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[54] DIAPHRAGM FOR SOUND INSTRUMENT AND METHOD FOR PRODUCING SAME

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[58] **Field of Search**.....260/2.5 AK; 161/162, 168, 161, 161/160, 170

[56] **References Cited**

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[57] **ABSTRACT**

A diaphragm for sound instrument and method for producing same in which the diaphragm comprises an assembly of foamed granules of thermoplastic resin, binder layer surrounding the foamed granules and connecting them together to form an integral body of the diaphragm and a fibrous reinforcing material applied on at least one surface of said body and embedded in the binder to form a reinforcing layer.

2 Claims, 2 Drawing Figures

FIG. 1

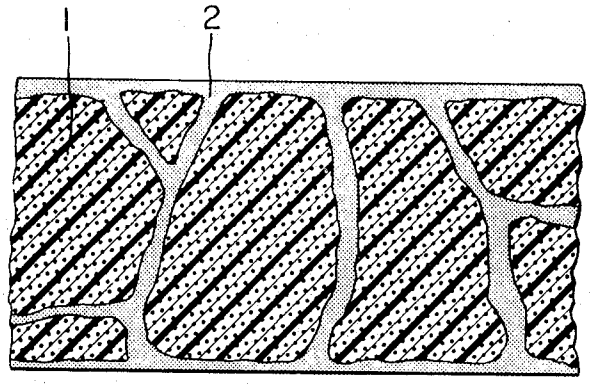
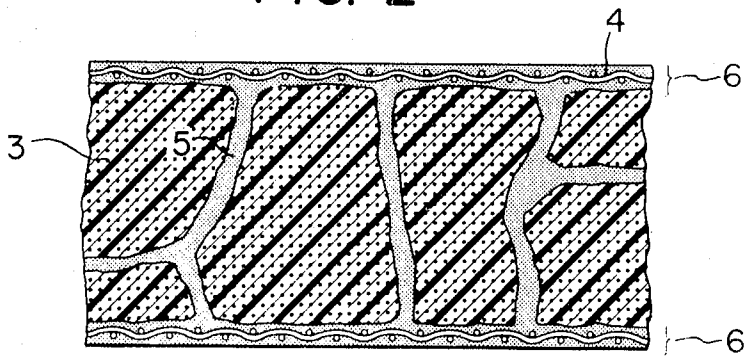


FIG. 2



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DIAPHRAGM FOR SOUND INSTRUMENT AND METHOD FOR PRODUCING SAME

BACKGROUND OF THE INVENTION

The present invention relates to a diaphragm for a sound instrument made of foamed synthetic resin.

In general it is essential that a diaphragm for a sound instrument be made of material which satisfies such requirements as low specific gravity, high Young's modulus and relatively high internal loss. Heretofore a diaphragm has been made of processed paper, which does not fully meet such requirements. Recently foamed synthetic resin, such as foamed polystyrene or foamed polyvinyl chloride, has become used as a material for making a diaphragm. Such foamed synthetic resinous material has a very low specific gravity and relatively high internal loss, resulting in a diaphragm in which good radiating efficiency can be obtained and extremely high partial resonance can be reduced. Moreover such diaphragm can be formed easily in any desired form. However the foamed synthetic resinous material has a low Young's modulus, so that the power level is greatly reduced in the high frequency sound range, which is undesirable.

The relationship between Young's modulus and specific gravity is such that the former is reduced as the latter is reduced, so that it is impossible to simultaneously satisfy all of the above requirements; consequently a diaphragm for a sound instrument having satisfactory performance cannot easily be produced.

An improved diaphragm has been proposed, which comprises a body of foamed synthetic resinous material and a film of synthetic resin coated on a surface thereof, but satisfactory results have not been obtained.

A diaphragm of foamed synthetic resinous material has a further defect in that it has relatively low mechanical strength and durability and it is liable to be broken by vibration of itself.

In order to eliminate such defects and attain satisfactory performance of a diaphragm for a sound instrument, an improved construction of a diaphragm for a sound instrument and a method for producing same have been invented. This improved construction of a diaphragm comprises an assembly of foamed granules of thermoplastic resin and a binder layer of thermosetting resin filling the gaps between the foamed granules and connecting them together to form an integral body of the diaphragm. The method for producing the diaphragm comprises preparing primarily foamed granules of thermoplastic resin, applying thermosetting resin of A stage on the surface of said foamed granules, secondarily foaming said granules into a diaphragm form and then curing said thermosetting resin.

FIG. 1 shows an example of such improved construction of a diaphragm, in cross section, in which 1 designates a foamed granule of thermoplastic resin, such as foamed polystyrene and 2 designates binder layer of thermosetting resin such as phenol resin. Such improved construction, in which foamed granules of thermoplastic resin are connected together by a binder of thermosetting resin, has superior properties, that is, higher Young's modulus, internal loss, mechanical strength and durability than a conventional construction made of foams of synthetic resin. However this improved construction has such a defect that when the thickness of the diaphragm is reduced, for example, below 2 mm., the diaphragm is locally constituted by one or two foamed granules in thickness, where the ratio of the thermosetting resin to the foams of thermoplastic resin is reduced so that the expected result cannot be obtained.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a diaphragm for a sound instrument which has superior properties, that is, low specific gravity, high Young's modulus and high internal loss.

It is another object of the present invention to provide a method for producing such a diaphragm.

It is a particular object of the present invention to provide a diaphragm for a sound instrument and a method for producing same which eliminate the disadvantage of the above diaphragm consisting of an assembly of foamed granules of thermoplastic resin and a binder layer of thermosetting resin.

In accordance with the present invention there is provided a diaphragm for a sound instrument comprising an assembly of foamed granules of thermoplastic resin, a binder of thermosetting resin surrounding the foamed granules and connecting them together to form an integral body of the diaphragm and a fibrous reinforcing material, such as glass fibers, applied on at least one surface of said body and embedded in the binder to form a reinforcing layer.

Further in accordance with the present invention there is provided a method for producing a diaphragm for a sound instrument comprising preparing primarily foamed granules of thermoplastic resin, adding binder of thermosetting resin of A stage to the foamed granules and mixing them together, arranging the mixed granules and binder in a form of sheet, applying a fibrous reinforcing material on at least one surface of said sheet and then heating and curing the sheet to form the diaphragm.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a cross sectional view of a diaphragm according to a prior art; and

FIG. 2 is a cross sectional view of a diaphragm according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 2 illustrates a preferred embodiment of the present invention, in which 3 designates foamed granules of thermoplastic resin, such as foamed polystyrene, 4 designates fibrous reinforcing material, such as glass cloth, 5 designates a binder of thermosetting resin filling the gaps between the foamed granules and between the fibers of the glass cloth, and 6 designates a reinforcing layer formed on the surfaces by the glass cloth and the binder.

Such diaphragm can be produced by the following method.

Firstly, polystyrene beads are primarily foamed and the foamed beads having 4–10 mesh size are selected. The most preferable size range is 6–8 mesh. Twelve g. of a mixture of epoxy resin and curing agent is added to 1,000 cc. (about 20 g.) of said primarily foamed beads and mixed together by a kneader. Two glass cloths are prepared. One of the cloths is placed on a molding surface of a cavity of a lower mold and the above mixture is charged in the cavity. The other glass cloth is placed on the charged mixture and then an upper mold is set on the lower mold. The molds are pressed together in a hot press to heat the mixture at the temperature of about 90° C. for about 15 minutes. Then the molds are cooled. Thus the diaphragm is formed and is removed from the mold.

The invention is further illustrated in detail by the following examples, which are not intended to be limitative of the scope of the invention.

EXAMPLE 1

At room temperature, A stage thermosetting binder in liquid state was prepared by mixing a thermosetting resin called Epikote No.828 (trade name, product of Shell Chemicals Co. Japan — epoxy resin of bisphenol A diglicydil ether type having molecular weight of about 380) and a curing agent called Thomide No.235S (trade name, product of Fuji Kasei Kogyo K.K. Japan — tetraethylenepentamine having molecular weight of 700 to 1,000), the weight ratio of the thermosetting resin to the curing agent being 1 to 0.2, the mixture having a viscosity of 7,000 c.p. 20 g. of polystyrene foamed beads having a molecular weight of 200,000, a bulk specific gravity of 0.02 and a particle size of from 6 to 8 mesh ASTM were put into a kneading vessel and then 12 g. of the above-prepared mixture of the thermosetting resin is poured little by little while kneading.

Glass cloth consisting of 60 warp strands and 60 weft strands per 25.4 mm., each strand including 100 filaments of 5 micron diameter, having weight of 25.8 g/m² and thickness of 0.035 mm. was prepared. One sheet of said glass cloth was placed on a molding surface of a cavity of a lower mold and the above mixture was charged in the cavity. Another sheet of the same glass cloth was placed on the charged mixture and then an upper mold was set on the lower mold. The mold was heated at 95° C. under a pressure of 3 kg/cm²(Gauge) for 30 minutes. At the end of this period, the mold was quenched with water for 6 minutes and the molded product was taken out. This product was then allowed to stand for 24 hours at room temperature.

The resultant diaphragm had specific gravity of about 0.1, Young's modulus of about 30–60 kg/mm², and tensile strength of about 0.5–1.0 kg/mm².

EXAMPLE 2

EXAMPLE 1 was repeated using the same foamed beads and the same procedures except that 12 g. of a mixture of Epikote No.828 and Versamid 115 (trade name, product of General Mills — versamide fatty polyamide resin having molecular weight of 800–1,000) was used as a binder. In the binder mixture, the ratio of Epikote:Versamid was 1:1, this mixture having a viscosity of 8,000 c.p.

The resultant diaphragm had identical physical properties to those of EXAMPLE 1.

EXAMPLE 3

EXAMPLE 1 was repeated using the same foamed beads and the same procedures described therein except that for the thermosetting resin mixed with curing agent, 12 g. of a mixture of Plyophen No.6000 (trade name, product of Reichhold Chemicals, Inc. — resorcinol/parafoamaldehyde resin having molecular weight of 100–400) and Plyophen Catalyst No.6002 (trade name, product of Reichhold Chemicals, Inc. — hexamethylenetetramine) was used. The weight ratio of thermosetting resin to curing agent was 1:0.2, resulting in a mixture having viscosity of 3,000 c.p. The molding period used was about 15 minutes.

The resultant diaphragm had physical properties similar to those in EXAMPLE 1.

EXAMPLE 4

EXAMPLE 3 was repeated using the same foamed beads and the same procedures described therein except that the thermosetting resin-curing agent mixture consisting of 12 g. of a mixture of Plyophen No.5023 (trade name, product of Reichhold Chemicals, Inc. — phenol/formaldehyde resin, Resol-type, molecular weight 140–280) and benzenesulfonic acid. The weight ratio of thermosetting resin:curing agent was 1:0.1; the resultant mixture having viscosity of 3,000 c.p.

EXAMPLE 5

EXAMPLE 3 was further repeated using the same foamed beads and according to the same procedures as described therein, except that as the thermosetting resin-curing agent mixture, 12 g. of a mixture of 9.4 g. of Epikote No.828 (defined in Example 1), 1.5 g. of Tritex H300 (trade name, product of Taiho Kogyo K.K., Japan — aliphatic polyamine) and 1.1 g. of methanol, were used.

The resultant diaphragm had physical properties similar to those in EXAMPLE 1.

EXAMPLE 6

EXAMPLE 3 was repeated using the same foamed beads and the same procedures described therein except that Nikanol (trade name, product of Nihon Gas Kagaku Kogyo K.K. — m-xylene-formaldehyde prepolymer having specific gravity of 1.05, molecular weight of 300 before curing and viscosity of 4,000 c.p. at A stage at 30° C.) was used as a thermosetting binder and 0.05 parts by weight of Nikanol LL (trade name, product of Nihon Gas Kagaku Kogyo K.K., — monoethylenediamine) was used per part by weight of said binder as a catalyst therefor.

The resultant diaphragm had physical properties similar to those in EXAMPLE 1.

Similar results were obtained when foamed beads of a styrene/diallylphthalate copolymer consisting of 80 percent by weight styrene and 20 percent by weight diallylphthalate was substituted for the polystyrene foamed beads, though more than 70 percent by weight of styrene may be used with a good result.

In the diaphragm of the present invention, the weight of thermosetting binder is about 0.1 to 2 parts by weight per part by weight of foamed beads. If less than 0.1 part by weight of binder is used, the mechanical strength of the resultant diaphragm is too low, and, with the use of more than 2 parts by weight of binder, the weight of the resultant diaphragm is too high.

In the diaphragm according to the present invention, the Young's modulus can be substantially increased without appreciably increasing the specific gravity of the diaphragm, because the thermosetting resin having relatively high Young's modulus fills up the gaps between the foamed granules of thermoplastic resin having low Young's modulus and the glass cloth or the like forms the reinforcing layer on the surface of the diaphragm. Thus a superior diaphragm for a sound instrument can be easily produced, in which radiation efficiency is increased and the decrease of power level in the high frequency sound range is effectively avoided. Because high Young's modulus is obtained by the reinforcing layer on the surface of the diaphragm, the diaphragm having small thickness such as below 2 mm. can be produced, without excessively reducing its Young's modulus owing to the reduction of the ratio of the thermosetting resin.

It has been known in the art that a diaphragm made of foamed beads of thermoplastic resin must include at least three beads in its thickness, otherwise bending strength of the diaphragm is excessively reduced, and if the thickness of the diaphragm is reduced below 2 mm. the diaphragm includes only one or two foamed beads in its thickness so that satisfactory bending strength cannot be obtained. In accordance with the present invention, however, satisfactory bending strength can be obtained even if the thickness is reduced below 2 mm. By varying the mixing ratio of the thermoplastic resin and the thermosetting resin and the degree of foaming of the foamed granules, the characteristic of the diaphragm can be controlled as desired. Because the foamed granules of the thermoplastic resin is covered by the thermosetting resin having high strength and weather-resistant property, the diaphragm is not likely to be broken by the vibration or the like and it has good durability.

The diaphragm according to this invention is suitable for a loudspeaker of stereophonic apparatus or an electronic musical instrument. It can be also used as a sounding board of a guitar or a piano.

I claim:

1. A diaphragm for a sound instrument, comprising: a body of foamed granules of polystyrene beads having a mesh size of between 4 and 10 mesh; a fiberous glass reinforcing material disposed on at least one surface of said body of foamed granules; and a binder of thermosetting resin comprising a mixture of thermosetting resin having a molecular weight of between about 100 to 400 and a curing agent, the weight ratio of said thermosetting resin to said curing agent being in the range of 1:0.1–0.2, said mixture having a viscosity of approximately 3,000 cp, said binder filling the gaps between said foamed granules in said body and between the fibers of said reinforcing material and constituting between about 0.1 to 2 parts by weight per part weight of said foamed granules; wherein said granules and therewith associated binder form an integral body of said diaphragm and said reinforcing material and therewith associated binder form a reinforcing layer

covering said integral body, said diaphragm having a Young's modulus of between about 30 to 60 kg/mm², and a tensile strength of between about 0.5 to 1.0 kg/mm².

2. A diaphragm for a sound instrument, comprising: a body of foamed granules of polystyrene beads having a mesh size of between 4 and 10 mesh; a fiberous glass reinforcing material disposed on at least one surface of said body of foamed granules; and a binder of thermosetting resin comprising a mixture of an epoxy resin having a molecular weight of about 380 and a curing agent having a molecular weight of between about 700 and 1,000, the weight ratio of said resin to said curing agent being 1:0.2, said mixture having a viscosity of about 7,000 cp, said binder filling the gaps between said foamed granules in said body and between the fibers of said reinforcing material and constituting between about 0.1 to 2 parts by weight per part weight of said foamed granules; wherein said granules and therewith associated binder form an integral body of said diaphragm and said reinforcing material and therewith associated binder form a reinforcing layer covering said integral body, said diaphragm having a Young's modulus of between about 30 to 60 kg/mm ², and a tensile strength of between about 0.5 to 1.0 kg/mm².

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