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Tabuchi

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[54] **DIAPHRAGM FOR ELECTROACOUSTIC TRANSDUCER**

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

[51] **Int. Cl.²** **H04R 9/02**

[58] **Field of Search** ..... 179/115.5 PV, 181 R

[56] **References Cited**

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Attorney, Agent, or Firm—Wolfe, Hubbard, Leydig, Voit & Osann, Ltd.

[57] **ABSTRACT**

A circular diaphragm for electroacoustic transducers made of a membrane of a nonmagnetic and insulative material and having on its surface a series of substantially parallelly spaced conductors including outlet parts for connecting said conductors to external input or output terminals, and additional metal parts disposed in spaces between the conductors and the outlet parts as insulated from them. The additional parts increase the rigidity of the diaphragm and at the same time balance the weight of the circular diaphragm in all radial directions.

6 Claims, 5 Drawing Figures

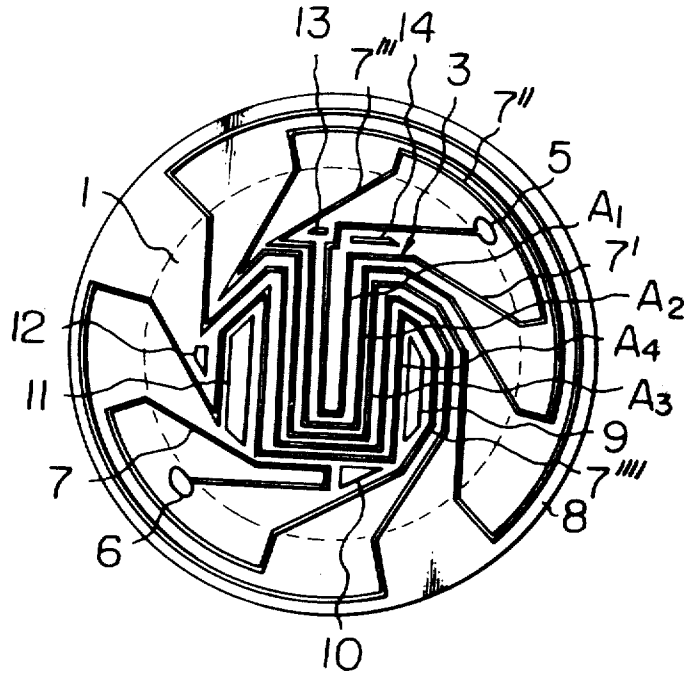


Fig. 1 PRIOR ART

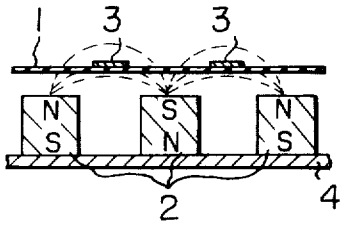


Fig. 2 PRIOR ART

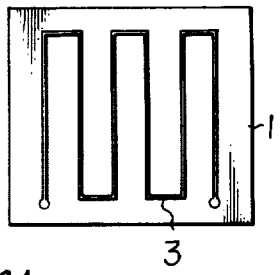


Fig. 3 PRIOR ART

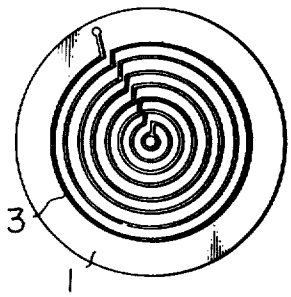


Fig. 4A

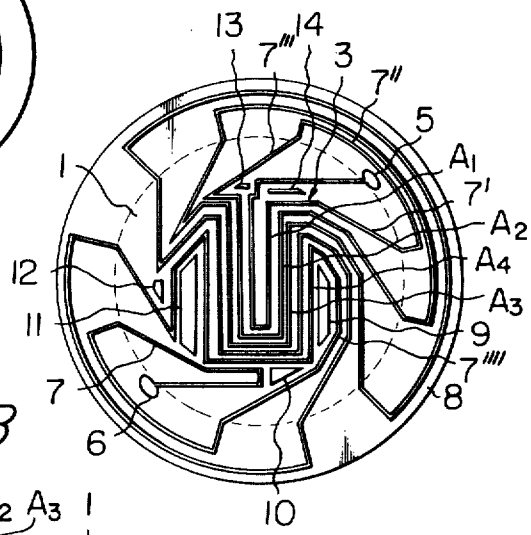
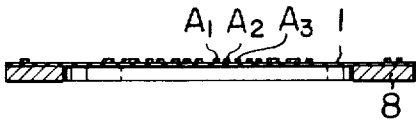


Fig 4B



DIAPHRAGM FOR ELECTROACOUSTIC TRANSDUCER

This invention relates to diaphragms for electroacoustic transducers and, more particularly, to an improvement in diaphragms for such electroacoustic transducers as microphones, headphones, speakers and the like of a type provided with a diaphragm of a nonmagnetic and insulative material having thereon a series of conductors and with a plurality of permanent magnets opposed with a slight clearance to said diaphragm to enclose the conductors in magnetic fluxes.

A known electrodynamic microphone of this kind has such structure as shown, for example, in FIG. **1**, in which **1** is a diaphragm made of a membrane of a nonmagnetic material, **2** is a plurality of elongated permanent magnets, each of the respective magnets of which is arranged as opposed with a slight clearance to the diaphragm **1** and in parallel relation to adjacent ones so that the magnetic poles of the respective magnets adjacent in expanding direction of the membrane **1** will be alternately of different polarities. **3** is a series of parallel strip conductors of copper, aluminum or the like formed on the diaphragm aluminium by such a means as a printing, laminating or the like process so that respective parallel sections will be positioned intermediate between the adjacent magnets **2.** These conductors are connected at the respective ends with one another so as to be at least one zigzag shaped continuous conductor, as shown in FIG. **2. 4** is a soft iron plate bonded to the other surfaces of the respective magnets **2,** so that magnetic fluxes as shown with dotted lines in FIG. **1** will be formed between the adjacent magnetic pole surfaces.

The operation of the electroacoustic transducer shown in FIGS. **1** and **2** shall be explained next.

Referring to FIG. **1,** the magnetic fluxes will be caused to flow from the respective N-poles to the respective adjacent S-poles so as to be substantially in parallel with the plane of the diaphragm **1.** The parallel sections of the continuous conductor **3** are disposed thus in such magnetic flux at right angles with respect to the flowing direction of the flux.

In case an electric current is passed through the continuous conductor in the above arrangement, the diaphragm **1** on which the conductor is provided is subjected to an electromagnetic force effective in a direction perpendicular to the plane of the diaphragm. While the direction of the electric current flowing each of the parallel section of the conductor is opposite to one another, the direction of the magnetic flux traversing each of such sections is also opposite to one another. Consequently, the diaphragm **1** is subjected to a driving force effective in a fixed direction, so that the electroacoustic transducer will be utilized as a speaker operated in response to the direction and magnitude of the current passed through the strip conductor.

It is obvious that in case the diaphragm **1** is caused to be vibrated by a sound contrarily to the above, there is produced an electromotive force in the conductor on the diaphragm **1** vibrated, so that the electroacoustic transducer will be able to be utilized as a microphone.

Now, the shape of such diaphragm as disclosed of the arrangement in the electroacoustic transducers referred to is generally rectangular as shown in FIG. **2** where the series of conductors is in a zigzag pattern so as to correspond to parallel rows of the elongated permanent magnets, or is often circular as shown in FIG. **3** where the conductors are arranged in a vortex shape having concentric circular sections. Such circular diaphragm having vortex-shaped conductor may be used in combination with the elongated permanent magnets of parallel arrangement but, in this case, the same driving effect at least as in the case of FIGS. **1** and **2** cannot be expected so that it will be required to arrange the permanent magnets in a special pattern other than the simple parallel pattern.

In either cases, further, the rigidity and elasticity of the diaphragm having the metal conductor thereon must be well balanced in order that the sound transducing or reproducing frequency bands of the transducer referred to will be made uniform and also expanded. With this regards, the circular diaphragm having vortex conductor may be preferable while confronting the above discussed problem. In the case of the rectangular diaphragm, the elasticity of the same is hard to be uniform depending on the extending direction of the respective conductor sections as the conductors act as a rib, so that the entire diaphragm is hard to vibrate uniformly. In the case of the circular diaphragm of vortex conductor, further, at least an end of the conductor comes to the centre of the circular diaphragm and it will be necessary to connect such a pull out lead wire as a copper foil to the centre of the diaphragm, which will cause bad influences to the vibration performance of the diaphragm.

The present invention has been suggested to solve the above problems and, according to the present invention, the problems have been successfully solved in such that, in a circular diaphragm of a membrane of a nonmagnetic and insulative material provided with a series of parallel conductors and outlet parts for connecting said conductors with external input or output terminals, additional metal parts are provided as disposed in spaces between the conductor and outlet parts and insulated from them so as to increase the rigidity of the diaphragm.

A main object of the present invention is, therefore, to provide a diaphragm for electrodynamic electroacoustic transducers having flat sound transducing or reproducing frequency characteristics by preventing divided vibrations of the diaphragm.

The present invention shall be detailed in the following with reference to a preferred embodiment of the present invention as shown in accompanying drawing, in which:

FIG. **1** is a fragmentary sectioned view of a known transducer referred to showing essential parts thereof and for explaining operating principle of such transducer;

FIGS. **2** and **3** are plan views of known diaphragms; and

FIGS. **4A** and **4B** show an embodiment of the diaphragm according to the present invention, wherein FIG. **4A** is a plan view and FIG. **4B** is a centrally sectioned view of the diaphragm of FIG. **4A.**

Referring now to FIGS. **4A** and **4B, 1** is a circular diaphragm made of a membrane of a nonmagnetic and insulative material, **3** is a substantially U-shaped conductor group, in which A_1 is a U-shaped conductor part provided at the innermost position substantially at the centre, A_2 is a similar and larger U-shaped conductor part arranged outside the part A_1 and many of similar and sequentially larger U-shaped conductor parts A_3, A_4 . . . are arranged sequentially in the same manner.

The innermost conductor part A_1 forms a starting terminal **5** for the whole group at one end and is connected at the other end with one end of the next conductor part A_2 through a radial outlet part **7'**, arcuate outlet part **7''** and another radial outlet part **7'''**, the conductor part A_2 is connected at the other end with one end of next conductor part A_3 through further radial outlet and arcuate outlet parts and so on, so that the whole conductor parts will be connected in series, while the outermost part forms with its one end an end terminal **6** for the whole conductors. The most of the arcuate outlet parts are located in peripheral field of the circular diaphragm, at which the diaphragm is fitted to a supporting ring **8**. The radial outlet parts are distributed as spaced from one another at regular intervals. Thus the conductors on the diaphragm are so arranged that, while the end terminals are positioned in the field butted to the supporting ring, the parallel conductor parts effective for the magnetic driving are concentrated in the central field of the diaphragm, so that the distribution density of the conductors and the inertia of the diaphragm will be both high at the central field of the diaphragm.

Nine to **14** are additional metal parts respectively located in each space between the respective radial outlet parts and between the outermost U-shaped conductor part and the radial outlet parts for the conductor part, as electrically insulated from those U-shaped conductor parts and outlet parts. These additional metal parts are localized area reinforcements which are only situated at locations of said membrane which do not contain the pattern voice coil conductors and are provided for the purpose of increasing the rigidity of the diaphragm and, at the same time, balancing the weight distribution of the conductors in all radial directions of the diaphragm, so that any divisional vibration of the diaphragm will be prevented from being produced and thus a uniform vibration will be obtained.

With the above described arrangement, the distribution of the conductors in the intermediate field between the central field and the peripheral field of the diaphragm is made at a lower density so that an increase of the inertia by the conductors at such intermediate field will be prevented, a proper resiliency will be kept remained at the intermediate field and a uniform vibration of the central field will be promoted. On the other hand, the conductor parts utilized for the magnetic driving of the diaphragm in combination with associated magnetic circuit are distributed as concentrated in the central field of the diaphragm with a higher density so that, with of aid oif the additional metal parts for balancing the weight distribution of the conductors and increasing the rigidity of the diaphragm at the central field thereof, the vibration of the diaphragm at the central field can be made remarkably and uniformly effective.

When the respective thicknesses of the conductor which is preferably of a copper, aluminium or the like material and the diaphragm membrane of preferably a polyimide, polyester, mica, phenol or the like resin material are properly selected so as to obtain a proper resiliency of the diaphragm, it is possible to render the sound transducing or reproducing frequency range expanded and also such frequency characteristics made uniform.

The diaphragm of the present invention can be extensively utilized for microphones, headphones, speakers and the like electroacoustic transducers.

Further, the additional metal parts to the central conductor parts may be provided advantageously at the same time of forming the respective conductor parts with the same material and thickness. It is of course possible to achieve the purpose of such additional parts by varying the thickness where their respective areas are restricted or vice versa, if necessary. The term "electrically insulated" as used herein applied to the parts **9–14** inclusive in the drawing is intended to convey that such additional parts do not affect the normal current path, that is, the parts are not in a bridging or short-circuiting relation with respect to the conductors. Thus a part could be considered to be "electrically insulated" even though it might be in a localized electrical contact with a single adjacent conductor.

What is claimed is:

1. A diaphragm for electroacoustic transducer comprising a circular membrane of a nonmagnetic and insulative material, and a series of conductors formed at least on a surface of said membrane, said conductors including parallel conductors and a group of outlet parts interconnecting said parallel conductors with one another and with external terminals of the transducer and a group of localized area reinforcements likewise formed on said membrance and only situated at locations of said membrane which do not contain said series of conductors and electrically insulated from said series of conductors and adapted to increase the rigidity of the diaphragm.

2. The diaphragm according to claim **1** wherein said reinforcements are metal parts and are distributed at radially separated positions with proper dimensions so as to balance the weight distribution of the conductors in the diaphragm.

3. The diaphragm according to claim **1** wherein said parallel conductors comprise a group of substantially similarly U-shaped conductor parts sequentially arranged in inside and outside relationship substantially in the central field of the diaphragm, and said outlet parts are adapted to connect the respective said U-shaped conductor parts in series.

4. The diaphragm according to claim **1** wherein said outlet parts comprise radial outlet parts arranged substantially at regular intervals and in intermediate field between the central field and the peripheral field of the diaphragm and connected respectively at an end with the parallel conductors, and arcuate outlet parts connecting most of the other ends of said radial outlet parts with one another.

5. The diaphragm according to claim **1** wherein said reinforcements are metal parts and are arranged respectively in spaces between said parallel conductors and said outlet parts.

6. The diaphragm according to claim **4** wherein said arcuate outlet parts are arranged substantially in the peripheral field of the diaphragm.

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