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.

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[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**

UNITED STATES PATENTS

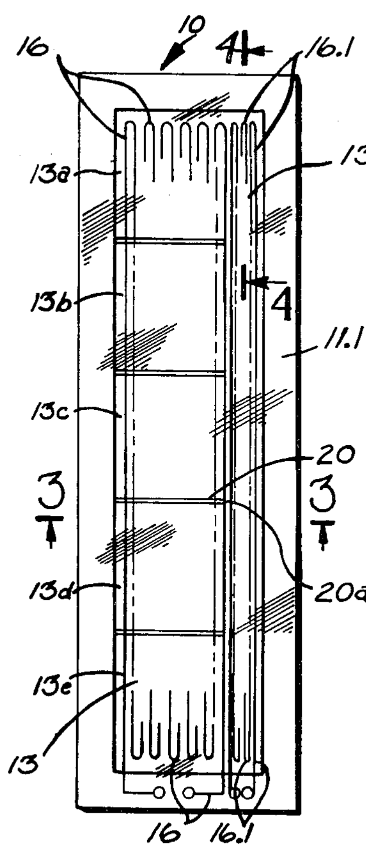
3,164,686	1/1965	Tibbetts	179/115.5 PV
3,674,946	7/1972	Winey	179/115.5 PV

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



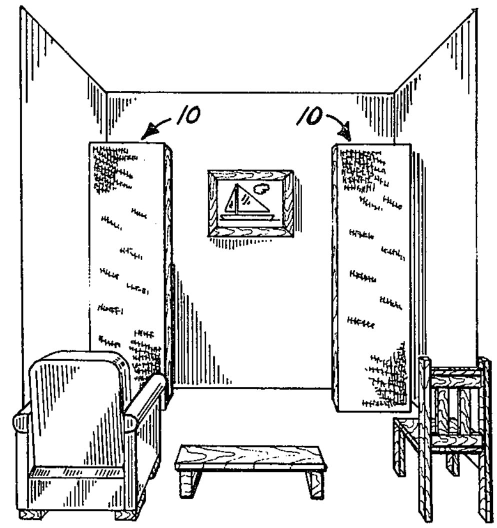


FIG 1

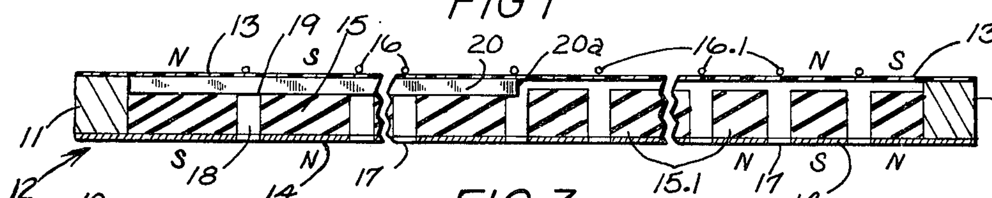


FIG 3

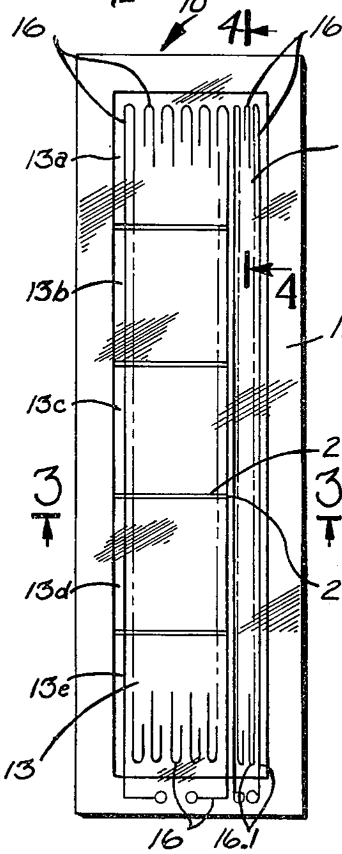


FIG 2

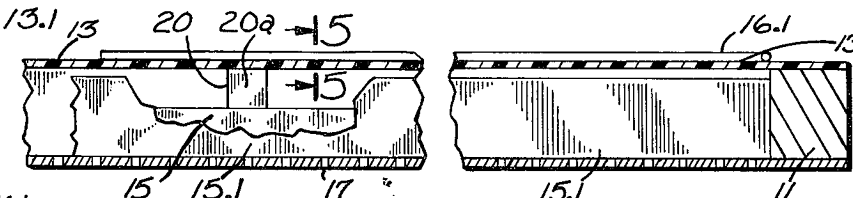


FIG 4

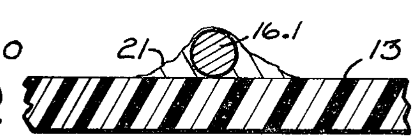


FIG 5

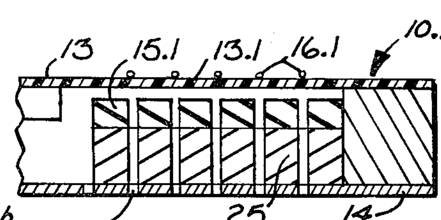


FIG 8

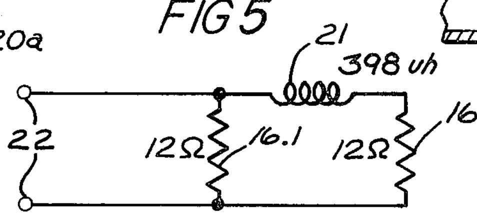


FIG 6

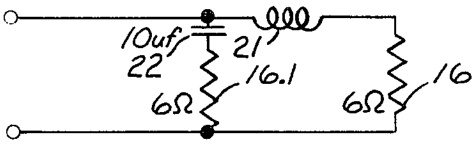


FIG 7

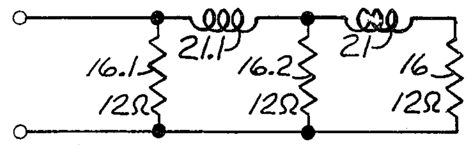


FIG 11

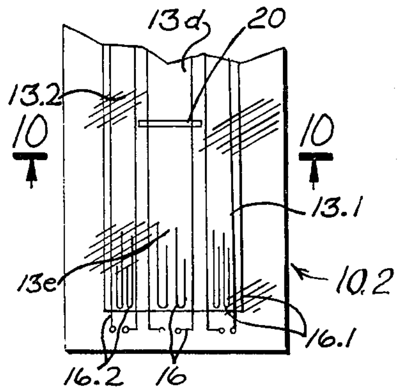


FIG 9

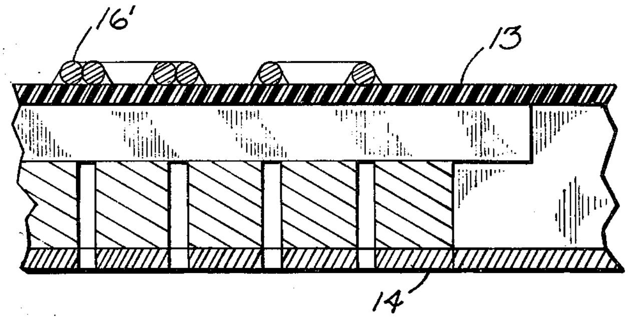


FIG 12

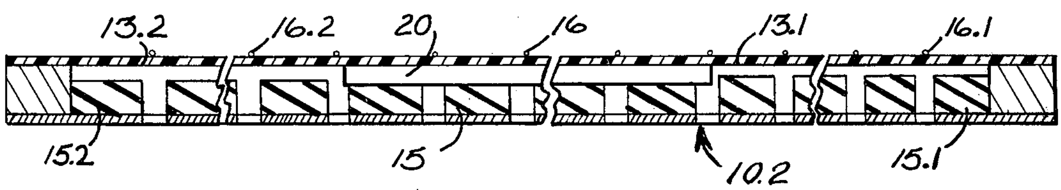


FIG 10

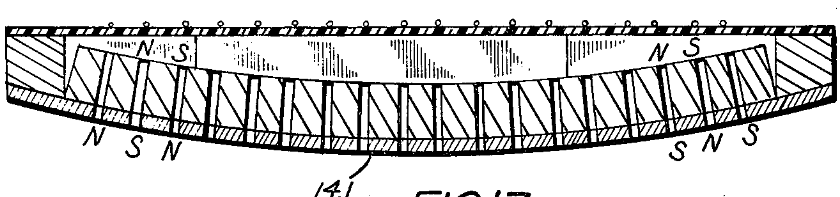


FIG 13

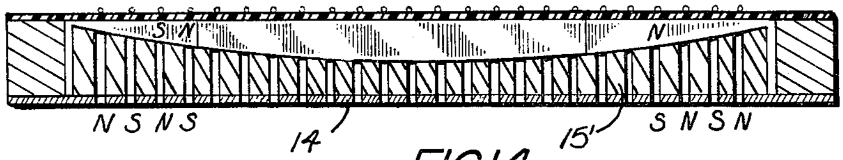


FIG 14

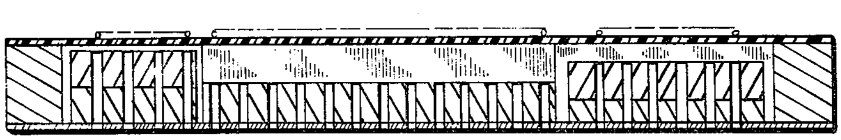


FIG 15

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 approximate 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 midrange 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.

* * * * *

United States Patent [19]

Winey

[11] **4,210,786**

[45] **Jul. 1, 1980**

[54] MAGNETIC FIELD STRUCTURE FOR PLANAR SPEAKER

[75] Inventor: **James M. Winey**, White Bear Lake, Minn.

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

[21] Appl. No.: **6,007**

[22] Filed: **Jan. 24, 1979**

[51] **Int. Cl.**^{2} **H04R 9/06**

[52] **U.S. Cl.** .... **179/115.5 PV**; 179/119 R

[58] **Field of Search** .... 179/115.5 PV, 117, 119 R

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3,013,905	12/1961	Gamzon et al.	179/115.5 PV
3,674,946	7/1972	Winey	179/115.5 PV
3,873,784	3/1975	Doschek	179/115.5 PV
3,919,499	11/1975	Winey	179/115.5 PV

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1,259,948	2/1968	Fed. Rep. of Germany	179/115.5 PV

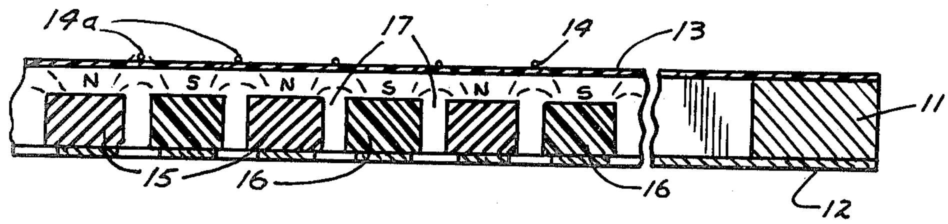
Primary Examiner—James W. Moffitt

Attorney, Agent, or Firm—H. Dale Palmatier

[57] **ABSTRACT**

An acoustical electromagnetic transducer as a loudspeaker and having a vibrating diaphragm with signal current carrying wires on the face thereof; a magnetic structure confronting the diaphragm in spaced relation and having a magnetic sheet metal plate and a plurality of permanent magnet strips on the panel and spaced from each other and along the runs of the conductor on the diaphragm, the permanent magnet strips being formed of a different magnetic material with a significantly different magnetic characteristic than the strips adjacent thereto.

10 Claims, 7 Drawing Figures



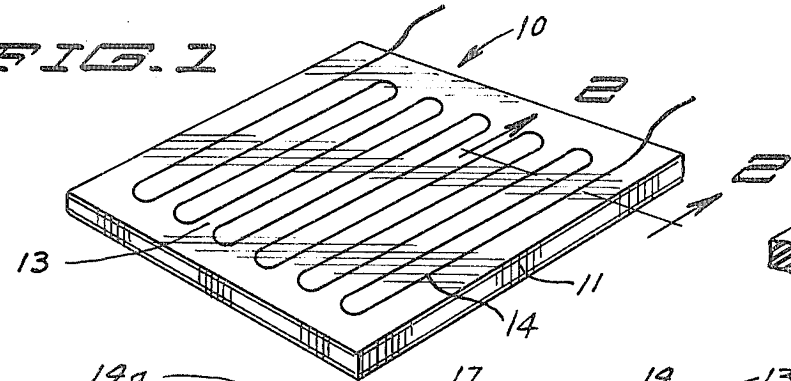


FIG. 1

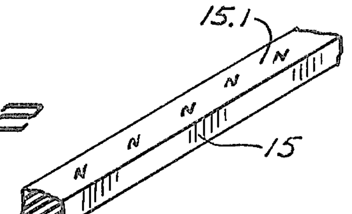


FIG. 3

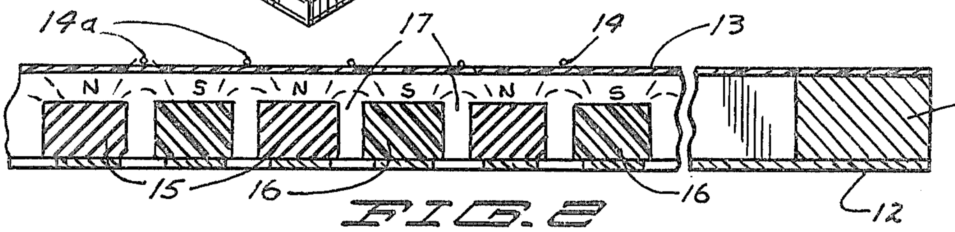


FIG. 2

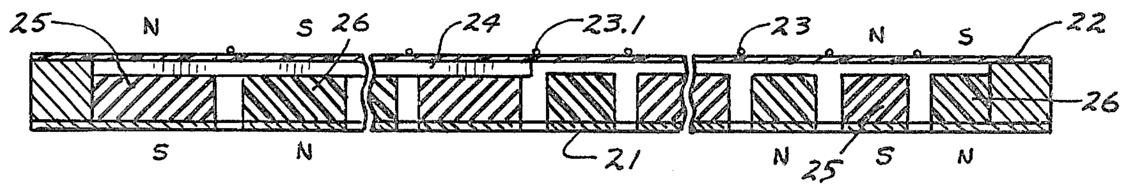


FIG. 5

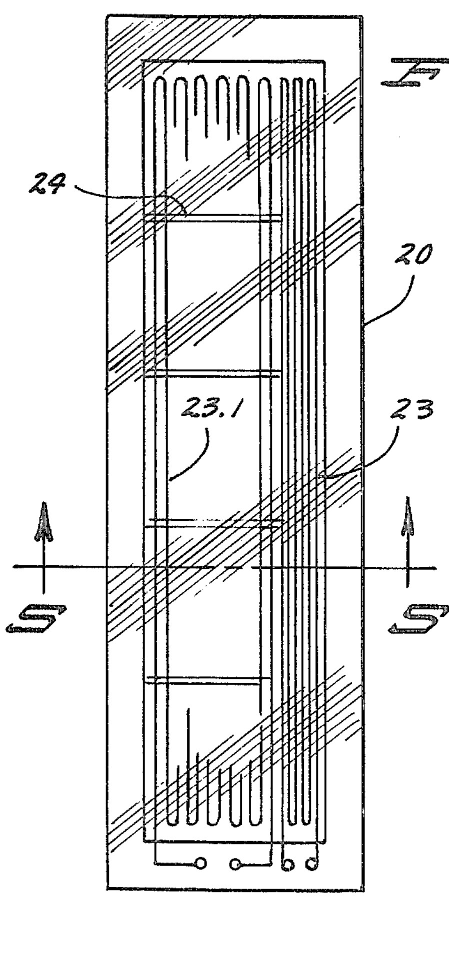


FIG. 4

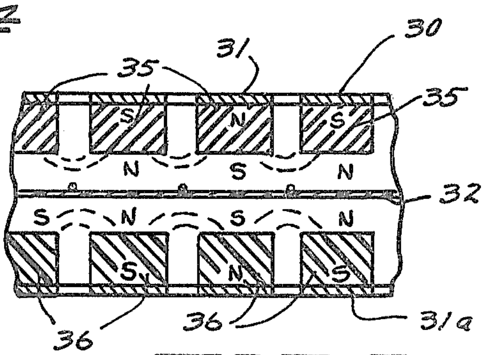


FIG. 6

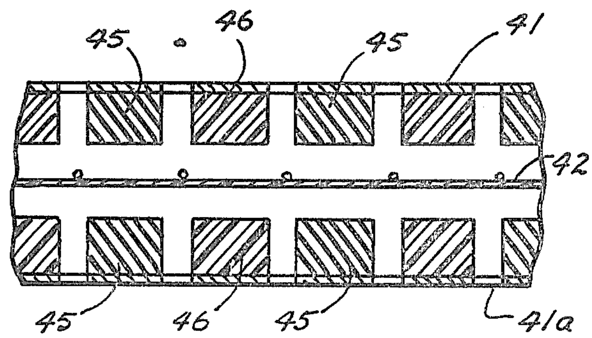


FIG. 7

MAGNETIC FIELD STRUCTURE FOR PLANAR SPEAKER

This invention relates to acoustical electromagnetic transducers of the type incorporating a vibrating diaphragm and more particularly relates to such a transducer to be operated as a loudspeaker.

BACKGROUND OF THE INVENTION

Electromagnetic loudspeakers utilizing a vibrating diaphragm as a sound generator have existed previously in various forms. Although the magnetic structures of such speakers have varied considerably, numerous problems have been encountered.

In Gamzon, U.S. Pat. No. 3,013,905, the magnetic structure includes ceramic magnets which are of considerable size and cannot be materially reduced in size. As a result, the magnetic zones must be widely spaced from one another and the conductors on the diaphragm must also be identically spaced from each other. As a result, the driving forces applied to the diaphragm cannot be maximized.

In the Winey U.S. Pat. No. 3,674,946, the permanent magnet is of a rubber bonded barium ferrite composite material wherein the ferrite particles are mechanically oriented during processing and bonded in the rubber or plastic matrix or binder to hold them in place. The specific magnetic material is known by its trademark PLASTIFORM, sold by 3M Company of Saint Paul, Minn. This magnetic material is formed in sheets which may be apertured so that the magnetic material is acoustically transparent, the material may also be cut in strips as disclosed in the patent and as subsequently illustrated in a later U.S. Pat. No. 3,919,499. Such PLASTIFORM material and other flexible magnetic material such as that made under the trademark KOROSEAL by B. F. Goodrich Company, Akron, Ohio, do not have sufficient coercive force as may be desired in such speakers under some circumstances.

Another U.S. Pat. No. 3,873,784, Doschek, discloses a transducer with a diaphragm and utilizing a permanent magnet of an alloy of iron, nickel, aluminum or cobalt, and preferably a sintered ferrite material. Such sintered material is extremely difficult to work with and cannot easily be used in small pieces, thereby encountering the same problems as in Gamzon patent above.

Recently, magnets with extremely high coercive force have been produced in sizes that may be suitable for use in the magnetic structures of diaphragm type loudspeakers. Such magnets include polymer molded samarium cobalt magnets. Such samarium cobalt magnets are also sintered instead of being carried in a polymer binder. Such new materials have a much higher coercive force and magnetic flux density than previously available materials, but such new materials are extremely expensive, especially for use in diaphragm type speakers wherein broad areas of diaphragm must be accommodated.

SUMMARY OF THE INVENTION

The present invention provides the diaphragm speaker with a magnetic structure which maximizes magnetic flux density in the gap between the magnets and diaphragm and at the same time minimizes the cost of the magnetic field structure.

The magnetic structure of the transducer utilizes a plurality of magnets in strips. The strips adjacent to each other are of different magnetic material and different flux density. For instance, one magnetic strip may be of rubber bonded barium ferrite composite material which has a rated flux density of 1200 gauss and coercive force of 1480 oersteds; and the adjacent magnetic strips may be of an entirely different magnetic material such as samarium cobalt in a polymer binder with a rated flux density of about 5500 gauss and a coercive force of 7500 oersteds. On the alternative one set of magnetic strips may be of barium ferrite in a ceramic magnet which has a flux density and coercive force somewhat greater than the rubber bonded material, and the adjacent strips may be formed of sintered samarium cobalt which has more coercive force, 16000 oersteds, and greater flux density, 8000 gauss, than the samarium cobalt in the polymer binder..

In a speaker or transducer, the magnetic strips are on a magnetic backing panel of iron plate or sheet metal; and each of the magnetic strips of one material is adjacent a magnetic strip of a different magnetic material. Preferably the strips of different material are alternated, first one material, and then the other material. The effect of alternating the strip magnets of different materials is to significantly increase the flux density in the gaps between the magnets and diaphragm; and to increase the magnitude of diaphragm movement and volume of sound generated, without disproportionately increasing the cost of the magnetic structure.

In suitable magnetic structures, alternating types of magnetic material in adjacent strips, the flux density measured in the gaps was somewhat less than rated flux density, but still a striking improvement.

Using PLASTIFORM (rubber bonded barium ferrite), ceramic magnet with barium ferrite, and samarium cobalt in a polymer binding in different arrangements, the flux densities were measured as follows:

ALL PLASTIFORM	900 gauss
All Ceramic	1300 gauss
All Samarium Cobalt	2000 gauss
½ PLASTIFORM, ½ Ceramic	1100 gauss
½ PLASTIFORM, ½ Samarium Cobalt	1300 gauss
½ Ceramic, ½ Samarium Cobalt	1500 gauss

In spaced and confronting magnetic structures with the diaphragm sandwiched between them, the different types of magnets may be arranged adjacent each other on the same side of the diaphragm, or adjacent each other on opposite sides of the diaphragm with magnets of like material being grouped together on one side of the diaphragm.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a transducer or speaker according to the present invention;

FIG. 2 is an enlarged detail section view taken approximately at 2—2 in FIG. 1;

FIG. 3 is an enlarged perspective view of a length of the strip magnet;

FIG. 4 is an elevation view of a modified form of transducer incorporating the invention;

FIG. 5 is an enlarged detail section view, taken approximately at 5—5 in FIG. 4 and having portions thereof broken away for clarity of detail;

FIG. 6 is an enlarged detail section view of a modified form of the invention;

FIG. 7 is an enlarged detail section view of still another modified form of the invention.

DETAILED SPECIFICATION

In the form of the invention shown in FIGS. 1–3, the transducer is indicated in general by the numeral **10** and includes a substantially rigid frame **11** sandwiched between a perforate and acoustically transparent sheet metal panel **12** made of galvanized iron, and a taut film type diaphragm **13** which may be made of any of a number of plastic films such as a film known by its trademark MYLAR and sold by 3M Company of Saint Paul, Minn. The diaphragm **13** and the panel **12** are both secured to the frame **11** to allow the diaphragm to vibrate while the panel stays stationary and to prevent any relative movement of the diaphragm with respect to the panel in a direction parallel to the plane of the diaphragm.

The diaphragm **13** carries a conductor **14** thereon arranged in a plurality of elongate and spaced apart conductor runs **14*a*** to which sound generating current from an audio amplifier system may be applied. The conductor **14** may be formed in various ways on the diaphragm **13**, but may simply be a wire as illustrated adhesively secured to the face of the diaphragm. Otherwise, the wire or conductor **14** may be formed by a printed circuit on the face of the diaphragm.

The sheet metal panel **12** is a part of the magnetic structure which also includes a plurality of magnetic strips **15** and **16** which are applied onto the surface of the panel **12**. The magnetic strips **15** and **16** are magnetized in a direction through their thinnest dimension so that all of the upper surface of each of the magnets has one polarity, as is indicated in FIG. 3, the upper surface being designated by the numeral **15.1**. The bottom surface of the strips **15** and **16** are of opposite polarity. The strips **15** and **16** are arranged in parallel and spaced relation to each other so as to define gaps **17** therebetween across which magnetic fields are established by the magnets. The gaps **17** are disposed immediately beneath the runs **14*a*** of the conductor so that the conductor runs are under the influence of these magnetic fields.

Each of the magnetic strips **15** and **16** comprises a permanent magnet and is formed of a magnetic material which is different than the magnetic material in the adjacent strips. For instance, the magnetic strips **15** may be formed of PLASTIFORM, a rubber bonded barium ferrite composite material wherein the ferrite materials are mechanically oriented during processing and are bonded in the rubber or plastic matrix or binder to hold them in place. Relatively speaking, the coercive force of the PLASTIFORM material is relatively weak or of low magnitude.

Alternate magnet strips **16** are formed of a different magnetic material such as samarium cobalt in a polymer binder, which is considerably more expensive than the PLASTIFORM in strips **15**, but which is also significantly different in its magnetic characteristics than PLASTIFORM, and is generally regarded as producing a substantially greater coercive force than the PLASTIFORM in the alternate strips. The material in one set of alternate strips may also be sintered samarium cobalt, or one set of the strips may be ceramic magnets. In any event, it has been considered significant to the present invention that alternate strips of the magnetic material in the magnetic structure are formed of different magnetic materials.

This use of the alternating magnetic strips of different materials is particularly useful in producing the transducers **10** used as tweeter or midrange speakers. FIGS. 4 and 5 illustrate a modified form of the invention wherein the transducer **20** has a magnetic metallic back panel **21** and a diaphragm **22** thereon with current-carrying conductors **23** and **23.1**. The conductors **23** are spaced quite close together in the tweeter section of the transducer, and the other runs **23.1** of the conductor are rather widely spaced in the midrange or base section of the speaker. The diaphragm is restrained against vibrating at certain areas by ribs **24** so as to divide the diaphragm into various areas which may resonate at different audio frequencies. The magnet strips **25** and **26** are again arranged along the runs of the wires on the diaphragm, producing gaps between the magnets. The several adjacent magnets **25** and **26** are of different magnetic materials as previously described in connection with FIGS. 1–3.

In the form illustrated in FIG. 5, the transducer is indicated in general by numeral **30** and has a magnetic structure including two separate back panels **31** and **31*a***. A diaphragm **32** is located between the two magnetic structures. In this case, all of the magnet strips **35** on the top panel **31** are formed of one nature of magnetic material such as PLASTIFORM or barium ferrite-containing material, and all of the adjacent magnetic strips **36** at the other side of the diaphragm and on the panel **31*a*** are formed of another magnetic material with significantly different magnetic characteristics.

In the form of the invention illustrated in FIG. 6, again, the diaphragm **42** is sandwiched between the two magnetic structures, the upper one including a backing plate **41** and the lower structure including a backing plate **41*a***. In this form, the magnetic strips on the upper panel are of alternate types of material and are designated by the numerals **45** and **46**. Similarly, the strips **45** and **46** on the lower panel **41*a*** also alternate in types of material and therefore in magnetic characteristics.

It will therefore be seen that diaphragm type speakers may be formed with magnetic strips of varying types of magnetic material with different magnetic characteristics in order to produce a greater magnetic field in the area of the conductors on the diaphragm. This type of speaker utilizing magnetic strips of alternating types of material produces a greater output without increasing the signal current input to the speaker and produces higher transient response in the transducer.

What is claimed is:

1. An acoustical electromagnetic transducer, comprising
   - a film type diaphragm having conductor means on the surface thereof and arranged in a plurality of elongate and spaced conductor runs through which a sound generating current is to be carried, and
   - a magnetic structure confronting the diaphragm in spaced relation and having a plurality of elongate and spaced magnetic strips extending along each other and defining elongate magnetic gaps therebetween and extending along the conductor runs of the diaphragm, the magnetic strips being permanent magnets establishing magnetic flux in and adjacent the gaps, magnetic strips adjacent to each other being formed of different magnetic materials with significantly different magnetic properties.

2. The acoustical electromagnetic transducer according to claim 1 and all of the magnetic strips being disposed at one side of the diaphragm.

3. The acoustical electromagnetic transducer according to claim 1 and the magnetic structure having magnetic strips disposed at both sides of the diaphragm.

4. The acoustical electromagnetic transducer according to claim 3 wherein the magnetic strips at one side of the diaphragm include first and second magnetic strips adjacent each other and respectively formed of said different magnetic materials.

5. The acoustical electromagnetic transducer according to claim 3 wherein adjacent magnetic strips of said different magnetic material are respectively disposed at opposite sides of the diaphragm.

6. The acoustical electromagnetic transducer according to claim 3 and all of the magnetic strips at one side of the diaphragm are of one of said magnetic materials, and all of the magnetic strips at the other side of the diaphragm are of another of said magnetic materials.

7. The acoustical electromagnetic transducer according to claim 1 wherein certain of the magnetic strips contain samarium cobalt.

8. The acoustical electromagnetic transducer according to claim 7 wherein certain of the magnetic strips contain barium ferrite.

9. The acoustical electromagnetic transducer according to claim 8 wherein the magnetic strips containing barium ferrite are a plastic or rubber bonded barium ferrite material.

10. An acoustical electromagnetic transducer comprising

a substantially planar diaphragm of film type material and having conductor means on the surface thereof and arranged in a plurality of elongate and spaced conductor runs through which a sound generating current is to be carried, and

a magnetic structure confronting the diaphragm in spaced relation and having means connected with the diaphragm and preventing relative movement between the magnetic structure and diaphragm in a direction generally along the diaphragm, the magnetic structure having a plurality of elongate and spaced magnetic strips extending along each other and defining elongate magnetic gaps therebetween and extending along the conductor runs of the diaphragm, the magnetic strips being permanent magnets establishing magnetic flux in and adjacent the gaps, the magnetic strips being disposed at one side of the diaphragm, the magnetic structure including an acoustically transparent panel of iron against which the magnetic strips lie, said magnetic strips adjacent to each other being formed of different magnetic materials with significantly different magnetic properties, certain of the magnetic strips containing samarium cobalt, and other of the magnetic strips containing barium ferrite, the samarium cobalt-containing strips producing a coercive force significantly greater than the coercive force produced by the barium ferrite-containing material.

* * * * *

United States Patent [19]

Winey

[11] **4,319,096**

[45] **Mar. 9, 1982**

[54] **LINE RADIATOR RIBBON LOUDSPEAKER**

[76] Inventor: **James M. Winey,** 367 Carolyn La., White Bear Lake, Minn. 55120

[21] Appl. No.: **130,209**

[22] Filed: **Mar. 13, 1980**

[51] **Int. Cl.**[3] **H04R 9/06**

[52] **U.S. Cl.** .... **179/115 V**

[58] **Field of Search** .... 179/115 V

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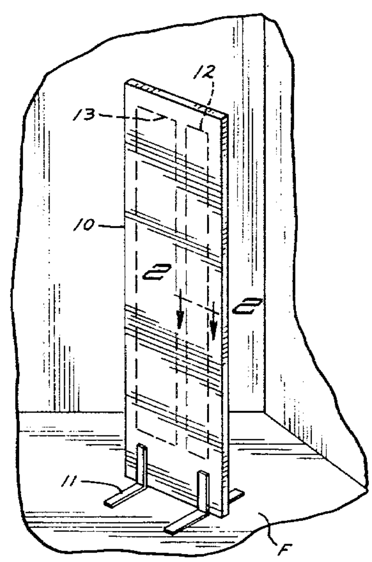
Primary Examiner—George G. Stellar

[57] **ABSTRACT**

An audio frequency transducer having a ribbon tweeter with a multiplicity of side-by-side elongate strip-like magnets with elongate spaces therebetween, the confronting sides of the magnets having pole faces of opposite polarity to create intense magnetic fields therebetween, signal-carrying ribbon-like conductors in the intense magnetic field between adjacent magnets vibrating to produce sound output.

17 Claims, 8 Drawing Figures



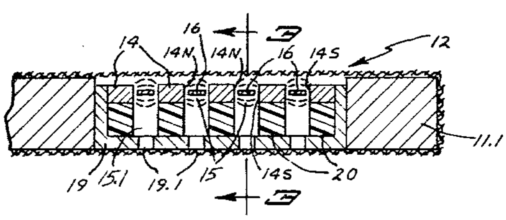
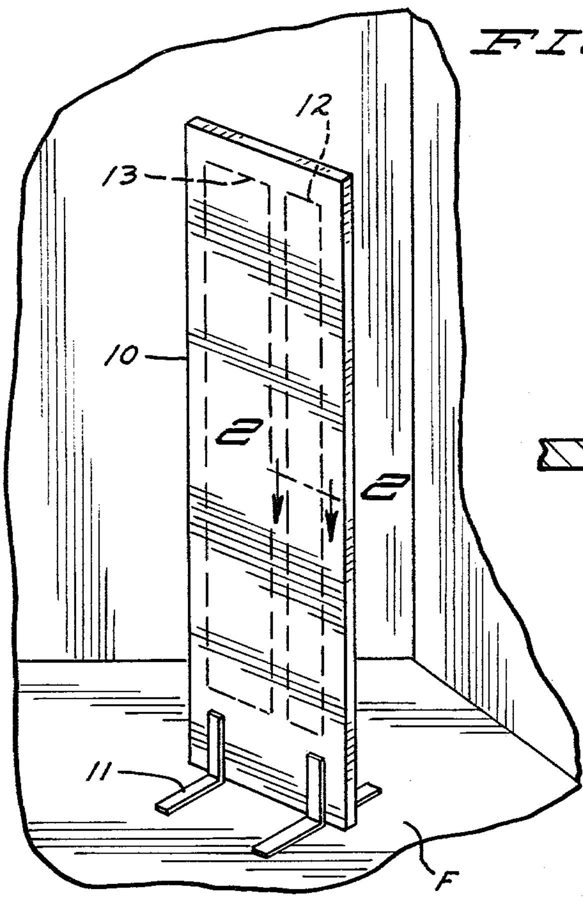


FIG. 1



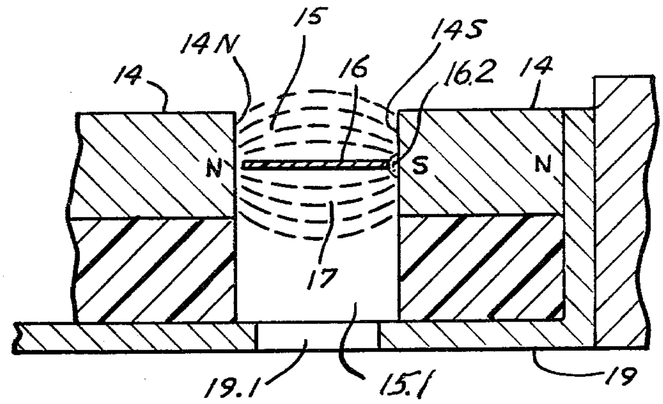
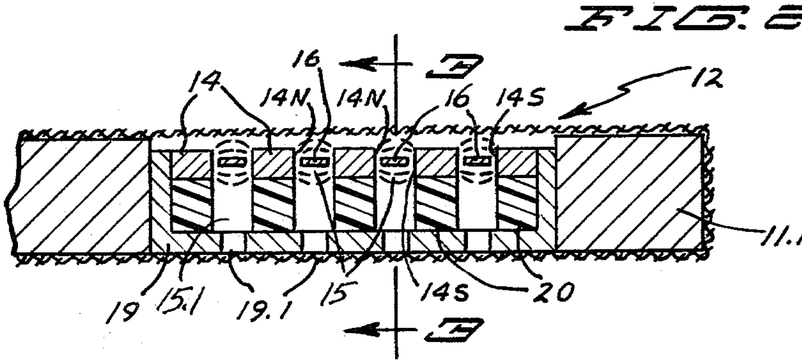


FIG. 4

FIG. 2



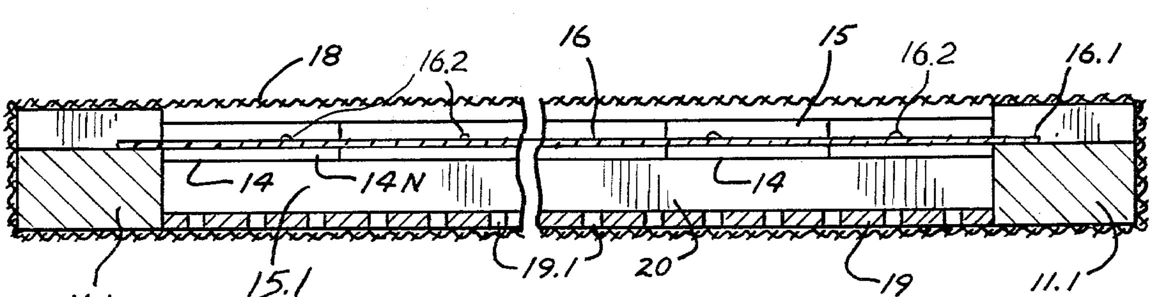


FIG. 3

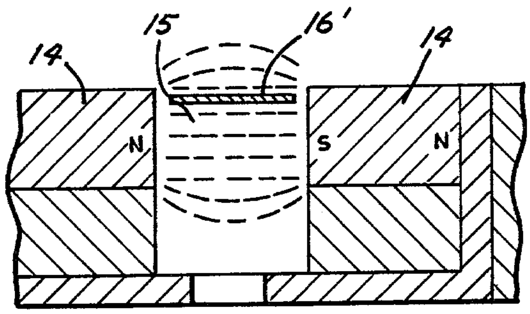


FIG. 5

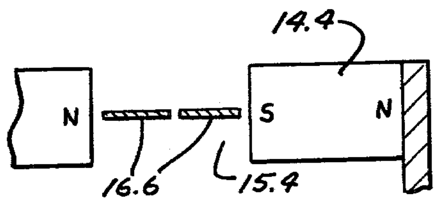


FIG. 6

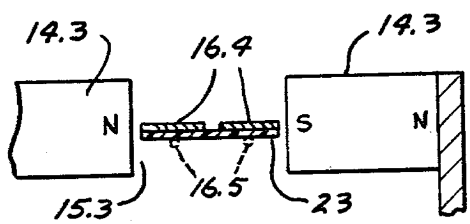


FIG. 7

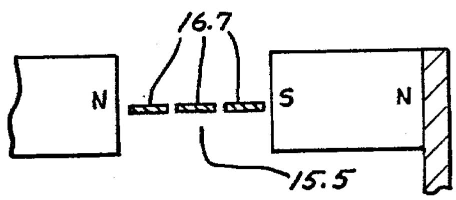


FIG. 8

LINE RADIATOR RIBBON LOUDSPEAKER

This invention relates to a ribbon tweeter.

BACKGROUND OF THE INVENTION

Transducers known as ribbon tweeters have been known in the past. They have been marginally useful for several reasons.

Such ribbon tweeters have been extremely large and bulky for the output obtained; have had objectionable beaming characteristics so that their output can be heard in only isolated locations; their impedance has been so low that expensive transformers have been required to match the transducer impedance to the amplifier impedance; and finally, only minimal output from such ribbon tweeters has been possible.

Accordingly, use of such ribbon tweeters has not proved effective, and use of such ribbon tweeters has not become widespread.

BRIEF SUMMARY OF THE INVENTION

An object of the invention is to provide an improved ribbon tweeter which takes substantially full advantage of the available magnetic fields in producing greater sound power output with the available input signal current.

A further object of the invention is to provide a novel ribbon tweeter which minimizes the effect of beaming in a vertical direction so as to make maximum sound output available to listeners at various locations relative to the transducer and to allow the listeners to move about without experiencing attenuation of the sound output.

Another object of the invention is to provide a ribbon tweeter which may be direct driven from the output stage of an amplifier.

Still another object of the invention is to provide a ribbon tweeter which may have a minimal mismatch in impedance as compared to the impedance of the output stage of an amplifier as to permit the tweeter to be driven by an inexpensive step up transformer at the output stage of the amplifier.

A feature of the invention is the construction of the ribbon tweeter type transducer with spaced parallel, elongate strip magnets polarized so that adjacent strip magnets have pole faces of opposite polarity confronting each other, and wherein said pole faces of adjacent strip magnets are separated by an elongate open space through which a conductor extends. The conductor carries the input signal current and is embraced by the magnetic field of maximum flux density. Accordingly, the conductor is vibrated with maximum intensity in the elongate space to generate intensive sound.

Another feature of this invention is the multiple sets of elongate strip magnets, in spaced side-by-side arrangement facilitating use of multiple conductors in the transducer.

Another feature of this invention is the arrangement of multiple ribbon-shaped conductors as the sound generator of the transducer.

Another feature of this invention is the capability of the transducer with the spaced, and oppositely polarized pole faces confronting each other across an elongate space, which has a magnetic field of substantially maximum density, and which may confine a conductor of round cross section like a wire, or a conductor of flat thin cross section like a ribbon. The conductor may be in several runs in each magnetic field, and in some instances may be carried on a strip type diaphragm confined wholly within the elongate space.

Still another feature of the invention is that the elongate strip magnets are laid along each other in spaced relation, and the adjacent magnets may be formed of various magnetic materials. For instance, a ceramic magnet may be laid adjacent a rare earth magnet or a samarium cobalt magnet, or barium ferrite. The magnetic field will typically have a strength of 1000 gauss to 4000 gauss depending upon the type of material in the magnet.

A principal advantage of this type of transducer is that the transducer may be directly coupled to and driven by the output stage of the amplifier, or the transducer may be so related to the amplifier that only a small mismatch exists between the impedances of the transducer and amplifier, thus making it possible to drive the transducer with an inexpensive transformer.

The advantage of this type of transducer is that the transducer is highly efficient, that is to say that a maximum of sound is produced in relation to the input signal current.

Furthermore, the transducer has low mass and therefore has extremely good transient response.

Also, the ribbon tweeter of the transducer provides the advantage of having a greatly increased length sufficient so that when the transducer is oriented in an upright position, a person's ear will be in front of it regardless of whether the person is standing up or sitting down. Accordingly, whether or not there is vertical dispersion of the sound from the ribbon tweeter of the transducer is essentially of no concern. Typically, the ribbon tweeter will oftentimes have a length in the range of three to five feet, but the length can vary considerably from that range, and may be as short as one and one-half feet or less. Although lengths longer than five feet are practical, there is not often significant need for such longer lengths.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view of a planar type speaker in upright position.

FIG. **2** is an enlarged detail section view taken approximately at **2—2** of FIG. **1**.

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

FIG. **4** is a greatly enlarged detail section view of the invention.

FIG. **5** is an enlarged detail section view of a modified form of the invention.

FIGS. **6**, **7** and **8** are diagrammatic sketches illustrating further modified forms of the invention.

DETAILED SPECIFICATION

The form of the invention illustrated in FIGS. **1-4** illustrates a planar type speaker or line radiator type transducer **10** which is generally rectangular shaped from an overall standpoint and is supported on the floor by feet **11** fastened to the lower portion of the frame of the transducer. The transducer **10** has a tweeter section **12** and a mid-range base section **13**. The narrow tweeter section has an overall length approximately the same as the speaker as a whole, and may be four to six feet in length, or longer.

The tweeter section of the transducer **10** includes a multiplicity of elongate strip-type magnets **14** in spaced and side-by-side relation with each other and lying substantially in a plane and defining elongate open spaces **15** therebetween.

The magnets **14** may be formed of any of a number of different magnetic materials, and may be sintered magnets, such as barium ferrite, or may be rare earth magnets, such as samarium cobalt. Although, in many cases, all of the magnets **14** will be formed of identical material, it is practical and advantageous in some instances to use magnets of different material in the transducer. For instance, alternate magnets lying side-by-side with each other may be formed of different material. As a result, certain economies may be effected, and the magnetic fields between adjacent magnets can be established as desired.

Each of the elongate spaces **15** between adjacent magnets **14** contains an elongate ribbon-like conductor **16** which extends substantially throughout the entire length of the transducer and which has a width very nearly the same as the width of the space between adjacent magnets. A typical conductor **16** is made of aluminum foil with a thickness of 0.0005 inches and approximately one-fourth inch wide; and the conductor may be either flat or corrugated. If corrugated, the corrugations may extend longitudinally or transversely of the conductor.

As clearly illustrated in FIG. **4**, the adjoining magnets **14** adjacent each of the spaces **15** have magnetic pole faces **14N** and **14S** which have opposite magnetic polarities. As a result, an intense magnetic field **17** is established in each of the spaces **15** and embraces the conductor **16** therein. Preferably, the conductor **16** is located midway of the thickness of the space **15** so as to be symmetrically arranged therein.

However, it may be desirable under certain circumstances, as illustrated in FIG. **5**, that the ribbon conductor **16'** may be disposed asymmetrically in relation to the thickness of the elongate space **15** between the magnets, but, as illustrated in FIG. **5**, the conductor **16'** is definitely disposed within the magnetic field disposed between the opposite pole faces of the adjacent magnets **14**. In some instances the conductor **16'** as illustrated in FIG. **5** may be located so that its edge does not directly confront the pole face of one of the magnets, that is to say, the conductor is moved above the top surface of the two confronting magnets; and the conductor will still be disposed in the magnetic field of the two magnets.

It will be recognized that the conductors **16** are substantially free of the magnets **14** and are free to oscillate in the spaces **15** so as to produce audible sound when audio frequency input currents are applied to the conductors. The conductors **16** are secured at their opposite ends **16.1** to the frame **11.1** of the transducer.

It is desirable to attach the edges of the conductor **16**, at spots located remotely from each other to the two pole faces **14S** and **14N** so as to control the side to side movement of the conductor **16** in the space **15**. In this respect, an edge of the conductor **16** may be attached by a spot **16.2** of adhesive to the pole face **14S** at one location; and then at a location one to two inches along the length of conductor **16** therefrom, the opposite edge of the conductor may be attached by a spot of adhesive to the opposite pole face **14N**, so as to stagger the points of attachment between the edges of the conductor and the opposite pole faces all along the length of the conductor. The magnets **14** are usually good insulators and the attachment of the conductor to the pole faces of the magnets will have virtually no effect on the flow of signal current through the conductors.

A fabric **18** overlies the magnets and conductors in spaced relation to enclose the transducer **12**.

The transducer also includes an armature **19** of magnetic material, such as soft iron, and the armature has a multiplicity of apertures or sound openings **19.1** therethrough. Armature **19** is secured to the frame **11.1** of the transducer so as to be rigid therewith.

In an alternative form the openings **19.1** may be omitted, and instead, the lower portions **15.1** of spaces **15** between the conductors **16** and the armature **19** may be substantially filled with sound absorbtive material. The effect of using the sound absorbing material instead of openings **19.1** will be minimal at high audio frequencies.

The armature **19** is rigid and serves to support the magnets **14** in stationary relation with each other and supports each of the magnets **14** on a spacer. The spacers **20** are non-magnetic material such as extruded plastic, but are affixed securely to both the armature **19** and to the magnets **14**. It will be recognized in FIG. **3** that the magnets **14** may be formed of a plurality of somewhat short segments. Certain magnetic materials are only available in short lengths, but for materials that are available in long lengths, each of the magnets **14** may be provided in one piece.

In operation, audio frequency currents are supplied to the conductors **16** which lie in the intense magnetic fields **17**, and the conductors **16** are thereby caused to vibrate or oscillate to produce audible sound. In this form of the invention, the conductors **16** are formed of a ribbon-like metallic foil material which has an extremely low mass and thereby provides a good transient response to the input signal current applied thereto. The efficiency of these transducers **12** is extremely good because the conductor **16** is entirely embraced in the most intense porton of the magnetic field **17** because the conductor is disposed within the elongate space between adjoining magnets. It has been found that a magnetic field of typically 1800 gauss in each of the elongate spaces **15** may be satisfactory in many transducers, but magnetic fields of significantly greater and lesser intensity will also be useful and desirable. The elongate shape of the transducer **12** in the speaker **19** minimizes the lack of dispersion of the high frequency sounds in a vertical direction. The transducer **12** is extremely useful in two foot lengths and is extremely useful in four foot lengths. Proper impedances in the range of 8 ohms are very easily achieved to avoid impedance matching problems with the amplifiers.

In the form illustrated in FIG. **6**, two side-by-side ribbon conductors **16.6** are disposed in spaced edge-to-edge relation within the space **15.4** between the adjacent stationary magnets **14.4**. These conductors may be attached at spaced locations along their edges to the faces of the magnets **14.4** so as to prevent the conductors from engaging each other and causing short circuits. Normally, the conductors **16.6** will be connected in series to raise the efficiency and also raise the impedance of the transducer as a whole. The conductors **16.6** will act together for producing the audible sound and will both carry the audio frequency input current.

In the form of the transducer of FIG. **7**, the ribbon conductors **16.4** are secured to a diaphragm **23** which lies directly in the elongate space **15.3** between the adjacent magnets **14.3**. In this form, the entire diaphragm **23** vibrates with the ribbon conductors **16.4** for the purpose of producing audible sound which responds well to the signals applied. In FIG. 7, wire conductors **16.5** may be substituted for the ribbon conductors **16.4** and the wire conductors **16.5** will also be affixed to the diaphragm **23** for producing vibration thereof within the elongate space wherein the diaphragm and conductors are entirely embraced by the intense magnetic field.

In FIG. **8**, three separate ribbon conductors **16.7** are incorporated in the elongate space **15.5** wherein the conductors are entirely embraced by the intense magnetic field established between the adjacent magnets. Care must be taken in this arrangement to prevent the conductors from touching each other while vibrating. The two outside conductors may be attached at isolated locations along the length of the pole faces of the magnets and suitable precautions taken to prevent the center conductor from engaging the two outside ones. The advantages in using multiple conductors in the magnetic field are to produce a greater audio output by supplying greater current flows in the space between the magnets, and also to increase impedance.

It will be seen that the present invention provides for the signal-carrying conductor to be disposed within the most intense portion of the magnetic field between adjacent stationary magnets which have confronting opposite polarity pole faces at opposite sides of the space therebetween through which the conductor extends. Improved efficiency and impedance and extremely good transient response result from the improved transducer.

What is claimed is:

1. An elongate sound-producing strip-shaped transducer of narrow width, which is narrow enough in a transverse direction to produce wide dispersion of sound in a side to side direction and which is long enough to minimize dispersion in the other direction and to respond to an audio frequency input current, comprising

a pair of elongate strip-like magnets extending longitudinally of the elongate transducer lying along and in spaced relation with each other, the magnets having strip-shaped pole faces of opposite polarity confronting each other across the width of the elongate space between adjacent magnets and thereby establishing an intense magnetic field in and adjacent the elongate space,

means mounting said magnets in stationary position relative to each other,

a ribbon-like conductor extending longitudinally of the elongate transducer and continuously between the ends thereof, the conductor extending along the elongate space between the strip-shaped pole faces of opposite polarity and in the magnetic field, the conductor having substantially the same length as the magnets, faces of the conductor being oriented normal to the pole faces, the conductor being free to oscillate in the space to vibrate and produce sound according to the input current applied to the conductor, and

an armature of magnetic material extending the length of the transducer and traversing the magnets and the spaces therebetween and intensifying the magnetic fields in the spaces.

2. An elongate sound-producing strip-shaped transducer of narrow width which is narrow enough in a transverse direction to produce wide dispersion of sound in a side to side direction and which is long enough to minimize dispersion in the other direction and to respond to an audio frequency input current, comprising

a pair of stationary elongate strip-shaped magnets of narrow width and lying along and in spaced relation with each other, the magnets having sides defining pole faces of opposite polarity confronting each other across the elongate space therebetween, whereby to establish intense magnetic fields in and adjacent the elongate space, the elongate magnets extending longitudinally of the elongate transducer and the length of the magnets being manyfold times the cumulative width of the elongate magnets and the space therebetween,

a continuous ribbon-like current-carrying conductor extending longitudinally all along the elongate space in the intense magnetic field to the ends of the transducers and lying normal to the pole faces, the ribbon-like conductor having substantially the same length as the magnets,

means mounting the conductor to permit oscillation of the conductor under the combined influence of the intense magnetic field and the audio frequency input current in the conductor,

and an armature of magnetic material extending along the length of the magnets and transversely thereof to provide a low reluctance flux path therebetween for intensifying the magnetic fields in the spaces.

3. The transducer according to claim **2** and an armature of magnetic material engaging the magnets and intensifying the magnetic field in said space.

4. The transducer according to claim **2** and the magnets being arranged in side-by-side relation and lying substantially in a common plane, the ribbon-shaped conductor having edges confronting the pole faces.

5. The transducer according to claim **2** and said current-carrying conductor being formed of wire.

6. The transducer according to claim **2** and the elongate space having width between adjacent pole faces and having a thickness in a direction transversely of the width, the conductor being disposed within the thickness of the elongate space.

7. The transducer according to claim **6** and the conductor being disposed in the space substantially midway of the thickness of the space.

8. The transducer according to claim **6** and said conductor being disposed in said space generally asymmetrically relative to the thickness of the space.

9. The transducer according to claim **2** and the edges of the ribbon conductor being in close proximity with the pole faces whereby the ribbon conductor substantially entirely traverses the width of the elongate space.

10. The transducer according to claim **2** wherein one of said magnets of the pair of magnets being formed of one magnetic material, and the other of said magnets of the pair of magnets being formed of a different magnetic material.

11. The transducer according to claim **2** and there being a second ribbon conductor lying along the first mentioned conductor, the conductors being in substantially edge to edge relation with each other.

12. The transducer according to claim **11** and the conductors in each of the elongate spaces being secured to a diaphragm all along the length thereof.

13. The transducer according to claim **12** and the diaphragm being in the elongate space between the pole faces.

14. The transducer according to claim **2** and each of the elongate magnets including a multiplicity of elongate magnet segments lying in end-to-end relation with each other.

15. An elongate, sound producing line radiator type transducer which is narrow enough in a transverse direction to produce wide dispersion of sound in a side to side direction and which is long enough to minimize dispersion considerations in the other direction and to respond to an audio frequency input current comprising

a multiplicity of stationary elongate strip-shaped magnets and a multiplicity of elongate ribbon-like current carrying conductors, the magnets and conductors extending all along each other and continuously to the ends of the transducer,

the magnets lying along and in spaced relation with each other, the magnets having obverse and reverse sides confronting each other across the elongate spaces between adjacent magnets, the obverse and reverse side of the magnets adjacent each elongate space defining magnetic pole faces of opposite polarity whereby to establish intense magnetic fields in and adjacent the elongate spaces, and

the ribbon-like conductors extending along the elongate spaces in the intense magnetic fields and lying normal to the pole faces,

means mounting the conductors to permit oscillation of the conductors under the combined influence of the intense magnetic field and the audio frequency input current in the conductors, and

an armature of magnetic material extending along the length of the magnets and traversing the magnets and the spaces therebetween and intensifying the magnetic fields in the spaces.

16. The transducer according to claim **15** and the multiplicity of magnets including a pair of outermost magnets with at least one additional magnet disposed therebetween, and an armature of magnetic material engaging both of said outermost magnets and spaced from said at least one additional magnet.

17. The transducer according to claim **16** and a non-magnetic spacer means mounting at least one additional magnet on the armature.

* * * * *

United States Patent [19]

Winey

[11] **Patent Number: 4,471,172**

[45] **Date of Patent: Sep. 11, 1984**

[54] **PLANAR DIAPHRAGM TRANSDUCER WITH IMPROVED MAGNETIC CIRCUIT**

[75] Inventor: **James M. Winey**, White Bear Lake, Minn.

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

[21] Appl. No.: **353,846**

[22] Filed: **Mar. 1, 1982**

[51] **Int. Cl.**[3] **H04R 9/00**

[52] **U.S. Cl.** .... **179/115.5 PV**

[58] **Field of Search** .... 179/115.5 PV, 115.5 ES, 179/115.5 VC, 115.5 DV, 115.5 R; 181/170, 173

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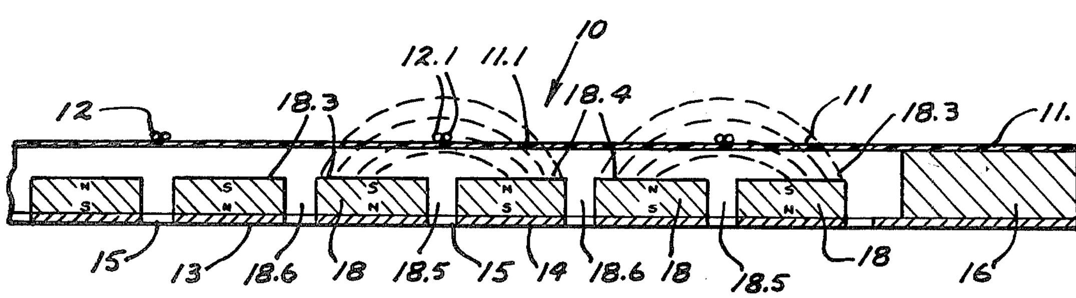
Primary Examiner—Gene Z. Rubinson
Assistant Examiner—L. C. Schroeder
Attorney, Agent, or Firm—Peterson, Palmatier, Sturm, Sjoquist & Baker, Ltd.

[57] **ABSTRACT**

A planar diaphragm type magnetic transducer with magnetic circuit wherein the magnet strips on the soft iron plate and confronting the diaphragm are arranged in a sequence south, north, north, south, south, north, north, south, et seq. The magnet strips are spaced across the transducer and the metal plates on which the magnet strips lie are apertured to make the plates acoustically transparent. Conductors are grouped in runs on the diaphragm opposite alternate pairs of magnet strips which have magnetic poles of opposite polarity at their front faces.

16 Claims, 9 Drawing Figures



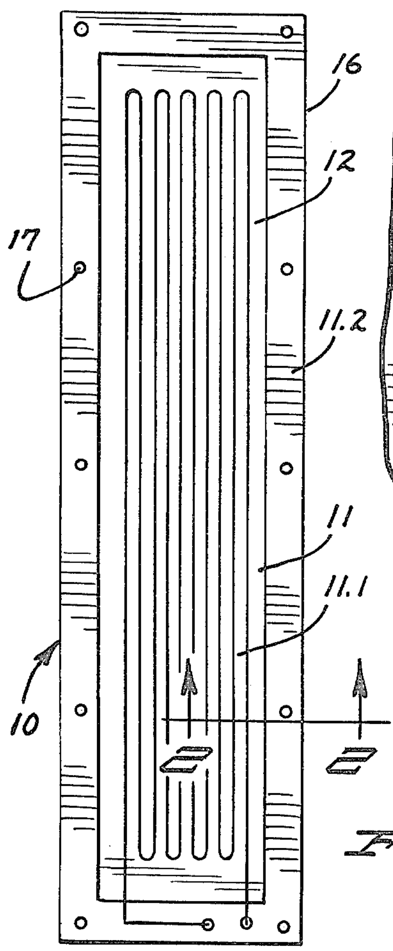


FIG. 1

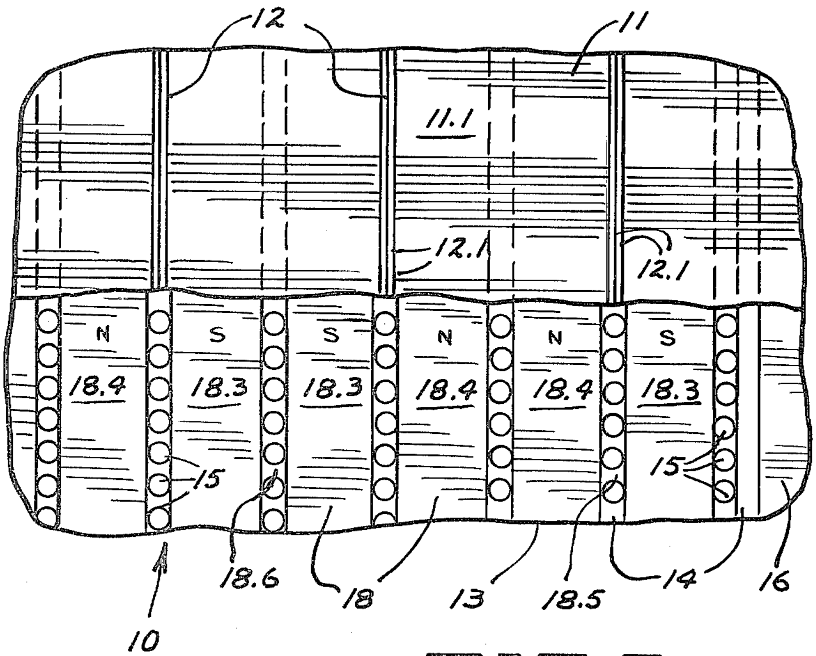


FIG. 3

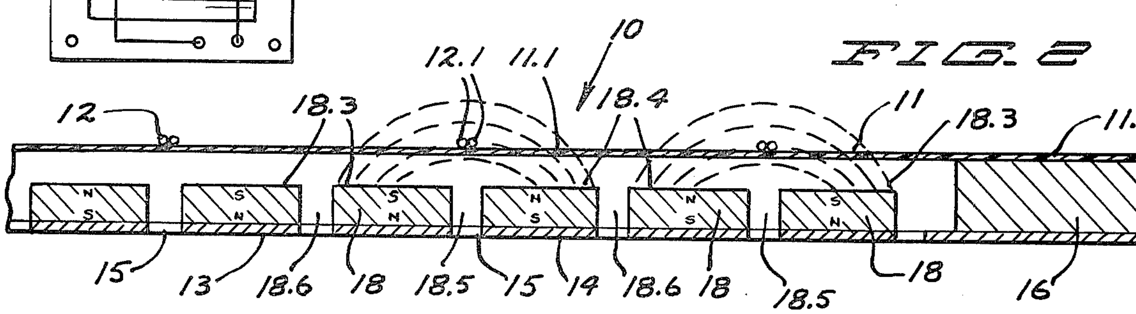
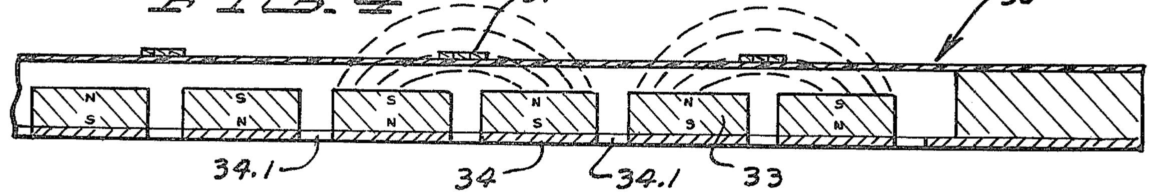


FIG. 2

FIG. 4



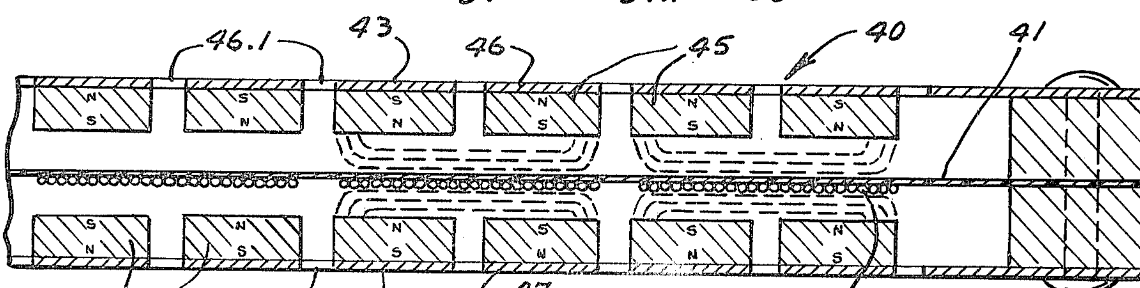


FIG. 5

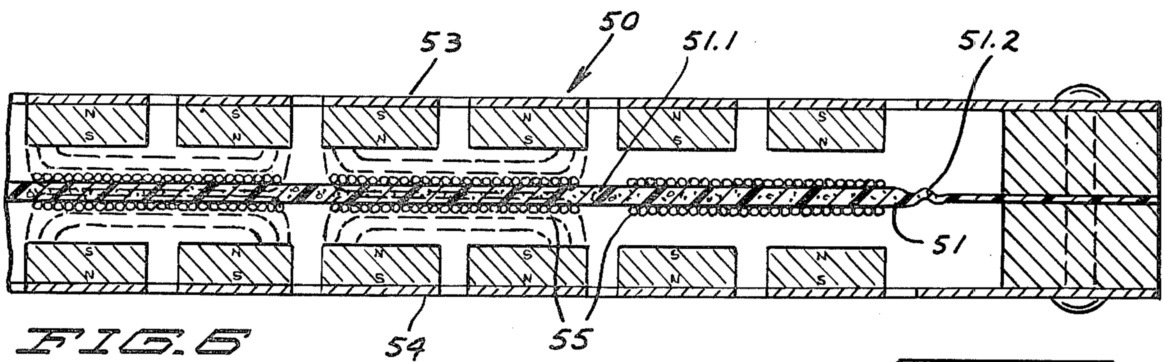


FIG. 6

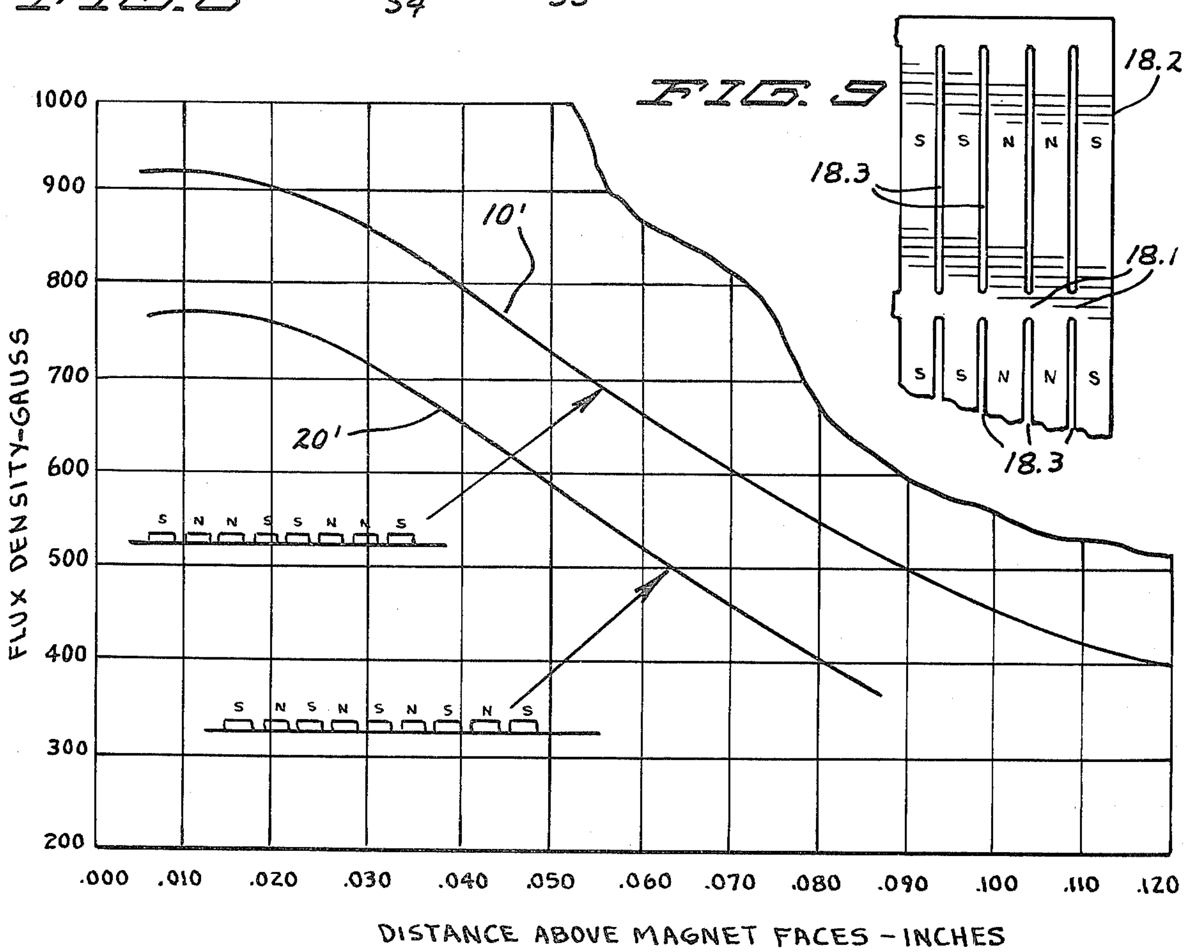
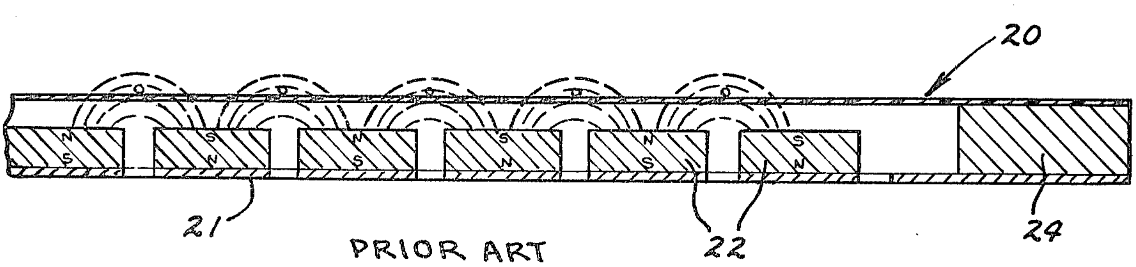


FIG. 9

FIG. 7



PRIOR ART

FIG. 8

PLANAR DIAPHRAGM TRANSDUCER WITH IMPROVED MAGNETIC CIRCUIT

This invention relates to planar diaphragm type magnetic transducers or speakers, and more specifically, to an improved magnetic circuit for such transducers.

BACKGROUND OF THE INVENTION

Diaphragm type magnetic speakers have been known for several years, and usually incorporate a diaphragm or membrane having a vibratable area with a multiplicity of runs of signal carrying conductors thereon. The diaphragm or membrane is spaced from and confronts a generally rigid magnetic backing, usually comprising a multiplicity of permanent magnetized strips lying against an acoustically transparent soft iron plate or armature. The magnetized strips are magnetized so that the front face of each magnetized strip which faces the diaphragm has one polarity and the opposite face of the strip which faces the magnetic plate is the opposite polarity. The magnetized strips are spaced from each other and are magnetized so that all magnetized strips have polarity arrangements opposite to the polarity arrangement of the next adjacent strips. That is to say, the accumulation of spaced magnet strips are polarized so that the adjacent faces have the polarity arranged, north-south-north-south-etc.

Prior transducers have had various physical constructions in the magnetic backing. In U.S. Pat. No. 3,674,946, the magnetized strips are incorporated into a single sheet or slab of magnetic material which is variously magnetized in parallel zones or strips which are spaced from each other. In U.S. Pat. No. 3,919,499, the magnetic backing utilized narrow strips of magnet material, each strip spaced from adjacent strips and suitably magnetized.

In these prior speakers or transducers, conductors on the diaphragm extend parallel to the magnetized strips and are located opposite all the spaces between the several magnets in the magnetic backing.

The arrangement of the magnetized strips has been such that the magnetic fields are formed between the adjacent magnetic poles at the front faces of adjacent magnetized strips; and approximately half of the magnetic field of each magnetized strip is associated with the pole face of the next adjacent strip and the magnetic field related thereto.

It has been recognized in the past that one of the principle problems encountered in the use of the diaphragm type magnetic transducers or speakers has been one of efficiency. In order that the magnetic fields in the vicinity of the conductors on the diaphragm have sufficient strength as to produce significant vibration of the diaphragm in response to application of a signal current through the conductors, it has been necessary to locate the diaphragm quite close to the faces of the magnet strips. It has been typical practice to space the diaphragm approximately sixty thousandths (0.060 inches) from the faces of the magnetized strips in commercial diaphragm type magnetic speakers.

It has been experienced that when a signal current of a substantial magnitude is applied to the conductors on the diaphragm, the diaphragm may have a sufficient excursion from its normal position as to "bottom" or slap against the faces of the magnetized strips. Of course, this bottoming of the diaphragm against the magnetized strips causes a sound which is quite unpleasant and which does not conform at all to the sounds intended to be produced by the signal current being applied.

If the diaphragm is to be prevented from bottoming against the faces of the magnetized strips, the magnitude of the signal current must be reduced, in which case the volume of the sound produced may not be as large as may be desired; or on the other hand, the spacing between the diaphragm and the faces of the magnetized strips must be increased to the point wherein only a minimum of magnetic field surrounds the conductors so that the signal current in the conductors has a significantly lesser effect for the purpose of producing vibration of the diaphragm.

SUMMARY OF THE INVENTION

An object of the invention is to provide a new and improved diaphragm type magnetic transducer or speaker of simple and inexpensive construction and operation.

Another object of the invention is to provide a novel magnetic circuit for a diaphragm type magnetic transducer or speaker which has significantly increased efficiency.

Another object of the invention is to provide an improved diaphragm type magnetic speaker which is adapted to accommodate increased excursion of the diaphragm from its normal position without bottoming or slapping against the magnetic backing.

A still further object of the invention is the provision of an improved magnetic circuit for a diaphragm type magnetic speaker which provides several functional advantages for the speaker in the normal operation thereof.

A principle feature of the present invention is a new and improved magnetic circuit for the planar diaphragm type transducer. The magnetized strips are arranged in functional pairs; and in each pair, the front face of one magnetized strip confronting the diaphragm has a south pole, and the front face of the other strip in the pair has a north pole. In addition, the polarity of each magnetized strip in each of said functional pairs is the same as that of the adjacent magnetized strip of an adjacent functional pair of magnetized strips. In other words, adjacent magnetized strips with opposite polarities at their front faces are a functional pair, cooperating to project a magnetic field embracing a portion of the diaphragm and a run of conductors thereon; each magnetized strip is also adjacent another magnetized strip of like polarity at their front faces. The sequence of spaced magnetized strips is north, south, south, north, north, south, et seq.

As a result, there is a neutral zone between adjacent functional pairs of magnet strips, wherein there is essentially no magnetic field, because the magnetic pole faces at opposite sides of the neutral zone are of like polarity.

On the other hand, magnet strips in each functional pair create a magnetic field of increased intensity between their front faces and the magnetic field has a depth of considerable magnitude in a direction outwardly from the faces of the magnetized strips and toward and beyond the conductors of the diaphragm.

Another feature is that there are conductors only opposite the functional pairs of magnet strips; and there are no conductors opposite the neutral zones between adjacent pairs of magnet strips. At each conductor therefore, the magnetic field is significantly more intense than in previously used magnetic circuits.

In addition, this magnetic circuit arrangement provides a broader base or width of the magnetic field at each pair of magnet strips, thus providing a different shape of magnetic field adjacent the diaphragm and conductors thereon. This different shape is especially important wherein the diaphragm is sandwiched between two magnetic backings incorporating identical magnetic circuits hereinbefore described. In this circumstance, the opposing magnetic fields from the pairs of magnet strips on each side of the diaphragm will adopt a substantially square shape, wherein practically all of the magnetic field and the lines of magnetic flux therein lie parallel to the diaphragm. A wider band of conductors in each run of conductors on the diaphragm is useful in such a magnetic field. The band of conductors may confront the entire functional pair of magnetized strips and more specifically, the magnetized strips of opposite polarity as well as the space therebetween. The band may be, advantageously, as wide as the overall width of the functional pair of magnetized strips and the space therebetween.

The magnetic circuit is useful with speakers with a variety of different types of diaphragms. Accordingly, the diaphragm may be film to flex in its normal vibration, and may be stretched extremely tight or may be relatively loose with only the wrinkles removed. Alternately, the diaphragm may have an essentially rigid vibratable area to move without flexing and connected to the frame by a flexible surround at its periphery.

The magnetic circuit may be made of separate strips of magnet material laid onto a soft iron armature plate with the polarities arranged as specified; or the magnet material may be molded in one panel. Slots may be formed in the panel or slab by molding or by punching out after molding, as to define separate strips as defined and as to avoid use of excessive magnet material.

The advantages of the improved magnetic circuit are primarily to improve the efficiency of the speaker, to intensify the magnetic field at the diaphragm, and to obtain more excursion of the diaphragm in relation to the signal current applied to the speaker, all without increasing the volume or quantity of magnet material used in the magnetic backing. In addition, an advantage is provided in that the spacing between the diaphragm and the faces of the magnetized strips can be signficantly increased to allow greater excursion of the diaphragm without bottoming against the magnet strips, thereby permitting production of louder sounds by the transducer.

In addition, the magnetic fields will be particularly intense and properly arranged at the conductor carrying diaphragm sandwiched between two identical magnetic backings which have like pole faces confronting each other, as to nearly maximize efficiency of the transducer.

A BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of a transducer incorporating the present invention.

FIG. **2** is an enlarged detail section view taken at **2—2** of FIG. **1**.

FIG. **3** is a greatly enlarged detail elevation view, partly broken away for clarity of detail, of the transducer.

FIG. **4** is a detail section view of a modified form of the transducer.

FIG. **5** is a greatly enlarged detail section view illustrating another modified form of the invention.

FIG. **6** is a detail section view illustrating still another modified form of the invention.

FIG. **7** is a graph illustrating the performance characteristics of certain transducers incorporating the present invention as compared to a transducer incorporating the magnetic circuit of the prior art.

FIG. **8** is a detail section view illustrating the prior art form of magnetic circuit utilized in diaphragm type magnetic speakers.

FIG. **9** is a detail plan view of a modified form of magnet construction.

DETAILED SPECIFICATION

A diaphragm type magnetic transducer or loud speaker is illustrated in one form in FIGS. **1–3** and is indicated in general by the numeral **10**. The loud speaker may be in any of a large range of sizes. The speaker may be especially adapted for mid-range bass frequencies in a size of 3 to 5 feet long and 6 to **12** inches wide. The speaker may also incorporate a tweeter section. Also, the speaker may be rectangular or oblong or circular as small as 3 inches in diameter or smaller. The speaker **10** includes a diaphragm **11** having a vibratable area **11.1** disposed inwardly from the outer periphery **11.2** which is secured as by adhesive to the spacer on frame **16**. The vibratable area **11.1** of the diaphragm has a multiplicity of elongate and parallel runs **12** of signal carrying conductors or strands **12.1**. The runs **12** may include single or multiple strands of the conductors as seen in FIGS. **2** and **3**.

The transducer also includes a substantially rigid and acoustically transparent magnetic backing **13** confronting substantially the entire diaphragm **11**. The magnetic backing has a substantially rigid acoustically transparent plate **14** of magnetic material such as soft iron or steel, which has a multiplicity of aperatures **15** therein. The edges of the plate **14** are secured to the spacer or frame **16** to which the periphery of the diaphragm is affixed. Mechanical fasteners such as rivets **17** may be utilized for securing the spacer to the edge portions of the plate **15**.

The diaphragm may be formed of various materials and it has been found successful to form the diaphragm **11** of a polyester film known by its trademark as Mylar. Typically, the diaphragm will have a thickness on order of 0.00025 to 0.0005 inches. Also, other films such as saran or plyofilm which is basically a rubber type material, or paper, catgut, or polyethylene may be utilized in the diaphragm. In addition, the diaphragm may be constructed with a substantially stiff and non-flexing vibratable area, of honeycombed styrofoam or similar material as illustrated in FIG. **6**.

Also, although the conductor runs in FIGS. **2** and **3** only show the use of two strands of conductors, a multiplicity of conductor strands in each run may be utilized on the diaphragm **11**, substantially as illustrated in FIG. **5**. It will be understood that the strands of conductors are secured by adhesives to the diaphragm **11** to retain them in the precisely desired locations, hereinafter more fully referred to. Conductors may range in size from 24 gauge to 32 gauge, or larger or smaller, depending upon the current to be carried.

The magnetic backing also includes a multiplicity of elongate strips **18** of magnet material, spaced from each other and lying on the plate **14** in spaced relation with the diaphragm **11**. The strips **18** do not signficantly obstruct the apertures **15** in the magnetic plate **14** as to produce any acoustical loading of the diaphragm in its normal operation. The strips **18** are magnetized as hereinafter described in detail and are referred to as magnetized strips.

The magnetized strips **18** may be formed of any of a number of materials which may be flexible or rigid. The magnetized strips are typically formed of a flexible rubber bonded barium ferrite magnetic material known by its trademark Plastiform of the 3M Company, St. Paul, Minn. In addition, the magnetized strips may be formed of samarium cobalt in a polymer binder or the magnetized strips may be scintered samarium cobalt, or also ceramic magnets or similar types of magnets available in strip form may be used. Although it may be desirable that the magnetized strips **18** extend the full length of the transducer **10** as seen in FIG. **1**, the magnetized strips may be used in short sections placed end to end as to effectively fabricate elongate end to end strips. The abutted ends **18.1** of certain magnetized strips are seen in FIG. **3**.

Also, the magnet strips may be incorporated into a sheet of magnetic material or may be connected together by narrow bridges **18.1** as illustrated in FIG. **9**, so that the magnetized strips are a part of a single panel **18.2** with slots **18.3** formed during molding or by punching after molding is complete.

All of the magnetized strips **18** are magnetized in a direction normal to the plate **14** and diaphragm **11** so as to define magnetic poles at the front faces **18.2** of the magnetized strips which face the diaphragm **11**. Certain of the magnetized strips **18** are magnetized so that there are south magnetic poles at their front faces **18.3**; and other of the magnet strips are magnetized so that there are north magnetic poles at their front faces **18.4**. It will be evident in FIGS. **2** and **3** that the sequence of pole faces on the magnetized strips is south, north, north, south, south, north, north, et seq. Each adjacent magnet strip which has a north magnetic pole at its front face **18.4** establishes a magnetic field in cooperation with the next adjacent magnet strip with a south pole at its face **18.3**. Such a functional pair of magnetized strips with opposite magnetic poles at their front faces **18.3**, **18.4**, and disposed opposite a run **12** of the signal carrying conductors on the diaphragm. There is a space **18.5** between the magnetized strips **18** of each functional pair of strips.

It will also be seen that there is a space **18.6** between each functional pair of strips **18**. Adjoining each space **18.6** are magnetized strips with like magnetic poles at their front faces. As a result, there is essentially no magnetic field at the diaphragm opposite the spaces **18.6**.

FIG. **7** dramatically shows the increase in the magnetic field by reason of the improved magnetic circuit illustrated in FIGS. **1–3** as compared to a diaphragm type magnetic transducer with a magnetic circuit as used in the prior art, as illustrated in FIG. **8**. In FIG. **8**, the magnetic backing **20**, utilizing a plate **21** of magnetic material, such as a soft iron, has magnetized strips **22** laid thereon in spaced relation to each other and confronting the vibratable area **23** of the diaphragm which is adhesively secured to the spacer **24** which affixes the periphery of the diaphragm to the edge portions of the plate **21** of magnetic material.

The traditional magnetic circuit utilizing the magnet strips **22** is illustrated in FIG. **8**, and the polarity of the magnetic fields is reversed in all of the strips adjacent each other across the width of the transducer **20**. In other words, alternate magnetic strips have north poles at their front faces **25**; and the remainder of the magnet strips which also are alternate have south poles at the front faces **26**.

Accordingly, the magnetic field as illustrated in FIG. **8** defines a magnetic field in the space between each of the magnet strips, and a run of conductor **27** is located opposite the space between each of the adjacent magnetized strips.

This prior art transducer of FIG. **8** is substantially identical in all respects to the transducer **10** of FIGS. **1–3** with the exception of the magnetic field occasioned by placing the magnet strips **18** of the transducer **10** in a different pattern, as illustrated. Also, although the total number of strands and total length of wire is the same as between 8 on the one hand and FIGS. **1–3** on the other hand, the transducer **10** has the strands grouped together or clustered in the magnetic fields as illustrated in FIGS. **2** and **3**.

In FIG. **7**, which compares the strength of the magnetic field of the prior art transducer **20** in curve **20′** with the magnetic field strength of the transducer **10** in the curve **10′**, it will be seen that for the same volume of magnetic material in the two magetic circuits and with the same soft iron plates on which the magnetized strips are laid, the magnetic circuit of the prior art transducer **20** in FIG. **8** establishes that a magnetic field of 650 gauss at a distance of approximately 0.042 inches from the front faces of the magnet strips, whereas, the transducer **10** with the improved magnetic circuit establishes magnetic field of 650 gauss at a spacing of 0.063 inches above the front faces of the magnet strips. Because in both the transducer **10** and **20**, the magnetized strips are spaced apart identically and the same proportion of the plates **14** and **21** are open, there is no change in acoustical loading. However, because a magnetic field of 650 gauss is established at a distance approximately half again as great from the faces of the magnet strips in transducer **10** as compared to the spacing from the magnet front faces in transducer **20**, the diaphragm **11** of transducer **10** may be spaced significantly farther from the faces of the magnet strips without losing operating efficiency of the transducer.

The increased spacing permissible with the improved magnetic circuit of transducer **10** permits the transducer **10** to operate on higher output level without the diaphragm bottoming against or slapping the magnet strip faces. This is especially important in transducers intended to produce the bass and mid-range audio frequency sounds and in smaller transducers where producing a sufficient volume of sound may be a problem. In comparing the improved magnetic circuit of transducer **10** with the prior art magnetic circuit of transducer **20**, it will be recognized that the same volume of magnet material is used in the improved magnetic circuit of transducer **10** so that costs are not increased and acoustical loading is not changed.

Other forms of transducers illustrated in FIGS. **4–6** illustrate variations in transducers that may be utilized with the improved magnetic circuits. In FIG. **4**, the transducer **30** utilizes the identical magnetic circuit of FIG. **1**, but illustrates the use of conductors **31** made of foil or metal deposited on the diaphragm **32** and etched away into individual strands of conductor. This transducer **30** also illustrates that the band of conductors **31** may have a width which is considerably wider than the spacing between the individual magnet strips **33**, the front faces of which are oppositely polarized. Again, the soft iron plate **34** is apertured at **34.1**. The shape of the magnetic fields established by the improved magnetic circuit will accommodate significantly wider bands of clustered conductors **31**. This use of wider bands of conductors may also be utilized in connection with round wires as illustrated in the other transducers. The foil conductors may have a thickness in the range of 0.010 inches more or less, depending upon the amount of current to be carried. The individual conductor strands are insulated from each other by spaces having roughly the same width as the thickness of the foil or strands.

In the transducer **40** of FIG. **5**, the diaphragm **41** with bands of clustered conductors **42** adhesively secured on the diaphragm, is sandwiched between two substantially identical magnetic backings **43** and **44**. In this form of transducer **40**, all of the magnetized strips **45** which are directly opposite each other, have like magnetic poles at their confronting front faces. As a result, the magnetic fields produced on both sides of the diaphragm in the vicinity of the conductor bands are substantially flat in configuration and the lines of magnetic flux lie parallel to the diaphragm and will accommodate wider bands of conductors than possible with a similar transducer of identical size with a prior art magnetic circuit. The metal plates **46** and **47** of the two magnetic backings **43** and **44** have apertures **46.1, 47.1** to make the backings acoustically transparent. In some instances, it may be desirable to carry conductor runs on both faces of the diaphragm.

In the transducer **50** of FIG. **6**, the same identical improved magnetic circuit of transducers **10** and **40** is utilized. In this form, the diaphragm **51** is substantially stiff and non-flexible, and all portions of the central vibratable area of the diaphragm have the same motion, in a piston-like manner. The diaphragm **51** has a surround or flexible joint **51.2** connecting the vibratable area **51.1** with the peripheral portions of the diaphragm which are clamped to the acoustically transparent magnetic backings **53** and **54**. Runs **55** of signal carrying conductors are carried on the vibratable area **51.1** of the diaphragm for producing reaction with the magnetic fields and causing vibration of the stiff and non-flexing vibratable area of the diaphragm.

It will be seen that the improved magnetic circuit of the diaphragm type magnetic transducer produces a significantly more intense magnetic field extending signficantly further out from the front faces of the magnet strips as compared to the prior art magnetic circuit so as to improve the efficiency of the transducer utilizing the improved magnetic circuit while allowing the spacing between the magnetic strips and the diaphragm to be significantly increased. The transducer has more power handling capability and may be driven harder to produce more output and still avoid the bottoming or slapping by the diaphragm onto the faces of the magnet strips.

What is claimed is:

1. A transducer to carry a signal current, comprising

a diaphragm having a vibratable area with a number of elongate signal carrying conductor runs thereon, the diaphragm also having a periphery adjacent the vibratable area,

a substantially rigid magnetic backing confronting the diaphragm and having anchoring means to which the diaphragm is secured,

the magnetic backing having a multiplicity of spaced permanent magnet strips with front faces in confronting and spaced relation with the diaphragm, the magnet strips being magnetized in an orthogonal direction relative to the diaphragm and with magnetic poles located at said front faces, the magnetized strips being arranged in functional pairs, wherein each pair has opposite magnetic poles at the front faces of the respective strips in the pair to project a magnetic field toward the diaphragm, each pair of magnet strips confronting and extending along one of the conductor runs to cause the magnetic field to embrace the conductor run, and the magnet strips adjacent each other and respectively included in adjacent functional pairs being of like polarity at their front faces.

2. The transducer according to claim **1** and the magnetized strips in each of said pairs of strips being spaced from the strips of adjacent pairs.

3. The transducer according to claim **1** and a second magnetic backing confronting the diaphragm and cooperating with said first mentioned magnetic backing in sandwiching the diaphragm therebetween, the magnetized strips of the second magnetic backing having polarities confronting magnetized strips of like polarity of the first mentioned magnetic backing, one of the first mentioned or second magnetic backings being acoustically transparent.

4. The transducer according to claim **1** wherein the magnetic backing includes an apertured plate of a magnetic material against which the magnetized strips lie.

5. The transducer according to claim **1** wherein the diaphragm is constructed of flexible film which flexes to accommodate vibration of said vibratable area.

6. The transducer according to claim **1** wherein the diaphragm is stiff and resists flexing and has a flexible periphery as to allow the whole vibratable area to have substantially the same movement during vibration.

7. The transducer according to claim **1** wherein the magnet strips in each functional pair of magnet strips are spaced from each other.

8. The transducer according to claim **1** and a second magnetic backing confronting the diaphragm and cooperating with the said first mentioned diaphragm in sandwiching the diaphragm therebetween, the magnetized strips in both magnetic backings being opposite each other and of like polarity, the conductor runs including a band of conductor strands with a width traversing a functional pair of magnetized strips, one of the first mentioned or second magnetic backings being acoustically transparent.

9. A transducer to carry a signal current, comprising

a diaphragm having a vibratable area with a number of elongate signal carrying conductor runs thereon, the diaphragm also having a periphery adjacent the vibratable area,

a substantially rigid magnetic backing confronting the diaphragm and having anchoring means to which the diaphragm periphery is secured, the magnetic backing including a low reluctance armature plate and

the magnetic backing having a multiplicity of first and second permanent magnet strips lying on the armature plate and having front faces in confronting and spaced relation with the diaphragm, the magnet strips being magnetized in a direction transversely to the disphragm and armature plate, said first magnetized strips having north poles at the front faces and said second magnetized strips having south poles at the front faces, the magnetized strips being in functional pairs wherein each pair includes a first and a second magnetized strip, each pair of magnetized strips confronting and extending along one of the conductor runs, adjacent functional pairs of magnetized strips being arranged with the first magnetized strips of adjacent functional pairs being adjacent to each other and second magnetized strips of adjacent pairs also being adjacent each other.

10. A transducer to carry a signal current, comprising

a diaphragm having a vibratable area with a number of elongate signal carrying conductor runs thereon, the diaphragm also having a periphery adjacent the vibratable area,

a substantially rigid magnetic backing confronting the diaphragm and having anchoring means to which the diaphragm periphery is secured, and

the magnetic backing having a multiplicity of regularly spaced permanent magnet strips with front faces in confronting and spaced relation with the diaphragm, the magnet strips being magnetized in a direction normal to the diaphragm whereby the front face of each magnetized strip has a predetermined magnetic polarity, the magnetized strips being arranged in predetermined sequence relative to each other and with the polarities of the front faces defining the repeating sequence of polarities, to wit: south, north, north, south, south, north, north, south, et seq, each adjacent pair of magnetized strips the front faces of which are oppostely polarized being opposite one of the conductor runs on the diaphragm.

11. The transducer according to claim **10** wherein the conductor runs have substantially the same width as the overall width of said pair of magnetized strips and the space therebetween.

12. The transducer according to claim **10** and the spaced magnet strips being connected together by spaced narrow transverse bridges.

13. A magnetic circuit for a conductor carrying diaphragm type magnetic transducer, comprising

an apertured soft iron plate,

and a multiplicity of elongate and regularly spaced permanent magnet strips lying on the plate and along each other to confront such a diaphragm, the strips being magnetized in a direction normal to the plate as to define a magnetic pole at the front face of each magnetized strip facing away from the plate, each magnetized strip with a polarity at its front face being adjacent another magnetized strip with like polarity at its front face,

and each magnetized strip also being adjacent another magnetized strip with opposite polarity at its front face.

14. The magnetic circuit according to claim **13** wherein the magnetized strips are arranged in predetermined sequence relative to each other and the front faces are polarized in the sequence south, north, north, south, south, north, north, south, et seq.

15. The magnetic circuit according to claim **13** and the spaced magnetized strips being connected with each other in a panel, there being spaced narrow bridges between the magnet strips.

16. The magnetic circuit according to claim **13** and including a second soft iron plate and a second set of permanent magnet strips, said second plate and second strips being the same and arranged the same as said first mentioned plate and stripes, and said second plate and stripes being fixed in confronting and spaced relation with said first mentioned plate and strips to receive the diaphragm therebetween, pole faces of like polarity in said first mentioned and second strips confronting each other to concentrate the magnetic fields along broad bands.

* * * * *

United States Patent [19]

Winey

[11] **Patent Number: 4,471,173**

[45] **Date of Patent: Sep. 11, 1984**

[54] **PISTON-DIAPHRAGM SPEAKER**

[75] Inventor: **James M. Winey**, White Bear Lake, Minn.

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

[21] Appl. No.: **353,848**

[22] Filed: **Mar. 1, 1982**

[51] **Int. Cl.**[3] **H04R 9/00**

[52] **U.S. Cl.** .... **179/115.5 PV**; 181/170

[58] **Field of Search** .... 179/115.5 PV, 115.5 ES, 179/115.5 VC, 115.5 DV, 115.5 R; 181/170, 173

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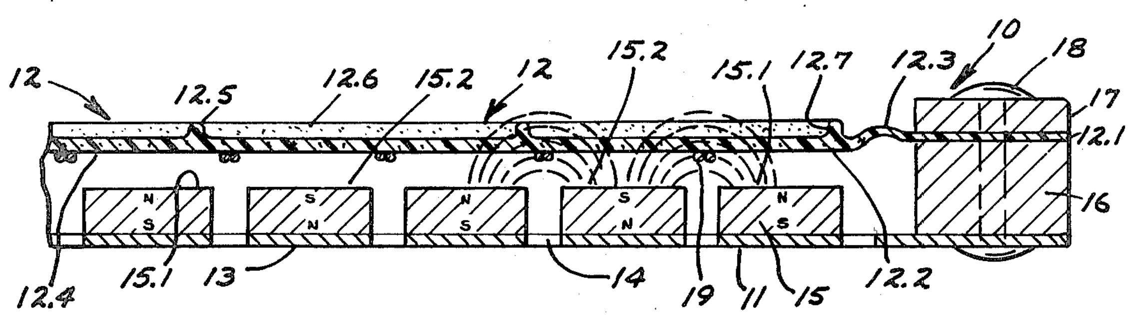
Primary Examiner—Gene Z. Rubinson
Assistant Examiner—L. C. Schroeder
Attorney, Agent, or Firm—Peterson, Palmatier, Sturm, Sjoquist & Baker, Ltd.

[57] **ABSTRACT**

A planar diaphragm type magnetic transducer with an acoustically transparent magnetic backing, and a diaphragm overlying and spaced from the magnetic backing, the magnetic backing having magnetized strips lying parallel to each other and adjacent magnetized strips having opposite polarities at their faces confronting the diaphragm, the diaphragm being stiff and resisting flexing and connected by a flexible surround at its periphery.

28 Claims, 18 Drawing Figures



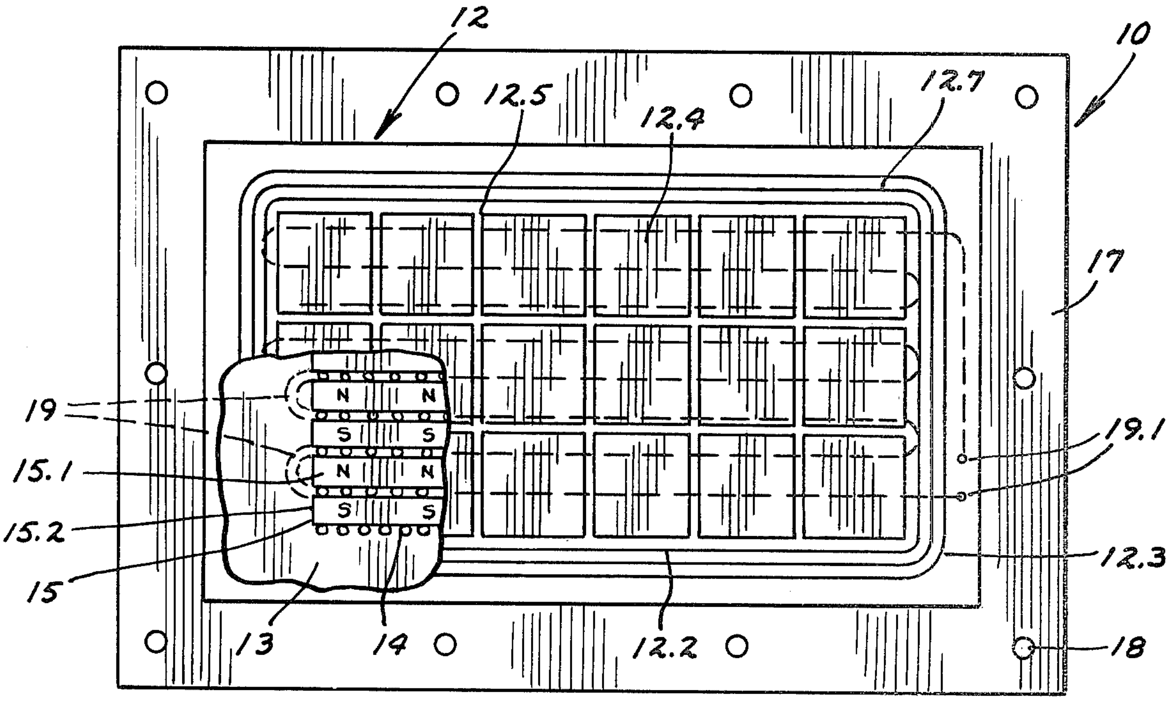


FIG. 1

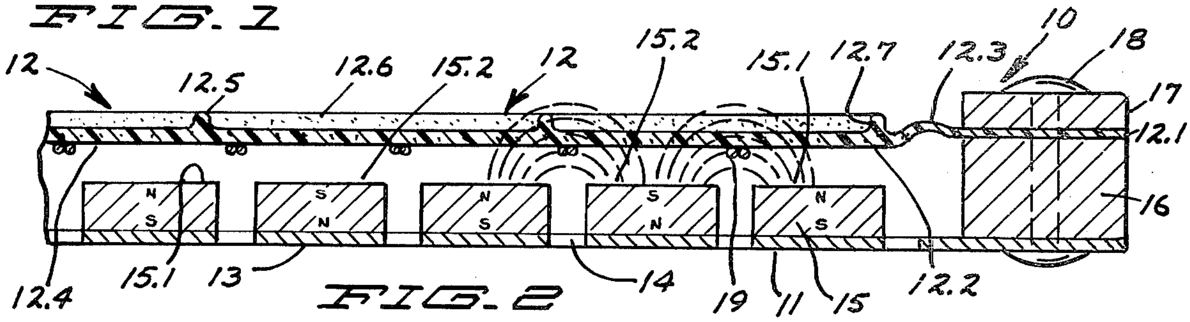


FIG. 2

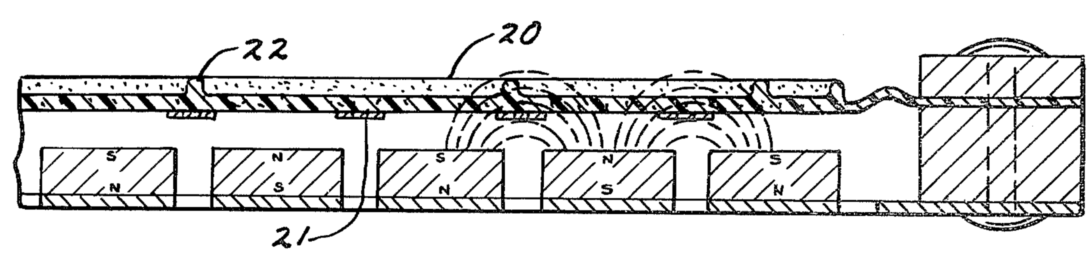


FIG. 3

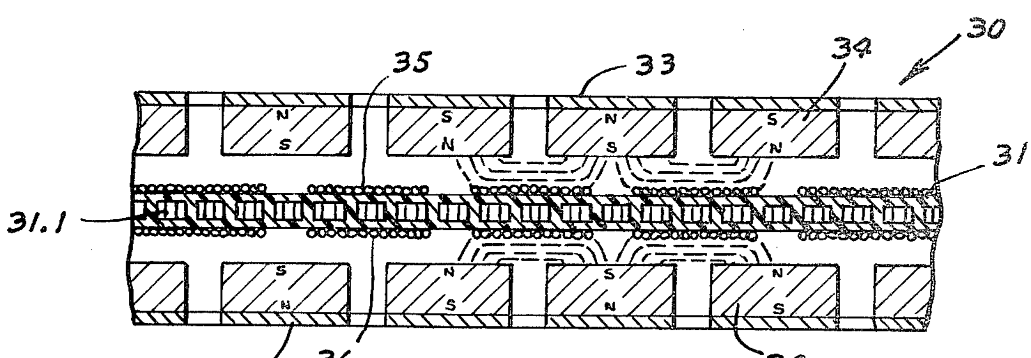


FIG. 4

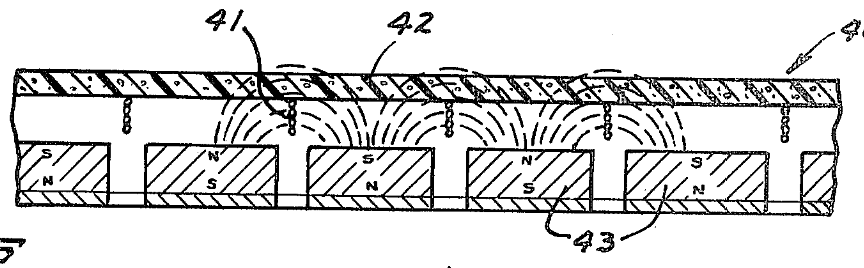


FIG. 5

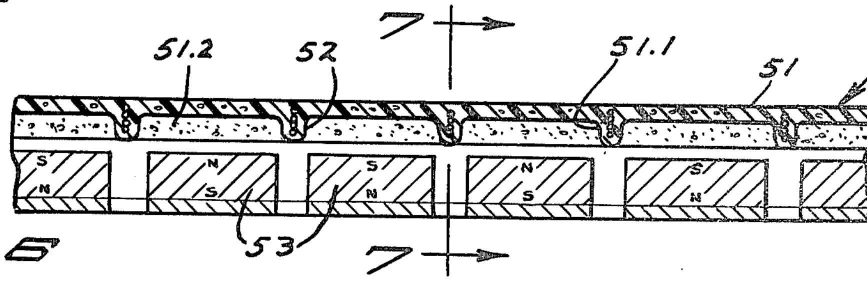


FIG. 6

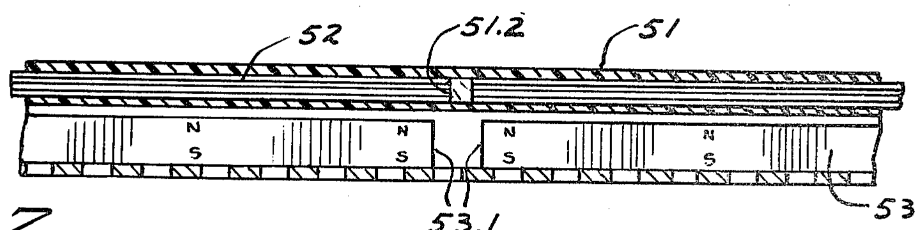


FIG. 7

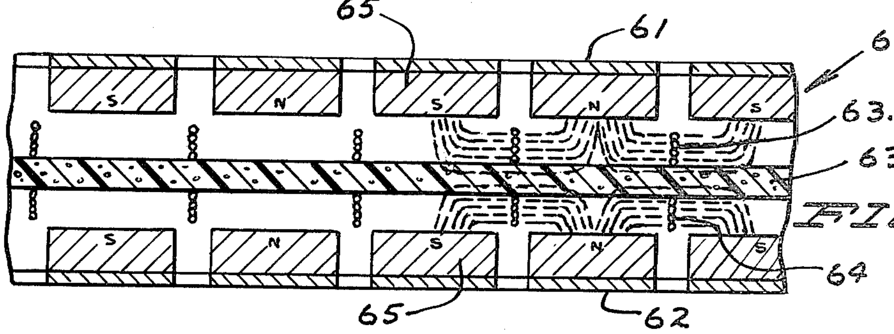


FIG. 8

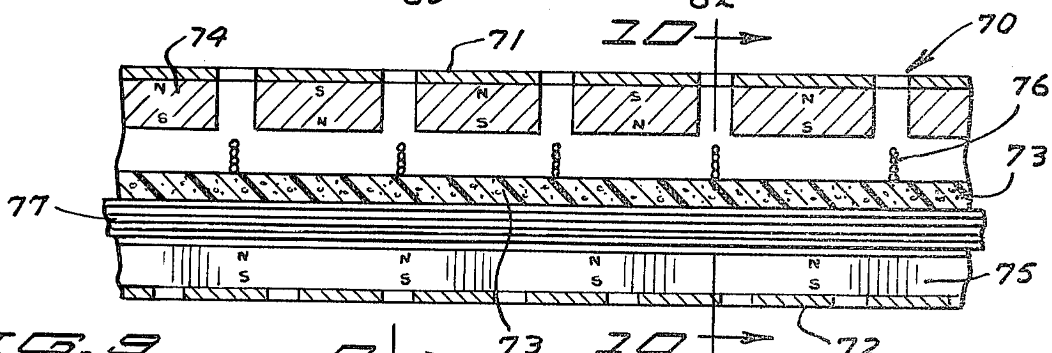


FIG. 9

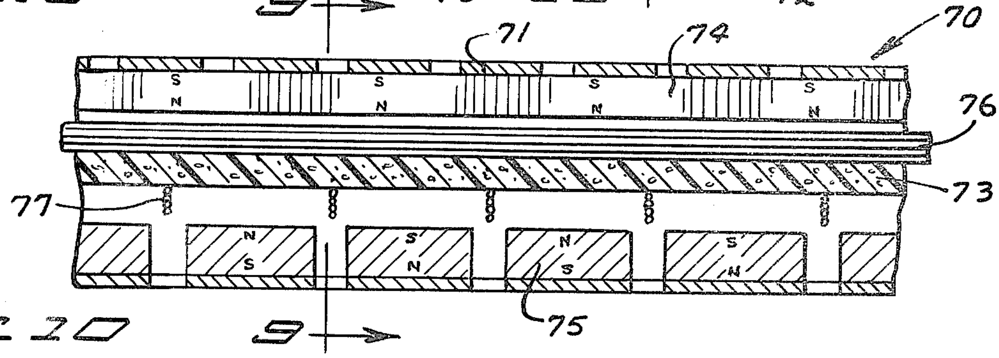


FIG. 10

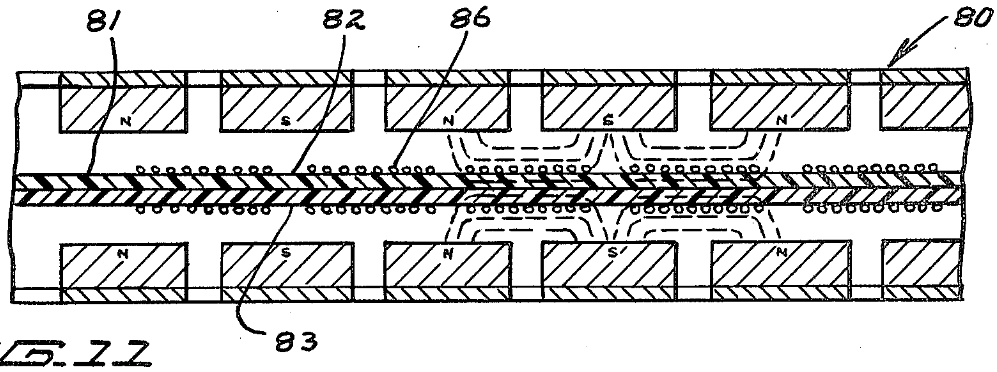


FIG. 11

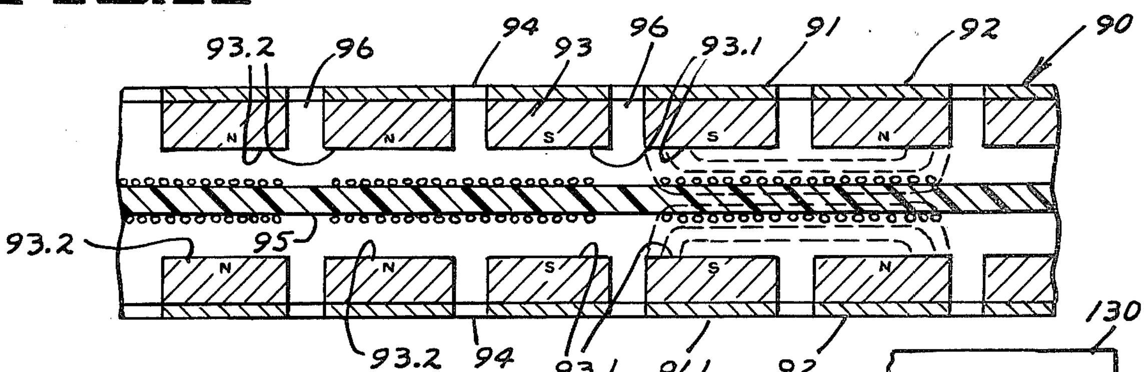


FIG. 12

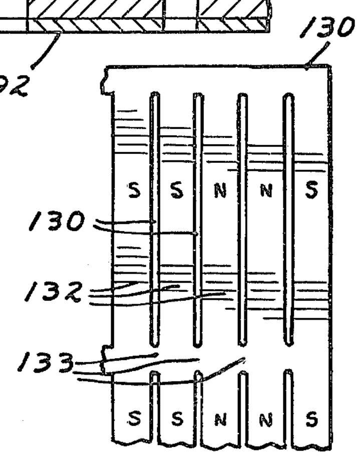


FIG. 16

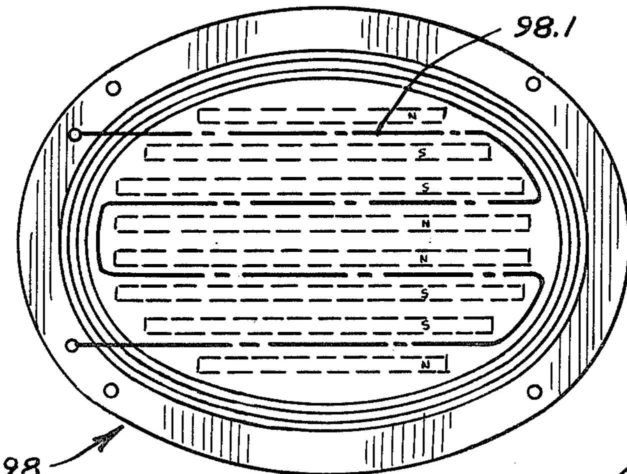


FIG. 13

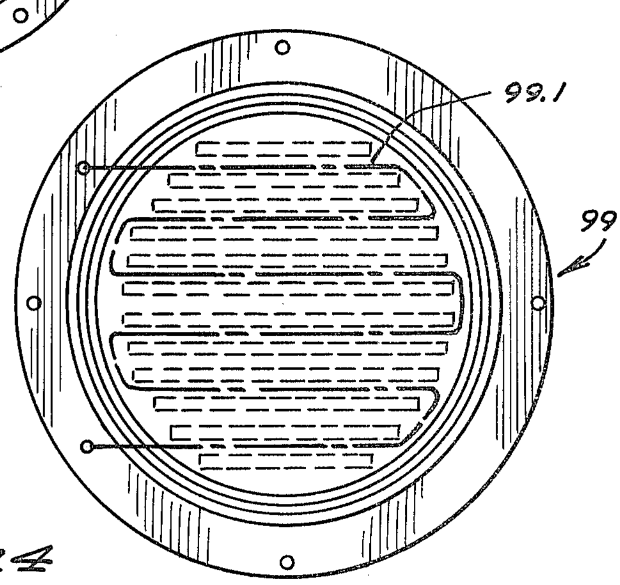


FIG. 14

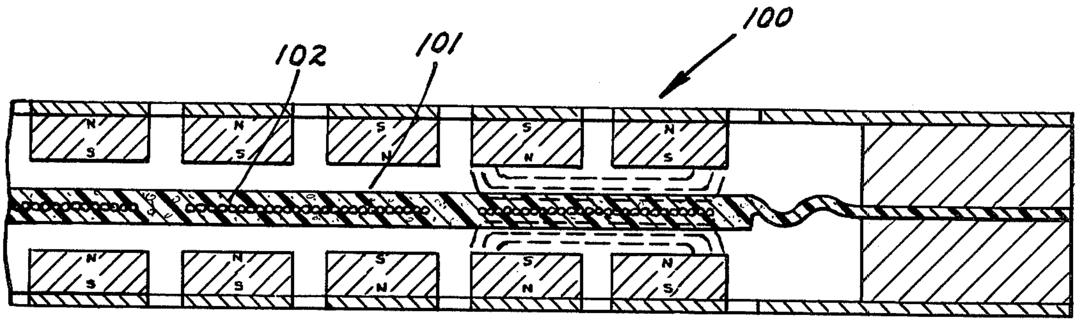


FIG. 15

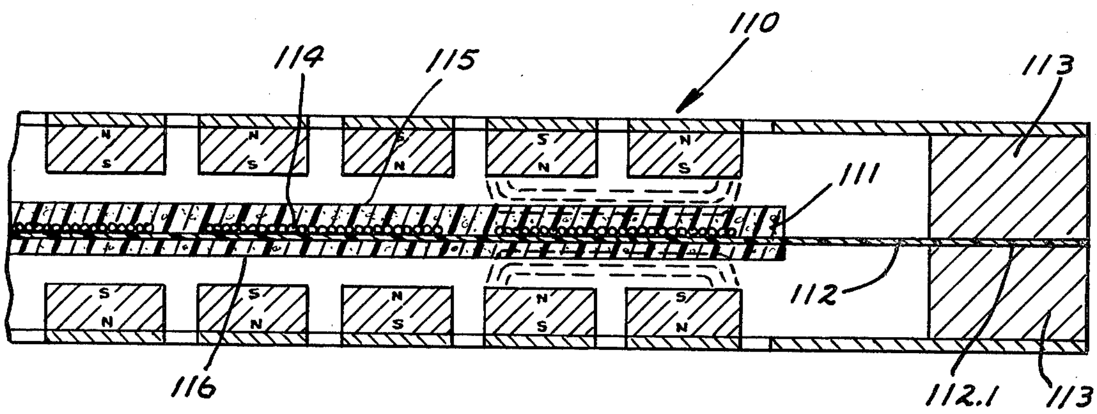


FIG. 16

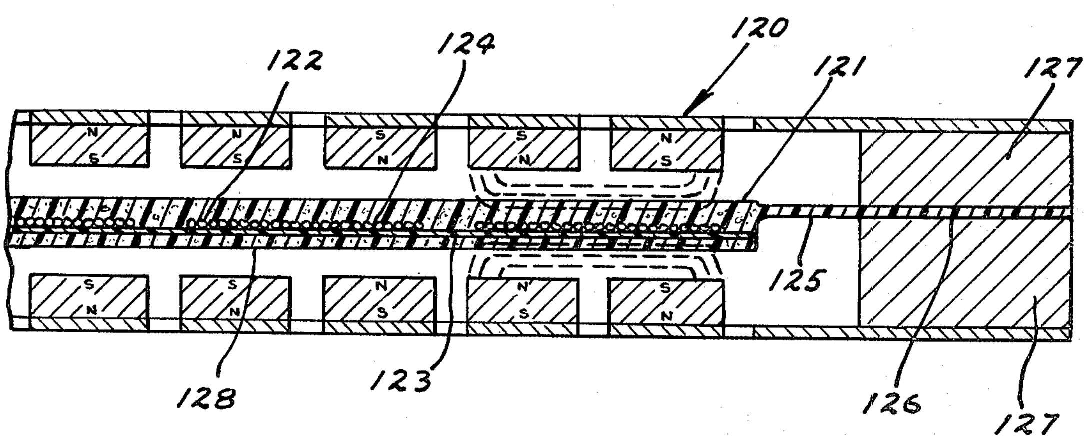


FIG. 17

PISTON-DIAPHRAGM SPEAKER

This invention relates to planar diaphragm type magnetic transducers or loud speakers.

BACKGROUND OF THE INVENTION

A diaphragm type magnetic transducer or loud speaker must have certain basic components including a diaphragm with a vibratable area to which signal conducting conductors are secured. The conductors may be round wire, or may be foil, or may be metallic film etched away into conductor shaped strips. The transducer must also include a source of magnetic fields which project to the diaphragm so that the runs of conductor wire are embraced in the magnetic field such that when an audio frequency signal is applied to the conductor, the vibratable area of the diaphragm will vibrate in synchronism with the frequency of the signal applied and produce sounds with the desired magnitude and frequency.

Typically, a magnetic backing adjacent the diaphragm is the source of the magnetic field and has an apertured soft iron plate spaced from the diaphragm and carrying a multiplicity of elongate magnet strips spaced from each other and laid upon the plate. The magnetized strips are related to one another so that their magnetic field will project from the faces of the magnetized strips to the diaphragm and conductors thereon.

Typical diaphragm type magnetic speakers have been illustrated and described in detail in prior U.S. Pat. No. 3,674,946 and 3,929,499. In the earlier patent, the magnetized strips were parts of a panel or sheet of magnetic matieral; and in the later patent; the magnetized strips were physically shaped as strips of the magnetic material. Accordingly, it is clear that such magnetized strips may take various forms.

All of the known prior diaphragm type magnetic speakers have used diaphragms of film type material which are anchored securely around their peripheries to the frame which is rigid with the magnetic backing. In many such transducers, the diaphragm is stretched very tight, but within the elastic limits of the film material. In some instances, the film type diaphragm has been left rather loose. However, in the prior art, the vibratable areas of the diaphragm in such speakers have consistently been caused to flex by reason of the interrelated function of the signal currents flowing through the wires on the diaphragm, together with the magnetic fields produced by the magnetized strips in the magnetic backing. The central portions of the vibratable areas have a very significant movement or excursion away from the normal position in response to the application of signal current in the conductors; but on the other hand, the edge portions of the vibratable areas have remained essentially stationary. As a result, the central portions of the vibratable areas contributes more to the production of sound as compared to the edge portions. Therefore, because the sounds produced in the bass and mid-range frequencies are produced mainly by the central portions of the diaphragm, there is a definite limitation on the magnitude of sounds produced.

SUMMARY OF THE INVENTION

An object of the invention is to provide a novel planar diaphragm type magnetic transducer which improves the magnitude of sound output in the bass frequencies.

A feature of the present invention is the provision, in a diaphragm type magnetic speaker, of a diaphragm having a vibratable area which is stiff or substantially rigid and which is secured at its periphery by a surround or flexible joint to the rigid peripheral frame. The substantially rigid vibratable area carries conductors in runs spaced from each other substantially entirely across its length and breadth. The substantially rigid vibratable area of the diaphragm may be formed of any of a number of different materials with a high stiffness to weight ratio and low density. Typical of the materials may be molded fibrous pulp, a paper-like material with considerable stiffness; molded styrofoam in slabs with considerable thickness and which may be honeycombed with numerous strengthening ribs or webs and recesses therebetween. Sectional thickness of the styrofoam may be in the range of 0.030 to 0.060 inches. Fibrous pulp may also be shaped or molded into a honeycomb shape for lightness and strength. Also, balsa wood may be fabricated or built up or otherwise shaped into a stiff slab to provide the vibratable area of the diaphragm. Certain expanded bead technology materials with carbon fibers, or other carbon fiber material, may also be used in the substantially rigid vibratable area of the diaphragm. In using certain of these materials, the vibratable area of the diaphragm may be molded, fabricated or built up; and certain of these materials may be utilized together for lightness and strength. Of course, the surround may be formed of material which is identical to or different than the substantially rigid material in the vibratable area of the diaphragm, and the surround may be integral and in one piece with the vibratable area or may be a separate piece of material and secured to the vibratable area.

The particular advantages obtained through the use of the present invention in a planar type magnetic transducer is to increase the power handling of the transducer for the bass frequencies, thereby producing substantially greater magnitude of sound output in the bass and midrange frequencies. The entire vibratable area of the diaphragm, from edge to edge and from end to end, will have essentially the same vibrating movement, toward and away from the magnetized strips behind the diaphragm. As a result, substantially more sound power output can be obtained in the bass frequencies than with the previously known speakers which rely on flexing of the diaphragm.

With this stiff vibratable area type diaphragm, conductors may be arranged on the diaphragm in numerous ways; and various magnetic circuits may be utilized which are especially adapted for use with this type of diaphragm.

The conductors on the diaphragm may be laid side by side, and the width of the bands of conductors in the runs may be either narrow or may be sufficiently wide as to exceed the spacing width between adjacent magnetized strips in the magnetic backing. The wide bands of conductors may traverse the entire front faces of adjacent magnetized strips of opposite polarity. The conductors may also be stacked one upon each other and adhesively held together in the conductor runs so that the stacked conductor runs have considerable depth in a direction normal to the plane of the diaphragm. In certain instances, these stacked conductors may be incorporated or molded directly onto the ribs or honeycomb shape of certain of the rigid vibratable areas. These stacked conductors provide ribbing to add to the stiffness of the diaphragm, and also add more power handling capabilities to the transducer for increasing the output in the bass frequencies.

Also, the rigid vibratable area type diaphragm may be used between confronting magnetic backings with opposed fields with the diaphragm sandwiched therebetween so that conductors on the diaphragm are influenced by magnetic fields originating from both sides of the diaphragm. The opposed fields causes flattening of the magnetic fields so that the line of magnetic flux lie parallel to the diaphragm, as to optimize the forces produced on the diaphragm for vibrating it in the bass frequencies.

It is also particularly useful to use an improved magnetic circuit in the magnetic backing so that the magnetic field produced by the magnet strips will be intensified at the diaphragm.

A BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of a typical diaphragm type magnetic transducer or speaker incorporating the present invention, the figure being partly broken away for clarity of detail.

FIG. **2** is an enlarged detail section view taken approximately at **2—2** of FIG. **1**.

FIG. **3** is an enlarged detail section view showing a modified form of the invention.

FIG. **4** is a detail section view showing a second modified form of the invention.

FIG. **5** is a detail section view showing another modified form of the invention.

FIG. **6** is a detail section view of another modified form of the invention and taken at **6—6** of FIG. **7**.

FIG. **7** is a detail section view of the form of the invention illustrated in FIG. **6** and is taken at **7—7** of FIG. **6**.

FIG. **8** is an enlarged detail section view of still another form of the invention.

FIG. **9** is an enlarged detail section view of an additional modified form of the invention and is taken at **9—9** of FIG. **10**.

FIG. **10** is a detail section view of the form of the invention illustrated in FIG. **9** and is taken at **10—10** of FIG. **9**.

FIG. **11** is a detail section view of one more modified form of the invention.

FIG. **12** is a detail section view of one additional modified form of the invention.

FIG. **13** is an elevation view of a speaker of somewhat different shape and embodying the invention.

FIG. **14** is an elevation view of still another speaker of different shape embodying the present invention.

FIG. **15** is a detail section view of still another modified form of the invention.

FIG. **16** is a detail section view of still another modified form of the invention.

FIG. **17** is a detail section view of one more modified form of the invention.

FIG. **18** is a detail plan view of an alternate form of magnet sheet which may be substituted for the strips illustrated in the other views.

DETAILED SPECIFICATION

One form of the invention is illustrated in FIGS. **1** and **2** wherein the rectangular transducer is indicated in general by the numeral **10**. The transducer has an acoustically transparent magnetic backing **11** and a diaphragm **12**. The transducer **10** may be in any of a wide range of sizes and shapes, and may in some instances have proportions of approximately 9 inches long by 6 inches wide or smaller, or the transducer may have a considerably longer shape, such as in the range of 36 to 48 inches or more, while the width may be up to 9 or 12 inches wide. Alternatively, the transducer may be round, down to three inches in diameter or smaller, or may have different shapes as illustrated in FIGS. **13** and **14**.

The magnetic backing **11** includes a soft iron magnetic plate or armature **13** having a multiplicity of openings or apertures **14** therein for the purpose of making the magnetic backing **11** acoustically transparent.

The magnetic backing also has a multiplicity of elongate magnetized strips **15** which are regularly spaced from each other, as illustrated, but could be in other physical arrangements relative to each other, such as illustrated in FIGS. **12** and **18**. The magnetized strips **15** lie between the apertures **14** so as to minimize interference with the openings of the apertures and thereby minimize acoustical loading on the transducer.

The backing includes a rigid spacer or frame strip **16** extending entirely around the outer periphery of the plate **13** and cooperating with another similar strip **17** in clamping and securing the peripheral edge **12.1** of the diaphragm therebetween. The strips **16** and **17** are rigidly affixed to the back plate **13** by mechanical fasteners such as rivets **18**. Althrough the strips **16** and **17** may be made of steel, the material in these peripheral strips **16** and **17** is not critical.

The magnetized strips **15** are formed of any of a number of different materials and may typically be formed of a rubber bonded barium ferrite known by its trademark "Plastiform" of 3M Company, St. Paul, Minn. The magnetized strips **15** are magnetized in a direction perpendicular to the plate **13** and to the diaphragm **12** so as to define magnetic poles at their front faces. It will be recognized that front faces **15.1** of the magnetized strips are polarized with a north pole all along the lengths thereof, and the front faces **15.2** are polarized with a south pole all along the lengths thereof.

In certain instances, it may be desirable to form the magnetized strips **15** of material for producing a more intense magnetic field, or a greater flux density at the diaphragm, in which case such materials such as samarium cobalt or other rare earth materials as ceramic magnets may be used. Also, a different magnetic circuit may be used, as illustrated in FIG. **12**. Using opposed magnetic backings on opposite sides of the diaphragm, as illustrated in FIGS. **4** and **12**, also intensifies the magnetic field at the diaphragm.

The diaphragm **12** has a stiff and substantially rigid vibratable area **12.2** with a size to confront substantially the entire magnetic backing **11** and especially to confront all of the magnet strips **15** thereof.

The diaphragm may be formed of various materials having a high stiffness to weight ratio and a low density so as to vibrate at most of the frequencies which are considered to be within the audio frequency range. It is expected in most cases that the vibratable area of the diaphragm will vibrate within the frequency range of approximately 20 cycles per second up to 15,000 cycles per second, and in some instances, the vibratable area may vibrate up to 20,000 cycles per second.

The diaphragm **12** may be formed entirely of one material, or it may be that the substantially rigid vibratable area may be formed of one material including the surround or flexible joint **12.3**, or in some instances the surround and outer periphery 12.1 may be formed of a separate material and connected to the vibratable area.

Typically, the diaphragm may be formed of a fibrous pulp, a paper-like material which can be readily molded into the desired shape. Otherwise, the diaphragm may be formed of a styrofoam or of a carbon fiber type of material or a combination of various materials to provide the requisite lightness and stiffness and durability. The diaphragm may be molded or fabricated or built up of several distinct parts and adhesively or otherwise secured together. In many instances, it is desirable that the vibratable area 12.2 of the diaphragm be shaped as a honeycomb, as illustrated in FIG. 4, and preferably the area 12.2 has a flat bottom panel 12.4 lying substantially in a plane and confronting the magnetic backing 11. Integrally formed ribs 12.5 and 12.6 extend in transverse directions relative to each other and are integrally molded with respect to each other will provide significant stiffness to the vibratable area. The vibratable area may have a peripheral rib or a rim 12.7 adjoining the surround 12.3 for adding stiffness and providing a secure connection to the surround. In some instances, depending upon the nature of the material used in the vibratable area of the diaphragm, the vibratable area may be a simple slab of finite thickness, as illustrated in FIG. 5. In other instances, the diaphragm may be fabricated somewhat as illustrated in FIG. 11 with a honeycombed shape, together with a second panel overlying and concealing the honeycombs. Otherwise the vibratable area of the diaphragm may be fabricated, substantially as illustrated in FIG. 6 wherein the strands of the conductor runs are embedded in the ribs of the diaphragm.

In FIGS. 1 and 2, the vibratable area of the diaphragm has a number of conductor runs 10 secured onto the flat surface of the bottom panel 12.4. The conductor runs 19 each have a multiplicity of conductor strands therein, which are in the magnetic fields created by the magnet strips. The conductor runs 19 are regularly spaced from each other across the width of the vibratable area and each of the runs is located in the magnetic field produced by one pair of the magnetized strips 15. The magnetized strips 15 and the conductor run 19 have approximately the same length. The conductors may have a size to carry the necessary signal current, and are typically in the size range of 24 to 32 gauge.

When an audio frequency electrical signal current is applied to the conductor runs, as at the terminals 19.1, the vibratable area 12.2 of the diaphragm vibrates or oscillates toward and away from the magnetic backing 11, thereby producing a sound which has the same pitch and frequency as the frequency of the signal current being applied. The surround 12.3 will yeild while the entire width and length of the substantially rigid vibratable area 12.2 moves under influence of the cooperating signal current and magnetic fields. All parts of the vibratable area of the diaphragm have essentially the same motion. As a result, an improved efficiency in the transducer is achieved and more power output from the transducer is possible, thereby obtaining sounds of larger volume than has been heretofore known, especially in the bass and midrange audio frequencies.

In the form of transducer 20 seen in FIG. 3, the transducer is essentially the same as that disclosed in FIGS. 1 and 2 with the exception that the conductor runs do not incorporate round wire strands as in FIGS. 1 and 2, but the conductor runs 21 are formed of conductor strands which are essentially flat in cross section and are made of strips of foil applied to the diaphragm 22 and adhesively secured thereto. The flat conductor strands may also be formed by applying a metal coating to the diaphragm and then etching away portions to define the individual strands. The functioning of the form illustrated in FIG. 3 is essentially the same as that of FIGS. 1 and 2. The foil may be up to 0.010 inches thick, or more, to carry the desired signal current. The individual strands are insulated from each other by a space which may have a width with the same order of magnitude as the thickness of the foil.

In FIG. 4, the transducer 30 has a substantially rigid diaphragm 31, which in this form is in the shape of a simple slab of low density material having a honeycomb structure with numerous cells or openings 31.1 therein. This diaphragm is made of light weight plastic so as to have a high stiffness to weight ratio. Alternately, the diaphragm may be of styrofoam or other stiff light weight material such as a rigid slab of balsa wood or similar material. In this form, the magnetic backing 32 is essentially identical to the backing 11 of FIGS. 1 and 2; and a second substantially identical magnetic backing 33 is incorporated and placed opposite the magnetic backing 32 and cooperating therewith in sandwiching the vibratable area of the diaphragm therebetween. Both of the magnetic backings 32 and 33 are spaced from the diaphragm and acoustically transparent and incorporate magnet strips 34, as previously described. In the backings 32 and 33, magnetized strips of like polarity confront each other. The conductor runs 35 and 36 are applied onto the open faces of the diaphragm 31. Alternately, one set of conductor runs may be omitted, depending upon power requirements.

In this form of the invention of FIG. 4, the functioning is nearly the same as in FIGS. 1 and 2 with the exception that the magnetic fields are created at both sides of the diaphragm to effectively produce an extremely flat magnetic field at the diaphragm due to the interaction of the magnetic fields. This flat field optimizes the forces applied for vibrating the diaphragm. Again, the substantially rigid vibratable area of the diaphragm has substantially the same movement in all portions thereof.

In FIG. 5, the transducer 40 is again substantially the same as the transducer 10 of FIGS. 1 and 2 with the exception that the conductor runs 41 on the substantially rigid vibratable area 42 of the diaphragm are arranged with the conductor strands stacked upon each other and adhesively secured together and secured to the face of the diaphragm 42. The stacked strands in the conductor runs 41 may be stacked sufficiently high as to extend substantially to the plane of the faces of the magnetized strips, but aligned with spaces between the adjacent magnet strips 43. The runs 41 extend to and slightly beyond the ends of the magnets, substantially in the manner illustrated in FIG. 1 so that there is no interference between the stacked strands in the conductor runs 41 and the magnetized strips. The stacked conductor runs 41 provide a stiffening effect for the diaphragm as well as providing for increasing the power handling capability of the transducer, especially in the bass frequencies.

In FIGS. 6 and 7, the transducer 50 has an open honeycombed shaped diaphragm 41 with the conductor runs 52 embedded directly in the ribs 51.1 of the diaphragm. The ribs 51.1 will extend longitudinally of the transducer as a whole and parallel to the magnetized strips 53 so that the ribs may move into and out of the spaces between the magnetized strips. It will be recognized that the diaphragm 51 also has strength ribs 51.2 extending transversely of ribs 51.1 and integrally formed and molded together with the ribs 51.1. The magnetized strips 53 are seen, in FIG. 7, to have spaced ends 53.1 confronting each other midway of the length of the magnetized strips so as to accommodate the transverse strength ribs 51.2 during oscillation of the diaphragm. This form of the invention in FIGS. 6 and 7 provides the advantage of concealing the conductor strands in the ribs and thereby allowing the conductors to contribute to the strength and stiffness of the diaphragm 51, as well as power handling capabilities.

The transducer 60 illustrated in FIG. 8 is very similar to the form of transducer illustrated in FIG. 4 and has a pair of magnetic backings 61 and 62 confronting each other and confronting the diaphragm as to sandwich the diaphragm 63 therebetween. Stacked conductor strands 64 form the conductor runs 63.1 on both sides of the diaphragm 63 and opposite the spaces between the magnetized strips 65 so as not to interfere with the magnetized strips. The stacked conductor strands in the runs 63.1 will contribute to the stiffness of the diaphragm 63, as well as contribute to the production of significant excursion of the diaphragm during application of the signal current.

The transducer 70 illustrated in FIGS. 9 and 10 is similar to the transducer 60 of FIG. 8 and has a pair of magnetic backings 71 and 72 disposed opposite each other and sandwiching the diaphragm 73 therebetween. In this form, the magnet strips 74 of the magnetic backing 71 extend transversely as relates to the magnet strips 75 of the opposite magnetic backing 72. Accordingly, the conductor runs 76 on the diaphragm 73 which are adjacent the magnetic backing 71 will extend parallel to the magnet strips 74 and are located in the spaces between the magnet strips to move in these spaces. The stacked conductor strands of conductor runs 77 extend across the face of the diaphragm 73 adjacent the magnetic backing 72, parallel to magnetized strips 75 and in a direction perpendicular or transverse to the direction of conductor runs 76. The magnetic fields from the opposite magnetic backings 71 and 72 in this form of the invention function substantially exclusively in relation to the currents in the respective adjacent conductor runs 76 and 77, respectively, to cooperatively produce the movement of the sound producing vibratable area of the diaphragm.

In FIG. 11, the transducer 80 is substantially the same as transducer 30 of FIG. 4 with the exception of the diaphragm 81 which is fabricated of panels 82 and 83 adhesively affixed together. One or both panels 82, 83 may be ribbed on their abutting faces to provide an overall honeycombed shape, and one panel may be formed with a surround and mounting edge for connection to the frame. The panels carry the conductors 85, 86. The fabricated diaphragm panels 81, 82 increase the rigidity of the diaphragm.

In the transducer 90 of FIG. 12, the transducer is substantially the same as that illustrated in FIG. 4 with the exception that a different and improved magnetic circuit is incorporated into the magnetic backings 91 and 91.1. The soft iron panels 92 have the magnetized strips 93 laid thereon between the apertures 94 and opposite the diaphragm 95. The magnetized strips 93 are arranged so that the magnetized strips have a predetermined sequence of poles at their front faces 93.1 and 93.2, the sequence being a repeated pattern, north, south, south, north, north, south, south, north, et seq. In this magnetic circuit, adjacent functional pairs of magnetized strips 93 which have opposite polarities at their front faces 93.1 and 93.2 cooperate to produce a magnetic field at the diaphragm 95 which has an increased intensity and permits a larger gap between the faces of the magnetized strips and the diaphragm. The magnetized strips adjacent each other, but not of the same functional pair, are of like polarity at their front faces as to produce a substantially neutral zone or dead zone without magnetic field, as at the space 96.

In the transducer 90, the conductors on the diaphragm are arranged in wide band runs 97 traversing the entire widths of functional pairs of magnetized strips and the spaces therebetween. The fields are flattened because of the opposed magnetic backings, to optimize the forces applied to the diaphragm.

FIG. 13 illustrates that the transducer 98 may have an oval shape with substantially all of the remaining characteristics of the transducer 10 of FIGS. 1 and 2. In FIG. 14, the transducer 99 is illustrated in a round shape, also incorporating substantially all of the features of the transducer 10. It will be recognized that the conductor runs 98.1 and 99.1 of the two transducers 98 and 99 vary slightly in length relative to each other to accommodate the curved periphery of the vibratable area.

In FIG. 15, the transducer 100 is very similar to the transducer 90 illustrated in FIG. 12, with the exception that the transducer 100 has the stiff or substantially rigid vibratable area 101 of the diaphragm formed with the conductor runs 102 embedded therein. The vibratable area of the diaphragm may be integrally molded with the conductor runs originally formed therein, and as indicated previously, the vibratable area 101 of the diaphragm may be typically formed of styrofoam.

Although all of the stiff diaphragms herein disclosed are connected to the peripheral frame strip and backing with a flexible surround, other devices may be used to hold the stiff diaphragm in predetermined relation to the magnetic strips while allowing the diaphragm to vibrate without substantial flexing. For instance, the diaphragm may have bearing apertures at its corners to receive stationary mounting posts upon which the diaphragm is free to slide; and the periphery of the stiff diaphragm may be free of the frame strips, while guided close to the frame strips, preferably but not necessarily in substantially air sealing relation. Also flexible links may attach the frame strips to the diaphragm to retain the diaphragm in alignment with the magnetized strips, without such posts.

The transducer 110 of FIG. 16 is very similar to the transducer 90 of FIG. 12 with the exception that the transducer has the diaphragm 111 formed on a film 112 as the base of the diaphragm providing connection at the outer periphery 112.1 to the frame strips 113 of the transducer. The film 112 may be formed of any of a number of materials such as polyester film, known as Mylar, with a thickness in the range of 0.000250 inches to 0.005 inches. The conductor runs 114 are laid upon the film diaphragm 112; and a stiff or substantially rigid panel 115 of styrofoam or other similar plastic material, overlays the conductor runs 114 and is adhered to the film diaphragm 112. The stiff panel 115 provides the stiff vibratable area of the diaphragm; and an optional additional panel 116 may be adhered to the opposite side of the flexible diaphragm 112 to cooperate with the panel in adding stiffness. In this form, application of a signal current produces substantial movement of the whole diaphragm because of the stiffness added by panels **115** and **116**. However, limited flexing of these panels is also experienced.

The transducer **120** of FIG. **17** is substantially similar to the transducer **90** of FIG. **12** with the exception of the diaphragm **121** which has a stiff panel **122** of styrofoam or other stiff material, against which a panel **123** of Mylar or other flexible film type plastic material, is laid and adhered to. The conductor runs **124** are sandwiched between the stiff panel **122** and the film panel **123** and are substantially embedded in the stiff panel **122**. The stiff panel **122** has a flat marginal connecting panel **125** and a peripheral edge portion **126** which is secured to the frame strips **127** of the transducer. An optional additional stiff or substantially rigid panel **128** may be adhered to the film panel **123** to sandwich the film panel between the two stiff panels **122**, **128**, for adding additional stiffness. As in the transducer **110** of FIG. **16**, the diaphragm **121** of the transducer **120** moves significantly over its length and breadth when signal current is applied to the conductor runs, however, there is some limited flexing whereby the central portions of the diaphragm have some greater excursion than the peripheral portions.

FIG. **18** illustrates a modified form of magnet structure which may be used in any of the disclosed forms of transducer. The magnet structure **130** is in sheet or panel form and may be molded or die cut to the shape illustrated. The magnet structure is formed of the same material as described for strips **15** of FIGS. **1–2**. A number of slots **131** are formed to define spaces between the magnetized strips **132**. The slots will align with the apertures in the iron or steel panel of the magnetic backing. Narrow bridges **133** traverse the slots and interconnect adjacent strips **132**. The magnetized strips may be magnetized with magnetic poles at their front faces as indicated or otherwise according to the magnetic circuit desired.

It will be seen that the transducers of the present invention incorporate a substantially rigid vibratable area of a diaphragm formed of a low density material which has a high degree of stiffness to weight ratio. The conductor runs are spread across substantially the entire length or breadth of the vibratable area and extend substantially throughout the length of the vibratable area so that substantially all portions of the vibratable areas have substantially the same motion. The flexible surround at the periphery of the vibratable area, accommodates the substantially uniform vibrating movement across the whole length and breadth of the vibratable area.

What is claimed is:

1. A transducer for carrying a signal current, comprising
   a generally flat and rigid acoustically transparent magnetic backing including a multiplicity of elongate magnetized strips lying along each other in spaced relation to each other, the magnetized strips being magnetized in a direction perpendicular to the backing, adjacent magnetized strips being oppositely polarized and having magnetic poles of opposite polarity at the front faces thereof for projecting a magnetic field outwardly from the front faces, and
   a diaphragm having a vibratable area confronting the front faces of the magnetized strips in spaced relation therewith, the vibratable area having signal carrying conductor runs thereon and extending along the magnetized strips, the vibratable area of the diaphragm being stiff to resist flexing relative to both the length and breadth of the diaphragm, and connecting means for connecting the diaphragm to the backing to permit the entire vibratable area of the diaphragm to vibrate under influence of the magnetic fields and the signal currents in the conductor runs.

2. The transducer according to claim **1** and the connecting means being flexible and formed integrally with the vibratable area of the diaphragm.

3. The transducer according to claim **2** and a stiffening panel adhered to the vibratable area of the diaphragm.

4. The transducer according to claim **1** and the connecting means being flexible and of a different material than the vibratable area of the diaphragm and being secured to said vibratable area.

5. The transducer according to claim **4** and the vibratable area including a stiff panel carrying the conductors and said connector means comprising a film plastic membrane secured to the vibratable area of the diaphragm and connected with said magnetic backing.

6. The transducer according to claim **1** wherein the vibratable area of the diaphragm has elongate ribs extending thereacross and stiffening the vibratable area.

7. The transducer according to claim **6** and the conductor runs being embedded in the ribs on the diaphragm.

8. The transducer according to claim **1** wherein said conductor runs are on the surface of the vibratable area of the diaphragm and secured thereto.

9. The transducer according to claim **1** and said conductor runs being embedded in the vibratable area of the diaphragm.

10. The transducer according to claim **1** and each of the conductor runs having a multiplicity of conductor strands clustered together in wide runs confronting and traversing oppositely polarized magnetic strips and the magnetic field emanating therefrom.

11. A transducer for carrying a signal current, comprising
   a generally flat and rigid acoustically transparent magnetic backing including a multiplicity of elongate magnetized strips lying along each other in spaced relation to each other, the magnetized strips being magnetized in a direction perpendicular to the backing, adjacent magnetized strips being oppositely polarized and having magnetic poles of opposite polarity at the front faces thereof for projecting a magnetic field outwardly from the front faces, and
   a diaphragm having a vibratable area confronting the front faces of the magnetized strips in spaced relation therewith, the vibratable area having signal carrying conductor runs thereon and extending along the magnetized strips, each of the conductor runs includes a plurality of conductor strands arranged in stacked relation to each other on the vibratable area of the diaphragam, the vibratable area of the diaphragm being stiff to resist flexing, and connecting means for connecting the diaphragm to the backing to permit the entire vibratable area of the diaphragm to vibrate under influence of the magnetic fields and the signal currents in the conductor runs.

12. A transducer for carrying signal current, comprising

a generally flat and rigid acoustically transparent magnetic backing having a multiplicity of magnetized strips in spaced relation to each other, the magnetized strips having front faces lying substantially in a plane and the strips being magnetized in a direction substantially perpendicular to the front faces of the strips, adjacent magnetic strips being oppositely polarized and having magnetic poles of opposite polarity at the front faces thereof for projecting elongate magnetic fields outwardly from said front faces, and

a diaphragm having a vibratable area confronting the front faces of the magnetized strips in spaced relation therewith, the vibratable area having a multiplicity of signal carrying conductor runs thereon and extending along the magnetized strips, the diaphragm also having a connecting area connecting the periphery of the diaphragm with the magnetic backing, the vibratable area being significantly stiffer in all directions than the connecting area whereby the connecting area flexes to permit the entire vibratable area to vibrate under influence of the magnetic fields and the signal current in the conductor runs.

13. The transducer according to claim 12 wherein said conductor runs include conductor strands secured to the vibratable area as to contribute materially to the stiffness of the vibratable area.

14. The transducer according to claim 12 wherein the magnetic backing includes an acoustically transparent soft iron plate against which said magnetized strips lie.

15. A transducer for carrying a signal current, comprising

a pair of generally flat and rigid acoustically transparent magnetic backings each including a multiplicity of elongate magnetized strips lying along each other in spaced relation to each other, the magnetized strips having front faces lying substantially in a plane and the magnetized strips being magnetized in a direction perpendicular to the front faces, adjacent magnetized strips being oppositely polarized and having magnetic poles of opposite polarity at the front faces thereof for projecting a magnetic field outwardly from the front faces, said pair of magnetic backings being arranged in opposed relation to each other with magnetized strips of like polarities being directly opposite each other and in spaced relation to each other, and

a diaphragm having a vibratable area between the magnetic backings and in spaced relation with the front faces of the magnetized strips, the vibratable area having signal carrying conductor runs thereon and extending along the magnetized strips and the magnetic fields projecting therefrom, the vibratable area of the diaphragm being stiff to resist flexing along and transverse to the conductor runs, and the diaphragm also having means connecting the vibratable area to the backing to permit the entire vibratable area of the diaphragm to vibrate under influence of the magnetic fields and signal currents in the conductor runs.

16. The transducer according to claim 15 and each of the conductor runs including a multiplicity of conductor strands clustered into wide bands confronting and traversing the front faces of adjacent oppositely polarized magnetized strips and the magnetic fields emanating therefrom.

17. A transducer for carrying a signal current, comprising

a pair of generally flat and rigid acoustically transparent magnetic backings each including a multiplicity of elongate magnetized strips lying along each other in spaced relation to each other, the magnetized strips having front faces lying substantially in a plane and the magnetized strips being magnetized in a direction perpendicular to the front faces, adjacent magnetized strips being oppositely polarized and having magnetic poles of opposite polarity at the front faces thereof for projecting a magnetic field outwardly from the front faces, said pair of magnetic backings being arranged in opposed relation to each other with magnetized strips of like polarities being directly opposite each other and in spaced relation to each other, and

a diaphragm having a vibratable area between the magnetic backings and in spaced relation with the front faces of the magnetized strips, the vibratable area having signal carrying conductor runs thereon and extending along the magnetized strips and the magnetic fields projecting therefrom, each of the conductor runs including a multiplicity of conductor strands stacked upon each other on the diaphragm and adhered together with the effect of strengthening ribs contributing to the stiffness of the vibratable area as to cause the entire vibratable area to vibrate with substantially the same motion, the vibratable area of the diaphragm being stiff to resist flexing, and having means connecting the vibratable area to the backing to permit the entire vibratable area of the diaphragm to vibrate under influence of the magnetic fields and signal currents in the conductor runs.

18. The transducer according to claim 15 and the conductor runs being embedded in the vibratable area of the diaphragm.

19. The transducer according to claim 15 and the vibratable area of the diaphragm having opposite sides respectively facing the magnetic backings, said conductor runs being disposed on both sides of the diaphragm and respectively confronting adjacent front faces of the magnetized strips.

20. The transducer according to claim 15 wherein the magnetized strips also being arranged with alternate magnetized strips being of like polarity at their front faces.

21. A transducer for carrying a signal current, comprising

a pair of generally flat and rigidly acoustically transparent magnetic backings including a multiplicity of elongate magnetized strips lying along each other in spaced relation to each other and having elongate front faces lying substantially in a plane, the magnetized strips being magnetized in a direction perpendicular to the front faces, the magnetized strips being arranged with the magnetic poles at their front faces having a sequence, to wit, north, south, south, north, north, south, et seq, for projecting magnetic fields outwardly from the front faces entirely across the width of adjacent front faces of opposite polarity, and the pair of magnetic backings being arranged in confronting relation with each other and with magnetized strips of like polarity disposed in directly opposed relation to each other whereby the magnetic fields between the backings are compressed and have lines of magnetic flux extending substantially parallel with the front faces of said strips, and

a diaphragm having a vibratable area with length and breadth and disposed between the magnetic backings and confronting the front faces of the magnetized strips in spaced relation therewith, the vibratable area having a multiplicity of signal carrying conductor runs each including a multiplicity of conductor strands clustered in wide flat runs confronting and transversing substantially the entire width of magnetized strips of opposite polarity and the space therebetween, the vibratable area of the diaphragm being stiff in the direction of both the length and breadth to resist flexing and having flexible means for connecting the periphery of the vibratable area to the backings to permit the entire vibratable area of the diaphragm to vibrate with substantially the same motion under influence of the magnetic fields and the signal currents in the conductor runs, whereby to accommodate increased power handling capabilities of the transducer and to significantly increase the magnitude of sound output in the bass frequencies.

22. The transducer according to claim **21** wherein the conductor strands have a configuration substantially flat and parallel with the vibratable area of the diaphragm.

23. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed of styrofoam.

24. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed of a honeycombed structure with open cells therein.

25. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed of multiple laminations of high strength low density material.

26. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed of fibrous pulp material.

27. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed with carbon fiber materials.

28. The transducer according to claim **1** wherein the vibratable area of the diaphragm is formed of predominently balsa wood.

* * * * *

United States Patent [19]

Winey

[11] **Patent Number: 4,480,155**

[45] **Date of Patent: Oct. 30, 1984**

[54] **DIAPHRAGM TYPE MAGNETIC TRANSDUCER**

[75] Inventor: **James M. Winey**, White Bear Lake, Minn.

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

[21] Appl. No.: **353,847**

[22] Filed: **Mar. 1, 1982**

[51] **Int. Cl.**³ **H04R 9/00**

[52] **U.S. Cl.** .... **179/115.5 PV**

[58] **Field of Search** .... 179/115.5 PV, 115 R, 179/115 V, 114 R, 117

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Primary Examiner—Gene Z. Rubinson

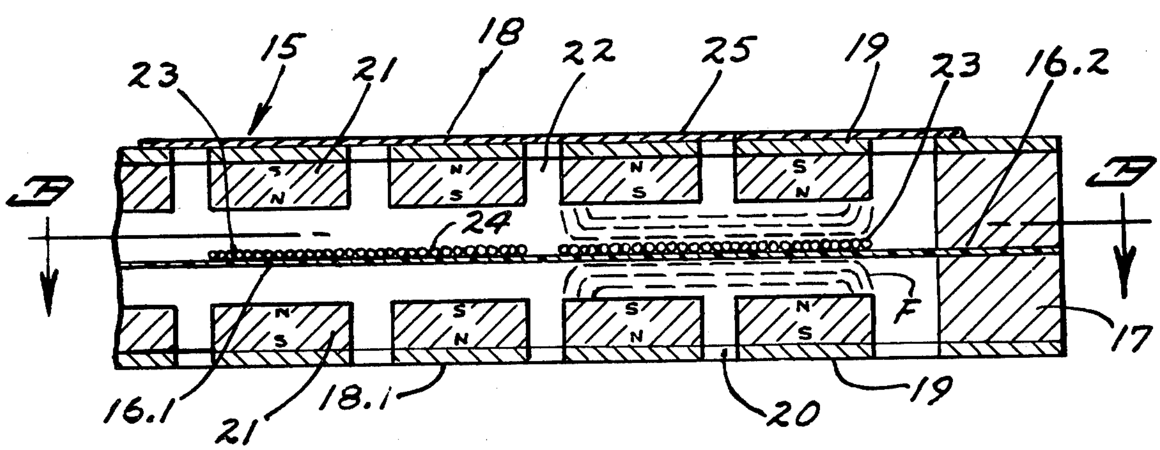
Assistant Examiner—L. C. Schroeder

Attorney, Agent, or Firm—Peterson, Palmatier, Sturm, Sjoquist & Baker, Ltd.

[57] **ABSTRACT**

A diaphragm type magnetic speaker with conductor runs on the diaphragm, the conductor runs having a multiplicity of conductors arranged in a band in each run which confronts portions of two magnetized strips with front faces of opposite polarity and the space between such magnetized strips. The width of the band of conductors exceeds the width of the space between adjacent magnet strips and traverses the entire transverse portions of both of the adjacent magnetized strips from which the magnetic field for the conductor run emanates.

11 Claims, 10 Drawing Figures



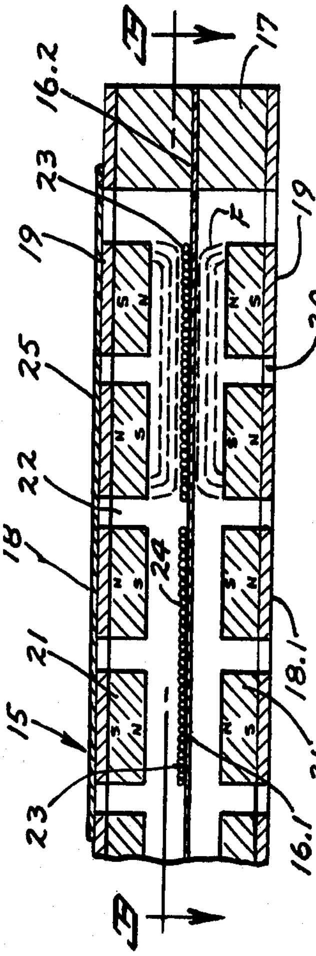


FIG. 2

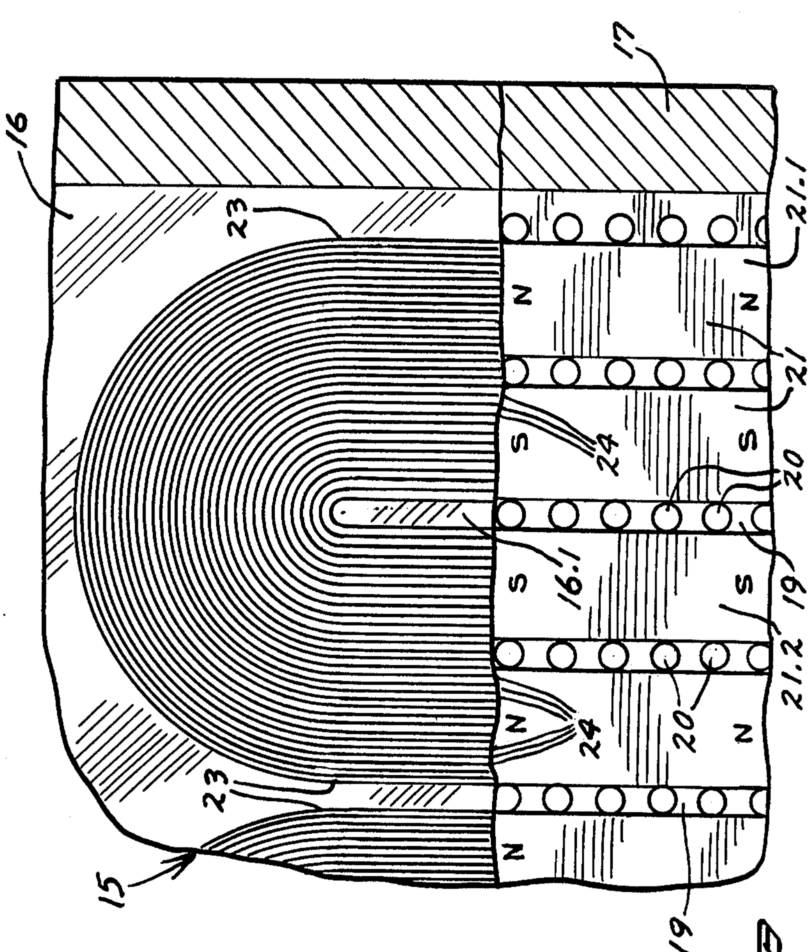


FIG. 3

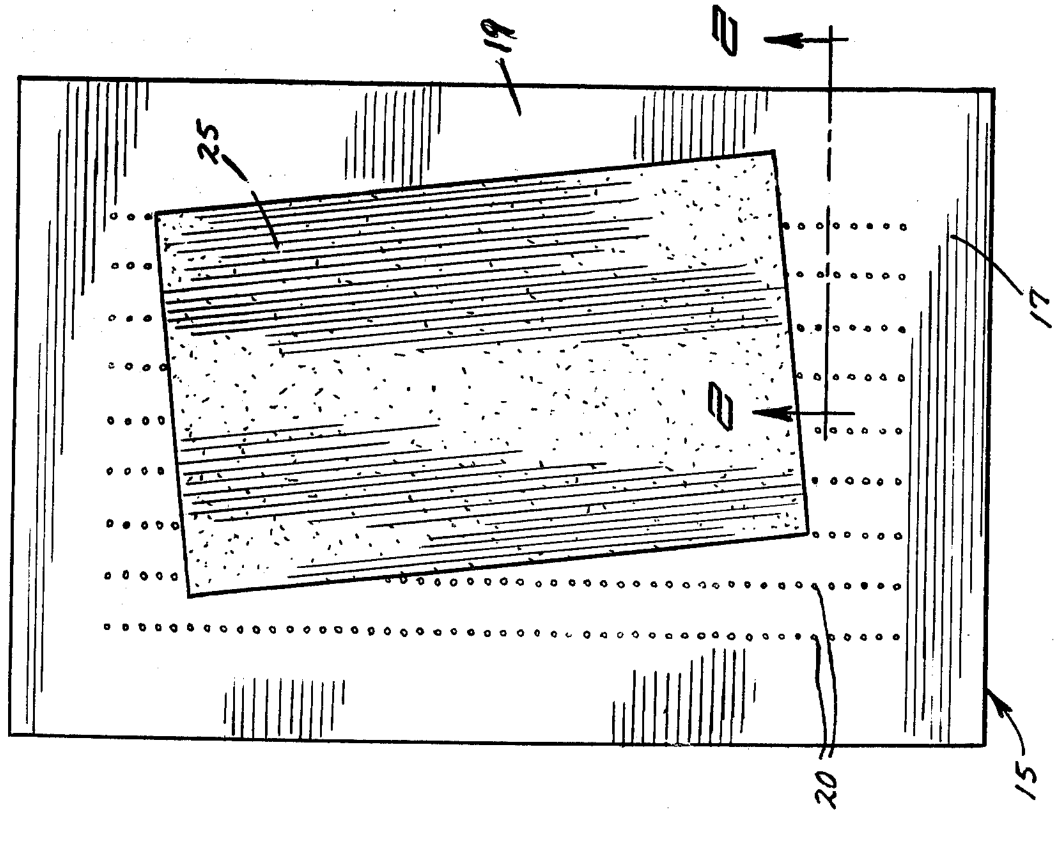


FIG. 1

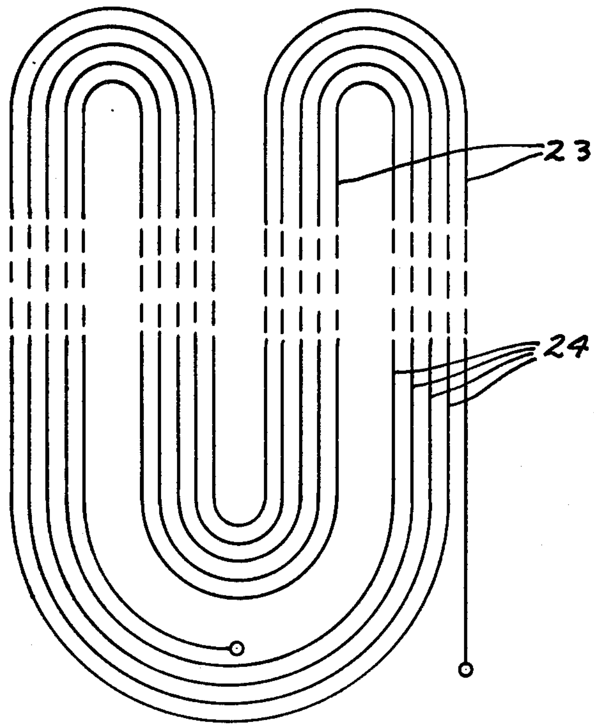


FIG. 4

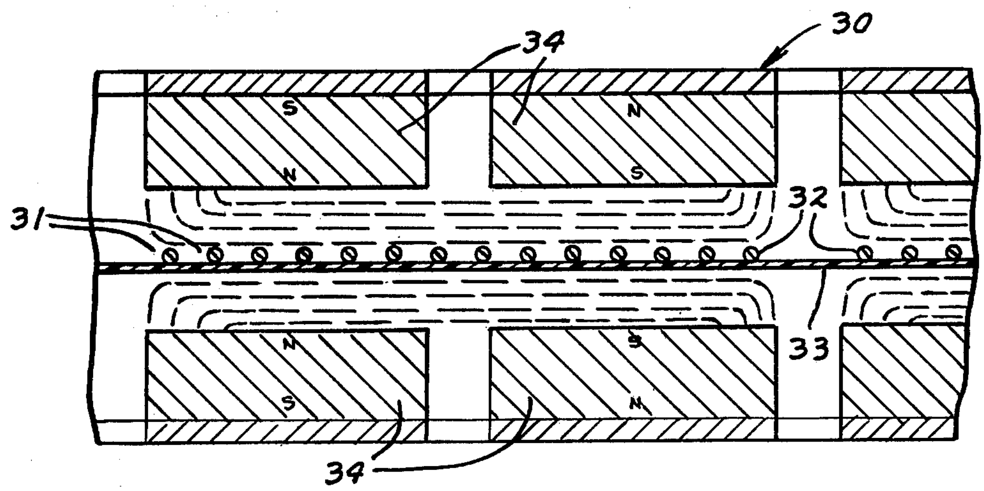


FIG. 5

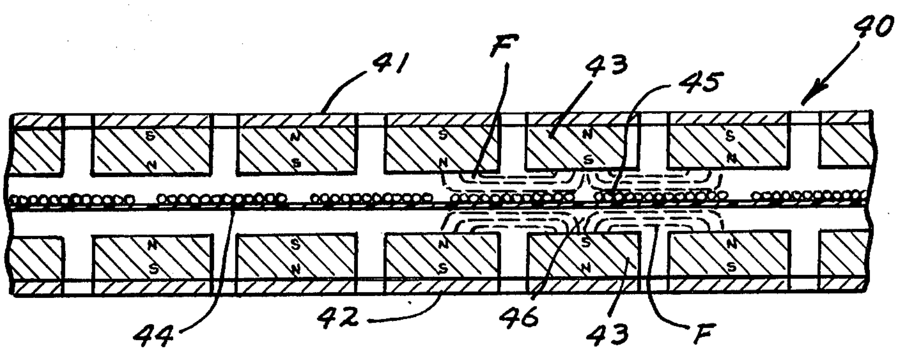


FIG. 6

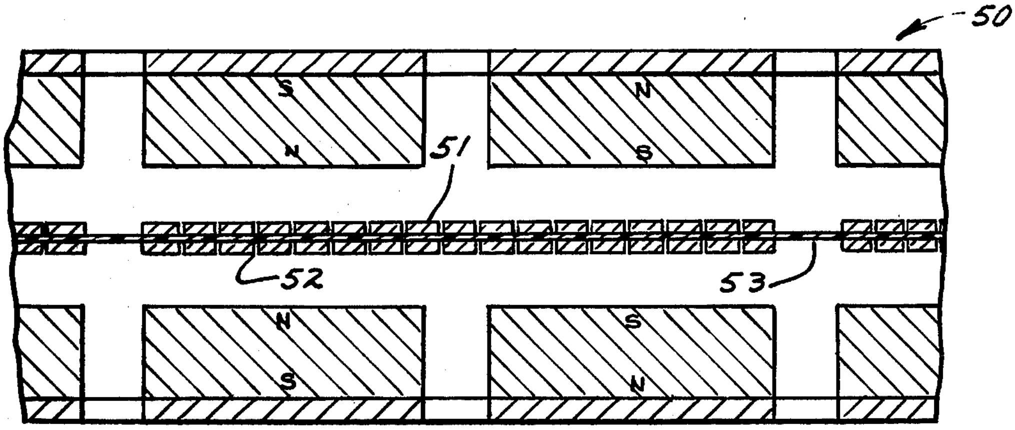


FIG. 7

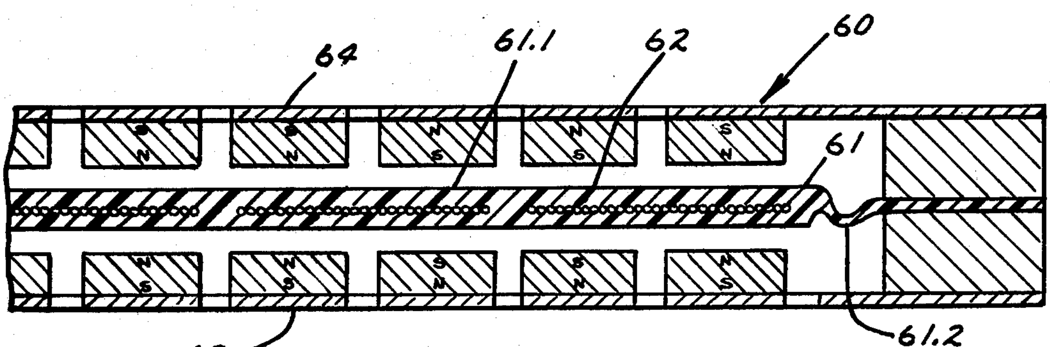


FIG. 8

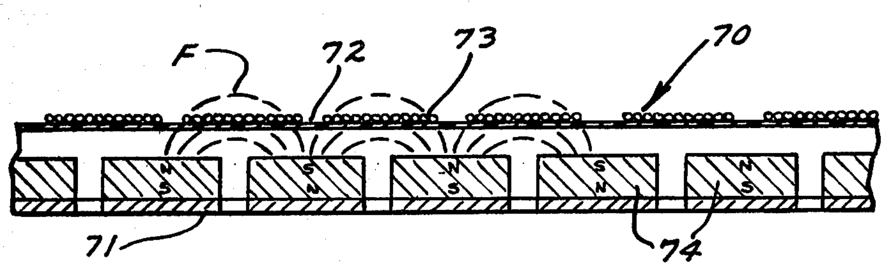


FIG. 9

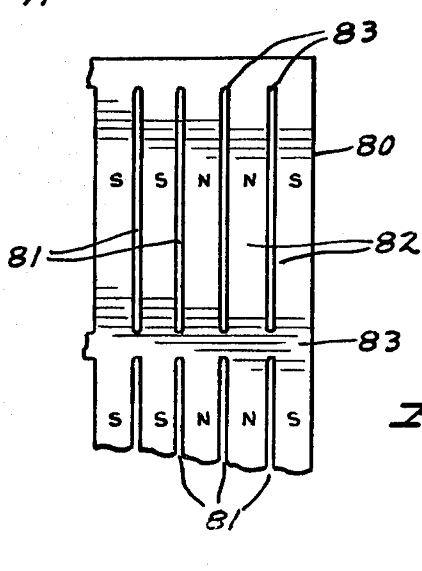


FIG. 10

DIAPHRAGM TYPE MAGNETIC TRANSDUCER

This invention relates to diaphragm type magnetic speakers.

BACKGROUND OF THE INVENTION

Diaphragm type magnetic transducers incorporate three basic components including a diaphragm, a magnetic backing, and conductors affixed on the diaphragm. The magnetic backing is magnetized in long zones or strips in a direction perpendicular to the diaphragm which confronts the magnetic backing. This arrangement of magnetizing the magnetic backing produces magnetic pole faces confronting the diaphragm and spaced from each other. Adjacent pole faces of opposite polarity produce magnetic fields which embrace portions of the diaphragm. A number or runs of the signal carrying conductors are arranged to extend along the pole faces of the magnetic backing and in the individual magnetic fields to produce the vibration of the diaphragm when an audio signal current is applied to the conductor runs. Transducers of this type are illustrated in U.S. Pat. Nos. 3,674,946 and 3,919,499.

The magnetic backing of such transducers usually includes an apertured soft iron armature plate upon which a magnet is laid. The magnet has taken the form of an apertured sheet of magnetic material which define such long magnetized zones and such pole faces. In many instances, it has been more efficient to form the magnet in a multiplicity of elongate magnetized strips laid on the soft iron armature plate in spaced relation to each other. Each such strip defines one long magnet with a pole face confronting the diaphragm and cooperating with an adjacent magnetized strip to define the magnetic field which embraces an adjacent conductor run on the diaphragm.

In such transducers, the conductor runs on the diaphragm lie along and confront the spaces adjacent the magnetized strips. Although such conductor runs have been known to include several individual conductors or strands, the runs of conductors have mainly confronted the spaces between the magnet strips, where the maximum depth of magnetic field, measured perpendicular from the pole faces, is located.

SUMMARY OF THE INVENTION

An object of the invention is to provide an improved planar diaphragm type magnetic speaker which provides improved efficiency and provides a high degree control of the diaphragm by actually driving a significantly greater proportion of the diaphragm.

A feature of the present invention is the provision of conductors in wide bands covering nearly 100% of the diaphragm area. The band of conductors in each conductor run confronts both the space between adjacent magnetized strips and also confronts substantially the entire front faces of the magnet strips adjoining the space and providing the field which embraces the conductor run. The band of conductors may be tightly clustered, or the conductors in each band may be spaced slightly from each other. Adjacent conductor runs may be spaced from each other or may be arranged without appreciable space therebetween. Conductors on the diaphragm may be round wires, or may be flat and formed of metal foil or deposited metal partially etched away into separate conductors.

The magnetic fields are in long zones, along magnetized strips of opposite polarity. The space between the long magnetic fields is narrow, and the conductor runs are spaced from each other only by the same narrow space.

Wide conductor bands as described are particularly useful on diaphragms in transducers with magnetic field sources on both sides of the diaphragm. In this arrangement where magnetic pole faces of like polarity confront each other with the conductors in between, the magnetic fields, or the lines of magnetic flux are configured to obtain maximum driving and controlling the diaphragm. In this arrangement, the lines of magnetic flux from both magnetic field sources lie parallel to the diaphragm and perpendicular to the conductors, resulting in application of forces against all of the conductors and the entire diaphragm in a direction perpendicular to the diaphragm as desired among magnetic circuits producing wide based magnetic fields.

The principle advantage of the invention is that the efficiency of the transducer is significantly increased, and that there is increased diaphragm control providing improved frequency response.

A BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an elevation view of a speaker embodying the present invention.

FIG. **2** is an enlarged detail section view taken at **2—2** in FIG. **1**.

FIG. **3** is an enlarged detail section view, taken at **3—3** of FIG. **2** and partially broken away for clarity of detail.

FIG. **4** is a diagrammatic illustration of one arrangement of conductors on the diaphragm.

FIG. **5** is a detail section view of a modified form of the invention.

FIG. **6** is a detail section view of another modified form of the invention.

FIG. **7** is a detail section view of another modified form of the invention.

FIG. **8** is a detail section view of still another modified form of the invention.

FIG. **9** is a detail section view of still another modified form of the invention.

FIG. **10** is a detail plan view of an alternate form of magnet sheet which may be substituted for the strips illustrated in the other views.

DETAILED SPECIFICATION

One form of the invention is illustrated in detail in FIGS. **1-4** wherein the transducer **15** has a diaphragm **16** with a vibratable area **16.1** and peripheral area **16.2** which is affixed as by adhesives to a peripheral rigid frame and spacer strip **17**.

The transducer **15** may exist in a wide range of sizes and shapes and may be rectangular in a size range of forty to sixty inches or more long by twelve or more inches wide, or may be relatively wide; or the transducer may be oblong or round, as small as three inches in diameter or smaller. Also the diaphragm may have two or more vibratable areas.

The diaphragm **16** as illustrated is formed of a flexible film type plastic, such as Mylar, a trademark of DuPont. The diaphragm may be stretched very tight, or in some instances, may be relatively loose, with such tautness as to remove wrinkles. Otherwise, the diaphragm may be stiff or substantially rigid as more specifically illustrated in FIG. **8**.

The transducer **15** also includes two identical substantially rigid magnetic backings **18** and **18.1** at opposite sides of the diaphragm **16** and confronting each other. Each of the magnetic backings has a soft iron armature plate **19** with a multiplicity of apertures **20** therein for making the magnetic backing acoustically transparent.

The magnetic backings **18** and **18.1** also include a multiplicity of elongate magnetized strips **21** which are laid on the plates **19** and between the apertures **20** thereof. The magnetized strips extend longitudinally of the elongate transducer and substantially throughout the entire length thereof. The elongate magnetized strips may be made of any of a number of materials. One typical material is a rubber bonded barium ferrite material sold under its trademark "Plastiform", by 3M Company, St. Paul, Minn. The magnet strips may also be formed of other magnetic type materials such as ceramic magnets or some of the rare earth magnets.

The magnetized strips **21** in FIGS. **1–3** are cut from large sheets of magnetic material and are laid on the plate **19** and magnetically secured thereon. The magnetized strips are magnetized in a direction perpendicular to the diaphragm **16** so that their front faces define pole faces of various polarities north and south. The north polarity front faces are designated **21.1** and the south polarity front faces are designated **21.2**. Other magnetic circuits may also be used in the magnetic backing **18**, such as the magnetic circuit more fully illustrated in FIG. **6**. Each magnetized strip **21** is directly opposite another magnet strip **21** of like polarity in the other magnetic backing.

The magnetized strips **21** are located on the plate **19** so that there are spaces **22** therebetween. As indicated in FIG. **2**, the adjacent magnetized strips having front faces of opposite polarity produce magnetic fields, indicated by the dotted lines F, which project from the magnetized strips to the diaphragm **16**. Because of the opposing magnetized strips of like polarity, the magnetic fields and magnetic lines of flux lie parallel to the diaphragm, as illustrated.

The transducer **15** also includes a multiplicity of conductor runs **23** adhesively secured on the diaphragm **16** and lying in spaced and parallel relation to each other throughout substantially the entire length and breadth of the vibratable area **16.1** of the diaphragm.

Each conductor run **23** comprises a wide band of individual conductors **24** which, as seen in FIGS. **2** and **3**, are tightly clustered together so that each strand or conductor **14** adjoins the next adjacent strand with no appreciable space therebetween. In this form, there is a slight space **25** between adjoining runs **23** or between the adjacent wide bands of conductors of the adjacent runs.

It is evident in FIGS. **2** and **3** that the edges of the bands of conductors are directly opposite the sides of the magnet strips. In this transducer with two magnetic backings **18, 18.1** confronting each other, the sides of each magnetic field are nearly perpendicular to the faces of the magnet, but taper slightly convergently away from the magnet face; and each magnetic field lies parallel to the diaphragm, between its slightly converging sides. The band of conductors has a width essentially the same as the width of the effective portion of the magnetic field, that is the portion which lies parallel to the diaphragm and which is effective to produce forces on the diaphragm and conductor run in a direction perpendicular to the diaphragm when a signal current is applied to the conductors. The band of conductors traverses the space between two magnet strips of opposite polarity; however, the space between two magnet strips of like polarity has no magnetic field, and therefore, the width of the space between adjacent conductor bands is about the same as the width of said space between the magnet strips of like polarity.

The effective portion of the magnetic field and lines of flux lie parallel to the diaphragm and to the conductor band. The forces generated by signal current in the conductors are therefore perpendicular to the diaphragm and conductors, as desired, to produce maximum vibration and control of the diaphragm for producing the desired sounds.

The conductors **24** may be round wire, as illustrated in FIGS. **2, 5,** and **6**, or may be foil, or metal film deposited on the film and etched away as seen in FIG. **7**. Wire size gauge may be within a wide range, for instance, twenty gauge aluminum or smaller. Conductor sizes in foil or metal deposited on the diaphragm should have comparable cross sectional areas as the wire sizes mentioned. Foils may typically be one half mil to ten mil thickness, more or less.

In this arrangement illustrated in FIGS. **1–4**, magnetized strips **21** are arranged in functional pairs with opposite polarities at their front faces. The strips adjacent each other but not in the same functional pair are of like polarity at their front faces. Accordingly, each conductor band traverses essentially the entire front faces of the magnetized strips of a funcational pair and the space therebetween.

In FIGS. **1** and **2**, a thin sheet or panel **25** of tissue paper, similar to bathroom tissue or facial tissue, is adhesively secured to the outside face of the soft iron plate **19** of the magnetic backing **18**. The sheet of tissue **25** obstructs a number of the apertures **20** and provides a limited acoustical loading to the diaphragm **16**. This acoustical loading may be varied by the size of the panel **25** and has the effect of providing a limitation on the movement of the diaphragm to minimize the likelihood of the diaphragm bottoming or slapping against the magnet faces.

FIG. **4** illustrates one arrangement of conductor strands **24** in the several runs **23**. The magnetized strips extend only along the straight portions of the runs. It will be seen that this configuration is suitable for a printed circuit (or etched) strands which do not need to cross each other.

In operation, it has been found that the arrangement of the conductor runs with the conductors in wide bands which overlap and confront the entire faces of the magnet strips, produce an improved control of the diaphragm of the speaker or transducer so as to obtain substantially improved frequency response. Also, there is an increased efficiency in the transducer.

In the form of the invention illustrated in FIG. **5**, the transducer **30** is very similar to that of FIGS. **1–4**. The difference in this transducer is that the individual strands **31** in the conductor runs **32** are spaced from each other instead of lying next to each other and in engagement with each other as illustrated in FIGS. **2** and **3**. The strands are adhesively secured to the diaphragm **33**, but are spaced slightly apart. FIG. **5**, being in an enlarged scale as compared to FIG. **2**, clearly illustrates the approximate shape of the magnetic fields produced by the functional pairs of magnetized strips **34** at opposite sides of the diaphragm.

In FIG. 5, the spacing between the adjacent runs **32** of conductors on the diaphragm at least slightly exceeds the spacing between the individual conductor strands **31** in the run.

In FIG. 6, the transducer **40** is again very similar to the transducer **15** of FIGS. **1–4** with the exception that the magnetic circuit in the magnetic backings **41** and **42** is slightly different. In this form of the invention, adjacent magnet strips **43** have opposite polarities at their front faces and alternate magnet strips have like polarities at their front faces. Again, as in FIGS. **1–3**, because the magnet strips in the opposite magnetic backings **41** and **42** confront magnet strips of like polarity, the effective portions magnetic fields created and the lines of magnetic flux are substantially flat and parallel to the diaphragm **44**, although the sides of the magnetic fields are slightly tapered.

It will be recognized that in this form, each magnetic field F has a width which traverses only half the width of the faces of adjacent magnet strips of opposite polarity; and the width of the band **45** of conductors is the same as the width of the effective portion of the field which lies parallel to the diaphragm. At approximately the location indicated by number **46**, between two adjacent fields F and approximately half way across the width of each of the magnet strips, there is a narrow space of minimum magnetic field, and accordingly, a space is left between adjacent conductor runs **45** opposite this space **46**. In the transducer **40** although the conductor runs have the same width as the effective portions of the magnetic fields F, there will be very slightly less percent of the diaphragm which is covered by conductor runs as compared to the transducer **15** of FIGS. **1–3**.

In the form of transducer illustrated in FIG. **7**, the transducer **50** is substantially the same as that illustrated in FIGS. **1–4** with the exception that the transducer **50** has the conductors **51** and **52** formed of foil or metal deposited on the faces of the diaphragm **53**. The foil or deposited metal is slightly etched away to form individual strands insulated from each other by means of a simple space. The space between adjacent conductors will have a width in the same order of magnitude as the thickness of the foil. The conductor runs are arranged similarly to those of FIGS. **1–3**, but may also be arranged similarly to those in transducer **40** of FIG. **6**. The arrangement of conductors as illustrated in FIG. **4** is important to FIG. **7** in order to minimize the likelihood of the need to cross one conductor over another.

In the transducer **60** of FIG. **8**, the transducer is substantially the same as that illustrated in FIGS. **1–4**, which the exception that in this form, the diaphragm **61** has a vibratable area **61.1** which is stiff or substantially rigid, being formed of materials such as styrofoam which may be honeycombed or other similar stiff type material. The vibratable area of the diaphragm has conductor runs **62** embedded therein, or otherwise affixed to the stiff vibratable area of the diaphragm. The diaphragm also has a flexible connection or surround **61.2** connecting the stiff vibratable area to the peripheral area which is clamped to the magnetic backings **63** and **64** of the transducer. All portions of the vibratable area **61.1** will move with substantially the same movement, and remain substantially planar during such movement. Accordingly, the diaphragm has a piston-like action rather than the flexing action of the diaphragm in FIGS. **1–3**.

In the form of the transducer **70** illustrated in FIG. **9**, the transducer is constructed with the magnetic backing **71** only on one side of the diaphragm **72**. In many instances, depending upon the overall size of the transducer, this arrangement is satisfactory for producing sufficient sound output. Again, in this form, the conductor runs **73** traverse essentially the entire width of the magnetic fields which intersect the diaphragm and are produced by the magnetized strips **74**. The magnetic field or lines of flux F in the transducer **70** have a slighty different rounded shape, and slightly less force on the conductors carrying signal currents, because there is no opposite magnetic backing as in FIGS. **1–3** to create the flattened effect upon the magnetic field. Again, the broad bands of conductors in the conductor **73** provide substantial control on the diaphragm and increase the frequency of response thereof.

FIG. **10** illustrates a modified form of magnet structure which may be used in any of the disclosed forms of transducer. The magnet structure **80** is in sheet or panel form and may be molded or die cut to the shape illustrated. The magnet structure is formed of the same material as described for strips **21** of FIGS. **1–3**. A number of slots **81** are formed to define spaces between the magnetized strips **82**. The slots will align with the apertures in the iron or steel panel of the magnetic backing. Narrow bridges **83** traverse the slots and interconnect adjacent strips **82**. The magnetized strips may be magnetized with magnetic poles at their front faces as indicated or otherwise according to the magnetic circuit desired.

It will be seen that the improved transducer according to this invention utilizes the wide bands of conductors to cover substantially the entire face of the diaphragm to produce a substantially increased control on the diaphragm and increase the frequency response thereof. Practically no portion of the diaphragm is without close control on its movement.

What is claimed is:

1. An audio frequency signal current carrying transducer, comprising

a diaphragm having a vibratable area,

a pair of magnetic backings connected with the diaphragm in confronting and spaced relation to each other and respectively on opposite sides of the diaphragm, each of said magnetic backings having an armature plate with a multiplicity of elongate magnetized strips spaced from each other and magnetized in a direction transverse to the diaphragm and having elongate front faces defining pole faces confronting the diaphragm, the pole faces of each magnet strip being opposite to and confronting a magnetized strip of like polarity in the opposite magnetic backing, the pole faces of adjacent magnetized strips and of opposite polarities producing elongate magnetic fields projecting toward the diaphragm, adjacent magnetic fields being separate and distinct from each other,

and a multiplicity of signal current carrying conductor runs on the diaphragm and confronting adjacent magnetized strips of opposite polarities and the spaces therebetween of both magnetic backings, the discrete conductors in each run adjoining each other and covering the entire diaphragm along the run and asserting full control of the diaphragm, the conductors in each run being arranged in a wide band traversing the width of the magnetic field projecting to the diaphragm, there being a narrow space between adjacent wide band conductor runs to maintain such adjacent runs separate and distinct in embraced relation to the respective separate and distinct magnetic fields.

2. The transducer according to claim **1** and the diaphragm being flexible and flexing under influence of the signal current cooperating with the magnetic fields.

3. The transducer according to claim **1** and the vibratable area of the diaphragm being stiff and resisting flexing.

4. The transducer according to claim **1** and the conductors having strands of round wire.

5. The transducer according to claim **1** and the conductors in the runs being in flat strands lying on the diaphragm.

6. The transducer according to claim **1** and the conductor runs being located on the surface of the diaphragm.

7. The transducer according to claim **1** and the conductor runs being embedded in the diaphragm.

8. The transducer according to claim **1** and the width of the vibratable area of the diaphragm being entirely covered with conductor runs, but for said spaces maintaining the runs in separate and distinct magnetic fields.

9. An audio frequency signal current carrying transducer, comprising

a diaphragm having a vibratable area,

a magnetic backing connected with the diaphragm in confronting and spaced relation with the diaphragm, said magnetic backing having an armature plate with a multiplicity of elongate side by side magnets laid thereon, the elongate magnets being spaced from each other and magnetized in a direction transverse to the diaphragm and having elongate front faces defining pole faces confronting the diaphragm, the pole faces of adjacent magnets being of opposite polarities and producing elongate magnetic fields projecting toward the diaphragm, the adjacent magnets having a sequence of polarities at their front faces as follows, to wit: north, south, south, north, north, south, et seq., each magnetic field traversing entirely across adjacent pole faces of opposite polarity,

and a multiplicity of signal current carrying conductor runs on the diaphragm and confronting adjacent magnets of opposite polarities and the spaces therebetween of both magnetic backings, the discrete conductors in each run adjoining each other and covering the entire diaphragm along the run and being arranged in a wide band with a width spanning across the width of a pair of said magnet pole faces and across the space between adjacent magnets to traverse the entire magnetic field at the diaphragm for asserting full control of the diaphragm.

10. A transducer according to claim **9** wherein the armature plate is of soft iron and the magnets are permanent magnets entirely to the pole faces thereof.

11. A transducer according to claim **9** and there being a second magnetic backing on the opposite side of the diaphragm from said first mentioned magnetic backing and being substantially identical with said first mentioned magnetic backing, the pole face of each magnet confronting a pole face in the opposite magnetic backing of like polarity, one of said magnetic backings being apertured for passage of air and sound as the diaphragm vibrates under influence of a signal applied to the conductor runs.

* * * * *