

[54] **VIBRATION DIAPHRAGM AND CONE EDGE OF A LOUDSPEAKER**

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[58] Field of Search..... 181/172, 167, 171

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[57]

ABSTRACT

Herein disclosed are an improved vibration diaphragm and an improved cone edge of a loudspeaker, wherein the vibration diaphragm is formed of a foamed plastics which is formed with portions having a density or densities lower than the remaining portion of the diaphragm and/or which has at least one coating of resin applied to at least one surface of the foamed plastics in the form of an aqueous emulsion and wherein the cone edge is formed of a foamed plastics having a closed-cellular structure. The vibration diaphragm and cone edge, which may preferably be used in combination with each other, will contribute to improving the acoustic characteristics of the loudspeaker to a considerable extent.

4 Claims, 9 Drawing Figures

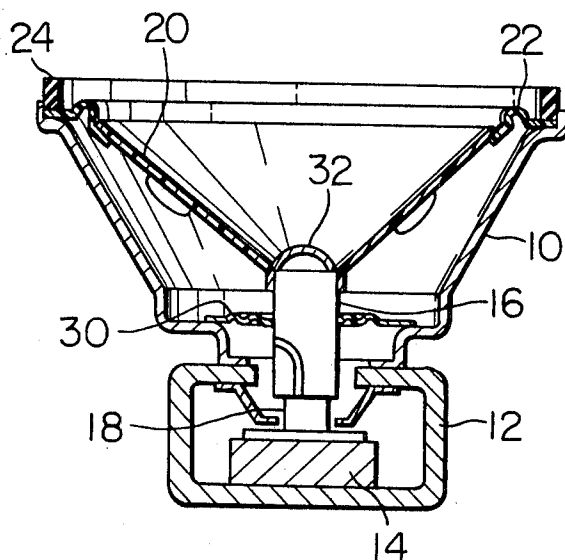


Fig. 1

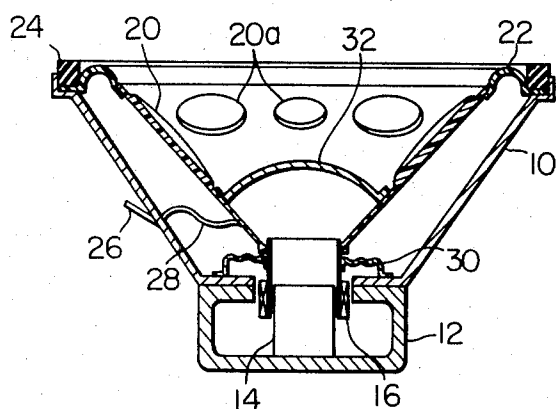


Fig. 2

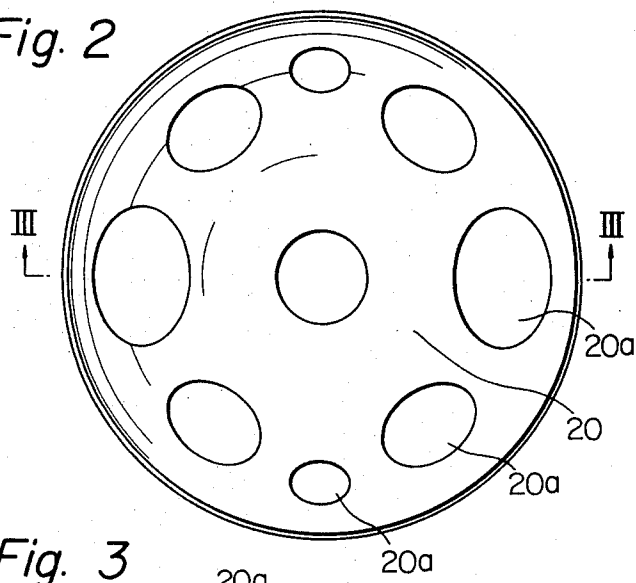


Fig. 3

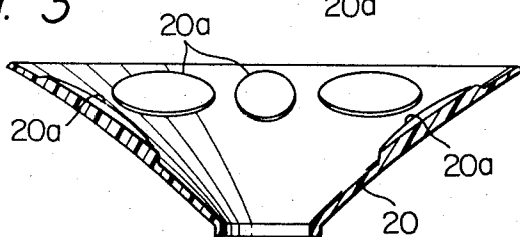


Fig. 4

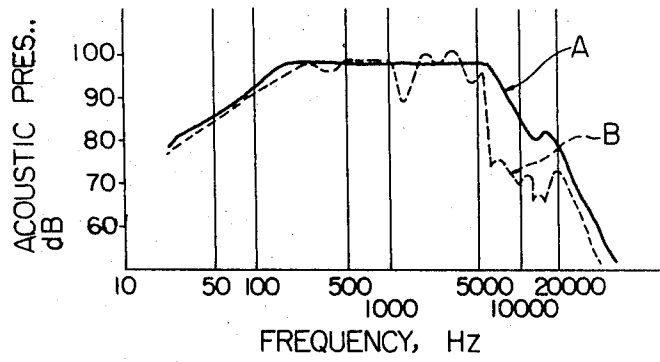


Fig. 5

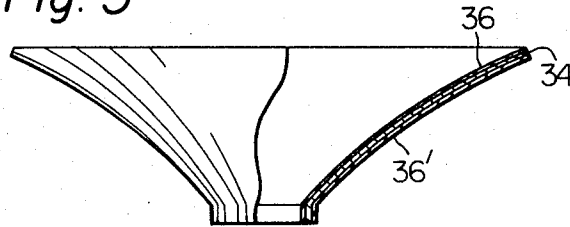


Fig. 6

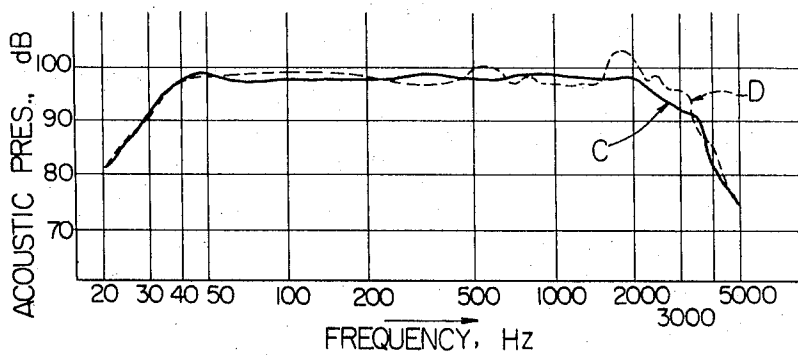


Fig. 7

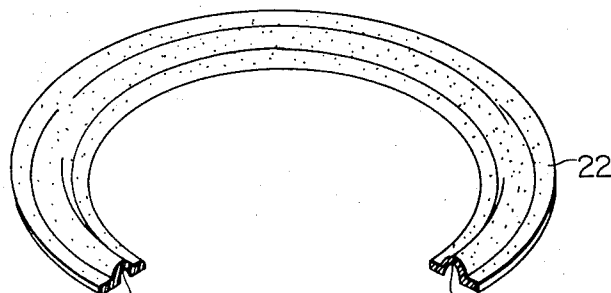


Fig. 8

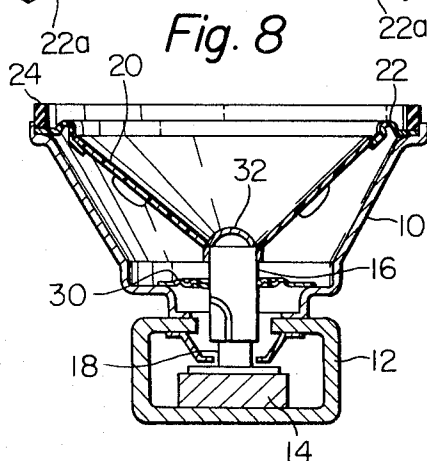
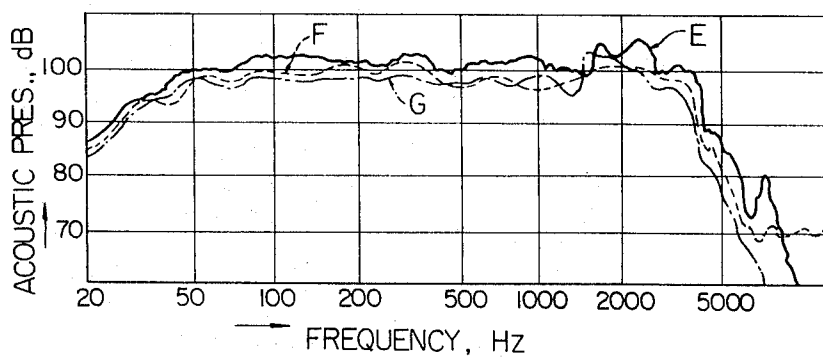


Fig. 9



VIBRATION DIAPHRAGM AND CFNE EDGE OF A LOUDSPEAKER

This is a division, of application Ser. No. 257,527, filed May 30, 1972.

The present invention is concerned generally with loudspeakers and, more particularly, the invention relates to vibration diaphragms of foamed plastics for use in the loudspeakers. The major goal of the present invention is to make available stabilized acoustic pressure-frequency characteristics of the loudspeakers.

The loudspeakers of the direct-radiator type generally use vibration diaphragms in the form of a truncated cone and it is well known in the art to have the vibration diaphragms formed of foamed plastics, typical of which is the foamed polystyrene. The vibration diaphragms of the foamed polystyrene have found broad and successful applications in the loudspeakers of the described type especially for their light-weight structures, pertinent Young's moduli and satisfactory internal losses and, from the production view points, for considerable ease of being fabricated to desired configurations by foaming in dies or vacuum molding the particular material.

A problem, however, arises in the vibration diaphragms of the foamed plastics from the fact that such vibration diaphragms have densities which are uniform throughout the total areas of the diaphragms. The uniform densities of the vibration diaphragms of the frusto-conical shape are often the causes of the motions of the diaphragms shrinking in the conical direction and being circularly warped from the centers of the diaphragms when the frequencies of the sounds produced fall within ranges of the proper frequencies resulting from the specific configurations and materials of the vibration diaphragms. This takes place especially in medium to high frequency ranges of the speaker performances, thereby causing abrupt drops in the acoustic pressures of the air coupled to the vibration diaphragms.

Also proposed for use in the loudspeakers is a vibration diaphragm which is made up of a base plate of foamed polystyrene and a thin coating of polystyrene or polyvinyl acetate or another suitable resin which is applied to the surface of the base material initially in the form of a solution dissolving therein the synthetic resin such as polystyrene or polyvinyl acetate. The vibration diaphragm of this nature has a drawback in that the thickness of the coating formed on the base material as applied in this manner is limited and, as a consequence, such vibration diaphragm is not acceptable where it is desired to have a relatively thick coating which is evenly formed throughout the base material. This is because of the fact that the viscosity of the solution of the resin increases as the quantity of its solid constituents increases and, especially where an organic solvent is used for the resin solution, the solvent evaporates only at a limited rate. If, thus, it is desired that the vibration diaphragm have an exceptionally thick coating in the face of the difficulty of the above noted nature, then irregular thickness of the coating will result throughout the total area of the vibration diaphragm and, furthermore, the thickness of the coating will vary from one final product to another depending upon the processes carried out on the individual vibration diaphragms. The vibration diaphragms produced in this manner have mechanical stiffnesses that are not only

irregular in themselves but vary from one diaphragm to another so that fluctuations are invited in the acoustic pressures in consequence of the split resonance of the vibration diaphragms.

Since, moreover, the foamed plastics are unstable to organic solvents such as ethyl acetate, the base material of the foamed plastics tends to be chemically attacked by the solvent of the polyvinyl acetate or other organic solvent applied to the surface of the base material. It is, thus, difficult or even impossible to have the initial shape of the base material maintained intact in the process of applying the resin to the base material in the presence of the organic solvent. It is therefore important that, in applying the resin solution to the base material of the foamed plastics, the solvent for the resin solution be selected in such a manner that the foamed plastics in the base material be resistant to the attack of the solvent and that only the resin to be applied to the base material is dissolved in the solvent. For this reason, there could be even a case where a resin can not be used as the material for the coating of the vibration diaphragm however advantageous the particular resin might be from the acoustic point of view.

The present invention contemplates elimination of the above described drawbacks of the prior art vibration diaphragms of the loudspeakers through appropriate selection of the foamed plastics to form the vibration diaphragms or the base materials to form part of the vibration diaphragms and through incorporation of an improvement in the constructions of the diaphragms with a view to providing improved acoustic pressure-frequency characteristics of the loudspeakers.

The loudspeakers usually have annular strips, customarily called the cone edges, which are attached to outer peripheral edges of the frusto-conical vibration diaphragms for the purpose of preventing radial displacements of the vibration diaphragms, facilitating calibration of the minimal frequencies available by the vibration diaphragms, and dampening out the propagation of the sounds produced during performance. The cone edges are usually made of sheetings of paper board or plastics laminated cloth and thus have drawbacks in that objectionable sounds are produced as a result of the split resonance and in the difficulty of exactly forming the material to the desired configurations. To remedy these drawbacks, cone edges formed of foamed polyurethanes are proposed. The formed polyurethanes are of the open-cellular structures having interconnecting voids as is well known in the art and as a consequence permeation of air takes place across the faces of the cone edges of the particular materials. This results in drops of the acoustic pressures especially in the vibrations in the piston ranges. If the foamed polyurethanes forming the cone edges are prepared to have increased densities ranging, say, from 0.1g/cm³ to 0.2g/cm³ as usually practised for the purpose of reducing the airpermeability of the cone edges, then increases in the weights of the cone edges will result, thereby inviting deterioration of the acoustic pressures of the loudspeakers. For these reasons and on account of the still insufficient moldability of the foamed polyurethanes, the cone edges of the particular materials are not fully acceptable for practical purposes.

Thus, the present invention further contemplates elimination of these drawbacks which have thus far been inherent in the cone edges of the prior art characters.

It is, therefore, an important object of the present invention to provide a loudspeaker having an improved vibration diaphragm which is adapted to achieve stabilized acoustic pressure-frequency characteristics substantially throughout an entire frequency range available with the loudspeaker using the vibration diaphragm.

It is another important object of the invention to provide a loudspeaker having an improved vibration diaphragm which is capable of maintaining the acoustic pressure at relatively high constant levels especially in the medium to high frequency ranges operable with the loudspeaker using the vibration diaphragm.

It is still another important object of the present invention to provide an improved method for preparing a vibration diaphragm of a loudspeaker for the purpose of providing stabilized acoustic pressure-frequency characteristics throughout an overall frequency range operable by the loudspeaker using the vibration diaphragm.

It is still another important object of the present invention to provide a loudspeaker having an improved vibration diaphragm having a sufficiently thick resin coating which is uniformly applied to the surface of a base material of foamed plastics.

It is still another important object of the invention to provide an improved method for preparing a vibration diaphragm of a loudspeaker whereby the base material of the foamed plastics is prevented from being chemically attacked and thus losing its initial shape by a process in which the base material is coated with a resin.

Yet, it is another important object of the present invention to provide a loudspeaker having an improved cone edge which is adapted to preclude production of objectionable sounds due to split resonance as heretofore been experienced in the loudspeakers using the prior art cone edges of the paper board or plastics coated cloth.

It is further and another important object of the present invention to provide a loudspeaker having an improved cone edge which can be readily and accurately formed to the desired configurations by a usual molding process during production.

It is further and another important object of the present invention to provide a loud speaker having a cone edge which is substantially impermeable to air across its faces and which is accordingly adapted to have the acoustic pressure of the loudspeaker maintained at proper levels during performance.

Yet, it is further and another important object of the present invention to provide a method for preparing an improved cone edge of a loudspeaker.

Other objects, features and advantages of the vibration diaphragm and cone edge of the loudspeaker and the method for preparing these will become more apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a sectional view showing a loudspeaker incorporating a vibration diaphragm proposed by the present invention;

FIG. 2 is a top end view showing, on an enlarged scale, the vibration diaphragm forming part of the loudspeaker which is illustrated in FIG. 1;

FIG. 3 is a section taken on line III—III of FIG. 2;

FIG. 4 is a graph indicating curves representative of the acoustic pressure-frequency characteristics achieved in the loudspeaker shown in FIG. 1 and in the

loudspeakers using the prior art vibration diaphragms of the foamed plastics;

FIG. 5 is a cut away view showing another form of vibration diaphragm which is applicable to the loudspeaker having the general construction shown in FIG. 1;

FIG. 6 is a graph indicating curves representative of the acoustic pressure-frequency characteristics achieved in the loudspeakers using conventional vibration diaphragms having resin coatings and the vibration diaphragm of the construction illustrated in FIG. 5;

FIG. 7 is a fragmentary perspective view showing an improved cone edge which is proposed by the present invention;

FIG. 8 is a sectional view showing an overall construction of a loudspeaker incorporating the cone edge which is illustrated in FIG. 7; and

FIG. 9 is a graph indicating curves representative of the acoustic pressure-frequency characteristics achieved in the loudspeakers using the existing cone edges and the loudspeakers using the cone edges which are prepared in accordance with the present invention.

The general construction of the loudspeaker shown in FIG. 1 is merely by way of example and, as such, the vibration diaphragm herein disclosed may be applied to the loudspeaker of any other constructions insofar as they use the vibration diaphragms. Thus, the loudspeaker is shown as including a frame 10 which is generally in the form of a truncated cone, and a yoke 12 supporting the frame 10 at its front end and having accommodated therein a magnet 14. A voice coil 16 surrounds a pole piece 18 projecting forwardly from the magnet 14 as customary. A vibration diaphragm 20 of a frusto-conical configuration is positioned within the frame 10 with its reduced inner end aligned with the voice coil 16. The vibration diaphragm 20 is secured at its outer circumference to a concentrically aligned outer circumferential end of the frame 10 by means of an annular strip 22 which is usually called the cone edge as previously noted. The cone edge 22 is bonded or otherwise secured at its inner circumference to the vibration diaphragm 20 and at its outer perimeter to the frame 10 by means of an annular gasket 24. The voice coil 16 is connected to a terminal plate 26 through a lead wire 28. Designated by reference numeral 30 is a damper and by 32 is a dust cap.

As previously discussed, the vibration diaphragm formed of the foamed plastics which is usually the foamed polystyrene has a density which is uniform throughout its total area and is consequently caused to shrink in its conical directions and to circularly warp from its center when the frequency of the sound produced falls within the range of the proper frequencies resulting from the specific configuration and material of the vibration diaphragm. Such tendency of the vibration diaphragm shrinking and warping is pronounced especially in the medium to high frequency ranges so that abrupt drops are invited in the acoustic pressure levels during operation of the vibration diaphragm in these particular ranges, as previously discussed.

To remove such difficulty, the present invention proposes to form the vibration diaphragm in a manner that the diaphragm has densities which are substantially irregularly distributed at least partially of the area of the diaphragm. Thus, as illustrated in FIGS. 2 and 3, the vibration diaphragm 20 has a multiplicity of spaced sections or portions 20a each of which has a density

smaller than or otherwise differing from the density of its environment or surrounding portion. More particularly, the vibration diaphragm 20 in its entirety is formed of a foamed plastics with a predetermined foaming ratio and a predetermined thickness and the portions 20a disposed therein are formed to a foaming ratio and thickness which are suitably larger than the remaining area of the vibration diaphragm. These spaced portions 20a of the vibration diaphragm may be sized and configured in any desired manner. In the shown construction of the vibration diaphragm 20, the portions 20a are shaped as generally circular and having respective areas which differ from each other. If preferred, however, the spaced portions 20a may have contours which are oval, rectangular or polygonal.

The foamed plastics operable to form the vibration diaphragm 20 having the portions 20a thus arranged may be either a foamed thermoplastic material selected from the group consisting of polystyrene, polyvinyl chloride, polymethacrylamide, cellulose acetate, acrylic resins, polyacrylonitrile resin, and polyacrylamide or a foamed thermosetting material selected from the group consisting of phenol resins, unsaturated polyester resins, polyoxy resins and polyurethane resins. It may be noted that the acrylic resins include a polymer or copolymer of acrylic acid, acrylic esters, methacrylic acid or methacrylic esters and that polymethyl methacrylate in particular will best suit the purpose.

Where the thermoplastic material of any of the above named types is to be used, a web of a foaming or foamed thermoplastic resin should be first placed in a die with a prescribed configuration and then heated under pressure to a predetermined temperature. The spaced portions 20a having lower density or densities as above described can be formed by locally varying the cooling rate and/or the fractional void in the die. Where, on the other hand, the thermosetting material is used, any of the expandable prepolymer of the named thermosetting resin in a liquid state should be poured into a die having a prescribed configuration and then heated under pressure to a predetermined temperature. The spaced portions with the smaller density or densities can also be produced by varying the cooling rate and/or the fractional void in the die.

Experiments were conducted with the vibration diaphragm of the above described character so as to determine the acoustic level in decibels in terms of the frequency in Hz of the vibrations achieved by the use of the vibration diaphragm in the loudspeaker of the construction shown in FIG. 1. The vibration diaphragm used in the experiments had been formed of a material foamed about 7.5 times and to a thickness of about 1.5 mm with the spaced portions foamed therein about 20 times and to a thickness of about 4.1 mm. The results of these experiments are indicated by a curve A in FIG. 4. For the purpose of comparison with these results, the acoustic pressure-frequency characteristics were determined of a loudspeaker using a similarly shaped vibration diaphragm which is formed, as customary, of polymethyl methacrylate foamed about 10 times to uniform thickness of about 2 mm, the results of which experiments are indicated by a curve B in FIG. 4. As clearly seen from the two characteristics curves A and B, the loudspeaker using the vibration diaphragm prepared in accordance with the present invention is capa-

ble of providing stabilized acoustic pressures throughout the operable frequency range, especially in the medium to high frequency ranges, compared to those achieved by the loudspeaker using the prior art vibration diaphragm. Such stabilized acoustic pressure-frequency characteristics apparently results from the elimination of the unusual resonance of the vibration diaphragm as would otherwise be produced within the range of the proper frequencies which are dictated by the specific configuration and material of the vibration diaphragm. The vibration diaphragm of this nature, furthermore, has an increased stiffness and accordingly an increased resistance to warpage or bending stress in consequence of the provision of the portions having a density or densities smaller than the density of the surrounding portions and will thus provide prolonged service life as compared to the prior art counterparts.

The present invention also contemplates provision of an improved vibration diaphragm having a coating of a resin applied to a base material of foamed plastics. As previously discussed, the vibration diaphragm having the resin coating is prepared in such a manner that a solution dissolving therein a resin such as polyvinyl acetate is applied to the surface of the base material. The thickness of the resin coating formed in this manner is limited for the previously described reasons and, if it is desired to have a relatively thick coating formed on the base material, then substantial irregularity of the thickness of the coating will result especially where an organic solvent is used to dissolve the resin. Where the organic solvent is used, moreover, the foamed plastics forming the base material will tend to be chemically attached by the solvent and, as a consequence, loses its initial shape.

To eliminate this difficulty, the present invention hereby proposes to have a base material of the foamed plastics coated with a resin through application of an aqueous emulsion of the resin to the surfaces of the base material so as to cause the particles of the resin to be deposited on these surfaces. FIG. 5 illustrates the configuration of the vibration diaphragm formed in this manner wherein the base material 34 of the foamed plastics has the resin coatings 36 and 36' on its inner and outer surfaces, respectively. The foamed plastics thus foaming the base material 34 may be any of the thermoplastic or thermosetting materials previously named while the resin to form the coatings 36 and 36' is selected from the group consisting of polyvinyl acetate, polyvinyl chloride, polystyrene and various acrylic resins or rubber resins such as for example butadiene-styrene rubber (S.B.R.) and butadiene-acrylonitrile rubber (N.B.R.). In accordance with the present invention, it is important that any of these resins be used in the form of an aqueous emulsion.

The aqueous emulsion of any of the named resins usually contains about 30 to 50 percent by weight of solid ingredients in the form of minute particles and thus possesses a viscosity which is appropriate for being applied to the surfaces of the base material of the foamed plastics. For applying the aqueous emulsion of the resin to the surfaces of the base material, the foamed plastics as the base material should be immersed in the aqueous emulsion of the resin so as to cause the solid particles of the resin to be deposited on the surfaces of the base material or, otherwise, the aqueous emulsion of the resin should be sprayed in an

atomized form onto or brushed on the surfaces of the base material of the foamed plastics.

For the formation of the vibration diaphragm thus made up of the base material of the foamed plastics and the coating of the resin in accordance with the present invention, either the base material in the form of a sheeting should be first coated with the aqueous emulsion of the resin and heated and then pressed to the desired frusto-conical configuration, or the base material which has preliminarily been formed to the desired frusto-conical configuration should be coated with the aqueous emulsion of the resin. Of these two methods, the former will prove advantageous for practical purposes because of the uniform thickness of the coating as achieved by application of the aqueous emulsion of the resin to the substantially flat surface of the base material.

FIG. 6 illustrates the results of the experiments conducted with the loudspeakers using the vibration diaphragms prepared in accordance with the present invention and in the method presently in common use. Thus, curve C indicates the acoustic pressure-frequency characteristics achieved in the loudspeaker using a vibration diaphragm formed of polymethyl methacrylate foamed about 7.5 times to a thickness of about 1.6 mm and having an inside diameter of about 25 cm at its outer circumference, wherein the coatings of a copolymer of acrylic ester were applied to the surfaces of the base material in a manner that the base material was immersed in an aqueous emulsion of such copolymer containing about 46 percent by weight of solid constituents. Curve D, on the other hand, is indicative of the acoustic pressure-frequency characteristics achieved in the loudspeaker using a vibration diaphragm which was made up of a base material of foamed polymethyl methacrylate and coatings of polyvinyl acetate applied to the base material by brushing a solution of the polyvinyl acetate dissolved in toluene. Comparison between these curves C and D will reveal that more stabilized acoustic pressure-frequency characteristics can be achieved by the use of the vibration diaphragm prepared in accordance with the present invention than in the vibration diaphragm of the prior art character.

Since, thus, the vibration diaphragm having the coatings of the resin is prepared with use of the aqueous emulsion of the resin in accordance with the present invention, the viscosity of the aqueous emulsion is maintained at relatively low values even though the emulsion happen to contain more than 50 percent by weight of solid resin particles and, as a consequence, the resin particles can be applied to the surfaces of the base material readily by immersing the base material in the aqueous emulsion or spraying or brushing the aqueous emulsion to the surfaces of the base material as the case may be. The vibration diaphragm can therefore be prepared by an extremely simplified process and can be formed with the resin coatings having sufficient thickness which is satisfactorily uniform throughout the surfaces of the base material. During the process of forming the coatings on the base material, moreover, the base material is free from chemical attacks as would otherwise be encountered where an organic solvent is used to apply the resin to the base material, with the result that the initial configuration of the base material is maintained in the final product.

The vibration diaphragm having these outstanding features may be placed on use as it is but, if desired, such features may be combined with the features of the vibration diaphragm formed with the spaced portions having reduced densities as previously described. For this purpose, the vibration diaphragm prepared to have the portions having the reduced density or densities should be used as the base material which is to be coated with the resin through application thereto of the aqueous emulsion of the resin. The vibration diaphragm produced in this manner will provide further stabilized acoustic pressure-frequency characteristics when incorporated in a loudspeaker.

The vibration diaphragm is secured to the frame of the loudspeaker by means of the cone edge extending along the outer circumferential ends of the frusto-conical frame and vibration diaphragm so as to prevent radial displacements of the diaphragm, to permit calibration of the minimal resonance frequency and to dampen out the propagation of the sounds produced, as previously discussed. The conventional cone edges are usually formed of the foamed polyurethanes for the purpose of eliminating the drawbacks inherent in the cone edges of the paper board or plastics laminated cloth. The foamed polyurethanes having the interconnecting voids have an airpermeable property and, as a consequence, tend to invite a drop in the acoustic pressure especially in the vibrations in the piston range. The insufficient adaptability of molding has also been pointed out as one of the drawbacks of the cone edges of the foamed polyurethane. The present invention thus further contemplates provision of a cone edge which is free from these drawbacks inherent in the prior art counterparts.

The cone edge herein proposed is formed of a foamed plastics of a closed-cellular structure. The foamed plastics of this nature may be an ethylene-vinyl acetate copolymer or a mixture of polyethylene and an ethylene-vinyl acetate copolymer. Where the foamed ethylene-vinyl acetate copolymer is used to form the cone edge, it is preferable that such copolymer contains about 65 to 90 percent by weight of ethylene and about 35 to 10 percent by weight of vinyl acetate. Where, on the other hand, the foamed mixture of the ethylene-vinyl acetate copolymer is to be used, the mixture may preferably contain more than 50 percent by weight of ethylene-vinyl acetate copolymer containing about 65 to 90 percent by weight of ethylene and 35 to 10 percent by weight of vinyl acetate and less than 50 percent by weight of polyethylene.

For the preparation of the foamed plastics of the closed-cellular structure, a blowing agent of the decomposing type such as for example azodicarbonamide may be admixed to the ethylene-vinyl acetate copolymer or to the mixture of such copolymer and polyethylene and heated to a predetermined temperature for forming myriads of closed foams therein or, otherwise, a blowing agent of the volatile type such as for example dichlorodifluoromethane may be added under pressure to the melted ethylene-vinyl acetate copolymer or the melted mixture of the copolymer and polyethylene and then subjected to an atmospheric pressure for forming the foams therein.

In order that the foamed plastics produced in this manner be formed with completely closed, uniformly sized and distributed, sufficiently minute foams and that the resultant foamed plastics have satisfactory heat

resistance and adaptability to molding and tooling process, the ethylene-vinyl acetate copolymer or the mixture of the copolymer and polyethylene may preferably be formed with cross-linking bonds through addition thereto of a suitable organic peroxide such as dicumyl peroxide or through irradiation with electron rays or ionizing radiations before the copolymer or the mixture of the copolymer and polyethylene is subjected to the foaming process.

The foamed plastics of the ethylene-vinyl acetate copolymer is advantageous especially for the purpose of providing sufficient flexibility which is required of the cone edge but such foamed plastics tends to be excessively soft and, at the same time, the heat resistance is liable to diminish where such foamed plastics is placed on a practical use. These problems will be completely solved if the mixture of the ethylene-vinyl acetate copolymer and polyethylene is used as the material of the cone edge in accordance with the present invention. Thus, it is herein pointed out that the mixture of the ethylene-vinyl acetate copolymer and polyethylene will proved more advantageous than the copolymer alone for practical applications.

FIG. 8 illustrates an example of the cone edge 22 which is prepared in a manner above described. This cone edge 22 is herein shown as having an annularly raised central portion 22a so as to be capable of transferring the vibratory motions there-through with satisfactory quality. The cone edge 22 thus having the annularly raised portion 22a is attached at its inner circumference to the outer circumferential edge of the vibration diaphragm 20 and at its inner circumference to the outer circumferential edge of the frame 10 through the gasket 24, as illustrated in FIG. 8.

Experiments were conducted with two cone edges prepared in different manners in accordance with the present invention so as to determine the acoustic pressure-frequency characteristics of the cone edges. One cone edge was prepared from an ethylene-vinyl acetate copolymer containing 20 percent by weight of vinyl acetate and foamed about 15 times. The resultant cone edge had a thickness of 1.5 mm and an inside diameter of 25 cm. The acoustic pressure-frequency characteristics of the loudspeaker using this cone edge are indicated by curve E. The other cone edge was prepared from a mixture of 75 percent by weight of ethylene-vinyl acetate copolymer containing 25 percent by weight of vinyl acetate and 25 percent by weight of lowdensity polyethylene. The mixture was foamed about 15 times and the resultant cone edge of the foamed plastics of the closed cellular structure had a thickness of 1.5 mm and an inside diameter of 25 mm. The acoustic pressure-frequency characteristics of the loudspeaker using this cone edge are indicated by curve F in FIG. 9. Both of the cone edges used in the experiments were formed to the configuration shown in FIG. 7 by heating and pressing the foamed plastics in the form of sheetings. Curve G in FIG. 9 is indicative of the acoustic pressure-frequency characteristics as achieved in the loudspeaker using a prior art cone edge prepared from foamed polyurethane having an open-cellular structure and foamed about 15 times, wherein the cone edge finally produced had a thickness of 1.5 mm and an inside diameter of 25 cm. Comparison between the characteristics curves E and F for the cone edges prepared in accordance with the present invention and the curve G for the cone edge prepared in the

conventional manner will apparently reveal that the acoustic pressure levels attained in the loud speakers using the cone edges according to the present invention are higher about 2 decibels on the average than that attained in the loudspeaker using the prior art cone edge in the piston range of about 50 to 1,000 Hz.

It will now be appreciated from the foregoing description that the cone edge hereby proposed can be prepared in an extremely simplified manner and in a considerably shortened process and can provide excellent acoustic performance. It is to be noted, in this regard, that the foamed plastics prepared from the ethylene-vinylacetate copolymer or the mixture of the copolymer and polyethylene can be pressed to the final configuration in about 6 to 7 seconds while, for the formation of the cone edge prepared from the foamed polyurethane, about 60 seconds are required. Since, moreover, the foamed plastics for forming the cone edge according to the present invention has the closed-cellular structure, the acoustic characteristics are significantly improved from those available by the conventional cone edge which is prepared from the foamed plastics such as the polyurethane having the open-cellular structure. Where the cone edge formed of the foamed plastics of the open-cellular structure is used in the loudspeaker, the acoustic pressure developed by the vibration diaphragm happens to be out of phase with the vibrations caused by the electric elements as a result of the permeation of air across the faces of the cone edge, with the consequent reduction in the levels of the acoustic pressure from the loudspeaker. Such drops in the acoustic pressure levels can be avoided where cone edge according to the present invention is incorporated in the loudspeaker because the cone edge is of the air-impermeable property.

The cone edge formed of the foamed polyurethane displays a considerable hygroscopic property, absorbing moisture in the atmospheric air when placed on a prolonged use. This causes the weight of the cone edge to gradually augment during use with the resultant deterioration of the ability of the loudspeaker controlling the inertia so that the damping performance of the loudspeaker and accordingly the acoustic characteristics are degraded. Contrary to the prior art cone edge of this nature, the cone edge proposed by the present invention has an extremely small hygroscopic tendency of, say, about 0.13 percent if the material plastics is foamed 15 times, and, as a consequence, the acoustic characteristics remain unchanged even though the loudspeaker using the cone edge is placed where relatively high humidity prevails and thus lasts for a satisfactorily prolonged time.

What is claimed is:

1. An annular cone edge for a loudspeaker, which cone edge is formed of a foamed copolymer of ethylene and vinyl acetate, having a closed-cellular structure.

2. An annular cone edge as claimed in claim 1, in which said copolymer contains 65 to 90 percent by weight of ethylene and 35 to 10 percent by weight of vinyl acetate.

3. An annular cone edge as claimed in claim 1, in which polyethylene is mixed with said copolymer in a quantity less than the quantity of said copolymer by weight.

4. An annular cone edge as claimed in claim 2, in which polyethylene is mixed with said copolymer in a quantity less than the quantity of said copolymer by weight.

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