Abstract:

The present invention provides an acoustic device comprising a panel having a core of lightweight wood to which a coating of resin and a textile material is applied. By appropriately sizing the panel, placing exciters at predetermined locations by using high frequency pucks of a certain size and mass ratio by applying weights of different sizes and masses for fine tuning, clamping the panel in certain frames and providing a rear cover with concentric apertures and applying damping material, a uniform break-up over a wide frequency range in bending waves and a fast, uniform, broadband decay of the bending waves is achieved.

Description

[0001] The present invention relates to an acoustic device, more specifically to electroacoustic transducers, in particular to bending wave transducers.

State of the art

[0002] In solid media or materials, waves propagate in different ways. In thicker media, expansion and density waves prevail. At interfaces to other materials, preferably fluids, surface waves are generated. In thinner materials, hereinafter referred to as panels, additional shear waves and/or bending waves are generated. Of all wave types, essentially only bending waves and shear waves are suitable for use in electroacoustic transducers, since they propagate with sufficiently high amplitudes on panels.

[0003] Electroacoustic transducers based on bending waves enable broadband sound radiation. The propagation behavior of the bending wave is determined, among other things, by the bending stiffness and the mass occupancy of the panel and is frequency-dependent. The phase velocity in the panel increases with increasing frequency, which is referred to as "dispersion of the bending wave".

[0004] The frequency at which the phase velocity of a wave on a panel is identical to the phase velocity in air is called coincidence frequency. At the coincidence frequency, the wave begins to separate from the panel at an angle of approximately 0°. In other words, from the coincidence frequency on, the wave runs parallel to the panel, which causes a sudden increase in the efficiency.

[0005] If the phase velocity in the panel increases with respect to the phase velocity in air, the detachment angle of the wave from the panel increases from 0° to a value less than 90°. The coincidence frequency is the actual lower limit frequency of a bending wave transducer. Below the coincidence frequency, the state-of-the-art electroacoustic transducer operates as a piston radiator.

Task

[0006] It is an object of the present invention to provide an acoustic device which has a low coincidence frequency, in which, after excitation by a white noise, all frequencies break up into bending waves, i.e. This device has a low coincidence frequency at which, after excitation by white noise, all frequencies break up into bending waves, i.e. have eigenmodes which decay rapidly after excitation, is as stiff as possible in the compression and tension direction of an exciter located on it, has damping properties in the direction of the propagating bending waves, has a low mass and is highly resistant to weathering and aging. The aim of the device according to the invention is to achieve the most accurate possible acoustic reflection of a signal, preferably an electrical signal, fed to the device.

[0007] This task is solved by devices according to claim 1 and claim 10.

[0008] According to the invention, the acoustic device comprises a panel with a core of a light wood, on which there is a coating with a high modulus of elasticity (Young's modulus), i.e. a textile material, preferably a fabric, more preferably surrounded by a resin. In this way, a low coincidence frequency, a high efficiency and a uniform reproduction over a wide frequency range are made possible.

[0009] By using an average density of the light wood of 400 kg/m3, preferably 260 kg/m3 and more preferably balsa wood, the efficiency and an advantageous frequency radiation can be further improved. In particular, the compressive stiffness in the thickness direction of the lightweight wood is exploited. Further factors for an advantageous use of lightweight wood, in particular balsa wood, as a bending wave transducer are the Young's modulus of the panel with coating, its thickness, its density and its weight.

[0010] Such an arrangement can obtain a high modulus of elasticity of the panel, a low speci c weight and a low membrane thickness while maintaining internal damping. [0011] The use of face balsa wood allows the transducer to still operate at least partially as a bending wave transducer even below the coincident frequency due to the internal damping. This is due to the controlled decay of the bending waves.

[0012] By impregnating the core with po-ren filler prior to coating with the textile material and the resin, absorption of the resin and adhesion problems are avoided.

[0013] The fiber direction of 45° of the textile material to the longitudinal extension of the preferably rectangular panel prevents standing waves in the panel.

[0014] A rectangular panel with a dimensional ratio of 1:1.2 to 1:3 has a positive effect on the eigenmode density of the panel.

[0015] A longitudinal dimension of the sound-radiating area in the range of 25 to 26 cm and a transverse dimension thereof in the range of 18 to 19 cm results in a particularly advantageous utilization of the damping properties of the panel with a simultaneously manageable dimensional ratio of the panel.

[0016] By arranging one exciter in the range of 41 to 43 % of the transverse dimension and 57 to 59 % of the longitudinal dimension and the second exciter in the range of 63.5 to 65.5 of the transverse dimension, the damping properties of the panel can be utilized in a particularly advantageous manner.

[0017] By means of cancellation bodies under the exciters, wherein the mass ratio of the cancellation body and the area of the panel covered by it is in the range of 1:2 to 1:5, cancellation of interfering bending waves under the exciter takes place.

[0018] In another subject matter of the invention, a concentric aperture is provided in a covering material, preferably of a medium density fiberboard, on one side of a panel which need not be the panel described above. In this way, a comb filter is generated which counteracts the comb filter by means on the panel, for example exciters and weights, in the form of an acoustic lens.

[0019] A distance of the frame in the range of 0.2 cm to 10 cm, preferably 1 to 4 cm, from the panel causes advantageous characteristics in the comb filter.

[0020] If a fibrous or open-pored insulating material with a sound absorption preferably from 1 kHz is used on the side of the frame facing away from the panel, frequency waviness generated by the panel is compensated to a greater extent.

[0021] By clamping the panel, preferably according to the invention, via a vibration-damping material, such as closed-cell synthetic rubber, in a frame, preferably an aluminum frame, a rapid decay of the natural resonance of the frame is ensured. The decay can already be improved by the fact that the vibration damping material is in contact with the frame. The artificial rubber ensures that less than 30 dB of the original signal from the panel is transmitted to the frame. The low frequency range is amplified by the frame.

[0022] The decay of the signals is assisted by filling the frame with a structure-borne sound damping compound.

[0023] By simultaneously providing a rear cover, preferably an MDF frame with concentric openings, and the frame, preferably the aluminum frame with the described enclosure, both the behavior in the low-frequency range and that in the high-frequency range are improved.

[0024] The sound radiation in the device according to the invention preferably takes place according to the multi-resonance principle, so that a main focus of the invention lies in the use with bending wave transducers.

[0025] With the present invention, a sandwich panel with several materials positively influencing each other was obtained. Directionality was provided by determining the orientation of the fabric members for the flexural waves. Multiple eigenmodes were excited and edge reflections were greatly reduced. The device according to the invention could be further op-timized by using suitable outer dimensions and ageing-resistant materials.

[0026] Further embodiments according to the invention are the subject of the sub-claims.

Example of embodiment

[0027] In the following, the invention is described with reference to the drawing in which

[0028] Fig. 1 shows a cross-section through the panel according to the invention,

[0029] Fig. 2 shows the fabric layer on a panel according to the invention,

[0030] Fig. 3 shows a side view of the exciter provided on the panel,

[0031] Fig. 4 shows the application points of the exciter on the panel,

[0032] Fig. 5 shows a cross-sectional view of the frame and the attachment of the panel thereto,
[0033] Fig. 6 shows a first embodiment for the backside of the panel,

[0034] Fig. 7 shows a second design for covering the panel from behind using an insulating material, Figs. 8a to d show variants for covering the panel from behind, [0035] Fig. 9 shows the amplitude frequency response for a prior art electroacoustic transducer with respect to sound radiation to the front,

[0036] Fig. 10a shows the amplitude frequency response for the electro-acoustic transducer according to the invention with respect to the sound radiation to the front, with covering and damping material from the rear, [0037] Fig. 10b shows the amplitude frequency response for an electro-acoustic transducer according to the prior art with respect to the sound radiation to the front,

[0037] Fig. 10b shows the amplitude frequency response for the electroacoustic transducer according to the invention with respect to sound radiation to the rear without covering and damping material from the rear,

[0038] Fig. 10c shows the amplitude frequency response for the electroacoustic transducer according to the invention with respect to sound radiation to the rear with covering and damping material from the rear,

[0039] Fig. 11 shows the impedance frequency response for a prior art electroacoustic transducer,

[0040] Fig. 12 shows the impedance frequency response for the electroacoustic transducer according to the invention,

[0041] Fig. 13 shows a waterfall diagram for a prior art electroacoustic transducer, and

[0042] Fig. 14 shows a waterfall diagram for the prior art electroacoustic transducer according to the invention.

[0043] Fig. 1 shows the cross-section of an acoustic device according to the invention with a panel having a core 1 made of a wood with a high lignin content, preferably light wood.

[0044] When the lignin content of the wood is high, a high compressive strength is present, which is advantageous for the present invention. The lignin content depends on the ambient heat of the tree in its growth process, so that tropical woods have a higher lignin content (30- 41%) than European woods (18 - 25%). The acoustic device works preferably as a multi-resonance plate.

[0045] A pore filler 2a, 2b is applied to this core 1, on which there is a coating 3a, 3b of resin and a textile material, hereinafter referred to as a top layer. The pore filler 2a, 2b and the coating 3a, 3b are each applied to opposite sides of the core. Alternatively, the coating 3a, 3b may be applied directly to the core 1 or a coating 3a may be provided on only one side of the core 1, and a pore filler 2a may be located between this one coating 3a and the core 1.

[0046] The acoustic device according to the invention preferably uses lightweight wood, since the efficiency of a bending wave transducer increases with lower average bulk density. It should be noted that the bulk density within a log can vary considerably due to the inhomogeneous structure of the wood. The inventor has found that it is precisely this inhomogeneity that can counteract individual resonances in multiresonance panels.

[0047] In this connection, reference is made to Figs. 9 and 10a. Fig. 9 shows the amplitude frequency response of a prior art bending wave transducer in a range of approximately 250 Hz to 20 kHz, more specifically the Imago 80×60 cm transducer from the front of Elac, which uses Rohacell (polymethacrylimide) as the core. Fig. 10a shows the amplitude frequency response of the device with cover according to the invention, as described below as a preferred design, when measured from the front in the range from about 350 Hz to 20 kHz. When comparing these amplitude frequency responses, it becomes clear that in the present invention, to a large extent also due to the use of lightweight wood, the waviness and the spacing of the extreme values could be substantially reduced.

[0048] The average density is determined at 12% - 15% moisture content and is less than or equal to 550 kg/m3 for light wood. Among the light woods that can be used in the present invention are mahogany with an average gross density of 490 kg / m3, spruce with an average gross density of 470 kg /m3, fir with an average gross density of 450 kg / m3, poplar with an average gross density of 450 kg / m3, willow with an average gross density of 450 kg / m3, Reedwood with an average gross density of 420 kg / m3, Wey-mouths pine with an average gross density of 400 kg / m3, Red Cedar Western with an average gross density of 370 kg / m3, Abachi wood with an average gross density of 370 kg / m3, Metasequoia wood (Chinese sequoia) with an average gross density of 330 kg / m3 and Balsa wood with an average gross density of 70 kg / m3 - 260 kg / m3.

[0049] Good results were still obtained at mean gross densities up to 400 kg/m3, and good results were obtained in a range from 100 to 200 kg/m3.

[0050] The best result was obtained with balsa wood 150 kg / m3 as core material. By using face or end balsa wood, the compressive and tensile strength in the direction of excitation of exciters applied to the panel, which will be explained below, could be increased even further.

[0051] In particular, with the aforementioned end balsa wood, the following further advantages could be obtained:

a) Lightweight core and thus a high efficiency of the bending wave transducer.

b) Due to the very high compressive and tensile strength in the exciter's direction of excitation, even the smallest energies in the high-frequency range are not swallowed by the core material.

c) The inhomogeneity of the lightweight wood counteracts pronounced resonances.

d) Due to the damping properties in the direction of propagation of the bending wave, the positive and negative amplitudes of the bending wave from the excitation point in the direction of the edge of the panel according to the invention become smaller and smaller. This results in a more rapid decay of the panel, pronounced resonances are reduced and a bending wave transducer with the panel according to the invention still operates to a certain extent as a bending wave transducer even below the coincidence frequency. The reason for the fact that the panel still works to a certain extent as a bending wave transducer below the coincidence frequency is seen in the fact that the negative and positive amplitudes become smaller and smaller from the excitation location towards the edge and thus below the coincidence frequency there is no complete cancellation (acoustic short circuit) of the amplitudes.

[0052] In this context, reference is made to the amplitude in the impedance frequency response according to the prior art of ELAC as shown in Fig. 11 and the amplitude in the impedance frequency response according to the present invention as shown in Fig. 12. As can be seen from these Figs, the resonances of the prior art amplitude are very pronounced, resulting in extreme values with a high rise in the environment, e.g. at 350 Hz in Fig. 11. The amplitude has a relatively homogeneous course in Fig. 12.

[0053] The waterfall diagram (measured from the front) improves over the prior art of ELAC (Fig. 13) with respect to rapid decay, especially at higher frequency in the present invention as shown in Fig. 14.

[0054] The thickness of the face balsa used depends, among other things, on the size of the panel, on the characteristics of an applied top layer, on the thickness and type of exciter used to excite the acoustic device, and on the preferred frequency range for reproduction. In the raw panel measurements mentioned further below, a preferred thickness of the face balsa is 1.5 mm.

[0055] By impregnating the core according to the invention with preferably a pore filler, adhesion problems of face layers due to the porous surface of the core are prevented and the absorption of face layers associated with a loss of damping properties in the direction of travel of the flexible shaft and an increase in weight are largely avoided.

[0056] The textile material of the cover layer comprises, among other things, textile composites, preferably woven fabrics or/and nonwovens. Glass mats, for example, can be used as nonwoven material. The fabrics used are preferably GRP (glass fiber) fabrics, AFK (aramide) fabrics, Diolen (polyester) fabrics, Dyneema (polyethylene) fabrics, carbon/aramid blend fabrics, carbon/glass blend fabrics and/or CFK (carbon) fabrics. These fabrics can be woven, for example, with one of the following weaves: canvas, grain-per, atlas, false leno, multiaxial (several layers of fabric with different angular positions to each other). The weaving directions of used scrims can be unidirectional or bidirectional. The weight and thickness of the textile material depends on the properties of the other components of the acoustic device.

[0057] Good results have been obtained with fiberglass scrims, of the linen weave type, bidirectional, i.e., offset 90° in two directions, at about 58 g/m2 and at an orientation of about 45° with respect to the rectangular core material as shown in Fig. 2.

[0058] The textile material is preferably in a resin system to provide a good bond between the textile material and the core material and to ensure good weathering and aging resistance. Polyester resins can be used to ensure very good chemical and thermal resistance. Good results were obtained when using vinyl ester resins. The best results were obtained with epoxy resins because of the high dimensional accuracy due to the low shrinkage. With the preferred embodiment and the raw dimensions of the core material of preferably 28.6 cm × 21.6 cm, good results were obtained at an application thickness of 7 to 20 g per side and the best results at about 9.5 g per side.

[0059] As an alternative to using pore filler 2a, 2b, the resin can be thickened. Satisfactory results can be obtained with microcellulose flour or glass powder. Calcium carbonate or thixotropic agent in the form of a powder or paste gives good results.

[0060] By determining the dimensions of the panel, the eigenmode density of the panel is influenced, i.e., it is determined how close together the eigenmodes are.

[0061] Satisfactory results are obtained with a ratio of the transverse to the longitudinal dimension of the sound radiating area of a rectangular panel of 1:1 to 1:8, good results with a ratio of 1:1.2 to 1:3 and very good results with 1:1.378.

[0062] Good results were obtained with a longitudinal measurement of the sound-radiating area in the range of 25 to 26 cm and with a transverse measurement of the sound-radiating area in the range of 18 to 19 cm. For the sound-radiating area of the panel, very good results were obtained with dimensions of 18.5 cm × 25.5 cm. Preferably, the raw panel dimensions are 28.6 × 21.6 cm, resulting in a mass of the core 1-including pore filler 2a, 2b of about 15 g. For such dimensions, two exciters with the positions shown below with approximately 58 g mass, 25 mmm voice coil and the preferred frames and insulating materials are preferably used.

[0063] At least one exciter 5 is arranged on the above-described panel, marked "I" in Fig. 3, for vibration excitation. This exciter is dimensioned and provided in such a way that a uniform excitation of the natural resonances (natural modes) takes place over the entire frequency range of the panel. Thereby the self-weight of the exciter shall be used for resonance damping.

[0064] The number of exciters depends on the size of the multi-resonant panel, the dimensions of the panel, the core material of the panel, the thickness of the panel, the type and characteristics of the face sheets of the panel, the weight of the panel, the weight of the exciter(s), and the voice coil diameter of the exciters. Exciter positions should preferably be non-symmetrical, since several eigenmodes can be excited by asymmetrical arrangement of the exciters.

[0065] The best excitation of the panel occurs when two exciters 5', 5'' are used, as shown in Fig. 4 in the view of the panel from the rear. The positions of these exciters 5', 5'' are shown in the x and y directions with respect to the reference point "o" and with respect to the sound-emitting area of the panel in Fig. 4. The first exciter 5' is arranged on the panel from a corner of the sound-emitting area of the panel at a distance of 41 to 43%, preferably in the range of 41.5 to 42.5%, with respect to the transverse dimension (x) of the panel and from said corner at a distance of 57 to 59%, preferably in the range of 57.5 to 58.5%, with respect to the longitudinal dimension (y). The second exciter 5'' is arranged on the panel from said corner at a distance of 63.5 to 65.5 % with respect to the transverse dimension (x) of the panel and from said corner at a distance of 38.5 to 40.5 % with respect to the longitudinal dimension (y). Preferred values for the exciter 5' are 41.89% with respect to the transverse dimension (x) and 58.04% with respect to the longitudinal dimension (y), and for the exciter 5'' are 64.32% with respect to the transverse dimension (x) and 39.41% with respect to the longitudinal dimension (y).

[0066] Preferably, the exciters 5', 5'' have a voice coil of 25 mm and a weight of about 58 g.

[0067] In Fig. 4, the direction of propagation of the flexural waves is shown by arrows A and B. The direction of the excitation force of the exciter is shown by arrows A and B, respectively. The direction of the excitation force of the exciter is shown by arrow C.

[0068] In order to cancel simultaneously radiated antiphase signals, especially in the range above 10 kHz, a weight is used to cancel the interfering bending wave under the exciter. This weight is shown in Fig. 3 with the reference sign 6 and is referred to in the following as a puck, or more precisely a high-frequency puck.

[0069] In order to achieve an optimum result, a certain ratio of puck mass to panel mass must be present in the area of the panel covered by the puck.

[0070] When the above ratio is in a range of 1:1 to 1:10, satisfactory results are obtained; when the ratio is in a range of 1:2 to 1:5, good results are obtained. The best result is obtained at a ratio of 1:3.5. In other words, in the preferred embodiment of the invention, the high frequency puck has a mass of one gram.

[0071] The puck diameter depends on the voice coil diameter of the exciter and the travel time of the bending wave, which are determined by the material properties of the panel. Best results were obtained in the preferred design example of the panel with the above-mentioned preferred exciters with a substantially cylindrical high-frequency puck, which has a diameter of 16 mm and thus a height of 2 mm with reference to the weight. The high-frequency puck is glued to the panel directly under the center of the exciter and is preferably made of rubber.

[0072] In order to fine-tune the acoustic device according to the invention, weights are glued to the panel from behind. In the preferred embodiment, 3 weights of 16 mm diameter and 2 g mass as well as a weight of 21 mm diameter and 16.6 g mass have proven to be favorable for this purpose.

[0073] Although values determined above for the panel, the exci-ter, the puck and the weights for fine-tuning have been described cumulatively as a preferred embodiment example, already the adjustment of one of the values leads to an audibly and measurably better result in the case of an acoustic device.

[0074] In the following, the frame and the clamping of the above-described pair are described in a preferred embodiment example, with reference to the cross-section in Fig. 5.

[0075] According to Fig. 5, a layer 7 of preferably closed-cell synthetic rubber (APTK) is provided on the outer periphery of the panel I and adjacent areas at the front and rear sides of the panel, above which there is preferably a hollow frame 9 having a substantially box-shaped hollow profile, which has a rubber overhang section 9a towards the front side of the panel I. The frame 9 is preferably made of a rubber material. The frame 9 is preferably an aluminum frame, but may also be a wooden frame, a metal frame, or a frame made of a light metal other than aluminum. The length of the chewing hatch covering section 9a is preferably less than the width of the aluminum frame adjacent to the rear side of the panel. The thickness of the layer 7 is preferably 2 mm. Towards the middle of the rear side of the panel, a silicone application with a substantially triangular cross-section is provided on the panel in abutment with the rubber layer 7 and the aluminum frame 9, i.e. on the inside of the frame. The aluminum frame 9 contains a structure-borne sound damping compound 10, preferably TEROPHON-112B from Henkel, NOISEX from DIETZ, NOISKILLER from Rockford Fosgate, which is cast into the aluminum frame 9. A cover frame 11, preferably a medium-density fiberboard, is applied to the aluminum frame 9. However, the cover frame 11 can also be made of a plastic or a metal. The closed-cell synthetic rubber 7 and the silicone 8 essentially form the edging of the panel I.

[0076] The above-described structure provides a frame with only low inherent resonance, which decays quickly. This is torsionally stiff and has a certain inertia, whereby a low-frequency extension takes place. With this frame, the panel is unevenly framed when the panel front is compared to the panel back, so that excessive edge reflection can be prevented. With the clamping, the panel is coupled to the frame with essentially the same force over the entire frequency spectrum, and the clamping is resistant to weathering and aging.

[0077] These results are due to the fact that the frame and the edging are made of several positively positively influencing materials.

[0078] Preferably, the frame has a certain mass ratio to the panel including the exciters and the weights in order to improve the sound radiation in the low-frequency range. The mass of the panel including the applied weights and the exciter is the reference value. Since the acoustic device according to the invention operates at least partially as a piston radiator below the coincident frequency, a certain inertia of the frame with respect to the panel is necessary.

[0079] The above mass ratio is in the range of 1:0.5 to 1:infinity, preferably up to 1:10, with the lower limit preferably being 1:2. The best result was obtained when the mass ratio was 1:5.

[0080] In summary, the enhancement of the low frequency range below the coincident frequency can be achieved by clamping the paneel in a rigid frame with the above described parameters.

[0081] The application of the above-described designs of frame and/or surround is not limited to the panel according to the invention, but can be applied to any acoustic device to achieve the aforementioned advantages.

[0082] In the following, a particular embodiment is described for rear sound radiation. The following is to be considered:

[0083] The panel radiates sound both to the front and to the rear. Since the exciters are fixed on the panel from the rear, they cover a certain surface area, creating a comb filter. The type of comb filter depends on the distance of the exciters from the panel, the positions of the exciters on the panel, and the size of the area covered. The result is a strong frequency ripple starting at about 3 kHz. In particular, narrowband, strong frequency overshoots in the amplitude frequency response are noticeable at about 4 kHz and 10 kHz with an amplitude that is about 10 dB higher.

[0084] To remedy this, the panel is covered from the rear at a certain distance from the panel with a measurement medium of a certain aperture size (principle of the acoustic lens), which in turn creates a comb filter that counteracts the comb filter created by the exciters and the weights on the panel.

[0085] Fig. 6 shows a perforated grid panel, preferably made of medium-density fiber material, which has openings with a certain diameter and with predefined hole spacings and which is provided at a certain distance from the panel.

[0086] Figs. 8a and 8b show the covering of the panel from behind by frames with concentric rectangular apertures of predefined size and with a certain distance to the panel.

[0087] For the above preferred dimensions of the panel, satisfactory results could be obtained with concentric apertures ranging from 16.5 cm by 9.5 cm to 4 cm by 1 cm, good results could be obtained in the range from 22.5 cm by 15.5 cm to 16.5 cm by 9.5 cm, and very good results could be obtained with a ratio of 22.5 cm by 15.5 cm. The distance of the openings from the panel should be in the range of 0.2 to 10 cm and preferably in the range of 1 to 4 cm. A distance of 1.2 cm is most preferred.

[0088] Figs. 8c and 8d show circular covers with predefined diameters and at a predetermined distance from the panel from behind over the exciters.

[0089] Furthermore, resonances are damped by an insulating material with a certain thickness and with a certain distance to the panel. Good results were obtained with open-cell dimpled foam with a thickness of 3 cm. However, several insulating materials with predetermined thicknesses and distances from the panel can also be used.

[0090] All fibrous or open-pored insulating materials that have a high sound absorption coefficient from 1 kHz, preferably from 2.5 kHz, provide good insulating results. A combination of several materials for insulation can be e.g. the following combination: three layers of plaster wool with a thickness of 1 mm each and one layer of BONDUM 800 with a thickness of 20 mm.

[0091] The use of insulating material and the creation of an acoustic lens are preferably combined. This combination is shown by way of example as viewed from the rear of the panel in Fig. 7. Here, with the above-dimensioned con-centric openings with the described distance to the panel, satisfactory results are obtained with a distance of the insulating material in the range of 0.2 to 10 cm, good results in the range of 1 to 4 cm and very good results at 2 cm.

[0093] Compared to the amplitude frequency response from the front shown in Fig. 9 according to the aforementioned prior art of Elac, the amplitude frequency response from the front shown in Fig. 10a and the amplitude frequency response from the rear shown in Fig. 10c could be achieved in the invention with the cover in place. It is noticeable that compared to the rear sound radiation without frame and without damping material, as shown in Fig. 10b, the extreme values at 4k and 10k from Fig. 10b can be substantially reduced by the cover and the damping material in Fig. 10c. The reduced values in Fig. 10c from about 4 kHz onward by more than 10 dB in some cases is desired toward the rear. [0094] In the present invention, crossovers may be used in a known manner, for example a high pass filter at 160 Hz. Preferably, the frequencies in the range of the coincident frequency from 700 Hz to 1 kHz are attenuated by up to 10 dB. These measures serve to adapt to the subjective perception of sound.

[0095] The present invention thus provides an acoustic device comprising a panel having a core of lightweight wood to which a coating of resin and a textile material is applied. By appropriately sizing the panel, by placing exciters at predetermined locations, by using high frequency pucks of a certain size and mass ratio, by attaching weights of different sizes and masses for fine tuning, by clamping the panel in certain frames and by providing a rear cover with concentric openings and applying damping material, a uniform break-up over a wide frequency range into bending waves and a fast, uniform, broadband decay of the bending waves is achieved.

[0092] The above-described rear sound radiation can be applied to any acoustic device even without the above-described frame, without the above-described clamping, without the above-described panel, and with only some of the above-described characteristics.

Claims

Acoustic device comprising a panel (I) with a core (1) of light wood on which a coating (3a, 3b) with a high modulus of elasticity, for example of resin and a textile material, is applied.

2. an acoustic device according to claim 1, in which the average density of the lightweight wood is less than 400 kg/m3, preferably less than or equal to 260 kg/m3.

Acoustic device according to claim 2, wherein the lightweight wood is balsa wood, preferably end balsa wood.

Acoustic device according to one of the preceding claims, wherein a pore filler (2a, 2b) is provided between the lightweight wood and the coating (3a, 3b).

Acoustic device according to any one of the preceding claims, wherein the fiber direction of the fabric is approximately 45° to the longitudinal extension of the panel.

6. acoustic device according to any one of the preceding claims, wherein the panel (I) is substantially rectangular in shape and has a ratio of transverse to longitudinal dimension of 1:1.2 to 1:3.

7. acoustic device according to claim 6, wherein the longitudinal dimension of the sound emitting area of the panel is in the range of 25 to 26 cm and the transverse dimension of the sound emitting area is in the range of 18 to 19 cm.

8. an acoustic device according to any one of the preceding claims, further comprising:

- a first electromechanical transducer (5') arranged on the panel from a corner of the sound radiating area at a distance of 41% to 43% with respect to the transverse dimension of the panel and from said corner at a distance of 57% to 59% with respect to the longitudinal dimension of the panel,
- an electromechanical transducer (5'') disposed on the panel at a distance of 63.5% to 65.5% from said corner with respect to the transverse dimension of the panel and at a distance of 38.5% to 40.5% from said corner with respect to the longitudinal dimension of the panel.

9. acoustic device according to claim 8 with a cancellation body (6) for cancellation of disturbing bending waves under at least one of the electromagnetic transducers (5', 5''), wherein the mass ratio of the cancellation body (6) and the area of the panel (1) covered thereby is 1:2 to 1:5.

10. Acoustic device with a panel, preferably according to claim 1, which is covered on one side by a cover frame (9, 11) with a con-centric aperture.

11. Acoustic device according to claim 10, wherein the frame comprises medium density fiber material.

12. Acoustic device according to claim 10 or 11, wherein the frame has a distance of 0.2 to 10 cm, preferably 1 to 4 cm, to the panel (I).

13. Acoustic device according to claim 12, wherein a fibrous or open-pored insulating material with a sound absorption preferably above 1 kHz is applied to the side of the frame facing away from the panel.

14. Acoustic device according to one of the preceding claims, wherein the panel is clamped in a frame (9) and a vibration-damping material for decoupling is provided between the frame (9) and the panel or in contact with the frame.

15. acoustic device according to claim 14, wherein the frame (9) is filled with a structure-borne sound damping mass (10).

16. acoustic device according to claim 14 or 15, when this depends on one of claims 10 to 13, wherein the cover frame (11) is located on the frame (9).

17. acoustic device according to any one of the preceding claims, in which the sound dispersion takes place according to the multi-resonance principle.

Anhängende Zeichnungen

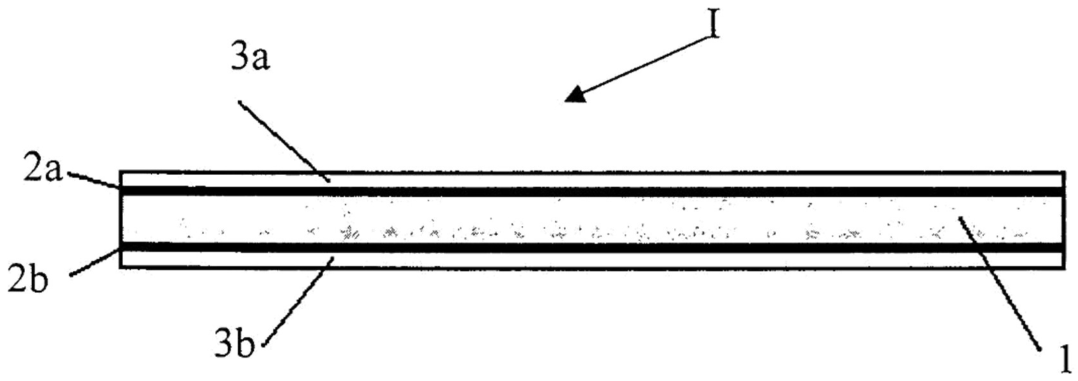


Fig. 1

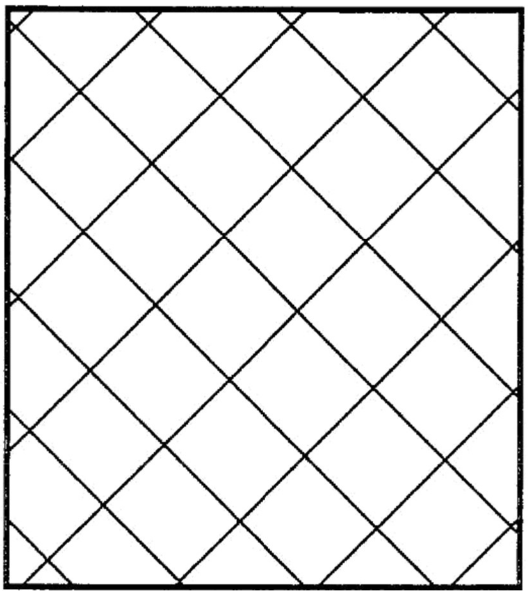


Fig. 2

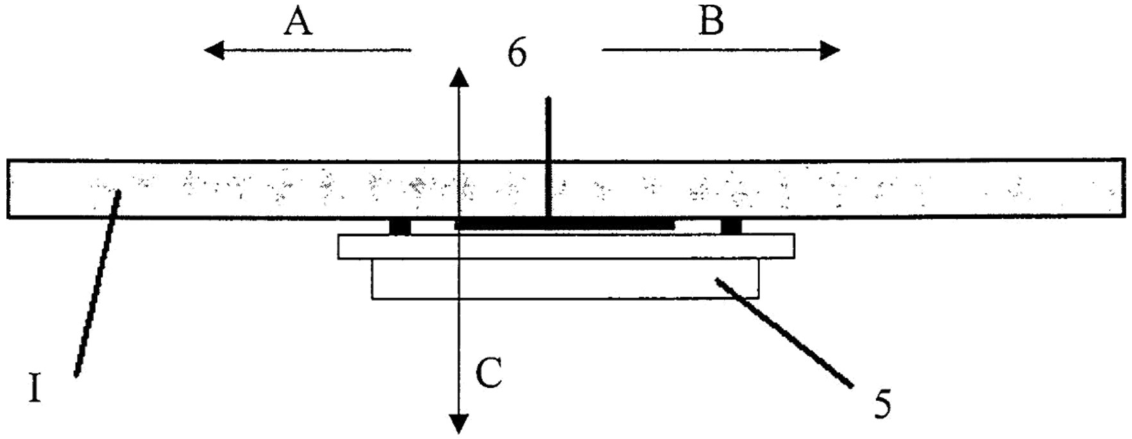


Fig. 3

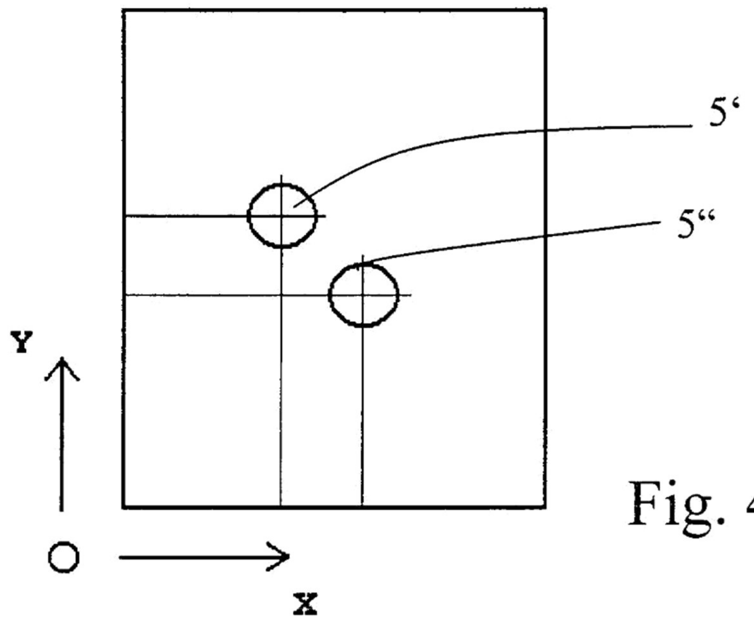
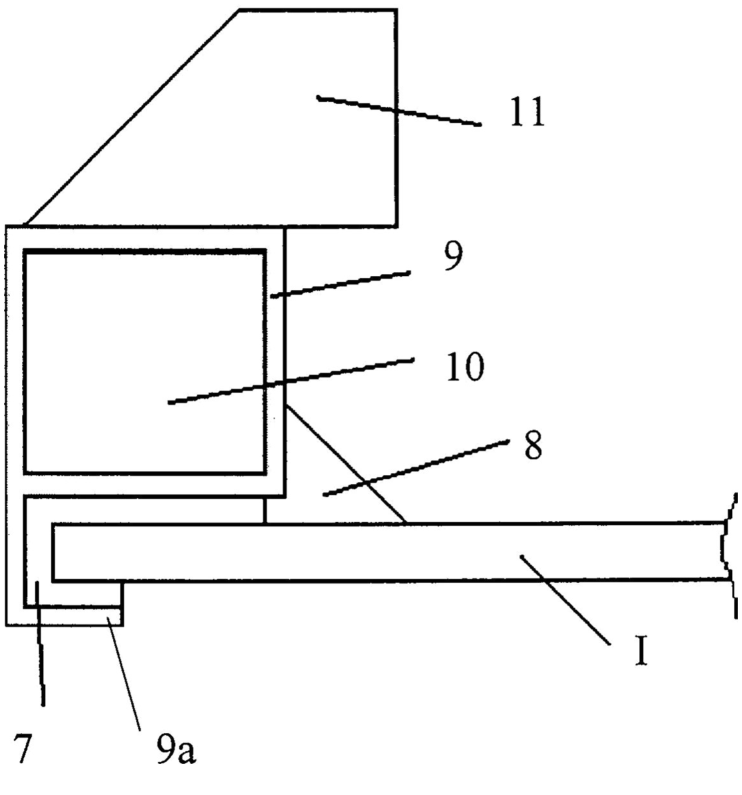


Fig. 4

Fig. 5



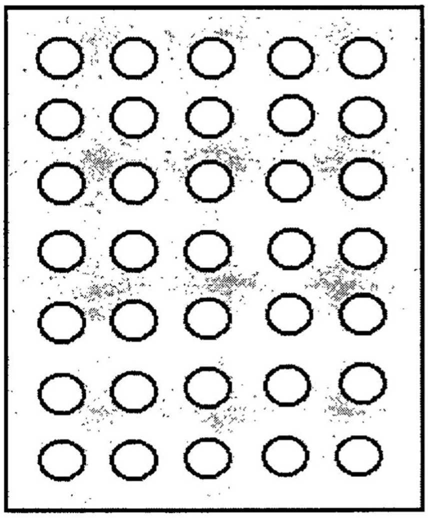


Fig. 6

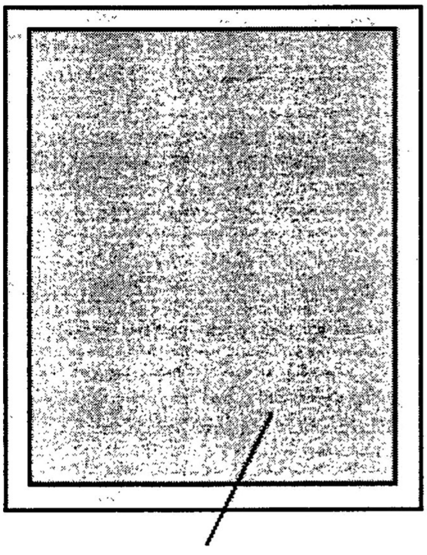


Fig. 7

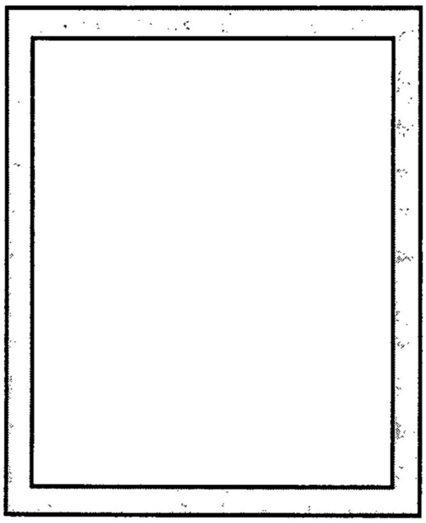


Fig. 8a

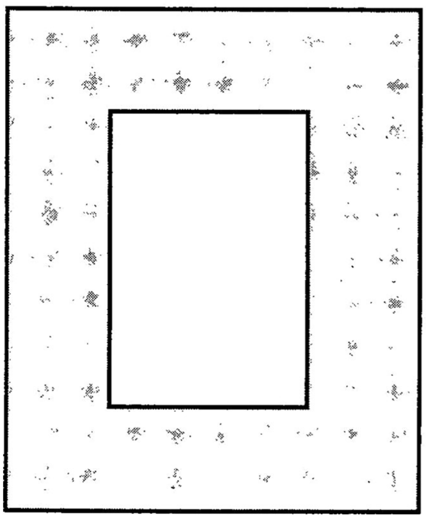


Fig. 8b

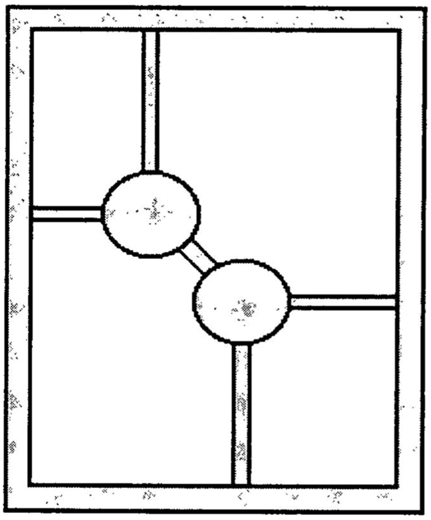


Fig. 8c

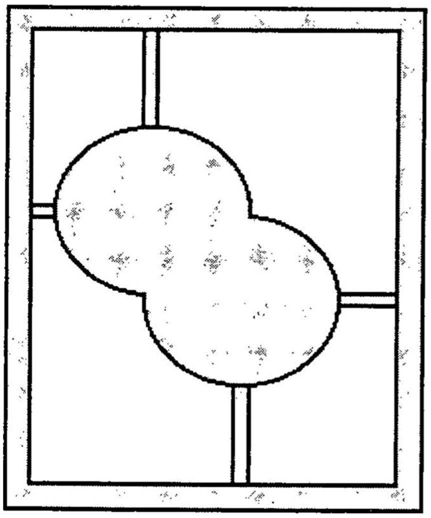


Fig. 8d

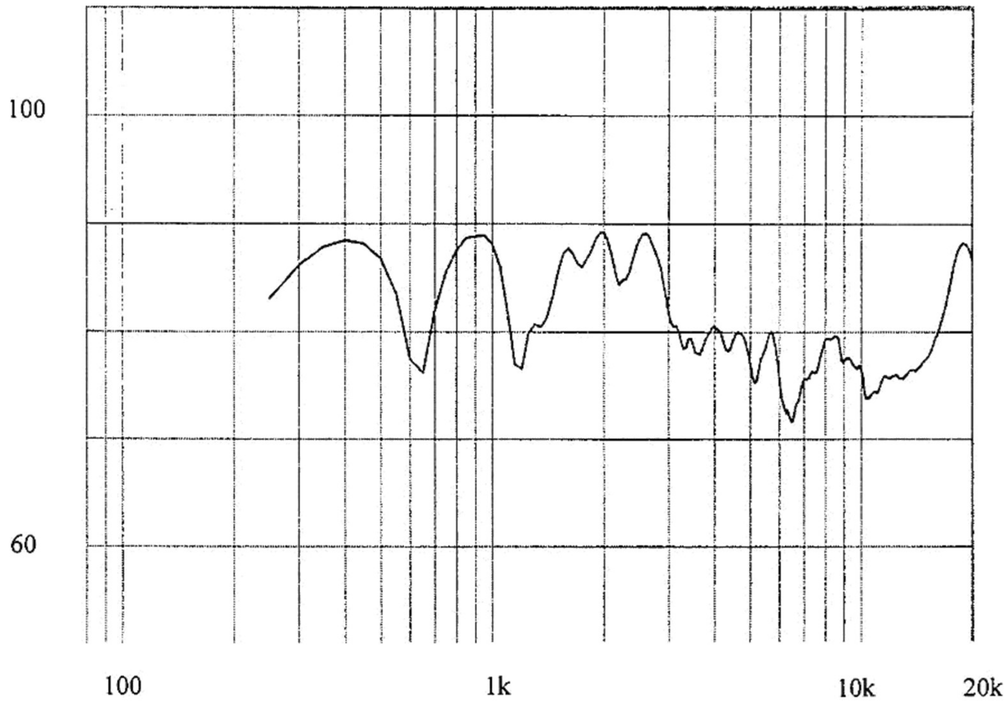


Fig. 9

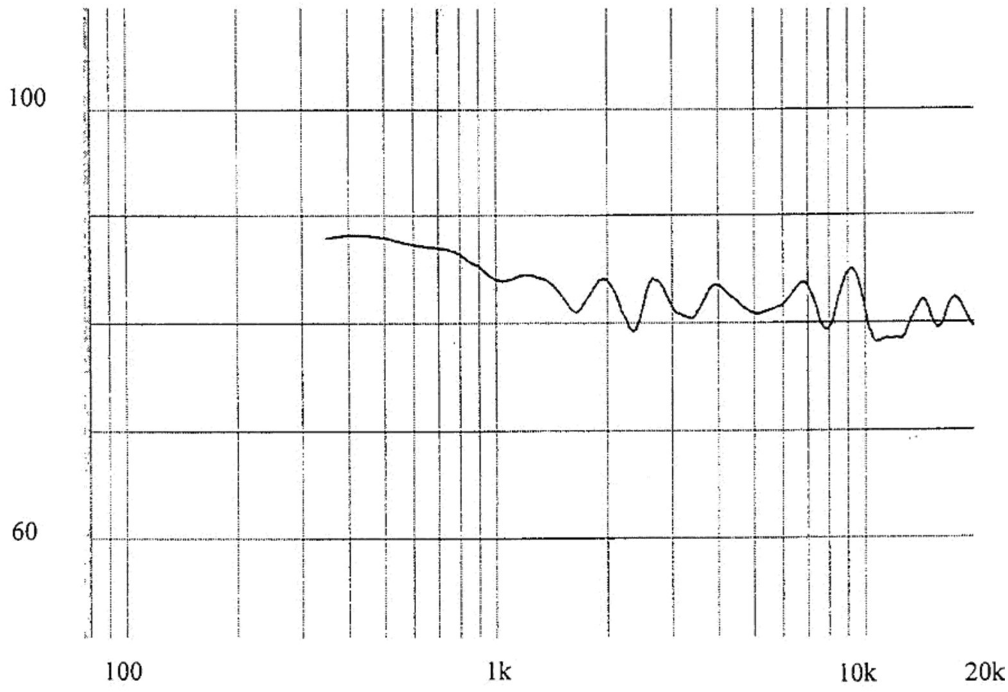


Fig. 10a

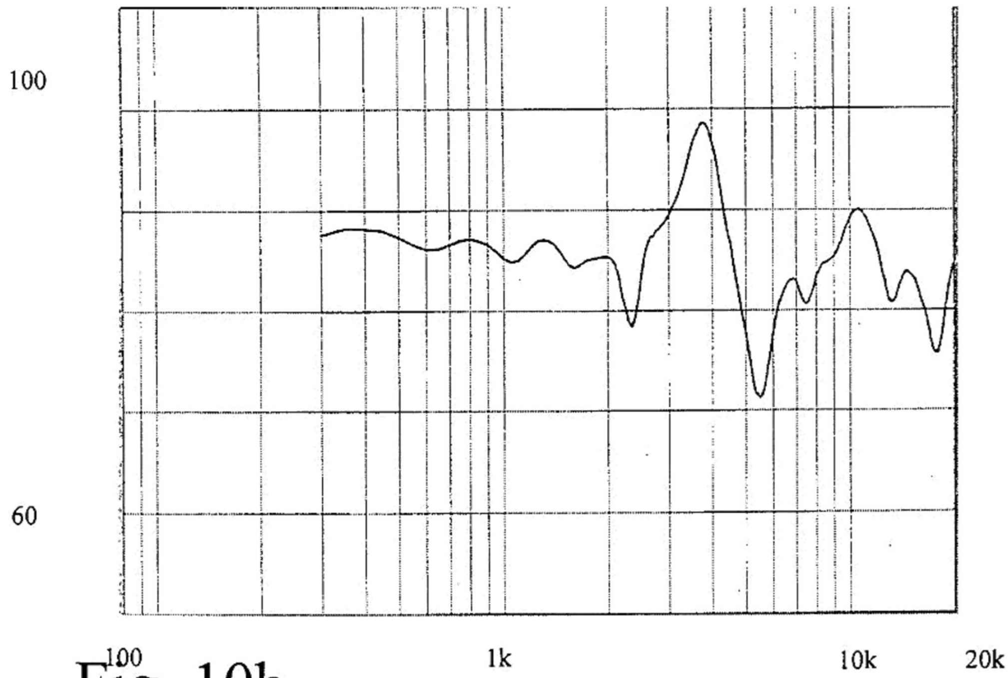


Fig. 10b

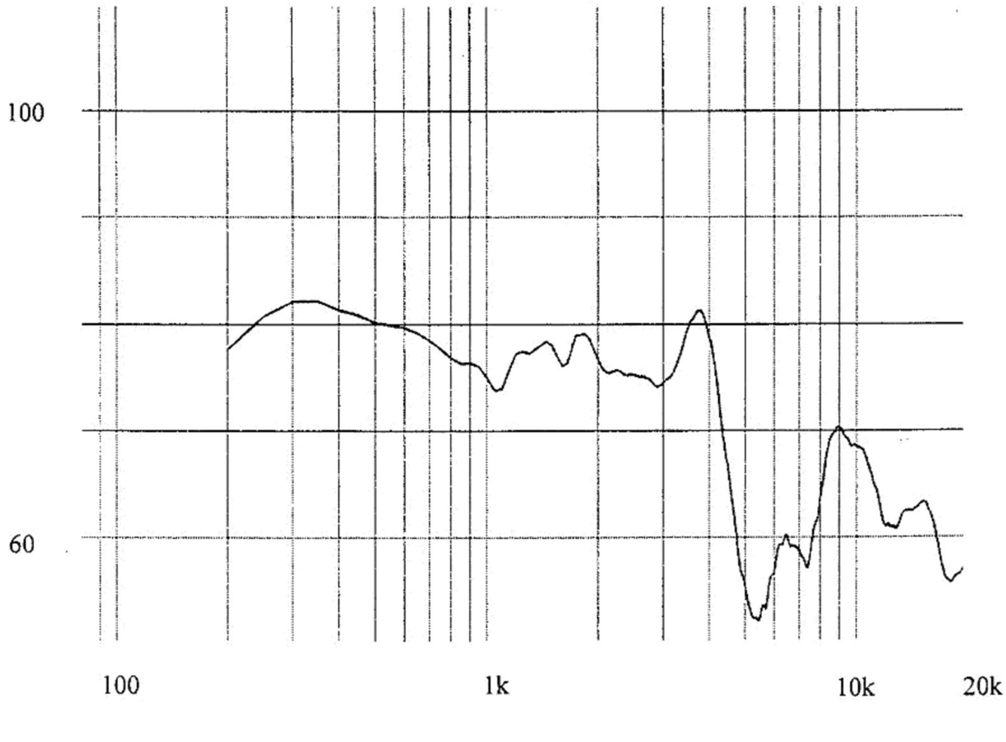
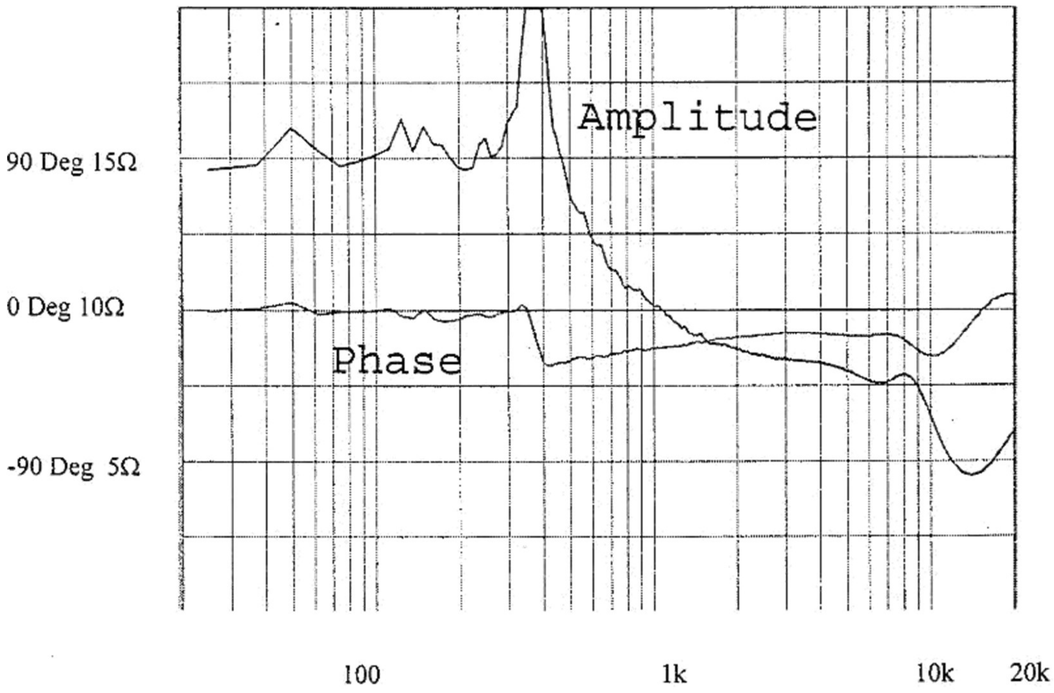


Fig. 10c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90 Deg 15Ω
0 Deg 10Ω
Phase
-90 Deg 5Ω
100
1k
10k
20k

Fig. 11

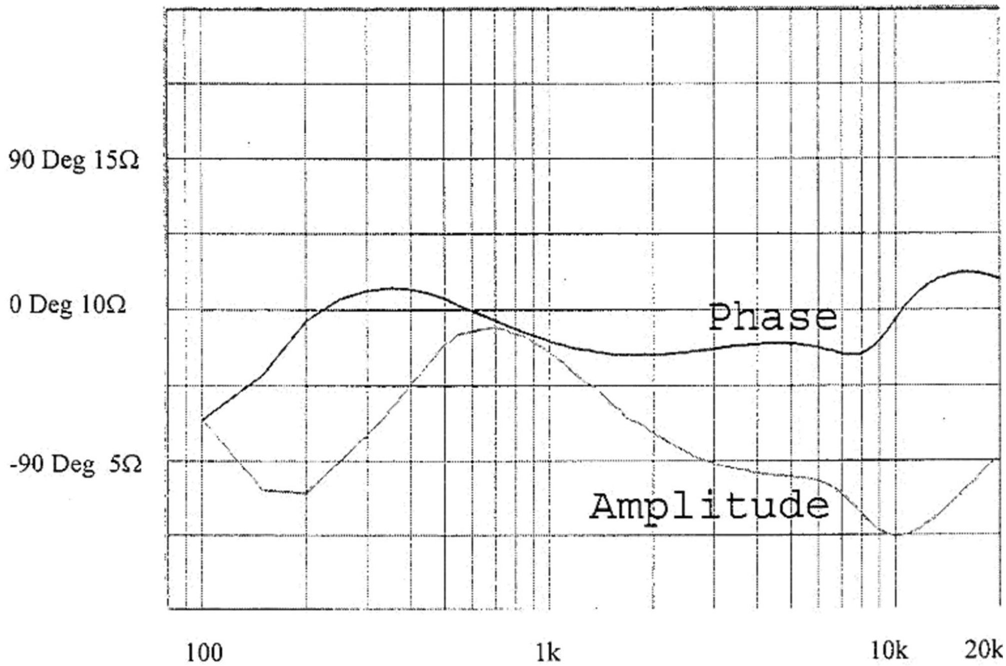
90 Deg 15Ω
0 Deg 10Ω
Phase
-90 Deg 5Ω
Amplitude
100
1k
10k
20k

Fig. 12

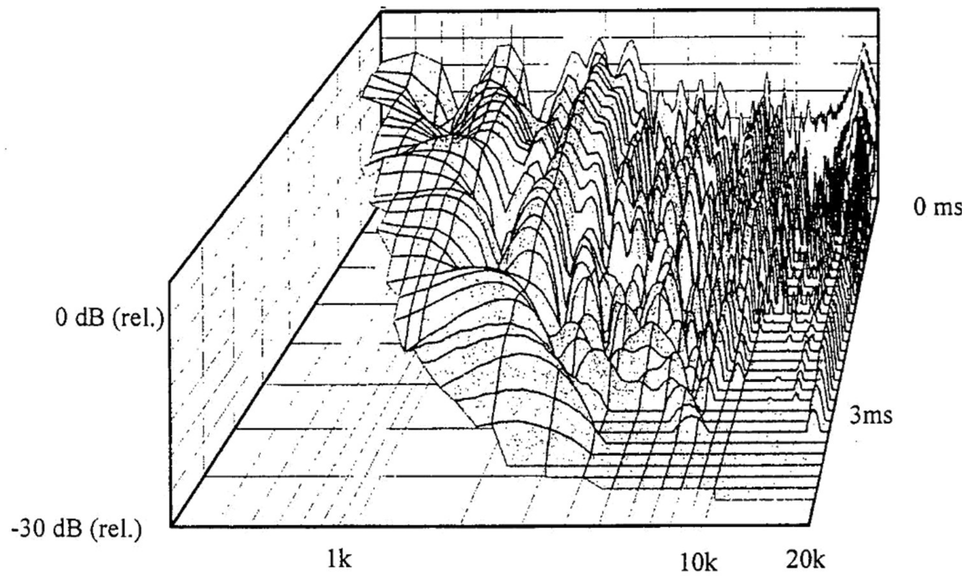
0 dB (rel.)
-30 dB (rel.)
1k
10k
20k
0 ms
3ms

Fig. 13

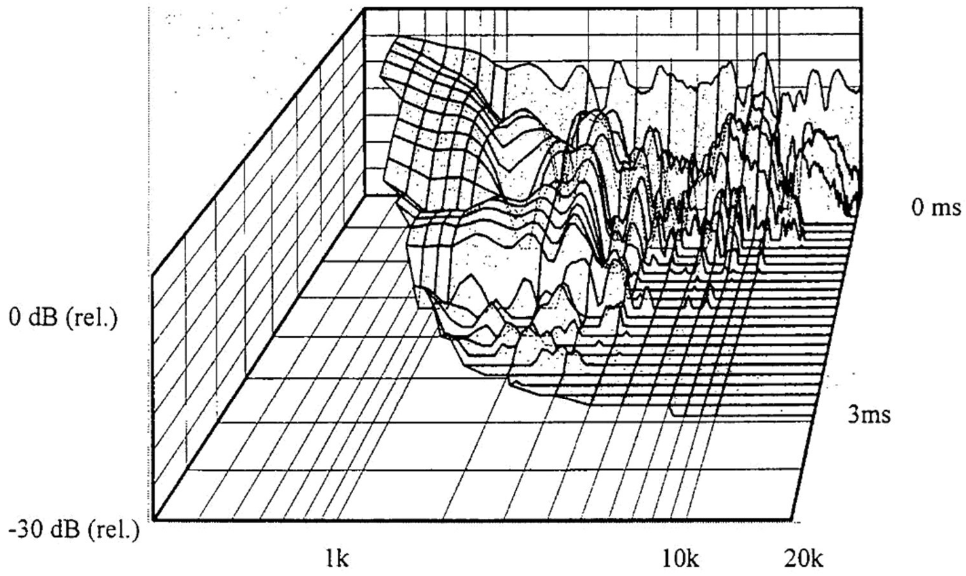
0 dB (rel.)
-30 dB (rel.)
1k
10k
20k
0 ms
3ms

Fig. 14