a diaphragm wherein vibrations impressed thereon will be truly reproduced, and where in there will be no point of resonance which would set up a sympathetic vibration of high p enough frequency to produce an audible sound, so that the only sounds produced by thediaphragm would be those resulting from the actual vibrations impressed upon the diaphragm.

' The said inventionfurther contemplates the impressing of vibrations on a diaphragm wherein tension as ordinarily provided is avoided, and wherein the vibrations are impressed upon the diaphragm in a direction parallel thereto instead of at right angles to the plane of the diaphragm as has been hitherto the common practice; and a still i further object of the said invention is to provide for the suspending ofy a diaphragm from opposite edges so that it assumes the form of a depending loop or U-shape, upon one (end of which the vibrations to be reproduced are impressed in the direction of of the diaphragm. ,Y

Still furtherobjects subsidiary to orme'- sulting from the aforesaidobjects, or :fromI the construction or operation of the invention as it may be carried into effect, will become apparent as the said invention is' ,o hereinafter further disclosed.

In carryin the said invention into eiect,

I may provi e within a suitable framework the length or housing a suspended needle or rodA adapted vto be vibrated in the direction of its length by means'of a suitable vibration reproducing unit, and one or m.ore diaphra s of fairly stiif paper or similar materia attached at one end to an abutment carried bythe saidv vibratory ro'd, and at the other end to a suitable `support such as the said housing, the

`said diaphragme being of. substantial area and of greaterlength than the distance between their points of attachment to the said support andl to the said abutment, so that sin a direction extending therealong.

Figure I is a sectional elevation/of a loud speaker embodying the said invention-g Figure 21sl a1 sectional elevation ofthe same, the section being taken lat rightanglesv to that- *shown in Figure 1;

lliigure 3 isda plan 011:"J tigsam, plzirt of the v1 ra or ro su or in ro en awa for the graka of el)p y Figure 4 is a detail view of one of the diasphragms detached, and in a ilat condition.

imilar Acharacters of reference findicate similar-parts in the several figures of the drawln l1in icates a box or framework which may have openings 2 and'3 provided at the sides thereof to permit greater `freedom of passage of sound waves for the diaphragms and 4 is a loud speaker unit, the details of which are not described herein, as it is of a ent types of units may be utilized, the par-` ticular form of vunit not being essential to the invention. The said unit has a vibrato member '5 to which is connected a vertical] disposed vvibratory rod for needle 6 which is suspended byV a spring 7 at its 'iupperend from an adjustable member 8 carried by a support 9'which extends from one side of the .framework v1, v10 `being a nut for effect ing the adjustment `of the said member 8. The spring 7 is of course of suchA a nature arity of i ustration; and

ice

that it does not itself have a resonant point tending to producean audible sound when the device is in operation. r

Securely mounted on the rod 6 is an abutment 11 comprising a air of small blocks y of wood or other suita le material, and 12 are diaphragme in the form of triangular pieces of stiff paper or other suitable material capable of vibrating in the desired manner, the smaller ends 13 of these diaphragms being secured to the outer vertical faces of the abutment 11 on opposite sides of the rod 6, and the broad ends 14 of the said diaphragms being secured such as by binding strips 15 and screws 16 to the upper inner margins of the framework 1.

These diaphragme are of substantially greater length than the distance between their points of attachment to the framework 1, and the abutment 11, so that they are bowed or looped' downwardly as a consequence of which the inner ends 13 of the said diaphragms extend upwardly in a direction approaching parallelism with the axis of said rod 6, so that longitudinal vibration of the said rod as a result of the action of the vibratory unit will cause the abutment'll to impress such vibration upon the ends 13 of the diaphragms 12 in a vertical direction, which 1s of course the direc tion of the disposition of such ends of the diaphragms. This is. contrary to the usual method of impressing vibrations upon a diaphragm, the common practice being to im-l press such vibrationslupon-a diaphragm at right angles or at a substantiall angle to its plane. n

In the presentinstance, the inner ends of the diaphragm are exerting to some extent ay downward ull on the abutment 11 in the direction of) the length of the -dia h'ragm at the point of its attachment, so that the vibrations may be said to be impressed upon such diaphragm in such direction and they are transmitted through said 'a hragm from their inner ends and set up vi ratory motions in the diaphragm corresponding thereto without setting up resonant, vibrations of yan audible nature which would otherwise distort'and reduce the quality of the sound reproduced by such diaphragms.

1,ess,24s

The invention is not limited to the number of diaphragms which may be utilized, as it will be obvlous that these may be varied to 4suit requirements or desirability.

The provision for adjustment of the rod 6 is of course optional and may in many cases not be utilized especially where the vibratory unit 4 is of such nature that no such adjustment isrequired, but in many cases the adjustment of the vibratory element 5 is desirable, and it may be effected in the suggested manner.

The hanging nature Vof the diaphragme overcomes the tendency so strongly presentv thereon other than that resulting from their own weight, and it is found that a loud speaker constructed in the manner described will reproduce both high and low notes without distortion4 and with great fidelity.

This invention may be developed within the scope of the following claim without departing from theessential features of the said invention, and it is desired that the specification and drawing be read as merely villustrative and not in a limiting sense, ex-

cept as-necessitated by the vprior art.

What I claim is In a sound reproducing device, a daphragm support, a vibratory member, means resiliently supporting said vibratory member, means for effecting the vibration of said member, and a diaphragm suspended from opposite ends from said support and said vibratory rod.

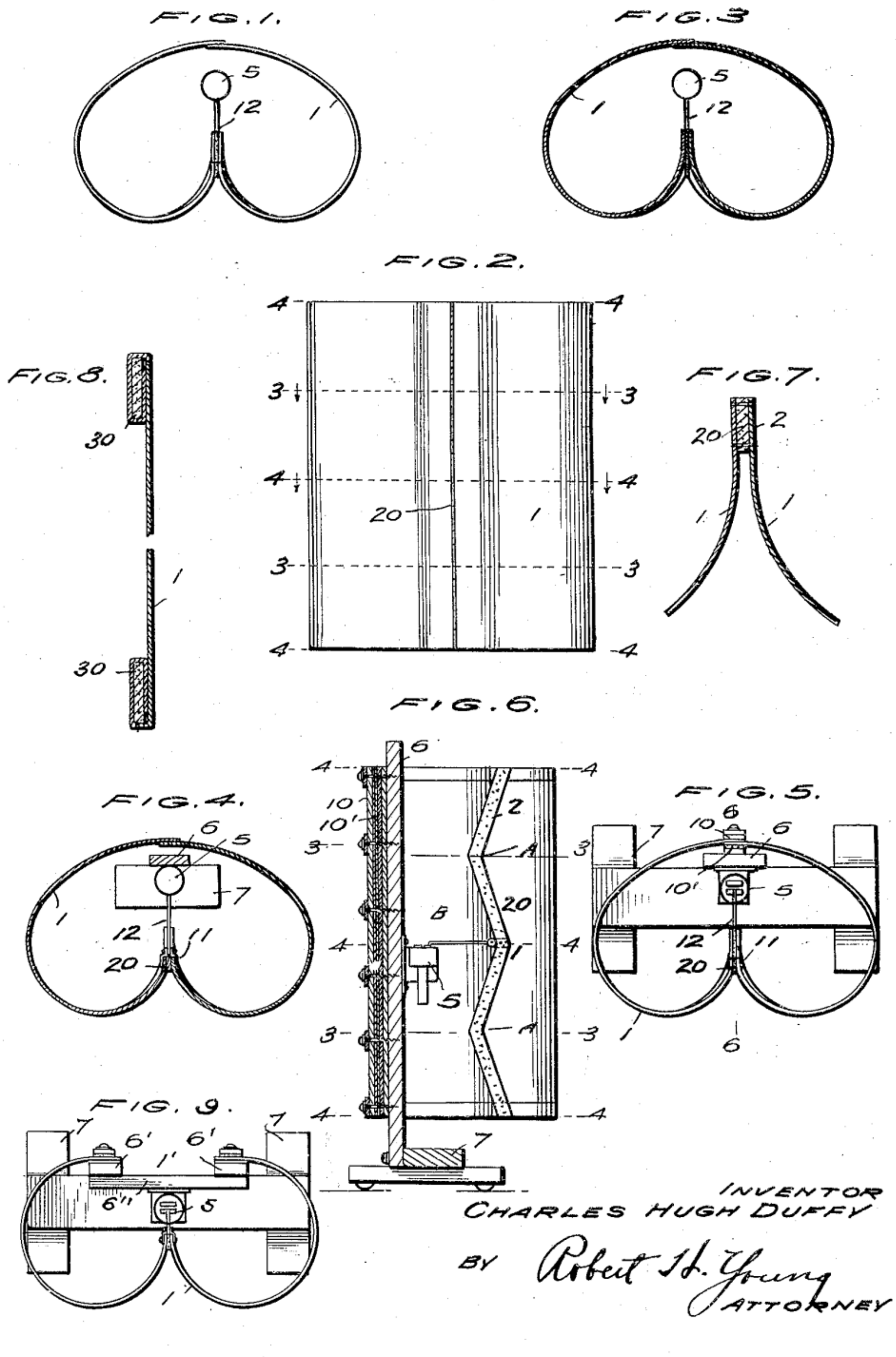
In testimony whereof I aix my signature.

CHARLES CRAWFORD Davis

Jan. 13, 1931. C. H. DUFFY 1,788,385

SOUND AMPLIFIER

Filed April 8, 1929



INVENTOR
CHARLES HUGH DUFFY
BY Robert H. Young
ATTORNEY

DESCRIPTION (Le texte OCR peut contenir des erreurs.)

C. H. DUFFY SOUND AMPLIFIER Jan. 13, 1931.

Filed April 8, 1929 //v://v To CHAAPL E 8 Has 0 urp/ Arr-o NE) horizontal cross member 6 which connects the two vertical supports 6 provides the mounting for the actuating motor 5, and stiffens the structure.

A suitable connecting clip 11 is employed to connect the diaphragm with the driving pin 12 of the actuating motor 5.

While the driving pin 12 of the actuating unit 5 lies tangential to the meeting edges 2 of the diaphragm 1 at the exterior angles A thereof, as will appear from the cross section illustrated in Figure 3, I prefer to connect the said driving pin 12 to the diaphragm 1 at the point or apex of the interior angle B, at which point the driving pin 12 does not lie tangentially to the meeting edges 2 of the diaphragm, as will appear from Figure 1, which shows a cross section through the diaphragm on a line with said interior angle 13. By this construction, when the diaphragm is flexed into its modified cylindrical formation, it is retained in such formation at three points along the meeting edges 2 of the diaphragm. These three points are located'at the interior angle B and at the juncture of the sheets of the diaphragm at their upper and lower edges. These three points resist the natural tendency of the flexed diaphragm toassume a simple cylindrical formation. Therefore, the greatest tension on the diaphragm is on the line of the interior angle B and on the lines of the upper and lower edges of the diaphragm, while areas of less tension exist on the lines of the exterior angles A. I therefore prefer to connect the driving pin at the interior angle B which is. at the central area of the greatest tension on the diaphragm so that the impulses from the actuating motor are imparted to the diaphragm at this central area of greatest tension to cause the diaphragm to respond more perfectly to the impulses imparted to it through the driving pin. lVhile this shaping of the meeting edges 2 as shown in Fig. 6, produces a very satisfactory diaphragm, the same may be otherwise shaped so that the point of connection with the driving pin may be tangential to the two curves formed by the diaphragm.

lVith particular reference now to Figures 7 and 8, it will be seen that between the forward meeting .edges 2 of the diaphragm, 1 interpose a layer 20 of sound damping material such as felt or the like, and prefer to stitch .or otherwise secure, the said edges and felt together so that the two sections forming the diaphragm are incapable of touching each other and thus create a rattle when the diaphragm is in a state of vibration.

When a diaphragm is made of two pieces of material which are connected together at their meeting edges, there is a tendency for the portions of the diaphragm at the meeting edges to strike against each other and produce a rattle which ruins the reproduction. This is because when in operation both sections of the diaphragm are vibrating, and when'the amplitude of the vibrations are sufficient to cause the meeting edge portions to strike each other, a rattling results.

In order to overcome this disadvantage the meeting edges of the diaphragm sections are spaced apart and preferably a soft material such as a layer of felt or the like is interposed as shown in Fig. 7 This insures that the two sections of the diaphragm vibrate independently in the sense that the vibrations of one section are not imparted to the other section and no rattling results. I

It is likewise to be seen fromFigure 8 that at the top and bottom edges of the diaphragm, I prefer to encase a strip 30 of sound damping material such aselastic webbing, felt or the like and to stitch, or otherwise secure, the same in position as shown. An additional purpose served by this latter construction is to stiffen the edges of the diaphragm. The result is a complete damping out of any rattling at the edges of the diaphragm and a more perfect reproduction of low frequencies which usually create the harsh and unpleasing rattling in speakers of usual design and construction.

I claim:

1. A device for reproducing sound including a modified cylindrical diaphragm having two front meeting edges, means for supporting the diaphragm, means for actuating the diaphragm, connecting means between the actuating means and the two front meeting edges of the diaphragm, and a layer of suitable sound damping material disposed between the two front meeting edges of the diaphragm to prevent the meeting edge portions of the diaphragm from striking each other zvhen the diaphragm is in a state of vibraion.

2. A device for reproducing sound including a curved diaphragm having two front meeting edges, means connected to the two front meeting edges of the diaphragm for actuating the same, and means for damping the vibrations at the two front meeting edges of the diaphragm to prevent the meeting edge portions of the diaphragm from striking each other when the diaphragm is in a state of vibration.

3. A device for reproducing sound including a curved diaphragm having two front meeting edges, means connected to the two front meeting edges of the diaphragm for actuating the same, and means between the two front meeting edges of the diaphragm for damping the vibrations at the said meeting edges to prevent the meeting edge portions of the diaphragm from striking each other when the diaphragm is in a state of vibration.

4. A device for reproducing sound including a flexed diaphragm having two front 7 meeting edges, means connected to the two striking each other when the front meeting edges for actuating the diaphragm and means interposed between the two front meeting edges of the diaphragm to space the same apart to prevent the meeting edge portions of the diaphragm from in a stateof vibration.

In testimony whereof I aflix my signature.

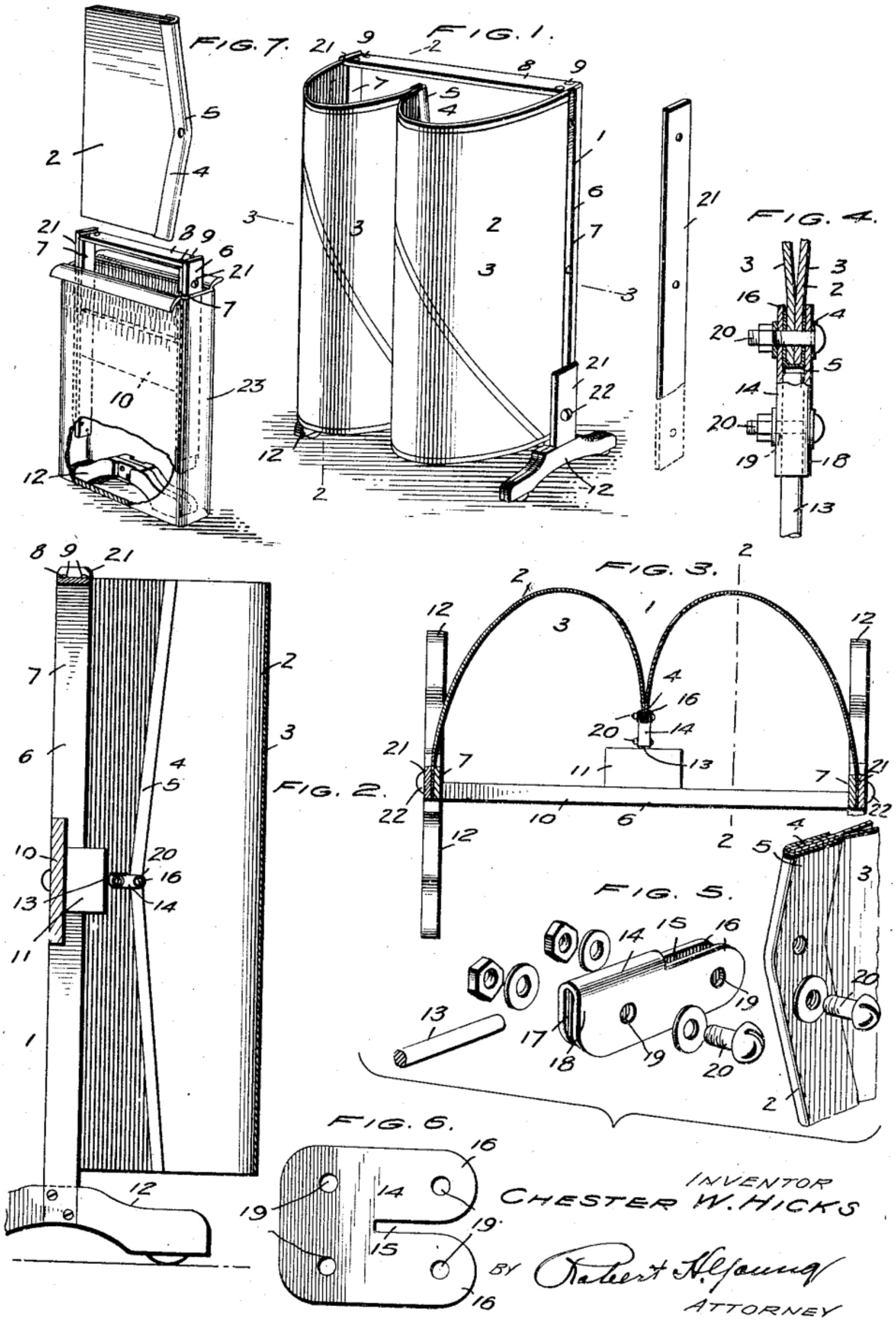
CHARLES HUGH DUFFY.

diaphragm is

Sept. 1, 1931. C. W. HICKS **1,821,469**

SOUND AMPLIFIER

Filed Aug. 3, 1928



DESCRIPTION (Le texte OCR peut contenir des erreurs.)

sept. 1, 1931. C, w HICKS 1,821,469

SOUND AMPLIFIER Filed Aug. 3, 1928 5 Pf6. E.

7 fo`/ 2a /6 /5 /4 /A/Vf/Vro/' Hl* /Z ,9 CHEST-e@ .H4/996K@ e II Patented Sept. 1, 1931 UNITED STATES PATENT OFFICE SOUND AMPLIFIER Application led August 3, 1928.

This invention relates to sound amplifiers orloud speakers for radio reception, phono graphs or the like, and has for its object to provide a device which embodies the characteristic of compactness for portability and at the same time provides the highest efciency in sound reproduction.

The device is particularly applicable to field use and for transportation by airplane,

because the compact-ness in which the same may be arranged for shipment is a feature of the invention.

While compactness for portability is an object of the invention, the invention has for its inventive purpose to employ a fibrous diaphragm preferably of a high grade blotting paper, so arranged in its mounting that objectionable interference and distortion of sound is eliminated, to the end that the maxi- 20 mum volume, tone, clarity, and definition is produced at high as well as at low frequencies of the diaphragm.

With these and other objects in view, the invention consists of the novel construction '25 of the device, and in the arrangement -and combinations of parts, all of which will be first fully described and afterwards specifically pointed out in the appended claims.

Referring to the accompanying drawings:

Figure 1 is a perspective view of the sound amplifier in opera-tive position.

Figure 2 is an enlarged vertical sectional view taken on line 2-2 of Figures 1 and 3.

Figure 3 is a horizontal sectional view taken on line 3-3 of Figure 1.

Figure 4 is an enlarged fragmentary plan view partly in section of the diaphragm connecting clip.

Figure 5 is a fragmentary perspective view of the diaphragm, diaphragm clip and assembly.

Figure 6 is a plan view of the blank of the diaphragm clip, and

Figure 7 is a perspective view of the device knocked down for transportation or shipment.

Like numerals of reference indicate the same parts throughout the several figures, in which:

1 indicates the amplifier or loud speaker,

Serial No. 297,222.

which includes the flexed diaphragm 2, which as shown in the drawing comprises two substantially semi-circularly curved sections 3 connected together at 4, and having their meeting edges bound together as by a strip of adhesive tape 5.

y6 indicates the diaphragm frame or mounting, which preferably includes the two vertical side-pieces 7 connected together by the horizontal top member 8 by screws 9, and again centrally connected together by the mounting 10 for the electromagnetic or other actuating unit 11. Suitably and demountably connected to the vertical side-pieces 7 are the transverse supporting feet 12.

13 indicates the connecting pin of the unit 11. To effect a simple and highlyefiicient connection between the unit 11 and the dia phragm 2, I provide a connecting clip 14, which, as shown in Fig. 6, is blanked out of suitable hard fibre or sheet metal. The blank is provided with a. slot 15 which bifurcates the blank for substantially one half its length. Them therefore, the blank is bent as shown in Fig. 5, the bifurcated portions 16 are opposed, and are spaced apart to conform to the thickness of the bound edges 4 of the two curved sections 3 of the diaphragm 2, while the opening 17 formed between the 0pposing faces of the body portion 18, is sufficient to snugly receive the connecting pin 13 of the unit 11. Holes 19 formed in the blank, register in pairs when the blank is bent or formed into shape as shown in Fig. 5, so as to receive the assembly screws 20, by means Vof which the body 13 of the clip is securely clamped around the connecting pin 13 and the bifurcated portion 16 is clamped on each side of the bound meeting edges 4 of the diaphragm 2.

The frame 6 having been assembled, the diaphragm 2 is mounted thereon by securing the side edges thereof to the vertical side pieces 7. This is conveniently accomplished by the side strips 21 which clamp said edges lto the vertical side pieces 7 by means of wood screws 22. The diaphragm being thus mounted, the connecting clip 14 is clamped around the connecting pin 13 of the unit 11. This completes the assembly.

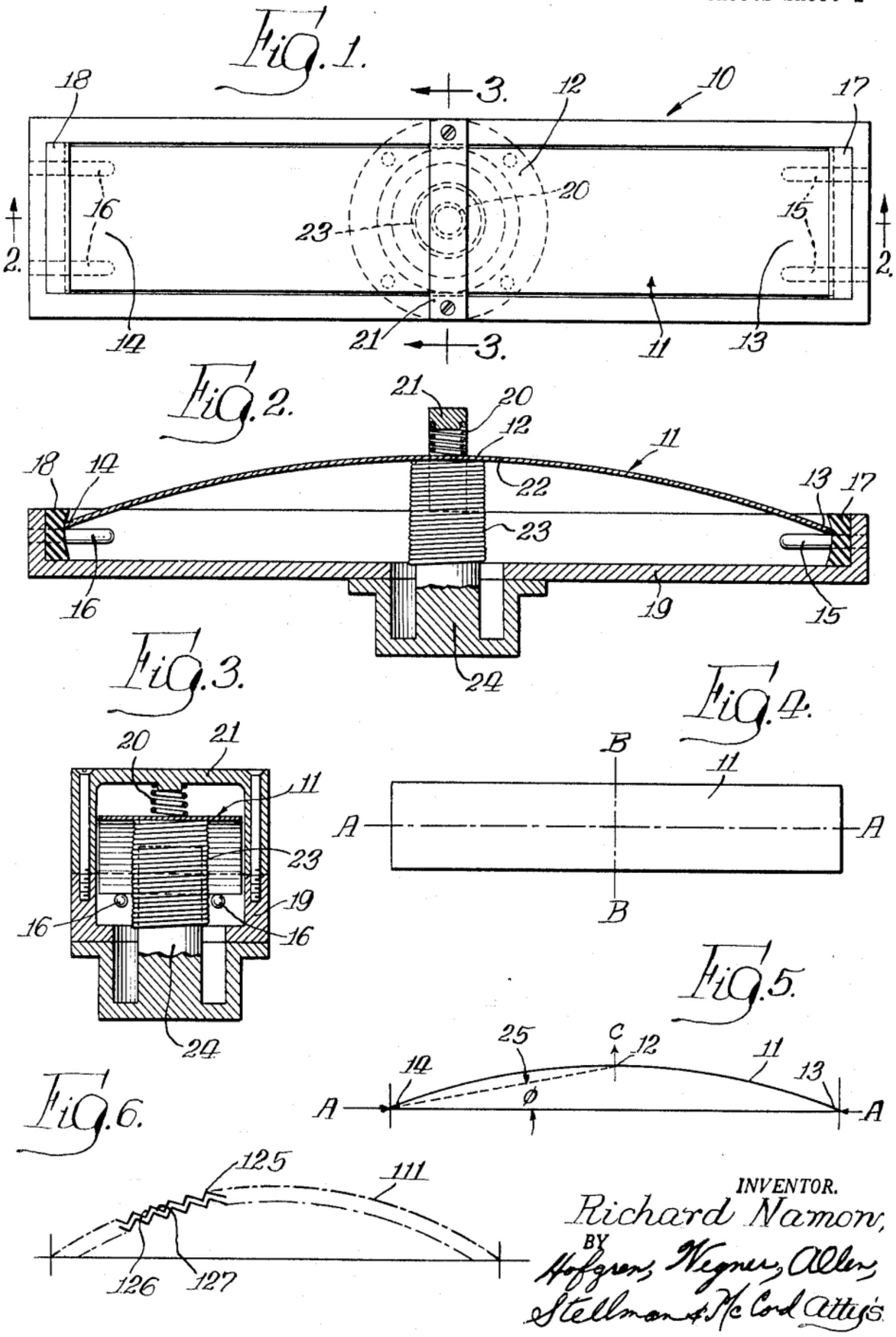
The ease With Which the device may be assembled is apparent. For shipment or transportation, a flat paper carton 23 is preferably employed. .The supporting feet 12 and the mounting frame 6 are inserted in the carton and the diaphragm 2 is flattened out into the normal form of the sheets and inserted in the manner as indicated in Fig. 7 A most convenient package is thus provided, which renders the device particularly adapted to field use and airplane transportation.

By reason of the employment of a high grade of blotting paper or of a fibrous material Which embodies the minimum inherent elasticity and the minimum capacity for self vibration to produce audible sound, the objectionable distortion is eliminated, While tone, clarity and definition is maintained in the highest degree, Without interference and the use of resonators or the like.

March 8, 1966 R. NAMON 3,239,029

SPEAKER DESIGN

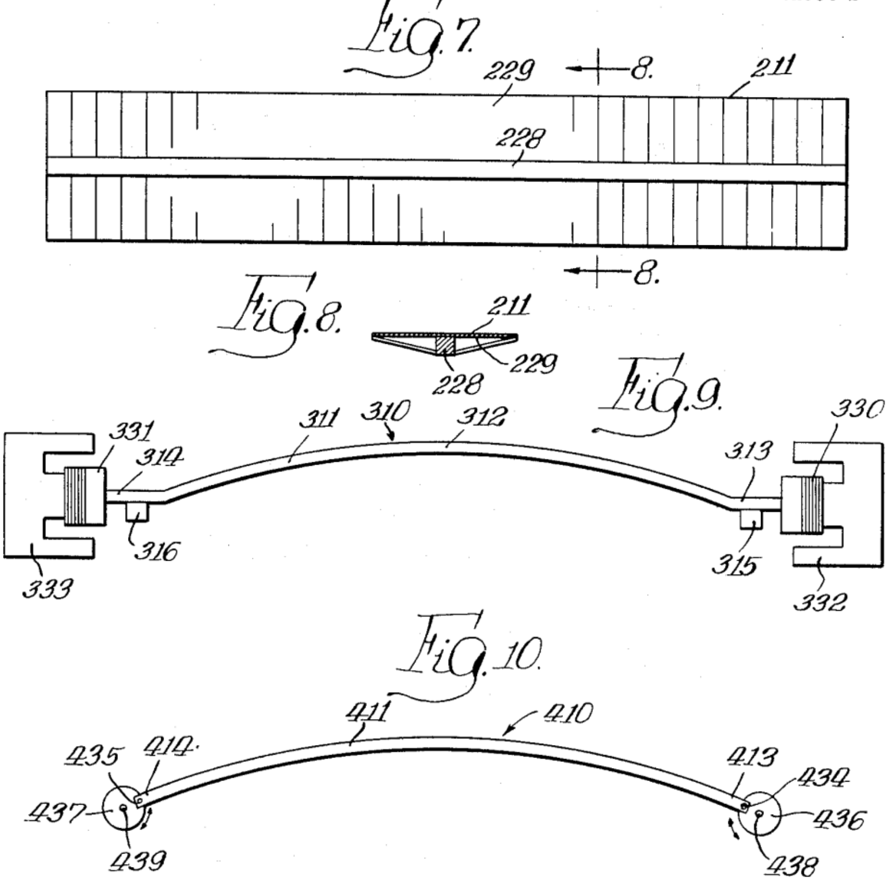
Original Filed April 29, 1960 2 Sheets-Sheet 1



March 8, 1966 R. NAMON 3,239,029

SPEAKER DESIGN

Original Filed April 29, 1960 2 Sheets-Sheet 2



INVENTOR.
Richard Namon
BY
Hofgren, Wegner, Allen, Stellman & McCord Attys.

DESCRIPTION (Le texte OCR peut contenir des erreurs.)

March 8, 1966 R. NAMN SPEAKER DESIGN Original Filed April 29. 1960 2 Sheets-Sheet 1 IN VEN TOR.

fia/'dard ,ZY/@mom l B/w@ March s, 196e R. NAMN 3,239,029

SPEAKER DESIGN Original Filed April 29, 19

6`O`/ 2 Sheets-Sheet 2 42]@ QJ@ 4Z] 35 3 43@ l JNVENTOR. Mam /l/zmom United States Patent O 3,239,029 SPEAKER DESIGN Richard Namen, 9515 Nassau Drive, Miami, Fla. Original application Apr. 29, 1960, Ser. No. 25,694, now Patent No. 3,107,746, dated Oct. 22, 1963. Divided and this application Aug. 19, 1963, Ser. No. 303,064

2 Claims. (Cl. 181-32) This invention relates to transducers and in particular to high fidelity speakers.

This application is a division of my co-p-ending application Ser. No. 25,694 filed Apr. 29, 1960, entitled Speaker Design, now U.S. Patent No. 3,107,746.

In the known speaker constructions, increased fidelity has required the provision of complex speaker structures and accurately coordinated and relatively expensive speaker enclosures. Further, the limited angle of sound dispersion produced by the known speakers has been a serious problem because of the highly directional characteristics thereof.

The present invention is concerned with a new and improved speaker eliminating the above discussed disadvantages of the known speakers. A p-rime feature of the present invention is, therefore, the provision of a new and improved transducer providing improved high fidelity operation.

Another feature of the invention is the provision of such a transducer comprising a flexible wall member having a mid-portion and edge portions on opposite sides of the mid-portion, first resilient means urging the edge portions toward each other and resultingly urging the midportion in a first direction transversely to a line between the edge portions, second resilient means urging the midportion in a second direction opposite to the first direction and resultingly urging the edge portions away from each other to balance the urging of the first resilient means, means precluding movement of the edge portions in the second direction, and means reciprocating one of (a) the mid-portion in the first and second directions and (b) an edge portion toward and from the other edge portion to flex correspondingly substantially the entire wall member.

A further feature of the invention is the provision of such a transducer wherein the exible wall member comprises a plate, the resilient means comprise spring elements, and the reciprocating means comprises a voice coil reciprocating the wall member at sonic frequencies.

Still another feature of the invention is the provision of a new and improved transducer comprising a iiexible wall member having a mid-portion and edge portions on opposite sides of the mid-portion, support means carrying the - edge portions for pivotal movement about a pair of spaced, parallel axes to move toward and away from each other and resultingly urging the mid-portion in a first direction transversely to a line between the edge portions, resilient means urging the mid-portion in a second direction opposite to the first direction, and means pivotally reciprocating the support means to reciprocate the edge portions toward and from each other to liex correspondingly substantially the entire wall member.

Other features and advantages of the invention will be apparent from the following description taken in c-onnection with the accompanying drawings, in which:

FIGURE 1 is a front elevation of a transducer embodying the invention;

FIGURE 2 is a vertical section thereof taken substantially along the line 2-2 of FIGURE 1;

FIGURE 3 is a transverse section thereof taken substantially along the line 3 3 of FIGURE l;

FIGURE 4 is a diagrammatic elevation of the wall member of the transducer;

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FIGURE 5 is a diagrammatic plan view thereof;

FIGURE 6 is a diagrammatic plan view of another form of wall member for use therein;

FIGURE 7 is an elevation of still another form of wall member for use therein;

FIGURE 8 is a transverse section taken substantially along the line 8 8 of FIGURE 7;

FIGURE 9 is a fragmentary plan view of another form of transducer embodying the invention; and

FIGURE 10 is a fragmentary plan view of still another form of transducer embodying the invention.

In th-e exemplary embodiment of the invention as disclosed in FIGURES 1 through 5 of the drawings, a transducer generally designated 10 comprises a flexible plate wall member 11 having a mid-portion 12 and edge portions 13 and 14 disposed on opposite sides of the midportion 12. Herein the plate 11 is segmentally cylindrical whereby the mid-portion 12 is displaced transversely from a line A-A drawn between the edge portions 13 and 14 (see FIGURE 5). The edge portions 13 and 14 are slidably carried on a pair of spaced supports 15 and 16, respectively, and are urged toward each other by a pair of resilient blocks 17 and 18, respectively, carried on a rigid frame 19.

As a result of the urging together of the edge portions 13 and 14 by the spring blocks 17 and 18, the mid-portion 12 of the plate 11 is urged away from line A-A along a transverse plane B-B in the direction of the arrow C in FIG. 5. This urging force is balanced by a counteracting spring 20 compressed between a transverse support 21 carried by frame 19 and the mid-portion 12 of the plate 11. Herein, the characteristics of spring 20 are coordinated with the characteristics of the spring blocks 17 and 18 so that the plate 11 is urged to its unbiased segmentally cylindrical configuration against the balancing action of the spring blocks.

Extending forwardly from the front face 22 of the plate mid-portion 12 is a voice coil 23 cooperating with a magnet 24, herein a permanent magnet, carried on frame 19 to reciprocate the plate mid-portion 12 as a function of an alternating electrical current passed through the voice coil 23. The deflection of the plate mid-portion 12 causes a corresponding movement of the edge portions 13 and 14 toward or away from each other along the line A-A depending on which direction along plane B B mid-portion 12 has moved from the static position of FIG- URE 2. Thus, when the mid-portion 12 is urged toward frame 19 the edge portions 13 and 14 are urged apart against the balancing action of spring blocks 17 and 18. When the mid-portion 12 is urged away from the frame 19 against the action of spring 20 the edge portions 13 and 14 are urged toward each other along the line A-A. Resultingly the entire plate member 11 is driven at the frequency of the current in voice coil 23; where the current alternates at a sonic frequency the plate 11 functions as a high fidelity speaker diaphragm faithfully reproducing the electrical current as sound Waves in the air surrounding the transducer.

As illustrated in FIGURE 5, the angle gb between the line A-A and a line 25 drawn between an edge portion, as edge portion 14, and the mid-portion 12 is preferably relatively small, in the range of approximately 5 or less. With such a small angle, the force relationship between the forces acting on the mid-portion along the plane B-B and the forces acting on the edge portions along the line A-A is given by the formula, forces (B-B) equal forces (A-A) tangent e. Thus, illustratively where 1: equals 5 the forces in plane B-B need be only .087 times the forces along line A-A for a balance thereof. Further, as a result of the small angle g5, the movement of the edge portions 13 and 14 along the line A A corresponding to a given movement of the mid-portion 12 along the plane B-B is relatively small.

In effect, the plate 11 vibrates in the direction of line A-A as Well as in the direction of the plane B-B although to a somewhat lesser extend. The resultant direction of motion of the sound propagation is not in alignment With either the line A-A or plane B-B but rather at an angle thereto. To utilize the sound producing effect of plate 11 most eiciently, it is desirable to provide the forward surface thereof with a plurality of grooves having the faces thereof substantially perpendicular to the effective sound propagation direction. Thus, referring now to FIGURE 6, a modified form of plate 111 is shown to comprise a flexible wall member 111 generally similar to plate 11 but provided on the front surface thereof with a plurality of grooves generally designated 125 each having a first surface 126 extending parallel to the direction of the resultant motion .of the plate and a second surface 127 extending perpendicular thereto. By virtue of the grooves 125, plate 111 is capable of producing an extended frequency range of sound having a wide dispersion comparable to, and in some cases exceeding, the dispersion characteristics of multispeaker installations.

Referring now to FIGURES 7 and 8, another form of plate wall member 211 is shown to comprise a flat plate having a reinforcing bar 228 extending longitudinally along and rearwardly from the center of the rear surface 229 of the plate. Thus reinforced, plate member 211 may be of substantial size such as six feet or longer in length.

Referring now to FIGURE 9, a portion of another modified form of transducer 310 is shown to comprise a flexible plate wall member 311 having end portions 313 and 314 slidably supported on fixed supports 315 and 316 respectively, and having secured thereto voice coils 330 and 331 respectively. Voice coil 330 cooperates with a suita-ble magnet 332 and voice cail 331 cooperates with a corresponding suitable magnet 333 to reciprocate the plate 311 by applying reciprocating opposing forces to the edge portions of the plate in the direction corresponding to the line A-A of plate 11. As the edge portions travel a distance especially less than the distance travelled by the mid-portion 312 of plate 311, extremely linear electro-mechanical conversion is obtained. While the vibration travel of the voice coil 330 and 331 is not linear with respect to the balanced position of the plate 311, the amplitude of the vibration of the plate in the direction of the maximum sound propagation will be accurately linear.

In FIGURE 10, a portion of still another transducer 410 is illustrated as comprising a flexible wall member plate 411 having its edge portions 413 and 414 pivotally secured by means of pins 434 and 435 respectively to a pair of corresponding pivot wheels 436 and 437. Wheel 436 pivots about an axis 43S parallel to an axis 439 about which Wheel 437 pivots, the axes 438 and 439 extending parallel to the direction of sound propagation of the plate 411. The wheels 426 and 437 are rotatively reciprocated by suitable transducer means (not shown) in correspondence with an electrical signal to move the plate edge portions 413 and 414 alternately toward and from each other in correspondence with the electrical signal to flex the plate 411 suitably for reproducing the signal in the form of sound.

In each yof the fragmentary showings of the different forms of transducer structures embodying the invention, only those elements differing from the elements of transducer 10 have been illustrated to disclose most clearly the different forms. Thus, except as -otherwise noted, each Iof the different structures functions in a generally similar manner to produce an improved high fidelity sound reproduction.

Through use of the improved transducer structure herein disclosed, a high fidelity speaker is obtained without need for cooperating enclosure means. Extremely wide dispersion of the sound may be effected by producing the speakers disclosed herein in large sizes; illustratively, the plate may be six feet long by six inches high and may be driven by a suitable number of voice coils. The inherent rigidity of the plate permits high power outputs with effectively minimized distortion over an extended frequency range, as for example 5-50,000 cycles per second. The simplified construction permits the speaker to be produced at extremely low cost and effectively eliminates maintenance problems.

Having described my invention in considerable detail, it is my intention that the invention be not limited by any of the details or description unless otherwise specified, but rather be construed broadly within the spirit and scope as set out in the accompanying claims.

Iclaim:

1. A transducer comprising, a flexible Wall member having a mid-portion and edge portions on opposite sides of said mid-portion, opposed support means carrying each of the edge portions for movement toward and away from the other edge portion and resultingly urging said mid-portion in a direction transversely to a line between said edge portions, means connected to each edge portion and operable in unison for reciprocating the edge portions toward and away from each other to ex correspondingly substantially the entire wall member to move said mid-portion in said direction.

2. A transducer comprising, a flexible wall member having a mid-portion and edge portions on opposite sides of said mid-portion, support means carrying opposite edge portions for movement toward and away Ifrom each other and resultingly urging said mid-portion in a direction transversely to a line between said opposite edge portions, means including a voice coil connected to each of the last mentioned edge portions for reciprocating such edge portions toward and away from each other along said line to flex correspondingly substantially the entire wall member to move said mid-portion in said direction.

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LEO SMILOW, Primary Examiner.

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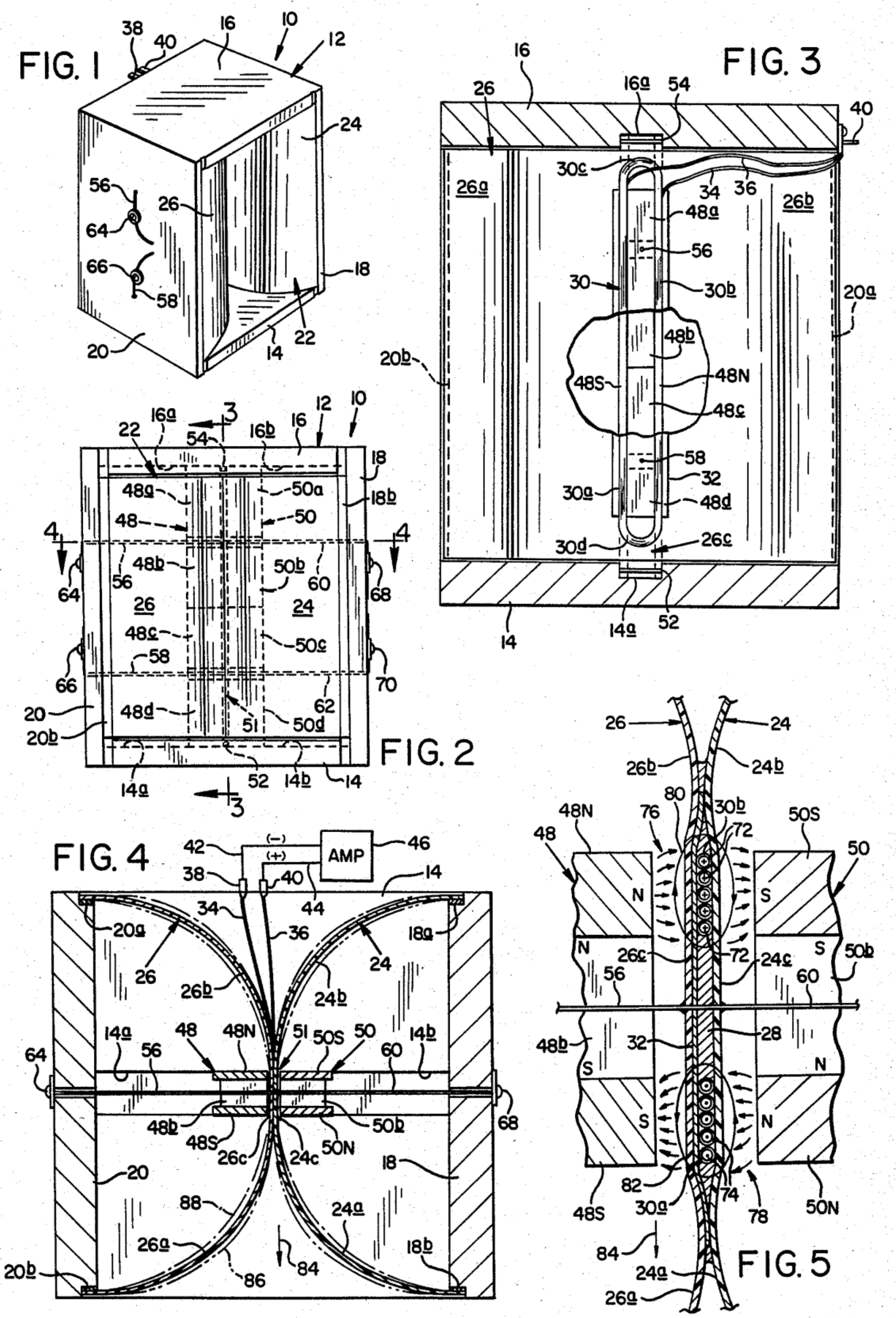

DESCRIPTION

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BACKGROUND AND SUMMARY OF THE INVENTION

This is in relation to improvements in transducers, and more particularly to a transducer which has a diaphragm with an expanse extending generally in a plane and mounted in such a fashion that this expanse is movable in the direction of the plane. Coil means are attached to this expanse. Magnetic field means for producing a magnetic field adjacent to the coil means complete the transducer.

Various types of audio transducers, as exemplified by audio loudspeakers, are known in the prior art. One common form of transducer comprises a cone, with an electromagnetic motor driving element, mounted on a frame through a flexible expanse which bounds the perimeter of the cone. Generally speaking, such a transducer is characterized by relatively high diaphragm and coil mass which results in high inertial forces in the diaphragm and reduces its frequency response at high frequencies; or, the diaphragm and coil may be of relatively low mass and have reduced low frequency reproducing ability. Typically, the diaphragm is molded from a paper type of product which renders it susceptible to changes in relative humidiity. This alters frequency response and limits the life of the transducer.

Another type of loudspeaker known in the art comprises a horn type speaker having a flat diaphragm element which oscillates normal to the plane of the diaphragm element in response to activation by an electromagnetic driving element. The central diaphragm element is again mounted on a frame by means of an annular portion bounding the central expanse described. In some instances, such may be suspended and directly attached to a voice coil. With this type of speaker a rather large horn is required properly to direct and focus the sound waves produced. Again, by reason of the mass of the diaphragm and voice coil, the frequency response of the transducer tends to drop off at high frequencies. The transducers just described furthermore tend to be very expensive.

Audio transducers have characteristically become more complicated in design, the manufacturers relying on sealed cabinets, extremely heavy machine parts, and complicated voice coil arrangements in order to achieve the ultimate transducer.

Prior art speakers generally have exhibited a sudden drop in frequency response at the high end of the audio spectrum, typically above 20K hertz. This sudden decrease in frequency response has generally been attributed to high inertial coils and diaphragms, which are incapable of vibrating at extremely high frequencies.

Additionally, since an audio transducer which is responsive to low frequencies, in the vicinity of 20 to 250 hertz, is generally not responsive to frequencies above 15K hertz, several types or sizes of transducers are incorporated into a single cabinet, in order to provide adequate frequency response over the entire audio spectrum. The use of multiple transducers requires the incorporation of complex crossover networks to isolate audio signals traveling to or emanating from the individual transducers.

Generally, an object of this invention is to provide an improved transducer featuring a construction which overcomes difficulties and shortcomings of the type I have indicated.

More specifically, an object of the invention is to provide a transducer with a novel diaphragm construction wherein the diaphragm is of relatively low mass, the diaphragm also being ultimately flexible to provide essentially linear frequency response over the audio spectrum.

A feature of the transducer of the invention is a construction of the diaphragm which enables the manufacture of the diaphragm from material other than pressed material such as paper. As specifically comtemplated, the diaphragm may be manufactured, for instance, from a Mylar type of material. Such and similar material are moisture resistent and produce, over extended periods of time, a consistent predictable response to oscillation induced by an electromagnetic driving element.

The further object and feature of the invention is the provision of a transducer which may be simply manufactured without extreme criticality required in placement of parts and mountings, etc. Materials involved in construction of the transducer are readily available. All of the above tend to result in economies of manufacture.

Another feature and advantage of a transducer contemplated is derived from the flexibility of the diaphragm. This flexibility enables the diaphragm to expend its energy in making sound waves with minimal transmission of energy to the frame mounting the diaphragm and subsequent reduction in speaker efficiency.

A further object of the instant invention is to provide an audio transducer which exhibits a linearly decreasing frequency response at frequencies above 20K hertz by virtue of having a low inertia coil and diaphragm.

Another object of the instant invention is to provide an audio transducer which does not require a complex crossover network to accurately reproduce sound over the full audio spectrum.

The transducer of this instant application includes a generally rectangular open frame which carries opposing permanent magnets which generate what is referred to herein as opposing magnetic fields. A flexible diaphragm is secured to the frame and passes through the magnetic field. An elongate looped coil is carried on the diaphragm adjacent the opposed magnetic fields. A signal of variable amplitude in the coil accompanies movement of the diaphragm in what is described as rolling, linear movement.

These and other objects and advantages of the instant invention will become more fully apparent as the description which follows is read in conjunction with the accompanying drawings.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a transducer according to the instant invention.

FIG. 2 is an enlarged front elevation of the a transducer.

FIG. 3 is a further enlarged median section view, taken along line 3--3 in FIG. 2, showing the configuration of a coil in schematic form.

FIG. 4 is a further enlarged sectional view, taken along line 4--4 in FIG. 2.

FIG. 5 is a greatly enlarged view of portions of FIG. 4 where the coil of the transducer is located.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Turning now to the drawings, and particularly to FIGS. 1 through 4, an audio transducer according to the present invention is shown generally at 10. The transducer of the preferred embodiment is intended for use as an audio loudspeaker, and the description of the transducer which follows will be addressed to use as a loudspeaker. It should be understood, however, that the transducer is also suitable for, and functions quite efficiently as, a microphone.

Transducer 10 includes an open rectangular frame, shown generally at 12. Frame 12 further includes a bottom member 14, a top member 16 and opposing side members 18, 20 which are rigidly attached to the top and bottom members. Frame 12 may be constructed of any suitable material of fairly high density and which has desirable acoustic properties, such as hardwood, or particle board. The frame may also be formed of injection molded plastic.

A diaphragm is shown generally at 22. Diaphragm 22 includes a pair of elongate resilient webs, 24,26. Each web includes flexible curved portions forming the ends of each web, joined to, and extending from, an intermediate, generally planar expanse. Thus, and considering web 24, such includes curved portions 24a, 24b, and a central expanse 24c. In the case of web 26 the curved portions are shown at 26a, 26b and the central expanse at 26c. The central expanses of the two webs are joined together, as with an adhesive, shown generally at 28 in FIG. 5, into a joined central expanse. The joined central expanse is supported on the frame by the flexible curved portions at the ends of the diaphragm. The joined central expanse, or diaphragm intermediate portion, may be thought of as an intermediate slack portion, with such being movable generally in the plane occupied by the expanse.

Side members 28 and 20 include isolation strips, 18a, 18b, and 20a, 20b, respectively, on their front and rear edges. Diaphragm webs 24, 26 are secured to frame 12 at the front and rear edges of sides 18 and 20, respectively, by attaching their end portions to the isolation strips. This arrangement provides that vibrations produced by the diaphragm are only minimally transmitted to the frame, enabling the diaphragm to expand most of its energy producing sound waves. The isolation strips may be made out of a suitable shock-absorbing porous or fibrous material, such as foam rubber or felt.

An electromagnetic coil, or coil means, shown generally at 30, is attached to the expanse of diaphragm 22 and is substantially enclosed by webs 24, 26 at their slack, intermediate portions 24c, 26c. Coil 30 is an elongate looped coil in the preferred embodiment, and contains what will be referred to herein (See FIG. 3) as an ascending portion 30a, a descending portion 30b, and an upper and lower transverse portions 30c, 30d, respectively. Coil 30, in the preferred embodiment is formed of 16 turns of 38 gauge copper wire. The wire is shaped on an adhesive backed tape 32 prior to being placed between webs 24, 26 and glued in place by adhesive 28. A pair of leads 34, 36 exit the diaphragm expanse and runs to frame side member 18 where it terminates in a pair of connectors, 38, 40, respectively. Audio transducer 10 is connected to a pair of amplifier leads 42, 44, which are in turn connected to an amplifier 46. Amplifier 46 generates alternating current impulses, which shift polarity between 20 and 20,000 times per second. The combination of leads 34, 36, connectors 38, 40 and amplifier leads 42, 44, constitute means connecting amplifier 46 to transducer 10. Amplifier 46 and transducer 10 comprise what is referred to herein as an audio assembly. The means connecting, or connecting means, conduct electrical impulses between amplifier 46 and transducer 10.

Two sets of opposed magnets 48, 50, are attached to the frame and held in place in magnet retaining grooves 14a, 14b, 16a, 16b which are cut in bottom and top members 14 and 16, respectively. Magnets 48, 50 may be of the metal bar-magnet type, or, as in the preferred embodiment, high quality (strontium ferrite) ceramic magnets, 48a, 48b, 48c, 48d, 50a, 50b, 50c, 50d, standard in the audio industry, fastened together with adhesive. The magnets must be polarized across their major faces, as indicated in FIG. 5, for the transducer to properly function. A pair of magnetically permeable plates 48N and 48S, 50N and 50S made of low carbon (0.003%) steel are attached to the major faces of magnets 48, 50, respectively. An opposing magnetic field is established in that plates 48N and 50N are polarized to a north magnetic pole and plates 48S and 50S are polarized to a south magnetic pole. The plates thus produce what is referred to herein as an opposing magnetic field, whose lines of flux are normal to the expanse of diaphragm 22 across a gap 51.

Magnets 48 and 50 are separated by a pair of non-ferrous spacers, 52, 54. The spacers in the preferred embodiment are copper rods which prevent magnets 48 and 50 from closing gap 51. The diaphragm central expanse is additionally supported and centered by string-like supports 56, 58, 60, 62 which are secured to and extend from the diaphragm central expanse through the frame side members to tensioning fasteners 64, 66, 68, 70, respectively. The supports in the preferred embodiment are made of a woven, non-stretch nylon thread.

Turning now to FIGS. 2 through 4, the workings of transducer 10 will be further explained. An electrical impulse arriving at connectors 38, 40 is transmitted to coil 30. Since coil 30 is a continuous loop, a flow of current is established in the coil, thereby producing a magnetic field about the coil. Current flow is represented in coil 30 by flow indicators at 72 and 74 in FIG. 5. Lines of magnetic flux between plates 48N and 50S are indicated by the arrows at 76; the magnetic flux between plates 50N and 48S are indicated by the arrows at 78.

The location of the plates on either side of magnets 48, 50, result in a uniform external magnetic field about coil 30. As current passes through coil 30, resultant lines of magnetic induction are established, which essentially form a clockwise field 80 around descending loop 30b and a counterclockwise field 82 around ascending loop 30a.

The motion of a charged wire within a magentic field is determined by the direction of current in the wire relative to the lines of magnetic flux. At any point where the two fields meet, the resultant magnetic induction will be the vector sum of the external field and the magnetic induction field associated with the current in the wire.

In the situation depicted, amplifier 46 has a "positive" lead connected to connection 38 and a "negative" lead connected to connection 40. This results in a current flow as depicted at 72 and 74. Under the influence of current produced by amplifier 46, coil 30 will tend to move in the direction indicated by arrow 84. When the amplifier alternates current flow, current flow in coil 30 reverses, moving the coil and the diaphragm in a direction opposite that of arrow 84.

It should be obvious to those skilled in the art that were coil 30 surrounded by a single, non-opposing magnetic field, the result of a current passing through coil 30 would be a torsional movement of the coil about its major axis, rather than a linear movement of the coil as is produced by the arrangement of the instant invention.

Amplifier 46 produces a current of varying intensity, thereby producing a resultant induced field about coil 30 of varying intensity. The result is an oscillation of coil 30, and a resultant oscillation of diaphragm 22 of varying travel distance relative the permanent opposing magnetic fields, 76, 78, established by magnets 48 and 50. A decrease in current intensity within coil 30 results in a collapse of the induced magnetic field and produces a resultant movement in coil 30 and diaphragm 22 in a direction opposite that shown by arrow 84.

Thus, as shown by the phantom lines in FIG. 4, diaphragm 22 is free to deform along its flexible curved portions in response to movement induced by coil 30. Movement of the diaphragm in the direction of arrow 84 results in diaphragm 22 assuming the shape illustrated by the dash-double-dot line 86, while movement of the diaphragm opposite that of arrow 84 results in the configuration shown by dash-dot line 88. Movement of the diaphragm between these two representative positions is accomplished through what may be described as a linear rolling-type action in that the flexible curved portions deform to some extent, while the movable intermediate expanse remains substantially unflexed and continues to move within a plane defined by the central expanse of the diaphragm.

Thus a new form of audio transducer has been disclosed. The transducer of the instant invention, when configured for use as a loudspeaker, has been found, in the preferred embodiment, to have a nominal impedance of eleven ohms. The transducer has been tested with a frequency response analyzer and has been found to have an essentially flat response from 100 to 20K+ hertz when driven by standard test equipment. Additionally, the transducer has been found to perform satisfactorily with a minimum input of 15 watts, and is capable of handling an input of at least 300 watts.

In the preferred embodiment, diaphragm webs 24, 26 are formed of 5 mil Mylar. This substance flexes predictably and has a relatively low mass per unit volume. Because both the coil and the diaphragm are relatively low mass structures, they do not produce high inertial forces when oscillated by an impulse from the amplifier. This use of light weight material results in an essentially flat frequency response which decreases linearly at its upper end.

An additional benefit which is gained by using Mylar for the diaphragm and nylon string for the diaphragm supports is a transducer which is not subject to variations in response as a result of changes in humidity.

A plurality of transducers may be incorporated into a single cabinet. Since the transducer, when used as a loudspeaker, radiates sound waves bi-directionally, it may be desirable to include some baffling in a speaker cabinet to prevent "dead-spots," which may result from sound wave cancellation at certain points in the listening room. When the transducer is used as a microphone, however, it is bi-directionally sensitive, producing a microphone with a figure eight sensitivity pattern.

The transducer may be constructed with diaphragm webs of varying thicknesses and coils of varying electrical characteristics in order to produce a transducer which will respond within predetermined frequency ranges. Several transducers with differing sound-reproducing characteristics may be incorporated into a single loudspeaker cabinet and connected by means of a simple crossover network to respond to electrical impulses representing a particular frequency range.

The overall construction of the transducer enables production of the units without the need for complex, highly accurate placement of component parts. Component parts are readily available, and, with simple construction techniques, enable production with minimal financial expenditure.

When the transducer is constructed for use as a microphone, the diaphragm webs are formed of 1 mil Mylar and the coil is formed of 50 gauge or finer wire.

While a preferred embodiment of the invention has been described, it is appreciated that variations and modifications may be made without departing from the spirit of the invention.

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FIG. 1

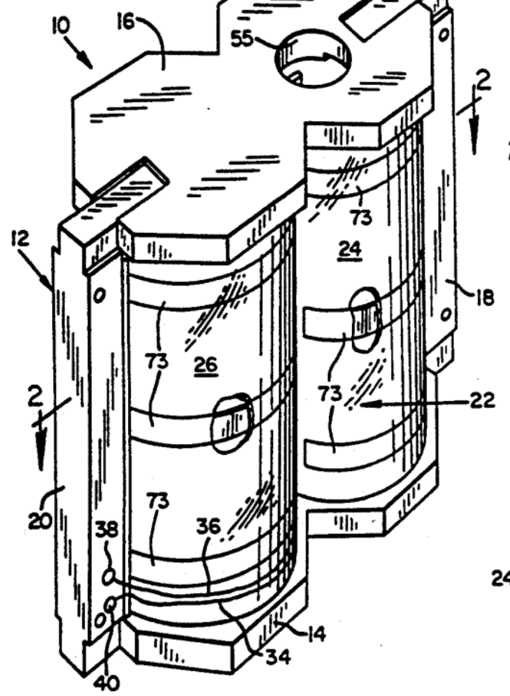

FIG. 3

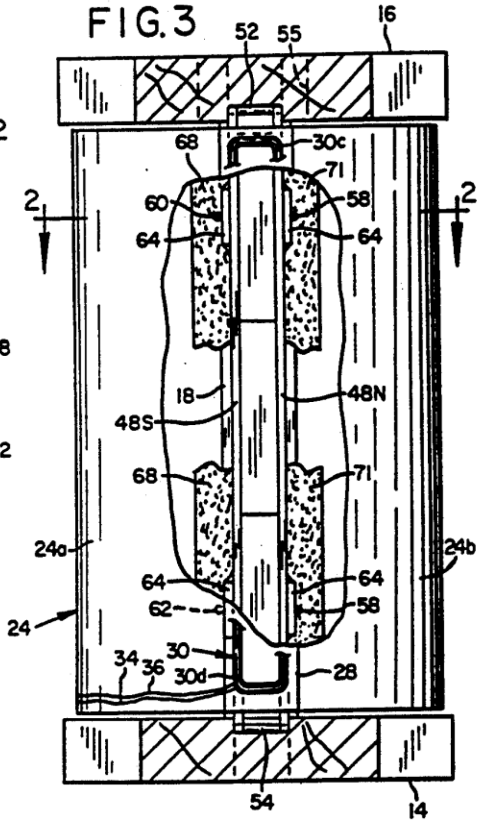

FIG. 2

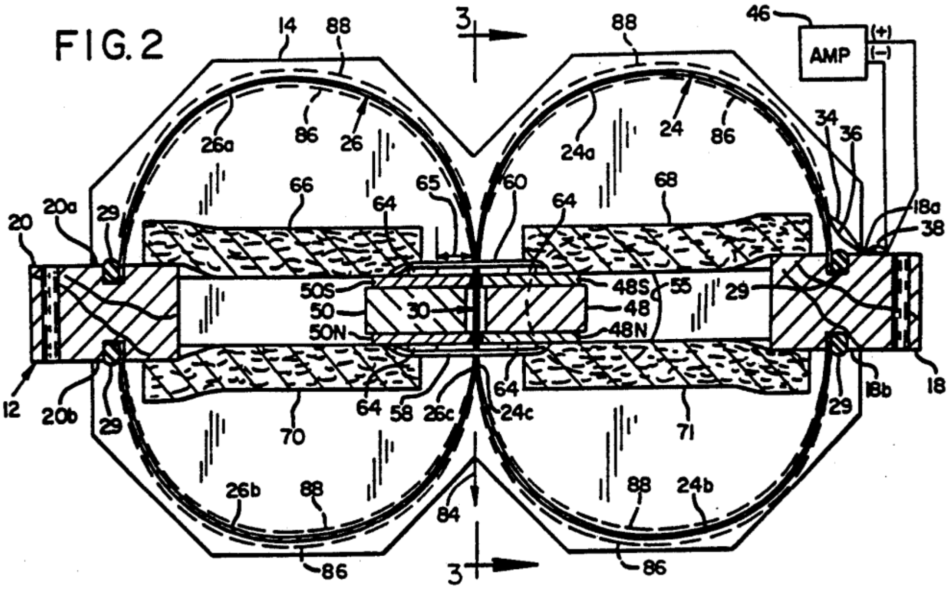

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FIG. 4

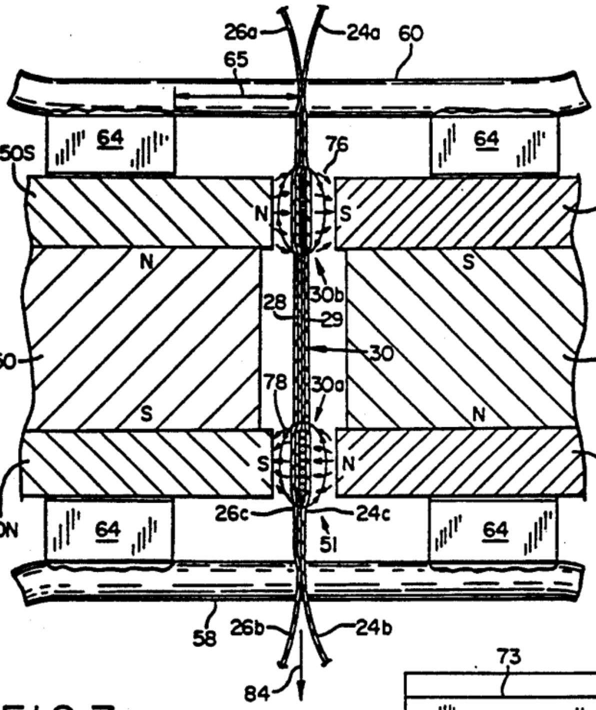

FIG. 8

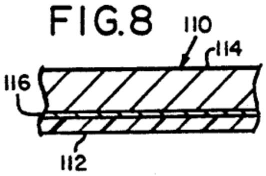

FIG. 5

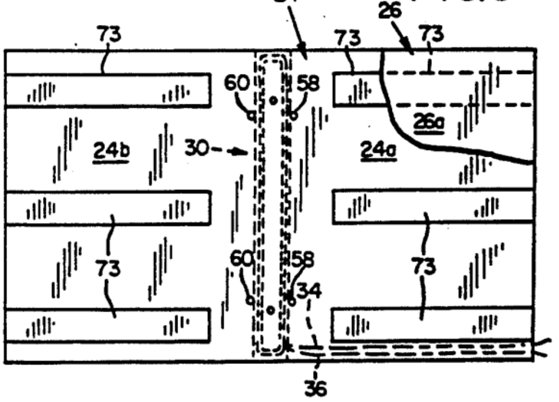

FIG. 7

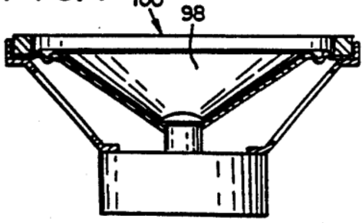

FIG. 6

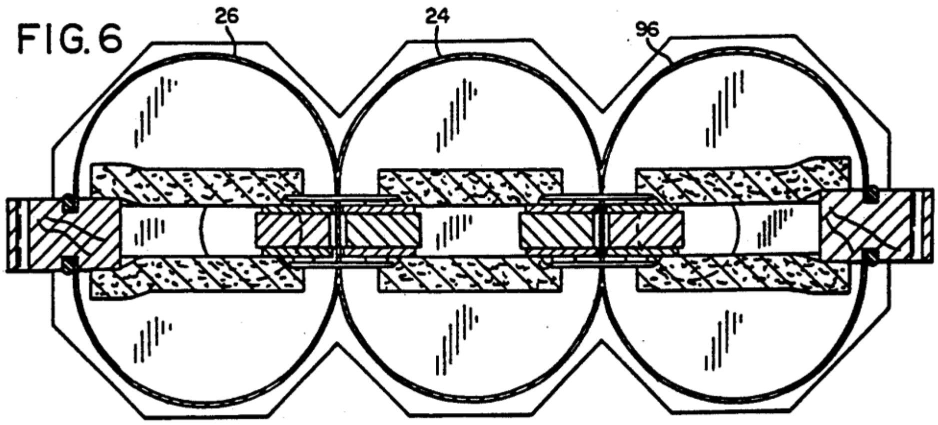

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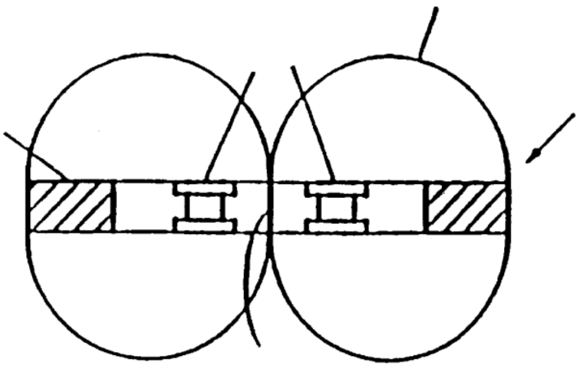
FIG. 1 (PRIOR ART)



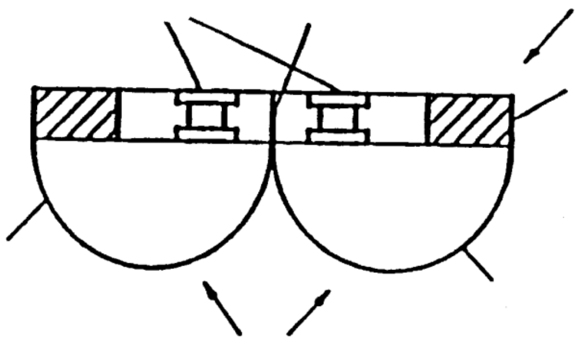


FIG. 2 (PRIOR ART)

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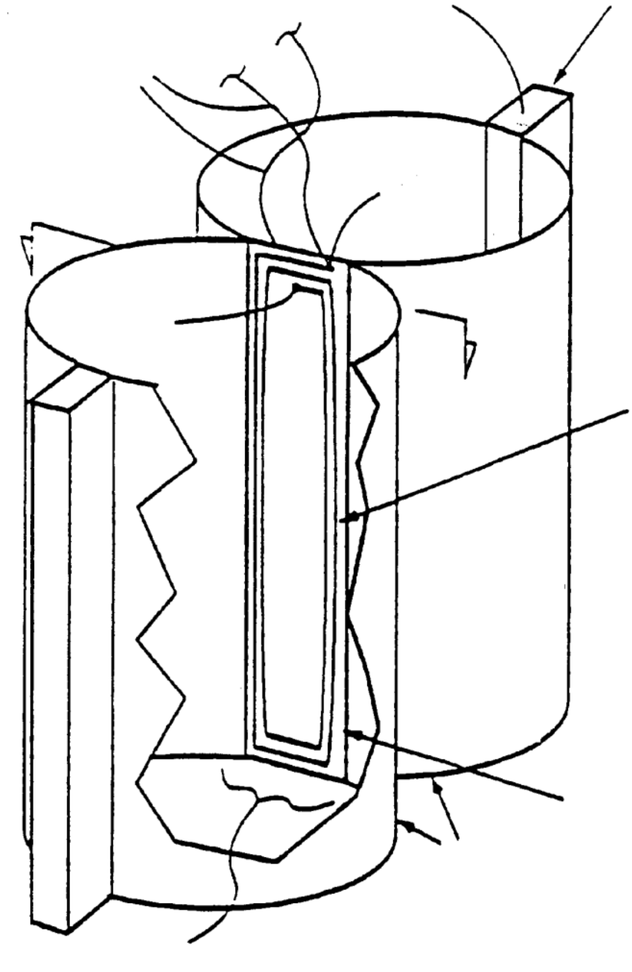

FIG. 3 (PRIOR ART)

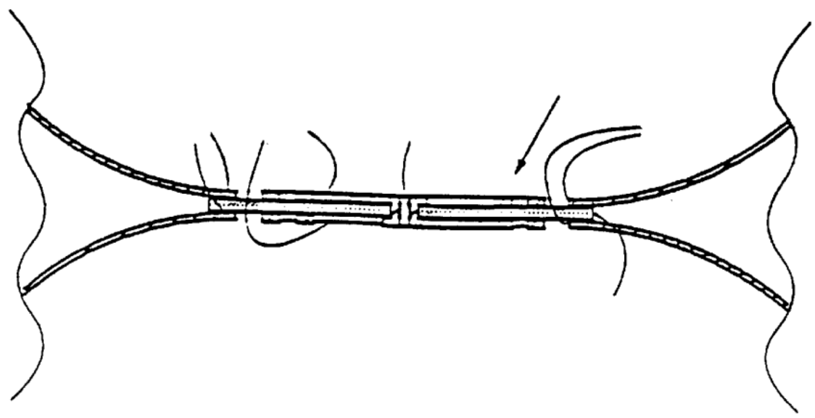

FIG. 4 (PRIOR ART)

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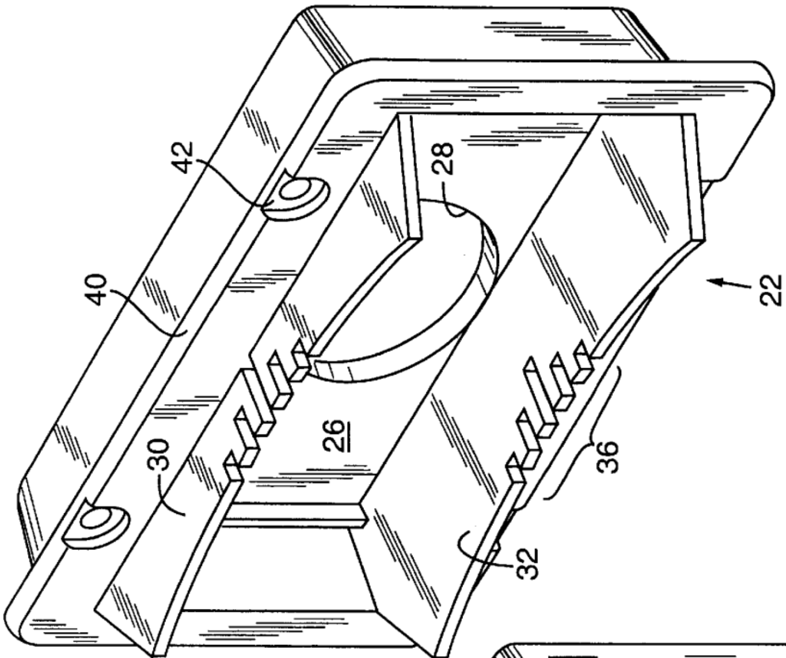

FIG. 6

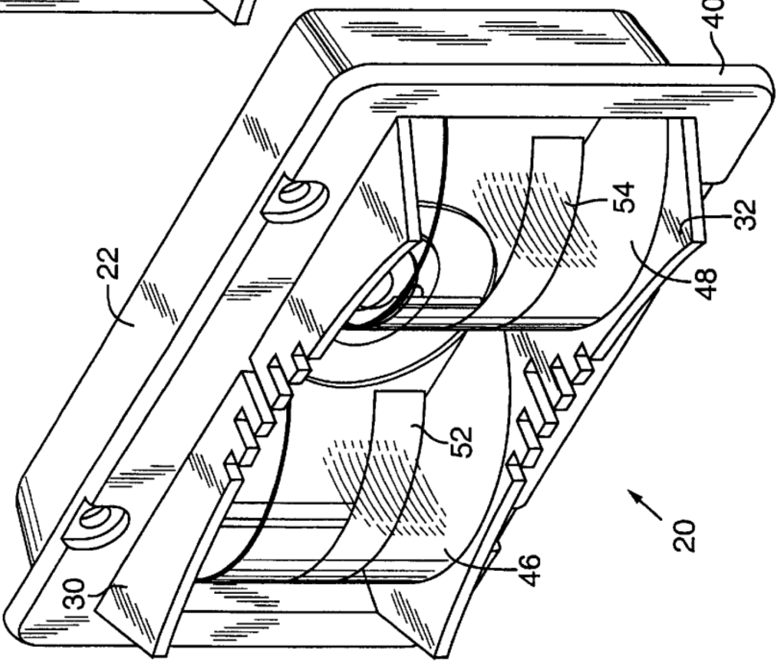

FIG. 5

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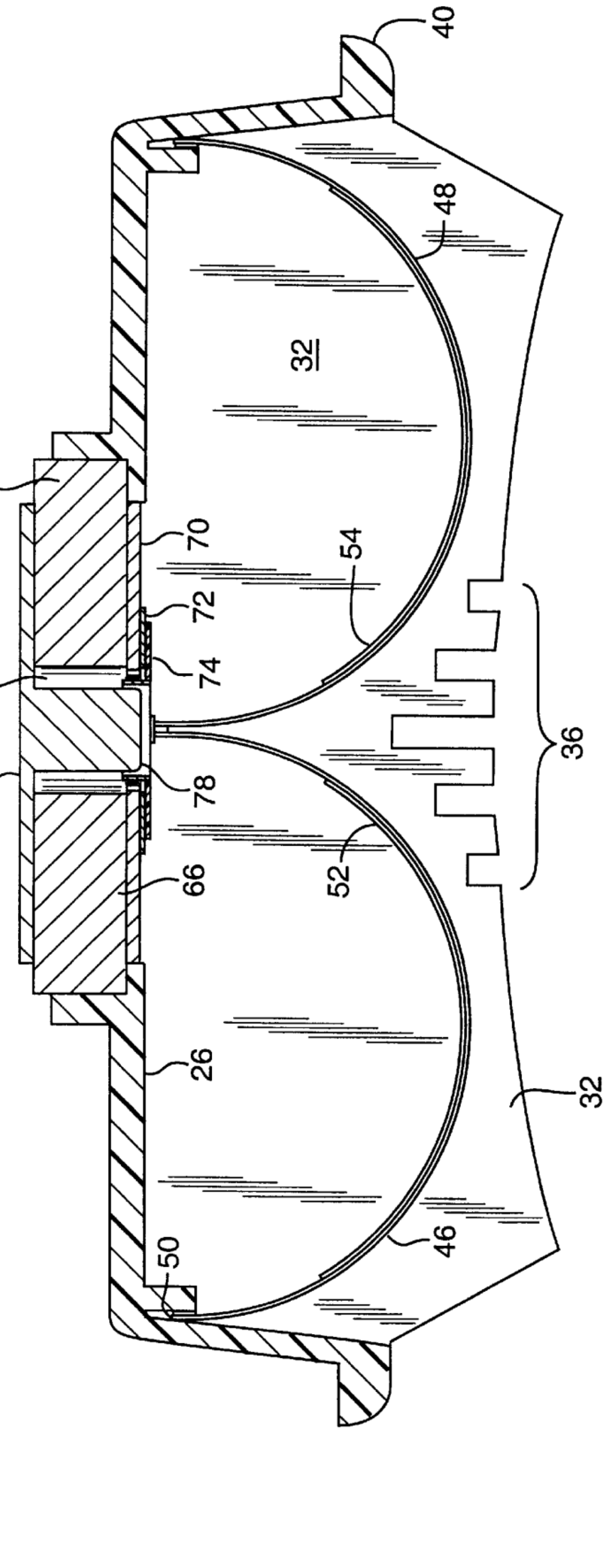

FIG. 7

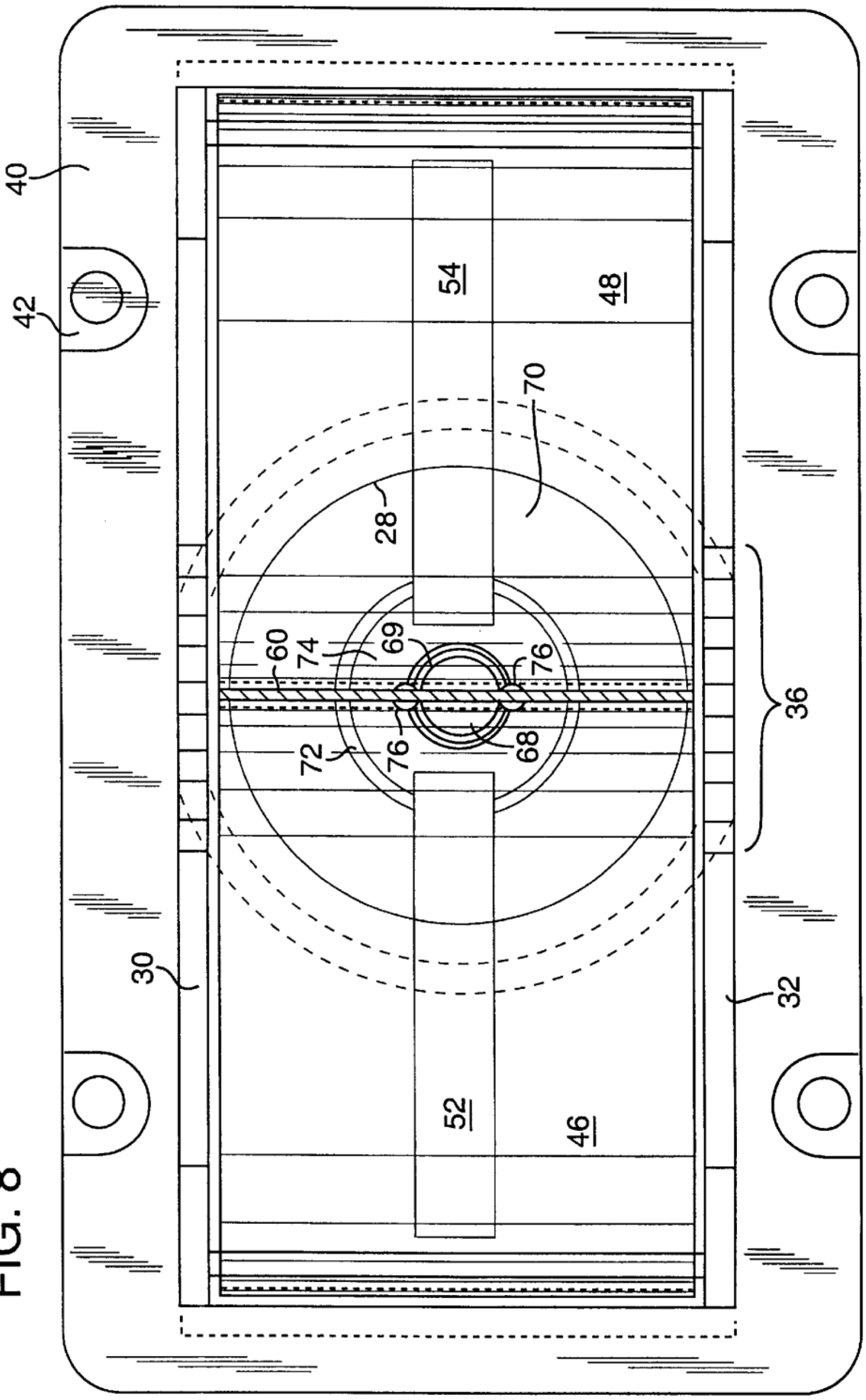

FIG. 8

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FIG. 9

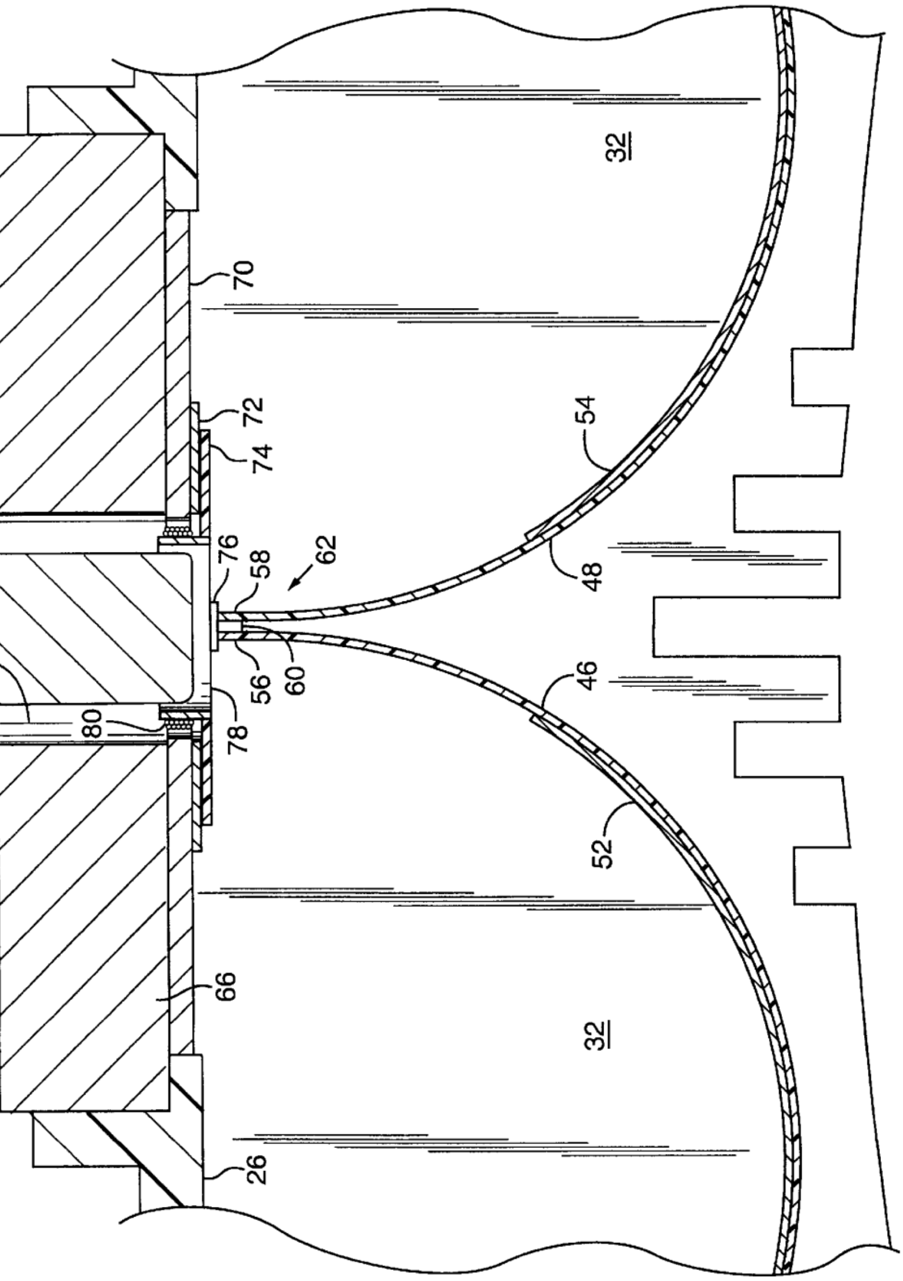

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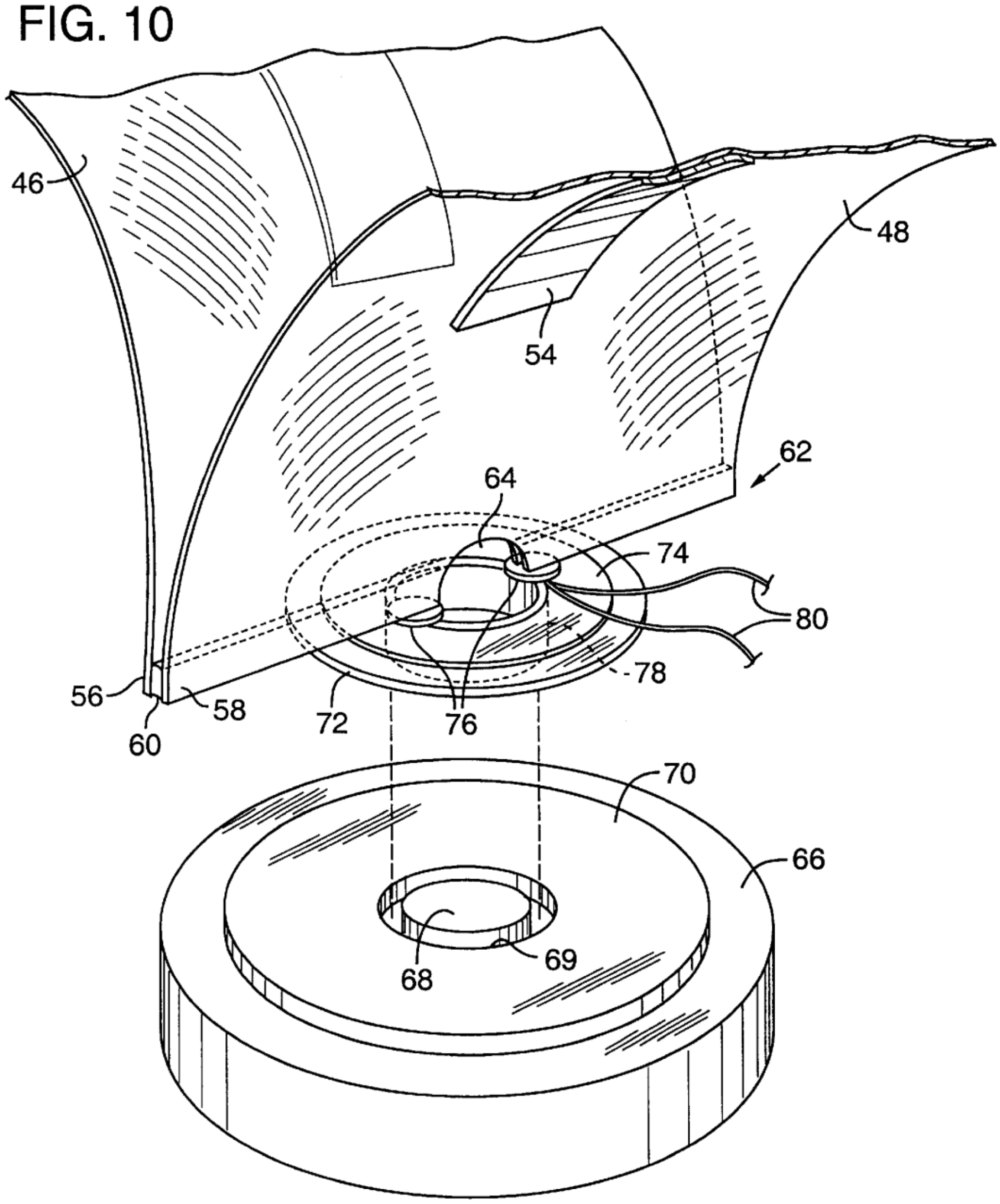
FIG. 10



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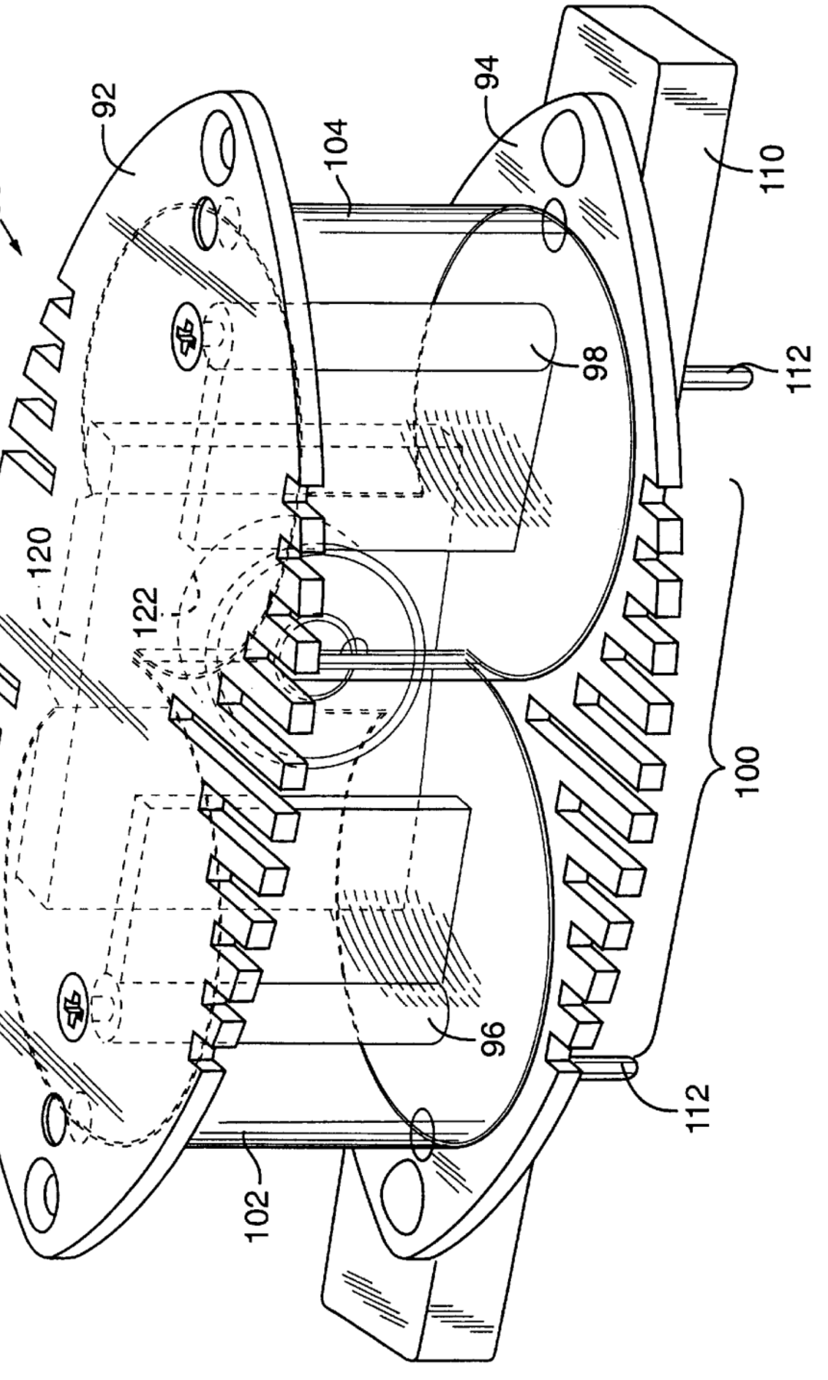

FIG. 11

Audio transducer

US 6061461 A

RÉSUMÉ

An improved transducer which includes a rigid frame and a permanent ring magnet mounted to the frame. A small bobbin, preferably formed of aluminum foil, is sized and arranged to fit within the open end of the magnetic gap while permitting motion of the bobbin therein. A voice coil is wound on the bobbin and connectable to receive an audio signal, similar to a conventional voice coil driver system. A pair of flexible, curved diaphragms are disposed in the frame, generally free to move except for a distal end of each diaphragm which is fixed to the frame. The diaphragms can be of generally cylindrical or partial-cylindrical shape.

REVENDICATIONS(22)

What is claimed is:
1. An audio transducer comprising:
a rigid frame;

a permanent magnet mounted to the frame, the permanent magnet including first and second opposite polarity plates, the plates defining a substantially annular gap therebetween;

a bobbin sized and arranged to fit within the annular gap while permitting motion of the bobbin therein;

a voice-coil wound on the bobbin and connectable to receive an audio signal;

a pair of flexible, curved diaphragms each having a distal end thereof fixed to the frame, and each having a proximate end;

a decoupling pad disposed intermediate the proximate ends of the first and second curved diaphragms and adhered to the proximate ends of both of the first and second curved diaphragms for decoupling the pair of diaphragms from one another; and

the bobbin connected to the pair of diaphragms adjacent the proximate ends thereof for transmitting energy to the diaphragms to generate sound in response to the audio signal.

2. An audio transducer according to claim 1 wherein the proximate linear ends of the diaphragms are oriented substantially normal to a central longitudinal axis of the bobbin.

3. An audio transducer according to claim 1 wherein the curved diaphragms are formed of a plastic film.

4. An audio transducer according to claim 1 wherein the curved diaphragms are formed of a polyester material.

5. An audio transducer according to claim 1 wherein the curved diaphragms have a thickness of approximately 0.002 inches.

6. An audio transducer according to claim 1 further comprising dampening means adhered to at least one of the curved diaphragms.

7. An audio transducer according to claim 1 wherein the decoupling pad is formed of a pliable material.

8. An audio transducer according to claim 1 wherein the decoupling pad is formed of a closed-cell foam tape.

9. An audio transducer according to claim 8 wherein the foam tape is adhered to the said proximate ends by a pressure-sensitive adhesive.

10. An audio transducer according to claim 8 wherein the tape has a thickness of approximately 1/32 inch.

11. An audio transducer according to claim 8 wherein the tape has a width of approximately 1/8 inch.

12. An audio transducer according to claim 1 and further comprising mounting means for supporting the bobbin suspended in the annular gap while allowing motion of the bobbin therein.

13. An audio transducer according to claim 12 wherein the mounting means including an annular mounting ring formed of a elastomeric material, the mounting ring disposed generally overlying and surrounding the annular gap and including a central aperture formed in the ring, the central aperture being sized to surround yet clear the bobbin and coil;
a radially outward circumferential region of the elastomeric ring being adhered to the frame to hold it permanently in place; and

a radially inward circumferential region of the elastomeric ring being connected to the bobbin so as to support the bobbin suspended into the annular gap while allowing motion of the bobbin therein.

14. An audio transducer according to claim 13 wherein the radially inward circumferential region of the mounting ring is connected to the bobbin at at least two locations.

15. An audio transducer according to claim 13 wherein the mounting ring further includes at least two joining discs each located intermediate the radially inward circumferential region of the elastomeric ring and the bobbin and each adhered to both the ring and to the bobbin for connecting the ring to the bobbin.

16. An audio transducer according to claim 15 wherein the joining discs are made of metal.

17. An audio transducer according to claim 16 wherein the joining discs are made of aluminum.

18. An audio transducer according to claim 13 wherein the joining discs are generally circular and have a size of approximately 0.5 mil thickness and are approximately 0.125 inch in diameter.

19. An audio transducer according to claim 13 wherein the joining discs are symmetrically spaced apart on opposite sides of the mounting ring and adhered to it adjacent the central aperture.

20. An audio transducer according to claim 13 wherein the joining discs are adhered to a top edge of the bobbin.

21. An audio transducer comprising:
a frame;

a permanent magnet mounted to the frame, the permanent magnet including first and second opposite polarity plates, the plates defining a magnetic gap therebetween;

a bobbin sized and arranged to extend into an open end of the annular gap while permitting motion of the bobbin therein;

a voice-coil wound on the bobbin and connectable to receive an audio signal;

a pair of flexible, curved diaphragms arranged substantially in parallel, each diaphragm each having a distal end thereof fixed to the frame, and each diaphragm having a proximate end;

a decoupling pad disposed in between and adhered to the proximate ends of the diaphragms for decoupling the diaphragms from one another; so that the proximate ends of the diaphragms and the decoupling pad together form an elongate diaphragm beam aligned substantially in parallel to the longitudinal axes of the diaphragm; and

the bobbin coupled to the diaphragm beam for transmitting energy to the diaphragms to generate sound in response to the audio signal.

22. An audio transducer according to claim 21 further comprising:
an elastomer mounting ring disposed overlying the ring magnet, the mounting ring having a central aperture aligned over the magnetic gap and sized to clear the bobbin and voice coil; and

a pair of rigid joining disks, each of the joining disks being adhered to the mounting ring and adhered to the diaphragm beam and adhered to the bobbin thereby coupling the bobbin to the diaphragm beam.

DESCRIPTION

BACKGROUND OF THE INVENTION

This invention generally relates to audio transducers. More specifically, the invention pertains to improvements in the design of a transducer having one or more cylindrical or partially-cylindrical arcuate diaphragm and methods and apparatus for coupling the diaphragm to a voice coil driver system.

The prior art includes various audio transducers, some of which have a diaphragm that can generally be described as cylindrical in the broadest sense of the term. The cross-sectional profile need not be circular, but may be an open or closed polygon or curve. The cylindrical diaphragms may generally be formed from flat sheets that are curved so that all lines normal to the curved surface remain perpendicular to the longitudinal axis of the diaphragm. A variety of diaphragms of this type are disclosed in PCT Application International Publication No. WO93/23967. FIG. 1 is a top view of a prior art audio transducer having a pair of generally cylindrical diaphragms as described in the PCT application. FIG. 2 is a top view of another prior art audio transducer, having a pair of diaphragms with semi-circular cross sections in a numeral three arrangement. Additionally, various driver systems are known in the prior art, including voice coils and etched coils. FIG. 3 is a simplified perspective view of a transducer having a pair of cylindrical diaphragms and a double-sided etched coil driver system. In this arrangement, a coil is formed on a printed circuit type of substrate material and connected to adjacent portions of the two diaphragm lobes. This arrangement is shown in greater detail in FIG. 4, an enlarged, top view of a central portion of the transducer of FIG. 3, showing detail of the etched coil connected intermediate proximate edges of the diaphragms. Additional detail of transducers of this general type are disclosed in my prior U.S. Pat. No. 5,249,237.

While various prior art transducers are reasonable efficient, and provide relatively flat frequency response, there remains a need for additional improvements in the performance and cost of audio transducer systems. The present invention provides an improved audio transducer that can be manufactured at very low cost, while still providing excellent performance.

SUMMARY OF THE INVENTION

One aspect of the invention is an improved audio transducer, especially useful as a tweeter but not so limited. The improved transducer includes a rigid frame and a permanent ring magnet mounted to the frame as is conventional. A small bobbin, preferably formed of aluminum foil, is sized and arranged to fit within the open end of the magnetic gap while permitting motion of the bobbin therein. A voice coil is wound on the bobbin and connectable to receive an audio signal, similar to a conventional voice coil driver system. A pair of flexible, curved diaphragms are disposed in the frame, generally free to move except for a distal end of each diaphragm which is fixed to the frame. The diaphragms can be of generally cylindrical or partial-cylindrical shape.

The proximate ends of the diaphragms are connected together in a spaced relationship by a pliable decoupling pad, preferably formed of a closed-cell foam tape, for decoupling the diaphragms from one another, while providing for driving them with the single voice coil driver assembly. The proximate ends of the diaphragms and the decoupling pad together form a diaphragm beam assembly. A central notch in the beam assembly reduces mass and improves performance.

The bobbin is suspended in place by a flexible elastomeric mounting ring, overlying the magnet and registered over the gap. The bobbin is connected to the mounting ring by way of two joining discs, preferably formed of aluminum. The same joining discs are also connected to the diaphragm beam for transmitting energy to the diaphragms to generate sound in response to the audio signal, while spacing the diaphragm beam apart from the mounting ring. These and other aspects of the invention described in greater detail below provide reduced material costs, ease of assembly, and good performance in the improved audio transducer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of a prior art audio transducer having a pair of generally cylindrical diaphragms.

FIG. 2 is a top view of a prior art audio transducer having a pair of diaphragms with semi-circular cross-sections in a numeral-three arrangement.

FIG. 3 is a simplified perspective view of an audio transducer having a pair of cylindrical diaphragms and a double-sided etched coil driver system connected intermediate the proximate edges of the diaphragms.

FIG. 4 is an enlarged, top view of a central portion of the transducer of FIG. 3 showing detail of the double-sided etched coil driver system connected intermediate the proximate edges of the diaphragms.

FIG. 5 is a perspective view of an improved audio transducer according to the present invention.

FIG. 6 is a perspective view of only the frame portion of the improved audio transducer of FIG. 5.

FIG. 7 is a cross-sectional top view of the audio transducer of FIG. 5

FIG. 8 is cross-sectional front view of the audio transducer of FIG. 5.

FIG. 9 is an enlarged, cross-sectional top view of the driver region of the audio transducer of FIG. 5

FIG. 10 is an enlarged, perspective view of the driver region of the audio transducer, showing the bobbin withdrawn from the magnet gap for clarity.

FIG. 11 is a perspective view of an alternative embodiment of the invention.

FIG. 12 is a top view partially in cross-section of the alternative embodiment transducer of FIG. 11.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 5 is a perspective view of a preferred audio transducer according to the present invention. In general, the transducer comprises a pair of generally cylindrical diaphragms coupled to a common voice coil driver system, all of which is mounted within a rigid frame, as described in greater detail below.

FIG. 6 is a perspective view of only the frame portion of the transducer system of FIG. 5. The frame can be formed of any rigid material, and preferably is molded of a polymeric material. The frame 22 has a solid backside 26 that includes a central aperture 28. The aperture 28 is sized for receiving the magnet of the driver system as further described later. Frame 22 further includes a flange 40 extending around its periphery for mounting the transducer. Recessed mounting holes 42 can be provided in the mounting flange 40 as appropriate. The frame 22 is generally bilaterally symmetric, and further includes an opposed top plate 30 and bottom plate 32, arranged in parallel and together defining an opening in the front of the frame sized to receive yet clear the diaphragms. The top and bottom plates, 30, 32, each include a series of slots, for example slots 36, which are cut into the front edge of a central portion of the top and bottom plates. Additionally, the front edges of the top and bottom plates are mildly concave, tapering inward toward the center portion. These slots improve performance of the transducer by impeding reflections particularly at higher frequencies. FIG. 5 shows the general arrangement of a pair of diaphragms 46 and 48 mounted in the open front of frame 22 as further described shortly.

FIG. 7 is a cross-sectional view of the transducer of FIG. 5 looking downward from the top of the transducer. In this view, one can observe that the diaphragms 46, 48 are symmetrically arranged, generally side by side in a parallel arrangement within the frame. The outside, or distal ends of the diaphragms, e.g., distal end 50 of the left diaphragm 46, are fixed to the frame, for example, by use of an adhesive in a slot provided for that purpose. In this view, one can better see the driver system mounted in the frame. The driver system includes a permanent ring magnet 66 which is fixed to the frame 22 in aperture 28. The permanent magnet further includes a steel pole 68 overlying the back side of the ring magnet as shown, and extending through the open core of the ring magnet toward the front of the frame. The steel pole 68 is sized to leave a magnet gap 69 between the steel pole and the ring magnet. A steel top plate 70 having a central aperture diameter as the ring magnet aperture is fixed to the front side of the magnet. The steel plates are fixed to the ring magnet so as to provide an annular magnet gap 69 between the poles of the magnet. In this view one can also observe damping tape 52 and 54, adhered to interior surfaces of the diaphragms 46, 48, respectively, as better seen in the perspective view of FIG. 5. These damping tapes are further described in the prior art patents identified above.

FIG. 8 is a front view of the audio transducer of the previous figures. In this view, one can observe various structures underlying the diaphragms as the diaphragm typically would be formed of a transparent material. Preferably, the diaphragms are formed of a plastic film and more specifically, a polyester material, having a thickness of approximately 2 mil. In this view from the open front of the transducer, one can observe the steel top plate 70 overlying the ring magnet and mounted in the aperture 28 of the frame. An annular spacer 72 is positioned in parallel with and overlying the top plate 70. An elastomeric mounting ring 74 is positioned overlying the spaced 72. One can also observe in this view the steel pole 68, magnet gap 69, and mounting discs 76, all of which are described in greater detail shortly.

FIG. 9 is an enlarged cross-sectional top view of the driver region of the audio transducer of FIG. 5. In FIG. 9, one can observe the ring magnet 66, steel pole 68 and top plate 70 of the magnet structure in greater detail. The magnet structure is fixed to the frame 22 as noted above. The annular spacer 72 is fixed to the top plate 70, using a suitable adhesive, and it includes a central aperture having about the same diameter as the ring magnet core, and aligned as positioned therewith. A voice coil as formed of suitable coil wire 80, is wound around a bobbin 78, also shown in perspective view in FIG. 10. Thus, the voice coil refers to a fine, multiple-turn wire coil, closely wound around a thin bobbin of suitable material. Preferably, in a tweeter application, the bobbin 78 is formed of 0.5 to 1 mil. aluminum foil. The winding (on the bobbin) is suspended in the annular magnetic gap in such a fashion that it moves in step with an alternating current applied to the wires 80 in an up and down motion relative to the view in FIG. 9. With reference to FIGS. 5 and 6, the bobbin and coil oscillate along an axis normal to the back plate 26 of the frame, i.e., in a front/back direction, as we have described the transducer.

The bobbin/voice coil suspension system depends primarily upon the elastomeric mounting ring 74. The mounting ring 74 is disposed overlying and surrounding the annular magnetic gap and includes a central aperture formed in the ring, sized to surround yet clear the bobbin and coil. A radially outward circumferential region of the elastomeric region 74 is adhered to the spacer 72 and is thereby fixed to the magnet and frame. A radially-inward circumferential region of the mounting ring is free to oscillate. Before describing how the diaphragms are connected to the voice coil driver system, it is necessary to first describe certain aspects of the diaphragms in greater detail. First, as illustrated in FIGS. 9 and 10, the diaphragms are not formed of a singled, folded sheet of material. Rather, the diaphragms are formed of two separate sheets. Each diaphragm 46, 48, has a respective proximate end region 56, 58, respectively. As shown in cross section in FIG. 9, and in perspective view in FIG. 10, the proximate ends of the diaphragms are aligned in parallel, and interconnected by a decoupling pad disposed intermediate the proximate ends of the diaphragms and adhered to each of them. The decoupling pad 60 preferably is formed of a pliable material, and more specifically, can be conveniently formed of a closed-cell foam tape. The foam tape is adhered to the diaphragms by pressure-sensitive adhesive. The foam decoupling pad extends the full length of the proximate ends of the diaphragms, as shown in FIG. 10. These structures together form the diaphragm beam 62. The diaphragm beam 62 includes a central notch 64 as shown in FIG. 10. Notch 64 reduces the mass in this critical area of the vibrating system, and breaks the pathway for immediate end-to-end standing waves, and forms a "hinge point" in the otherwise ridged central beam area, allowing the vertical line to flex a higher frequencies--therefore improving vertical dispersion.

FIG. 11 is a perspective view of an alternative embodiment of an audio transducer 90. In this embodiment, a rigid frame comprises a top frame member 92 and similar bottom frame member 94 interconnected by a pair of mounting posts 96, 98, for holding the top and bottom frame members in a parallel, spaced apart relationship. The top and bottom frame members include a series of recesses, for example recesses 100, formed along both the front and back edges of the frame members to break up and disperse acoustic reflections between these frame members. Audio transducer 90 further includes a pair of generally cylindrical diaphragms 102 and 104 positioned in proximate, parallel relationship. The transducer 90 optionally further includes a rigid mounting member 110 which can further include electrical terminals 112 for connecting an audio signal source to the voice coil driver as further explained shortly.

FIG. 12 is a cross-sectional top view of the audio transducer 90. The frame further includes a rigid magnet mounting member 20 which is fixed in between the top and bottom frame members 92, 94 and includes a central aperture 122 (FIG. 11) sized to receive a permanent ring magnet mounted therein. In FIG. 11, the voice coil driver system includes a permanent ring magnet 124 with attached steel plate 126 extending through the central core of the ring magnet as described previously with reference to the first embodiment. Proximate ends 132, 134 of the diaphragms 102, 104, respectively, are connected to a decoupling pad as describe previously in the first embodiment with references to FIGS. 9 and 10. The alternative embodiment 90 further includes an elastomeric mounting ring 136, annular spacer 138, and a voice coil wound on a bobbin, again as described previously. Embodiment 90 also includes damping pads 144, 146 disposed in the interior regions of diaphragms 102, 104, respectively. The damping pads preferably are formed of a felt-type material and extend the full height between the top and bottom frame members 92, 94, as illustrated. These damping pads supress internal acoustic reflections.

Holes 150 in frame members receive elastomeric pads which extend to diaphragm edges--helping locate them in correct relationship with their fixtured ends and further supplying additional physical damping. This is not the only possible location for the "buttons"--a multiplicity of them could be distributed along the curved edges of the diaphragm and therefore supply enough physical damping to the diaphragm to obviate the need for the previously described damping tape (54).