United States Patent [19]

Winey

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[11] **3,919,499**

[45] **Nov. 11, 1975**

[54] **PLANAR SPEAKER**

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[73] Assignee: **Magnepan, Incorporated**, White Bear Lake, Minn.

[22] Filed: **Jan. 11, 1974**

[21] Appl. No.: **434,214**

[52] **U.S. Cl.** .... **179/115.5 PV**
[51] **Int. Cl.²** **H04R 9/06**
[58] **Field of Search** .... 179/115.5 PV

[56] **References Cited**

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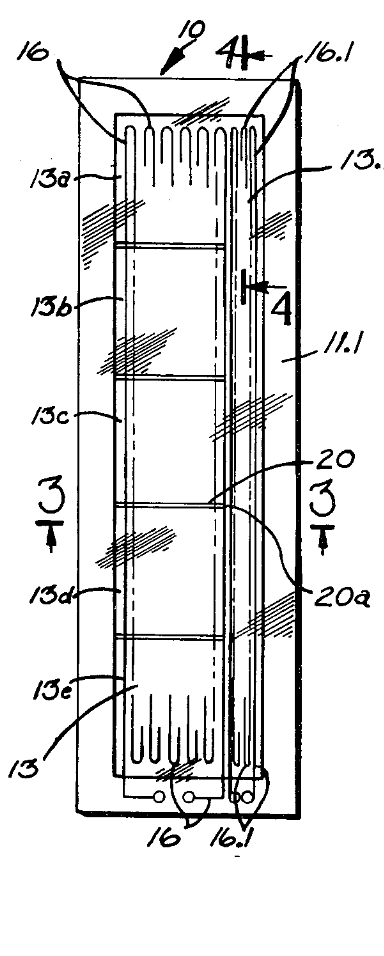
3,164,686	1/1965	Tibbetts	179/115.5 PV
3,674,946	7/1972	Winey	179/115.5 PV

Primary Examiner—William C. Cooper
Assistant Examiner—George G. Stellar
Attorney, Agent, or Firm—H. Dale Palmatier; James R. Haller

[57] **ABSTRACT**

A sound generating transducer or speaker including a vibratable diaphragm on a frame and in spaced and confronting relation with a polarity defining backing, preferably magnetic in nature, conductive means on the diaphragm to receive an audio frequency electric signal to cause attraction and repulsion between the diaphragm and the backing, the diaphragm being divided into definite vibratable areas by divider strips bearing against the diaphragm such that each diaphragm area has a fundamental resonant frequency different than other adjacent areas. The ends of the divider strips are spaced from one edge of the diaphragm to define a long strip-like edge portion of the diaphragm which transcends the several vibratable areas of the diaphragm. The conductive means are separate bass and mid-range audio frequency signal conductors and high range audio frequency signal conductors on the diaphragm and separated in distinct zones, the high range audio frequency signal conductors located in a zone extending along the strip-like edge portion and defining a long, narrow tweeter transcending the several vibratable areas and through the edge areas of the several vibratable areas or woofers which are excited by the signal current in the bass and mid-range audio frequency signal conductors. The mid-range audio frequency signals may be separately applied along another edge portion or zone of the diaphragm in a separate conductor on the diaphragm.

19 Claims, 15 Drawing Figures



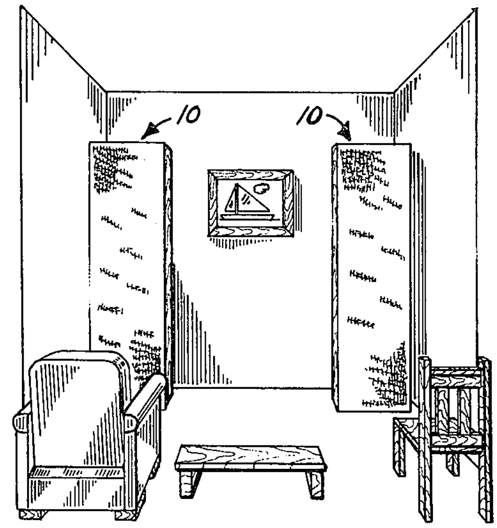


FIG 1

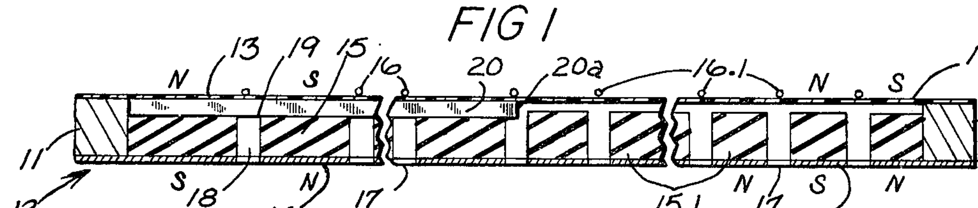


FIG 3

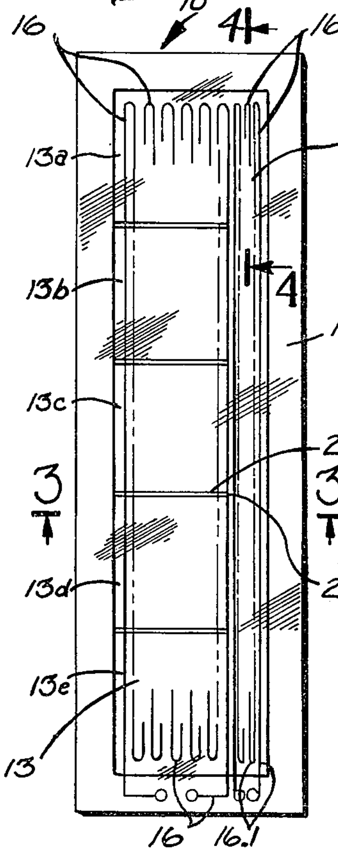


FIG 2

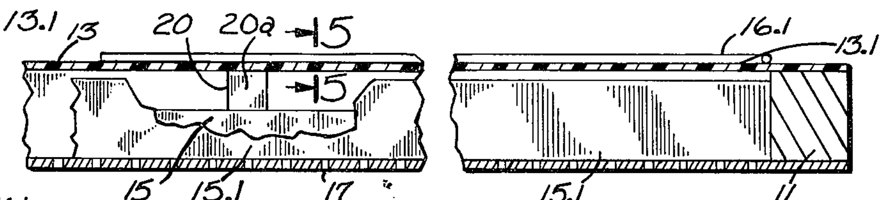


FIG 4

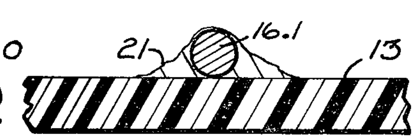


FIG 5

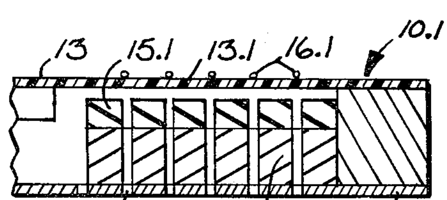


FIG 8

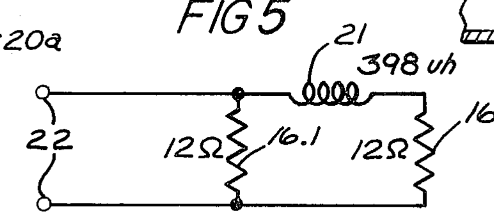


FIG 6

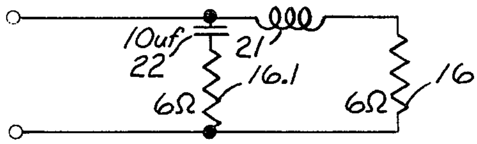


FIG 7

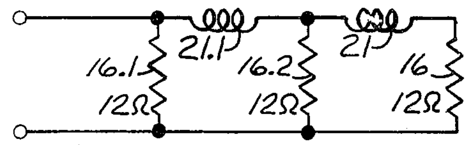


FIG 11

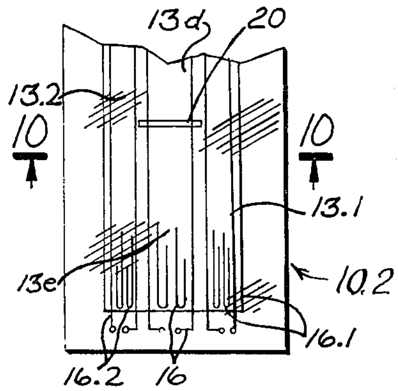


FIG 9

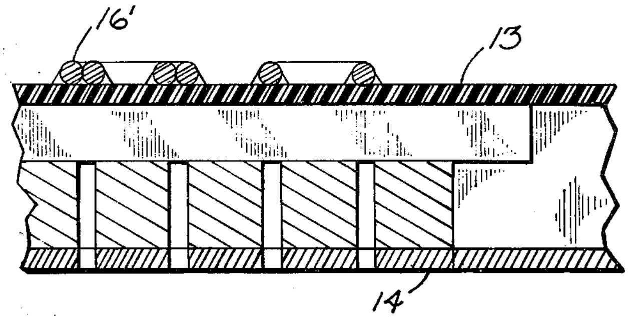


FIG 12

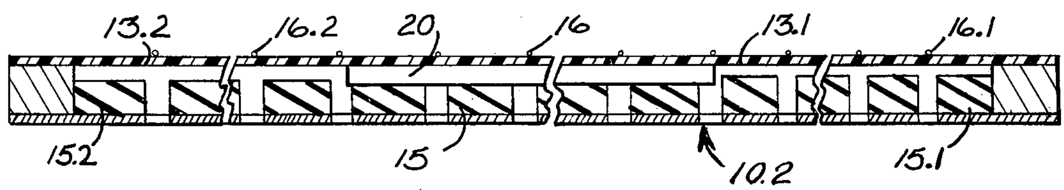


FIG 10

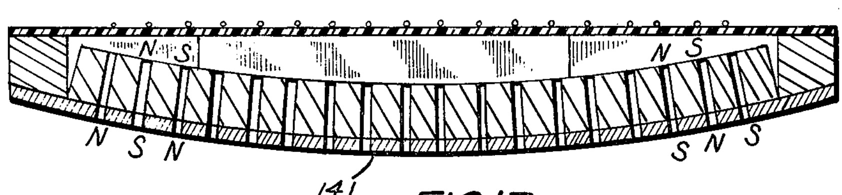


FIG 13

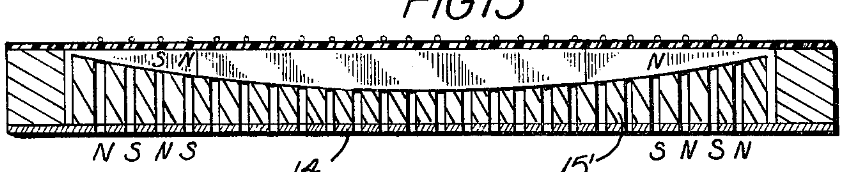


FIG 14

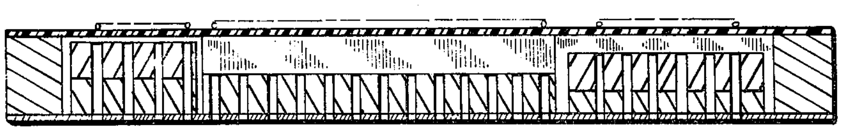


FIG 15

PLANAR SPEAKER

BACKGROUND OF THE INVENTION

Loudspeakers employing vibrating planar diaphragms to produce the sounds have been previously known, and certain advantages have been obtained as compared to cone speakers with wound signal coils. As described in my U.S. Pat. No. **3,674,946**, diaphragm areas having various resonant frequencies, and being stretched beyond a mere taut condition, contribute materially to high level of output from such speakers.

SUMMARY OF THE INVENTION

It has been discovered that in a diaphragm type transducer or speaker, it is very desirable that high audio frequency sounds be produced and emanate from a narrow and long strip-like zone or area of the diaphragm. If such a strip-like tweeter zone is oriented in upright position, the high audio frequency sounds will emanate horizontally in substantially all directions, that is to say, will emanate directly out in front of the diaphragm and the strip-like zone and also to the left and to the right at all various angles. Similarly, because the generally rigid backing for the transducer is acoustically transparent, such high audio frequency sounds will also emanate horizontally to the rear of the diaphragm in substantially all directions.

The actual magnitude of vibration or excursion of diaphragm areas producing such high audio frequency sounds is extremely small, amounting to only a few thousandths of an inch. Because of this incremental diaphragm excursion in the tweeter zones, the magnet or source of magnetic field may be located very close to the diaphragm. It has been found that the diaphragm and the conductors thereon in the strip-like tweeter zone should be quite close to the magnet so the magnetic field will have maximum intensity at the diaphragm. The sound output of the tweeter zone will thereby be maximized for any level of signal current in such conductors.

It has been discovered that in broad diaphragm areas from which bass and mid-range audio frequency sounds emanate, almost edge areas of the diaphragm have a minimum and alomost negligible vibratory movement or excursion, principally because the extreme edge is clamped or physically retained against movement by the frame. However, such edge areas are extremely important and significant to the transducer because they contribute materially to the establishment of a desired low resonant frequency of the diaphragm area of which the edge areas are a part.

Although such edge areas are needed for establishment and maintenance of desired resonant frequencies, such edge areas may be simultaneously utilized for such strip-like tweeter zones for generating and radiating the higher audio frequency sounds. Whereas such edge areas may vibrate slightly with the diaphragm as a whole, such edge areas may be separately driven or vibrated with higher audio frequency signals to generate sounds of corresponding frequency.

Such strip-like tweeter zones may transcent diaphragm areas which are otherwise independent of each other. The edge areas of adjacent large and independent diaphragm areas may be connected together into such a unitary, elongate strip-like tweeter zone.

For such a transducer wherein high audio frequency signal carrying conductors are arranged in strip-like tweeter zones along the edge of the diaphragm area, and bass and mid-range audio frequency signal carrying conductors are located predominately in the central or woofer zone of the diaphragm area, the magnet or magnetic system producing the magnetic field at the diaphragm may be advantageously arranged. The magnet may be spaced sufficiently from the woofer zone of the diaphragm area as to avoid interference with the vibration of the diaphragm. Adjacent the tweeter zone, the magnet may be located extremely close to the diaphragm.

Other edge areas of the vibrating diaphragm may carry conductors into which only mid-range audio frequency signals are supplied. The magnet will be spaced somewhat farther from such edge areas than from the high frequency tweeter zones.

Audio frequency signals from the amplifier may be separated for application to the energizing conductive means of the diaphragm areas. For instance, in a magnetic transducer (speakers or transducers may also be of the electrostatic type) a simple frequency separating network or crossover circuit may be used. The single output from the amplifier may be connected directly to the conductors of the tweeter section of the transducer diaphragm, and the woofer section conductors in series with a blocking coil may be connected in shunt with the conductors of the tweeter section. The blocking coil will be of such a size as to block the high audio frequency signals from the woofer section conductors. If separate mid-range audio frequency signal carrying conductors are utilized on the diaphragm, either in a separate zone of the diaphragm or in juxtaposed or clustered relation with the bass signal conductors on the diaphragm, a separate blocking coil may be series-connected with the bass signal conductors to also block the mid-range audio frequency signals from the bass signal conductors.

Because many, or most, amplifiers currently utilize predominately solid state components, the use of one or more coils to block high and mid-range audio frequency signals from the bass frequency signal conductors takes advantage of the fact that solid state amplifiers put out their maximum power into low impedance loads. The bass signal conductors, which need the most power to produce bass sounds, present the lowest impedance to the amplifier and are therefore supplied with a maximum of power.

The favorable heat dissipation characteristics of the transducer should be noted. The several signal conductors on the diaphragm, in the tweeter, woofer and mid-range zones are spread out over a substantial area. Any heating produced by the substantial current carried by the conductors is rapidly dissipated without any adverse effect. Heating is therefore not a limiting factor in the amount of power that may be supplied to the transducer. The high energy bass and mid-range frequency signals need not be blocked from the high frequency tweeter section conductors because of the adequate heat dissipation.

One extremely important aspect of this speaker is that the speaker is complete with one diaphragm. Sounds across the entire audio frequency range are accurately reproduced by the speaker. Because the speaker is complete in the use of one diaphragm, numerous and substantial economies are effected, without any significant change in sound reproduction.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a small scale perspective view illustrating such transducers in use in a room.

FIG. **2** is an elevation view of the transducer with the decorative fabric cover removed.

FIG. **3** is an enlarged detail section view taken approximately at **3—3** in FIG. **2.**

FIG. **4** is an enlarged detail section view taken approximately at **4—4** in FIG. **2.**

FIG. **5** is a greatly enlarged detail section view taken approximately at **5—5** in FIG. **4.**

FIG. **6** is a schematic circuit diagram of the transducer for connection to an amplifier.

FIG. **7** is a slightly modified schematic circuit diagram of the transducer for connection to the output of an amplifier.

FIG. **8** is an enlarged detail section view somewhat similar to a portion of FIG. **3** and showing a modified form of a portion of the magnetic system.

FIG. **9** is a detail elevation view illustrating a modified form of the invention.

FIG. **10** is an enlarged detail section view taken at **10—10** of FIG. **9** and having portions thereof broken away facilitating use of a large scale.

FIG. **11** is a schematic circuit diagram including the transducer of FIG. **9** and adapted for connection to the output of an audio amplifier.

FIG. **12** is an enlarged detail section view showing a modified form of conductor arrangement on the diaphragm.

FIG. **13** is a diagrammatic section view showing a modified form of the invention.

FIG. **14** is a view similar to FIG. **13** and showing another modified form of the invention.

FIG. **15** is a view similar to FIG. **13** and showing still another modified form of the invention.

DETAILED SPECIFICATION

The transducers hereof are indicated in general by numeral **10** and are generally panel shaped. The transducers are shown in a typical arrangement in FIG. **1** wherein two such transducers are used as a part of a stereophonic system to generate sound in accordance with the electric signals provided.

These panel shaped transducers may be approximately **5** feet high by **12** to **15** inches wide and approximately an inch in overall thickness, principally due to the thickness of the frame.

In FIG. **1**, the transducers are illustrated with plain fabric covers which give a desired decorative effect and provide some degree of protection for the transducer from physical damage.

The transducer is shown in FIG. **2** and is set into a frame **11.1** extending about the entire periphery of the transducer to produce a rigid structure and resist warpage. The frame **11.1** may be considered a part of the rigid backing which is indicated in general by numeral **12** which provides the functions of mounting a flexible diaphragm **13** along its edges and defining fields adjacent the diaphragm. Accordingly, the backing **12** includes a rigid spacer **11** extending around the entire periphery of the transducer, and a stiff and generally rigid panel-shaped armature **14** constructed of magnetic material, specifically a ferrous metal or soft iron material and suitably glavanized to resist corrosion. Armature **14** is concavely bowed slightly adjacent each diaphragm area to accommodate diaphragm excursion. The armature panel is affixed adhesively and, in some cases, mechanically, to the spacer **11** which may be constructed of wood, pressed fiber, rigid plastic, aluminum, iron or other rigid materials, and the panel may be approximately **18** to **24** gauge galvanized sheet metal, or approximately **0.050** inches thickness. The field-generating backing **12** also includes a plurality of elongate thin flexible strips or magnets **15** formed of any suitable material, but it has been found that a plastic rubber bonded barium ferrite magnetic material known by its trademark PLASTIFORM sold by Minnesota Mining and Manufacturing Company of St. Paul, Minnesota, has proven satisfactory. It should be recognized that, instead of the strips, the magnets may be formed in broad sheets of the same material; in any event, the strips or magnets are magnetized in a direction transversely of the armature plate **14** and of diaphragm **13** so that elongate magnetic zones are defined which extend all along the length of the diaphragm **13.** The strips **15** are arranged so that pole faces of adjoining magnetic zones are of opposite polarity as indicated in FIG. **3.**

The magnetic fields, in elongate zones, are of maximum strength at locations just between adjacent strips **15,** and, accordingly, the conductors **16** are secured on the diaphragm **13** at locations approximately between adjacent magnetic strips **15.**

The backing **12** is acoustically transparent to the sounds produced by the vibrating diaphragm **13,** and, accordingly, the plate-like armature **14** has a plurality of apertures **17** therethrough. The apertures **17** are aligned with the spaces **18** between the strips or elongate magnets **15.**

The top surfaces or pole faces **19** of the strips or magnets **15** are spaced substantially from the diaphragm **13** so as to allow the diaphragm to have a significant excursion from its normal position without engaging or impinging the strips **15.**

The diaphragm **13** is divided into a number of substantially independent vibratable areas **13*a***, **13*b***, **13*c***, **13*d*** and **13*e***, each of which is a different size than the areas adjacent thereto. Accordingly, each of the separate vibratable areas **13*a*** – **13*e*** has a fundamental resonant frequency which is significantly different than the fundamental resonant frequencies of the other areas. In this version of the transducer, the diaphragm may be uniformly stretched on the spacer **11** so that it has a permanent stretch of approximately one percent or more over its natural size. Ordinarily, the diaphragm **13** will be stretched in a transverse direction, but may also, if the need arises, be stretched in a longitudinal direction. In order to produce the various fundamental resonant frequencies at the various areas, the areas may under certain circumstances all be the same and the mass of the diaphragm in each of the areas may be varied slightly so as to produce a different fundamental resonant frequency.

The areas **13*a*** – **13*e*** of the diaphragm are defined by divider strips **20** which underlie and are secured as by adhesive to the diaphragm **13.** The divider strips **20** overlie and bear upon the magnet strips **15,** and may be adhesively secured to the magnet strips. The effect of the divider strips **20** is to immobilize the diaphragm **13** at each of the strips so as to require that the diaphragm, in each of the vibratable areas **13*a*** – **13*e***, will vibrate independently of vibrations of the diaphragm in each of the other areas.

It will be seen that one end **20***a* of each of the divider strips is located in spaced relation with the edge of the diaphragm and the adjacent portions of spacer **11.** As a result, there is an elongate narrow strip or edge portion **13.1** of the diaphragm extending longitudinally of the transducer and along one side of the spacer **11.** This elongate edge portion of the diaphragm is not anchored by the strips **20** and transcends all of the several vibratable areas **13***a* – **13***e*. Conducters **16.1** are secured on and extend longitudinally along the full length of the narrow edge portion **13.1** of the diaphragm.

As depicted in FIG. **5,** the conductors **16.1,** and also conductors **16,** are secured to the diaphragm **13** by an adhesive **21.** The backing **12,** adjacent the edge portion **13.1** of the diaphragm includes the elongate strip magnets **15.1,** which are essentially identical to strips **15,** but of somewhat different dimensions, being somewhat narrower, but somewhat deeper or thicker. The spacing between the magnet strips **15.1** and the edge portion **13.1** of the diaphragm is significantly less than the spacing between the diaphragm and the strips **15.** This smaller spacing adjacent the edge portion **13.1** of the diaphragm is permissible because the edge portion of the diaphragm is retained against vibration by the spacer **11** and there is no significant excursion of the diaphragm in the edge portion **13.1.**

The divider strips **20** may extend entirely across the diaphragm and to the opposite spacers **11**; however, the strips would have to be thinner adjacent magnets **15.1** to correspond to the reduced spacing between the magnets **15.1** and the diaphragm **13.** Such full width strips **20** produce no hearable change as compared to the operation of the construction illustrated.

Vibration of this portion **13.1** of the diaphragm is caused by vibration of the adjacent vibratable areas **13***a* – **13***e*, caused by the application of an audio frequency signal or current in the conductors **16.** Ordinarily, the signal applied to conductors **16** will be of bass audio frequency, or midrange audio frequency, and, accordingly, the diaphragm areas **13***a* – **13***e* will be vibrated with a corresponding bass audio frequency. This vibration of the diaphragm induced by the signal in conductors **16** is produced in the edge portion **13.1** as well as in the central portions of the areas **13***a* – **13***e*. However, because the actual movement of the edge portion **13.1** of the diaphragm is minimal, there is no significant sound generated by the vibration of the edge portion **13.1** under influence of the bass frequency vibrations. The fact that the edge portion **13.1** is a portion of each of the adjacent vibratable areas **13***a* – **13***e* of the diaphragm, and is free to vibrate therewith, is extremely significant in defining the fundamental resonant frequency for each particular vibratable area **13***a* – **13***e*. The effective diaphragm area for establishing the fundamental resonant frequency for any of the particular diaphragm areas **13***a* – **13***e* is somewhat larger because the edge portion **13.1** is included, and therefore the fundamental resonant frequencies of the areas are as low as possible.

The conductors **16.1** which extend along the narrow edge portion **13.1** of the diaphragm will ordinarily be high audio frequency signals so as to generate the corresponding high audio frequency sounds. This edge area of the transducer including the narrow edge portion **13.1** of the diaphragm is considered a tweeter. As required to produce a significant sound output from this tweeter section, the pole faces of the magnetic strips **15.1** are located in close proximity to the diaphragm. The appròximate spacing between the diaphragm and the pole faces of the magnetic strips **15.1** may be **0.020** inches.

In one example the impedance of the conductors **16** may cumulatively amount to approximately cumualtive **12** ohms; and, similarly, the conductors **16.1** have cumulative impedance of **12** ohms. A blocking coil **21** is connected in series with the conductors **16** to block the high audio frequency signals from the conductors **16,** thus preventing any significant generation of high audio frequency sounds thereby, which sounds would be highly directional. The coil **21** may have an impedance of **398** microhenrys. Typically, the conductors **16** are arranged in side by side runs on the diaphragm and are regularly spaced from each other at a spacing of about four conductors per inch. The tweeter conductors **16.1** are spaced equally from each other, and approximately eight conductors per inch. The effective width of the long strip-like tweeter may be approximately ½ to 1 inch, and the width of the diaphragm area to which conductors **16** are applied may be approximately seven inches. The rigid divider strips **20** are approximately 7 inches long. With the transducer conductors connected as indicated in FIG. **6,** and connected to the output of an audio amplifier at the terminals **22,** the high audio frequency signals are effectively blocked from the low audio frequency signal-carrying conductors **16** on the diaphragm so that the amplifier, if a solid state amplifier, will put out its maximum power into the low impedance load, the conductor **16.**

Whereas each of the diaphragm areas **13***a* – 13*e* includes the adjacent edge portion **13.1** as a part of it for defining its fundamental resonant frequency, and driven by bass frequency signals applied in conductors **16.1,** the edge portion **13.1** also acts separately as a tweeter for independently and separately generating the high range audio frequency sounds.

In another form conductors **16** may be **22** gauge copper wire in runs approximately **0.310** in. apart, and conductors **16.1** may be **32** gauge aluminum wire spaced **0.210** in. apart. The mass of the conductors **16.1** will be considerably less than the mass of conductors **16.** Magnet strips **15** may be **0.085** in. thick by **0.260** in. wide and minimally spaced **0.040** in. from the half mil diaphragm; and the magnet strips **15.1** may be **0.105** in. thick by **0.150** in. wide and spaced **0.020** in. from the diaphragm. Strips **20,** with thicknesses of approximately **0.020** to **0.040** in., and spacers **11** maintain the minimum edge spacing in each area **13***a* – **13***e*, and the center of each areas has the magnets **15** spaced up to **0.100** inches from the diaphragm by concavely bulging or dishing the metal armature plate **14** away from the diaphragm.

Published wire conductor data tables indicate that **22** gauge copper wire weights **1.94** pounds per **1,000** feet of wire; and that **32** gauge aluminum wire weighs **0.0589** pounds per **1,000** feet of wire. Simple computation indicates that **22** gauge copper wire therefore weighs 16.2×10^{-5} pounds per lineal inch; and **32** gauge aluminum weighs 0.491×10^{-5} pounds per lineal inch. In the foregoing example wherein the **22** gauge copper wires are in runs approximately **0.310** inches apart, there are approximately **3.23** inches of **22** gauge copper conductors **16** per square inch of diaphragm area, and therefore the weight of the 22 gauge copper conductor 16 amounts to 52.2×10^{-5} pounds of copper wire per square inch of diaphragm area.

The high frequency signal carrying 32 gauge aluminum wire, in the aforesaid example, is in runs 0.210 inches apart, therefore requiring 4.76 lineal inches of aluminum wire per square inch of diaphragm area which weighs 2.34×10^{-5} pounds per square inch of diaphragm area. The mass or weight of the aluminum wire per square inch of diaphragm area will therefore be seen to be significantly less than the mass or weight of the 22 gauge copper wire per square inch of diaphragm area, by a ratio of approximately 1 to 22.3. In comparing the relative weights of the 32 gauge aluminum and 22 gauge copper wire per square inch of diaphragm area, the aluminum wire weighs only 4.5 percent of the weight of the copper wire, or otherwise stated, the mass of the aluminum conductor 16.1 is 95.4 percent less per unit of area of the diaphragm than the mass of the copper conductor 16.

Low range or bass audio frequency sounds will therefore emanate from each of the several vibratable areas 13*a* – 13*e* in both forward and rearward directions and at all the various angles from side to side. The high range audio frequency sounds are generated at the tweeter strip or edge portion 13.1, and, because of the narrow configuration, these high range audio frequency sounds will emanate horizontally outwardly in substantially all directions, both forward and rear.

Although the conductors 16 and 16.1 may carry a significant current, there is little concern for heating because the conductors are spread out widely on the diaphragm with the effect of dispersing large amounts of heat without damage to any of the components.

In the circuit arrangement of FIG. 7, the several conductors 16 and 16.1 are typically designed with an impedance of 6 ohms each. The blocking coil 21 is connected in series with the bass audio frequency signal-receiving conductor 16, and a condenser 22 of approximately 10 microfarads is connected in series with the tweeter conductor 16.1. This arrangement is a conventional L-C crossover circuit. In addition to blocking the high audio frequency signals from the conductor 16, it also blocks the low or bass range audio frequency signals from the high frequency tweeter section or conductors 16.1. The impedance is the same at any frequency. It can handle larger amplifiers and does not shift maximum power to the low frequency end. A more accurate sound is thereby produced.

The form of the transducer 10.1 illustrated in FIG. 8 is substantially identical to that illustrated in FIGS. 1 – 5 with the exception that the magnetic strips 15.1′ beneath the narrow edge portion or tweeter section 13.1 of the transducer are of thin construction and are supported upon an acoustically transparent spacer plate 25 which is a portion of the magnetic armature. The spacer plate 25 is also constructed of a ferrous metal and preferably a soft iron so as to form a low reluctance path for the magnetic field, together with the magnet strips 15.1′ and the armature plate 14.

The transducer 10.2 illustrated in FIGS. 9 – 11 is substantially the same as that illustrated in FIGS. 1 – 5. In this form of transducer, the diaphragm 13 is similarly divided into a number of separate vibratable areas, each with a different fundamental resonant frequency, the separate vibratable areas illustrated in FIG. 9 being designated 13*d* and 13*e*. Of course, additional separate vibratable areas with different fundamental resonant frequencies will be utilized as illustrated in connection with FIG. 2. In this form of the invention, the bass audio frequency signal-carrying conductors 16 traverse the central portion of each of the separate vibratable areas of the diaphragm; and in a manner similar to that described in connection with FIGS. 1 – 5, the high audio frequency signal-carrying conductor 16.1 extends the full length of the narrow edge portion of tweeter strip 13.1 to generate and emanate high audio frequency range sounds.

In this form of the invention of FIGS. 9 – 11, an additional edge portion 13.2 of the diaphragm remains free of the divider strips 20, both ends of which are in spaced relation with the adjacent frames and the edges of the diaphragm. However, as in the form of FIGS. 1 – 5, strips 20 may extend entirely across the diaphragm to opposite sides of the frame, making provision for varying magnet to diaphragm spacings. The elongate and narrow diaphragm area 13.2 carries additional conductors 16.2 for receiving midrange audio frequency signals and producing vibration of the diaphragm area 13.2 in accordance with these frequencies. As seen in FIG. 11, in addition to the blocking coil 21 which blocks the midrange and high audio frequency signals from the conductor 16.1, and additional blocking coil 21.1 is connected in series with the midrange frequency signal-carrying conductor 16.2 so as to block all of the high range audio frequency signals. Whereas the impedance to high audio frequency signals remains high at about 12 ohms, the impedance of the transducer to signals in the approximate range of 2 KHz may be approximately 6 ohms, while the impedance to signals of approximately 12 Hz may be approximately 4 ohms. Of course, this provides an advantageous balancing effect for producing a well balanced sound. Of course, conventional L-C crossovers for three way systems may also be used.

Under certain circumstances it may be desirable to produce multiple runs of conductors 16′ as illustrated in FIG. 12 over certain of the portions of the diaphragm for increasing the cooperative effect between the current and the magnetic field for vibrating the conductor and obtaining the desired excursion.

It will be observed that in FIG. 10, the magnet strips 15.2 adjacent the edge portion 13.2 of the diaphragm are somewhat higher than the strips 15 beneath conductors 16 and somewhat lower than the magnet strips 15.1 beneath the edge portion 13.1 of the diaphragm. This spacing between magnet strips 15.2 and the diaphragm allows some additional excursion of the diaphragm in producing the midrange frequency signals as is required for such signals.

FIGS. 13, 14 and 15 show various modes of producing the variance in the spacing between the diaphragm and the face of the magnet in the backing. In FIG. 13, the armature 14.1, as well as the magnets or strips thereon, are arcuately curved so that the edge portions of the backing including the magnet are closer to the diaphragm than the middle portion. In FIG. 14, the same armature 14 is utilized as in FIGS. 1 – 5, but the upper faces of the magnets or strips 15′ on the armature are comulatively concavely curved to vary the spacing across the width of the transducer.

The form of the transducer illustrated in FIG. 15 employs acoustically transparent spacers beneath the magnets at the edge portions of the transducer, both beneath the tweeter section, but also beneath the mid-range audio frequency section of the transducer.

What is claimed is:

1. A sound generating transducer comprising:

a stiff and acoustically transparent backing having a broad and substantially flat shape,

an audio sound-producing flexible diaphragm secured to the backing in confronting relation therewith and defining a vibratable area, the edges of the vibratable area being stationary against vibration with respect to the backing, the vibratable area of the diaphragm having a central portion with low frequency signal carrying conductive means thereon for vibrating the entire vibratable area generating low frequency sounds,

said vibratable area also having an elongate and narrow strip portion with high frequency signal carrying conductive means affixed thereon and substantially throughout said strip portion for vibrating the narrow strip portion of the diaphragm and generating high frequency sounds, and the mass of the high frequency signal carrying conductor means per square inch of diaphragm area on said strip portion being substantially less than the mass of the low frequency signal carrying conductive means per sqare inch of area of the diaphragm, and

said backing having means defining polarity characteristics to alternately attract and repel the diaphragm and cause diaphragm vibrations for sound production upon application of audio frequency electric signals to the conductive means.

2. The transducer according to claim 1 and the backing being spaced significantly closer to the diaphragm at said narrow strip portions than at said central portion of the vibratable area.

3. The transducer according to claim 1 and both of the conductive means including current carrying conductors on the diaphragm, the high frequency signal conductors on the narrow strip portion having significantly less mass per unit of lenth than the low frequency conductors on the central portion of the vibratable area, and the polarity characteristics defining means of the backing being magnetic.

4. A sound generating transducer comprising:

a stiff and acoustically transparent backing having a broad and substantially flat shape,

an audio sound-producing flexible diaphragm having its edges secured to the backing, the diaphragm being disposed in confronting and spaced relation with the backing and having a pair of adjacent vibratable areas, each of said vibratable areas having a central portion with conductive means thereon to receive bass audio frequency signals for vibrating the diaphragm area as a woofer,

divider means between said adjacent vibratable areas and engaging and retaining the diaphragm against vibrating at the edge of the vibratable areas,

the diaphragm having an elongate and narrow edge portion extending into both vibratable areas, said elongate and narrow edge portion of the diaphragm having conductive means thereon to receive high audio frequency signals for vibrating the narrow edge portion of the diaphragm as a tweeter, the tweeter forming a portion of and transcending adjacent woofers, and

said backing having means defining polarity characteristics to alternatively attract and repel the diaphragm and cause diaphragm vibrations for sound production upon application of audio frequency electric signals to the conductive means.

5. The sound generating transducer according to claim 4 and said pair of adjacent vibratable areas of the diaphragm having different fundamental resonant frequencies separated significantly from each other.

6. The sound generating transducer according to claim 4 wherein both ends of the divider means are respectively spaced from opposite edges of the diaphragm, and

the diaphragm also having an elongate edge portion located along the edge of the diaphragm opposite the tweeter and also extending across the adjoining end of the divider means and into both vibratable areas and carrying conductive means to receive midrange audio frequency signals for vibrating the diaphragm.

7. The sound generating transducer according to claim 4 and the divider means having one end in spaced relation with one edge of the diaphragm, said one end being disposed adjacent the tweeter.

8. The sound generating transducer according to claim 4 and said acoustically transparent backing including a magnetic means,

the woofer and tweeter conductive means including current-carrying conductors cooperating with the magnetic means of the backing in vibrating the diaphram.

9. The sound generating transducer according to claim 8 and the conductors of the tweeter extending the full length of the tweeter and into both adjacent vibrating areas of the diaphragm.

10. The sound generating transducer according to claim 9 and the conductors of the tweeter extending longitudinally of the tweeter throughout substantially the full length of the diaphragm and to the edges thereof.

11. A sound generating transducer comprising:

a stiff and acoustically transparent backing having a broad and substantially flat shape and including a magnetic means producing magnetic fields adjacent the backing,

an audio sound-producing flexible diaphragm secured to the backing in confronting relation therewith and defining a vibratable area, the edges of the vibratable are being stationary against vibration with respect to the backing, the vibratable area of the diaphragm having a central portion with current-carrying conductors thereon to receive low audio frequency signals for vibrating the entire vibratable area,

said vibratable area also having an elongate and narrow edge portion with current-carrying conductors thereon to receive high audio frequency signals for vibrating the narrow edge portion of the diaphragm, and the magnetic means of said backing having pole faces confronting the diaphragm and lying parallel to the diaphragm adjacent said elongate narrow edge portion and the pole faces also being spaced significantly closer to the diaphragm adjacent said elongate narrow edge portion than at said central portion.

12. The sound generating transducer according to claim 11, and said magnetic means including a plate-like armature of magnetic material, and field generating means on the armature adjacent the central and

along the narrow edge portions of the vibratable area.

13. The sound generating transducer according to claim **12** and the field generating means including thin flexible magnets magnetically adhered to the armature and variously spaced from the diaphragm adjacent the edge portion and central portion of the vibratable area.

14. The sound generating transducer according to claim **11**, and the conductors of the central and edge portions being separated from each other without overlap or commingling.

15. The sound generating transducer according to claim **11** and including a blocking coil connected in series with the current-carrying conductors on the central portion to exclude the high audio frequency signals therefrom.

16. A sound generating transducer comprising:

a stiff and acoustically transparent backing having a broad and substantially flat shape, the backing including magnetic means defining elongate zones to form magnetic pole faces, adjacent pole faces being of opposite polarity to define a plurality of elongate magnetic fields adjoining the magnetic means,

an audio sound-producing flexible diaphragm having edges secured to the backing in confronting and spaced relation therewith and defining a vibratable area, the edges of the vibratable area being stationary against vibration with respect to the backing, the vibratable area of the diaphragm having a central portion with current-carrying conductors thereon and extending along the elongate zones of the magnetic means to receive low audio frequency signals and causing vibration of the entire vibratable area and generating low frequency sounds,

said vibratable area also having an elongate and narrow edge portion with current-carrying conductors thereon and extending along the elongate zones of the magnetic means to receive high audio frequency signals for vibrating the narrow edge portion of the diaphragm, and

the conductors in the elongate and narrow edge portion having a spacing from each other significantly less than the spacing between adjacent conductors at the central portion of the vibratable area, and the elongate zones and magnetic pole faces of the magnetic means being spaced from adjacent zones and faces in accordance with the spacing between adjacent conductors on the diaphragm.

17. The sound generating transducer according to claim **16**, and the pole faces of the magnetic means being uniformly spaced from the diaphragm adjacent the elongate narrow edge portion of the vibratable area, and also being positioned significantly closer to the diaphragm and conductors thereon adjacent the elongate narrow edge portion of said area than adjacent the conductors on the central portion of the vibratable area.

18. The sound generating transducer according to claim **16** and the field generating means having a generally concavely shaped surface confronting and facing the diaphragm and being spaced significantly closer to the elongate and narrow edge portion of the vibratable area than from the central portion of the vibratable area of the diaphragm.

19. A sound generating transducer comprising:

a stiff and acoustically transparent backing having a broad and substantially flat shape, the backing including magnetic means defining a plurality of elongate and parallel magnetic zones forming magnetic pole faces, adjacent pole faces being of opposite polarity to define a plurality of elongate magnetic fields adjoining such faces,

an audio sound producing flexible diaphragm having edges secured to the backing and defining a vibratable area in confronting and spaced relation with said pole faces, the diaphragm being permanently stretched in excess of its natural size, but within the elastic limits of the diaphragm,

the vibratable area of the diaphragm having adjoining portions with current carrying conductors thereon and extending along the elongate zones of the magnetic means, one of said portions of the vibratable area being broad with low frequency carrying conductors thereon and extending along the elongate zones of the magnetic means to receive low audio frequency signals and causing vibration of the entire vibratable area and generating sounds of comparable low frequencies,

another of said portions of the vibratable area being in the form of an elongate and narrow strip with high frequency conductors thereon and extending along the elongate zones of the magnetic means to receive high audio frequency signals for vibrating the elongate and narrow strip at such high audio frequencies, the spacing between said high frequency current carrying conductors in said strip being significantly less than the spacing between the low frequency carrying conductors on the diaphragm, the width of said elongate magnetic zones adjacent said high frequency current carrying conductors being substantially less than the width of the elongate magnetic zones adjacent said low frequency carrying conductors, and the spacing between adjacent elongate mangetic zones conforming to the corresponding spacing between the adjacent low frequency and high frequency current carrying conductors on the diaphragm, respectively.

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