(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 182 907 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.02.2002 Bulletin 2002/09

(51) Int Cl.^{7}: **H04R 9/00**

(21) Application number: **01307079.2**

(22) Date of filing: **20.08.2001**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.08.2000 JP 2000253584**

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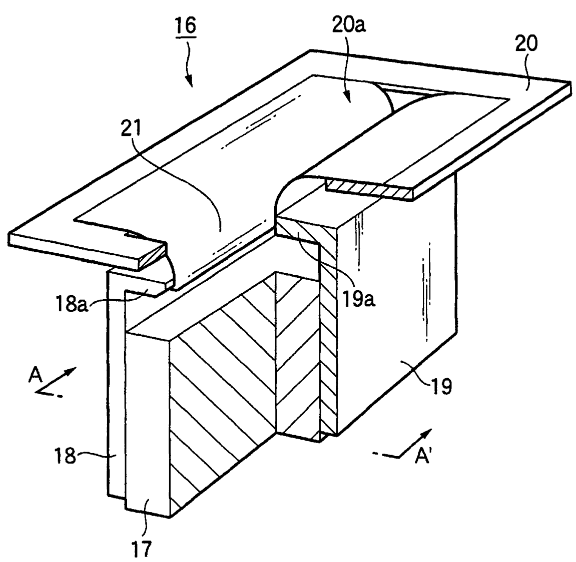
(54) **Electroacoustic transducer**

(57) Conductor pattern portions CLa1 and CLb1 are printed on a center portion of a polymeric resin film, and the center portion is folded and then bonded, thereby forming a diaphragm 21 which integrally has a flat plate-like portion 23 having the conductor pattern portions CLa1 and CLb1, and first and second vibrating sections 21a and 21b having a curved shape. A magnet 17 and yokes 18 and 19 form a magnetic circuit and a magnetic gap MG. The flat plate-like portion 23 is inserted into the magnetic gap MG. The whole diaphragm 21 is supported by a support member 20 in a floating state. In this structure, when an audio signal is supplied to the conductor pattern portions CLa1 and CLb1, the flat plate-like portion 23 is vibrated in a direction H by dynamic force generated by the magnetic field in the magnetic gap MG, and currentin the conductor pattern portions CLa1 and CLb1 which are inserted into the magnetic gap MG, and also the first and second vibrating sections 21a and 21b are vibrated in the direction H, so that a reproduced sound of excellent high-frequency characteristics is released.

FIG.1



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Description

1. Field of the Invention

[0001] The present invention relates to an electroacoustic transducer such as an audio speaker, and more particularly to an electroacoustic transducer having excellent characteristics in the high frequency region.

2. Description of the Related Art

[0002] Conventionally, as an electroacoustic transducer of this kind, known are audio speakers respectively having structures shown in Figs. 14 and 15.

[0003] The conventional audio speaker shown in the section view of Fig. 14 comprises: a diaphragm 3 which is stretched between support members 1 and 2; and plural pairs of magnets 4a and 4b to 6a and 6b in each of which the paired magnets are vertically opposed to each other across a diaphragm 3.

[0004] The diaphragm 3 has a structure in which a conductor pattern 7 corresponding to a voice coil is formed on the surface of a flat plate-like thin film material.

[0005] The magnets 4a and 4b to 6a and 6b are arranged so that gaps are formed at predetermined intervals L in a lateral direction. According to this configuration, the conductor pattern 7 crosses magnetic fields generated by the magnets 4a and 4b to 6a and 6b, and a reproduced sound is released in the vertical direction X through the gaps of the interval L.

[0006] In this structure, when an audio signal is applied to the conductor pattern 7, the whole diaphragm 3 is vibrated in the vertical direction X by the driving force generated by magnetic fluxes between the magnets 4a and 4b to 6a and 6b and the conductor pattern 7, and the reproduced sound which is generated by the vibrations is released in the vertical direction X through the gaps of the interval L.

[0007] The conventional audio speaker shown in the section view of Fig. 15 comprises: a diaphragm 8 having curved portions 8b and 8c; support members 9 and 10 which supports the diaphragm 8; yokes 11a, 11b, 12a, and 12b which are opposed to each other across a portion 8a of the diaphragm 8; and magnets 13a and 13b.

[0008] The diaphragm 8 is configured by the three portions 8a, 8b, and 8c which are formed basically by a thin film material. The first portion 8a is sandwiched by the yokes 11a, 11b, 12a, and 12b and the magnets 13a and 13b. The second and third portions 8b and 8c are coupled to an upper end P of the first portion 8a, and convexly upward curved in right and left sides, respectively. In the first portion 8a, conductor patterns 14 and 15 corresponding to a voice coil is formed on the surface of the film material. The outer ends of the second and third portions 8b and 8c are supported by the support members 9 and 10, respectively, whereby the whole of the diaphragm 8 including the first portion 8a is supported in a floating state by the support members 9 and 10.

[0009] The yokes 11a and 11b, and 12a and 12b are opposedly arranged across the conductor patterns 14 and 15 with forming an interval W therebetween, respectively. According to this configuration, the conductor patterns 14 and 15 cross magnetic fields generated by the yokes 11a and 11b, and 12a and 12b.

[0010] In this structure, when an audio signal is applied to the conductor patterns 14 and 15, the first portion 8a of the diaphragm 8 is vibrated in the vertical direction X by the driving force generated by magnetic fluxes between the yokes 11a and 11b, and 12a and 12b and the conductor patterns 14 and 15, and the second and third portions 8b and 8c are vibrated in conjunction with the first portion 8a, whereby the reproduced sound which is generated by the vibrations of the second and third portions 8b and 8c is released in the vertical direction X.

[0011] In the conventional audio speaker shown in Fig. 14, since the magnets 4a and 4b to 6a and 6b are disposed so as to sandwich the diaphragm 3, however, the reproduced sound which is generated by the vibrations of the diaphragm 3 is blocked by the magnets 4a and 4b to 6a and 6b, thereby producing a problem in that the sound pressure characteristics and the high-frequency characteristics are lowered. Namely, the reproduced sound which is generated by the vibrations of the diaphragm 3 is released only through the gaps of the interval L between the magnets 4a and 4b to 6a and 6b, and hence there is a problem in that the sound pressure characteristics and the high-frequency characteristics are lowered.

[0012] Furthermore, the frequency characteristics of the reproduced sound which is generated by the vibrations of the diaphragm 3 are affected by the frequency characteristics (transfer function) of the space defined by the magnets 4a and 4b to 6a and 6b, thereby producing another problem in that the frequency characteristics are changed.

[0013] In order to enhance the sound release effect, the intervals L between the magnets 4a and 4b to 6a and 6b may be increased. In this case, the efficiency of the magnetic circuit is lowered, and it is therefore very difficult to obtain a high magnetic flux density the absolute value of which is larger than, for example, 0.5 Tesla, as the magnetic flux density of the magnets 4a and 4b to 6a and 6b, with the result that there arises a problem in that the sensitivity of the speaker is low.

[0014] In the conventional audio speaker shown in Fig. 15, the diaphragm 8 of the integrated structure is formed by bonding in the upper end P the separate first, second, and third portions 8a, 8b, and 8c, by means of an adhesive agent or the like. This causes problems in that the diaphragm 8 is large in weight and its high-frequency characteristics are lowered, and that the number of production steps is increased.

[0015] The speaker has the structure in which the conductor patterns 14 and 15 of the diaphragm 8 are inserted into the two gaps (magnetic gaps) between the upper yokes 11a and 11b, and the lower yokes 12a and 12b, respectively. Namely, the magnetic circuit has the two magnetic gaps according to the two conductor patterns 14 and 15. Therefore, a current must flow through the conductor patterns 14 and 15 in opposite directions in accordance with an audio signal, and the magnetic field in the magnetic gap between the upper yokes 11a and 11b must be opposite in direction to that in the magnetic gap between the lower yokes 12a and 12b, so that the magnetic circuit is complicated. As a result, there arise problems such as that the conductor patterns 14 and 15 must be formed into a complicated pattern, and that the production cost is increased.

[0016] Since the conductor patterns 14 and 15 of the diaphragm 8 are separately formed so as be vertically juxtaposed along the vibrating direction (the vertical direction X), the vibrational energy of the first portion 8a is not sufficiently transmitted to the second and third portions 8b and 8c, thereby producing a problem in that the energy loss is large. Particularly, the vibrational energy which is generated in the first portion 8a by the magnetic circuit consisting of the lower conductor pattern 15 that is remote from the upper end P, and the yokes 12a and 12b attenuates during propagation to the second and third portions 8b and 8c. As a result, there arises a problem in that the sound pressure characteristics and the frequency characteristics in the high frequency region are lowered.

[0017] As a method of improving the defect of attenuation of the vibrational energy, it may be contemplated to employ a method in which the rigidity of the base material (film material) of the first portion 8a is enhanced. When this method is employed, it is required, for example, to increase the weight of the whole diaphragm 8, or to increase the thickness of the first portion 8a. As a result, there arises a problem in that it is eventually difficult to improve the sound pressure characteristics and the frequency characteristics in the high frequency region.

[0018] It is an object of the invention to provide an electroacoustic transducer which can solve the problems of the conventional art, and in which characteristics such as the sound pressure characteristics and the frequency characteristics in the high frequency region are excellent, and miniaturization, a high efficiency, and a low production cost can be realized.

[0019] In order to attain the object, the electroacoustic transducer of the invention is an electroacoustic transducer having a thin diaphragm which is formed into a curved shape, wherein the transducer has a structure in which a thin linear conductor is formed integrally on a surface of the diaphragm, and only a region of the diaphragm where the conductor is formed is inserted into a magnetic gap of a magnetic circuit.

[0020] In order to attain the object, the electroacoustic transducer of the invention is characterized in that the conductor is formed in a center region of the diaphragm, and a flat-plate like portion which is formed by folding and bonding the center region is inserted into the magnetic gap.

[0021] In order to attain the object, the electroacoustic transducer of the invention is characterized in that the transducer has a structure in which the magnetic gap is formed in an even number of places, the conductor is formed to be substantially axisymmetrical with respect to the center region of the diaphragm, and an even number of portions of the conductor which is substantially axisymmetrical with respect to the center region are inserted into the even number of magnetic gaps, respectively.

[0022] In the thus configured electroacoustic transducer of the invention, the diaphragm is formed into a curved shape, and the conductor is formed integrally on the surface of the diaphragm. In the diaphragm, only the region where the conductor is formed is inserted into the magnetic gap, a driving force is generated by an interaction between a current change caused in the conductor in response to a supply of an audio signal, and the magnetic field in the magnetic gap, and the whole diaphragm is vibrated by the driving force to release a reproduced sound.

In the Drawings;

[0023]

Fig. 1 is a partially cutaway perspective view showing the structure of a first embodiment of the invention.

Fig. 2 is a longitudinal section view showing the structure of the first embodiment and taken along the line A-A' in Fig. 1.

Fig. 3 is a plan view showing in a developed form the structure of a diaphragm in the first embodiment.

Fig. 4 is a longitudinal section view showing the structure of the diaphragm in the first embodiment.

Fig. 5 is a partially cutaway perspective view showing the structure of a second embodiment of the invention.

Fig. 6 is a longitudinal section view showing the structure of the second embodiment and taken along the line B-B' in Fig. 5.

Fig. 7 is a plan view showing in a developed form the structure of a diaphragm in the second embodiment.

Fig. 8 is a longitudinal section view showing the structure of a third embodiment.

Fig. 9 is a plan view showing in a developed form the structure of a diaphragm in the third embodiment.

Fig. 10 is a longitudinal section view showing the structure of the diaphragm in the third embodiment.

Fig. 11 is a view showing the directional frequency characteristic of the speaker of the third embodiment.

Fig. 12 is a view showing the directional frequency characteristic of the speaker of the second embodiment.

Fig. 13 is a view showing the directional frequency characteristic of the speaker of the first embodiment.

Fig. 14 is a section view showing the structure of a conventional speaker.

Fig. 15 is a section view showing the structure of another conventional speaker.

[0024] Hereinafter, embodiments of the invention will be described with reference to the accompanying drawings. The embodiments which will be described are high-frequency audio speakers which can perform reproduction in a high frequency region of, for example, 20 kHz or higher.

[0025] Fig. 1 is a perspective view showing the structure of a high-frequency audio speaker of a first embodiment, partly cutaway in order to facilitate the understanding of the structure.

[0026] The high-frequency audio speaker 16 comprises: a rectangular parallelepiped magnet 17; yokes 18 and 19 which are fixed so as to sandwich the poles (N and S poles) of the magnet 17; a rectangular annular support member 20 which is substantially horizontally placed with respect to a convex upper end (magnetic pole) 18a of the yoke 18 and a convex upper end (magnetic pole) 19a of the yoke 19; and a diaphragm 21 which is supported by the support member 20 in a state where the diaphragm floats in a gap 20a of the support member 20 and between the poles 18a and 19a.

[0027] As shown in a longitudinal section view (a section view taken along the line A-A' in Fig. 1) of Fig. 2, a magnetic circuit is formed by the magnet 17 and the yokes 18 and 19. The poles 18a and 19a of the yokes 18 and 19 are opposedly arranged with forming a predetermined interval therebetween, to form a magnetic gap MG. The diaphragm 21 which is supported by the support member 20 is inserted in a floating state into the magnetic gap MG.

[0028] The magnet 17, the yokes 18 and 19, and the diaphragm 21 constitute a structure which is bilaterally symmetrical with respect to the center position of the magnetic gap MG.

[0029] As shown in a plan view (development view) of Fig. 3, the diaphragm 21 is formed basically by a rectangular polymeric resin film which has relatively high heat resistance, and which is flexible and thin (in the embodiment, the thickness is set to be within a range of 10 to 50 μm), such as polyimide, or polyester, and has a structure in which a thin conductor pattern 22 made of copper, aluminum, or another metal material of high conductivity is formed integrally on the surface of the polymeric resin film by the printing technique.

[0030] The conductor pattern 22 is configured by first and second conductor patterns 22a and 22b which are substantially axisymmetrical with respect to a portion indicated by the phantom broken line Q in Fig. 3, and which are electrically integrated with each other. The first conductor pattern 22a which is rectangular and helical so as to become larger as moving in a counterclockwise direction from the inner side to the outer side is formed in a portion (hereinafter, referred to as "first vibrating section") 21a which is on the left side in the figure with respect to the portion indicated by the phantom broken line Q. The second conductor pattern 22b which is rectangular and helical so as to become smaller as moving in a clockwise direction from the outer side to the inner side is formed in a portion (hereinafter, referred to as "second vibrating section") 21b which is on the right side in the figure with respect to the portion indicated by the phantom broken line Q. The first and second conductor patterns 22a and 22b are electrically connected to each other at one end QP of the portion indicated by the phantom broken line Q.

[0031] Specifically, the first conductor pattern 22a is formed into a rectangular and helical shape by: a linear conductor pattern portion (corresponding to a voice coil) CLa1 which is on the side of the phantom broken line Q; a conductor pattern portion (corresponding to a voice coil) CLa2 which is on the side of the support member 20; and conductor pattern portions CLa12 through which the corresponding conductor pattern portions CLa1 and CLa2 are connected to each other. The second conductor pattern 22b is formed into a rectangular and helical shape by: a linear conductor pattern portion CLb1 which is on the side of the phantom broken line Q; a conductor pattern portion CLb2 which is on the side of the support member 20; and conductor pattern portions CLb12 through which the corresponding conductor pattern portions CLb1 and CLb2 are connected to each other. The first and second conductor patterns 22a and 22b which are electrically connected to each other are simultaneously integrally formed in a printing step, so that the production steps are simplified.

[0032] As shown in a section view of Fig. 4, the polymeric resin film which is the base material is folded along the phantom broken line Q so as to direct the first and second conductor patterns 22a and 22b to the outer side, whereby the conductor pattern portions CLa1 and CLb1 which are axisymmetrical with respect to the phantom broken line Q are positioned in a back to back relationship. As described above, the first conductor pattern 22a is formed in a counterclockwise direction, the second conductor pattern 22b is formed in a clockwise direction, and the patterns are axisymmetrical with respect to the phantom broken line Q. Therefore, the conductor pattern portions CLa1 and CLb1 are positioned in a back to back relationship by folding the polymeric resin film which is the base material, along the phantom broken line Q.

[0033] Furthermore, contacting faces AR of the polymeric resin film corresponding to the conductor pattern portions CLa1 and CLb1 are bonded together, so that the diaphragm 21 has a structure in which a portion where the conductor pattern portions CLa1 and CLb1 are formed has a flat plate-like shape, and the first and second vibrating sections 21a and 21b are arcuately widened.

[0034] In a state where the flat plate-like portion 23 corresponding to the conductor pattern portions CLa1 and CLb1 is placed in the gap 20a of the support member 20, the both outer ends of the first and second vibrating sections 21a and 21b are symmetrically fixed to the support member 20. The flat plate-like portion 23 including the linear conductor pattern portions CLa1 and CLb1 is inserted into the magnetic gap MG, and the support member 20 is then positioned and fixed to a case (not shown), thereby obtaining a structure in which, as shown in Figs. 1 and 2, the diaphragm 21 is set to a floating state, and the portion of the speaker 16 contributing to electroacoustic conversion is symmetrically structured.

[0035] Thin lead wires (not shown) of high conductivity are fused and connected to the both ends Sa and Sb of the conductor pattern 22, respectively, so as to allow an audio signal to be supplied through the lead wires.

[0036] In the thus structured speaker 16, when an audio signal is applied to the conductor pattern 22 through the lead wires, a driving current due to the audio signal flows in the same direction through the linear conductor pattern portions CLa1 and CLb1 which are inserted into the magnetic gap MG. A driving force is generated by an interaction between a change of the magnetic flux caused by the driving current flowing in the same direction in accordance with the audio signal, and the magnetic field in the magnetic gap MG. The flat plate-like portion 23 is vibrated by the driving force in a direction H which is perpendicular to the magnetic field in the magnetic gap MG.
The first and second vibrating sections 21a and 21b receive the vibrations to vibrate, whereby a reproduced sound is released.

[0037] In this way, the speaker 16 of the embodiment has the structure in which, as shown in Fig. 4, only the flat plate-like portion 23 that is very thin, and that is obtained by folding and bonding a very thin polymeric resin film is inserted into the magnetic gap MG. Therefore, it is possible to reduce the magnetic gap MG to a very small size.

[0038] Specifically, the magnetic gap MG can be set to be within a range of about 0.1 to 0.5 mm which is very smaller than a magnetic gap of a usual speaker, so that it is possible to realize a high magnetic flux density of about 1.5 Tesla.

[0039] As described above, the structure is obtained in which the first and second conductor patterns 22a and 22b are formed in counterclockwise and clockwise directions, respectively, and the conductor pattern portions CLa1 and CLb1 are positioned in a back to back relationship by the folding process. When an audio signal is applied, therefore, the driving current flows through the conductor pattern portions CLa1 and CLb1 in the same direction, and the magnetic fluxes of the same direction are generated in the conductor pattern portions, so as to enhance the magnetic flux density. As a result, it is possible to realize a speaker of a high electroacoustic conversion efficiency.

[0040] The improvement of the electroacoustic conversion efficiency is realized by the simple structure in which the first and second conductor patterns 22a and 22b are formed in counterclockwise and clockwise directions, respectively, and the conductor pattern portions CLa1 and CLb1 are positioned in a back to back relationship by the folding process. Therefore, the problems discussed in the paragraph of the conventional art, such as that the whole of the conductor patterns must have a complicated shape, and that the magnetic circuit must be complicated can be solved. As a result, simplification of the production steps, reduction of the production cost, and the like are enabled.

[0041] As shown in Figs. 2 to 4, the first and second vibrating sections 21a and 21b of the diaphragm 21 can be structured to be symmetrical about the conductor pattern portions CLa1 and CLb1 which are to be inserted into the magnetic gap MG, by the very simple means in which the polymeric resin film serving as the base material of the diaphragm 21 is folded. Therefore, the first and second vibrating sections 21a and 21b are enabled to vibrate in a well-balanced manner, so that a faithful, distortionless, and clear sound can be reproduced in accordance with an audio signal.

[0042] The first and second vibrating sections 21a and 21b which are used for generating a reproduced sound are not positioned in the magnetic circuit formed by the magnet 17 and the yokes 18 and 19, but are in an open state. Therefore, it is possible to improve the sound pressure characteristics and the frequency characteristics.

[0043] The diaphragm 21 has the simple structure in which the weight can be reduced, and enables the vibrational energy of the flat plate-like portion 23 to be transmitted to the first and second vibrating sections 21a and 21b at a high efficiency. Consequently, the reproduction characteristics in the high frequency region can be largely improved.

[0044] In the first and second conductor patterns 22a and 22b shown in Fig. 3, the linear conductor pattern portions CLa1 and CLb1 which are to be inserted into the magnetic MG are the driving portions contributing to the electroacoustic conversion. In the structure, when the conductor pattern portions CLa2, CLa12, CLb2, and CLb12 excluding the conductor pattern portions CLa1 and CLb1 are sufficiently lowered in electric resistance and formed into a pattern shape in which the weight reduction is enabled, therefore, a structure is obtained in which the sound pressure characteristics and the frequency characteristics can be easily improved.

[0045] Specifically, as shown in Fig. 3, measures such as those for lowering the electric resistance by forming the conductor pattern portions CLa2 and CLb2 which are to be fixed to the portions supported by the support member 20, to be wider, and for reducing the weight by reducing the widths of the conductor pattern portions CLa12 and CLb12 are taken. Therefore, it is possible to realize the conductor pattern 22 in which the electric loss is small as a whole and the weight is reduced. As a result, the diaphragm 21 which is light and in which the loss of the vibrational energy is very small can be realized, and the speaker 16 in which the sound pressure characteristics and the frequency characteristics in the high frequency region are excellent can be realized.

[0046] Next, a second embodiment of the invention will be described with reference to Figs. 5 to 7.

[0047] Fig. 5 is a perspective view showing the structure of a high-frequency audio speaker of the second embodiment, partly cutaway in order to facilitate the understanding of the structure.

[0048] The high-frequency audio speaker 25 comprises: two rectangular parallelepiped magnets 26 and 27; three yokes 28, 29, and 30 which are fixed so as to sandwich the poles of the magnets 26 and 27; a rectangular annular support member 33 which is substantially horizontally placed with respect to convex upper ends (magnetic poles) 31, 28a, 28b, and 32 of the yokes 28, 29, and 30; and a diaphragm 34 which is supported by the support member 33.

[0049] As shown in a longitudinal section view (a section view taken along the line B-B' in Fig. 5) of Fig. 6, a magnetic circuit is formed by the magnets 26 and 27 and the yokes 28, 29, and 30. The pole 28a of the yoke 28 and the pole 31 of the yoke 29 are opposedly arranged with forming a predetermined interval therebetween, to form a first magnetic gap MG1, and the pole 28b of the yoke 28 and the pole 32 of the yoke 30 are opposedly arranged with forming a predetermined interval therebetween, to form a second magnetic gap MG2. The support member 33 is disposed inside the yokes 29 and 30, and the yoke 28 is disposed in a gap 33a of the support member 33.

[0050] In the diaphragm 34, the ends are fixed to the support member 33, and passed through the first and second magnetic gaps MG1 and MG2, respectively, so as to have a curved shape which protrudes to the outside of the yoke 28.

[0051] The width of the diaphragm 34 is formed to be larger than the gap 33a of the support member 33. The ends of the diaphragm 34 are fixed to the inner ends of the support member 33 so as to be directed toward the magnets 26 and 27, respectively. The ends of the diaphragm 34 are curved by the same curvature toward the magnets 26 and 27, respectively, and the center portion which is passed through the first and second magnetic gaps MG1 and MG2 to protrude to the outside of the yoke 28 is curved into a semicylindrical shape, so that the whole diaphragm 34 is supported in a dynamically balanced condition by the support member 33.

[0052] The structure of the diaphragm 34 will be further described in detail with reference to a plan view (development view) of Fig. 7.

[0053] As shown in Fig. 7, the diaphragm 34 is formed basically by a rectangular polymeric resin film which has relatively high heat resistance, and which is flexible and thin (in the embodiment, the thickness is set to be within a range of 10 to 50 μm), such as polyimide, or polyester, and has a structure in which a thin conductor pattern portion 35 made of copper, aluminum, or another metal material of high conductivity is formed integrally on the surface of the polymeric resin film by the printing technique.

[0054] The conductor pattern portion 35 is substantially axisymmetrical with respect to a center portion of the rectangular polymeric resin film (the portion indicated by the phantom broken line Q), and formed into a rectangular and helical shape. In the conductor pattern portion 35, linear conductor pattern portions 35a and 35b which are parallel to the phantom broken line Q are formed with forming a predetermined interval L1 therebetween. The interval L1 is larger than the interval L2 of the first and second magnetic gaps MG1 and MG2 shown in Fig. 6 (L1 > L2).

[0055] The diaphragm 34 of this structure is fixed to the inner ends of the support member 33, and curved in three places as shown in Fig. 6, whereby the conductor pattern portions 35a and 35b are positioned in a well-balanced manner in the first and second magnetic gaps MG1 and MG2, respectively, and the portion of the phantom broken line Q constitutes a peak portion which is separated from the first and second magnetic gaps MG1 and MG2 by the same distance.

[0056] Thin lead wires (not shown) of high conductivity are fused and connected to the both ends Sa and Sb of the conductor pattern 35, respectively, so as to allow an audio signal to be supplied through the lead wires.

[0057] In the thus structured speaker 25, when an audio signal is applied to the ends Sa and Sb of the conductor pattern 35 through the lead wires, the whole diaphragm 34 is vibrated in a direction H which is perpendicular to the magnetic fields in the magnetic gaps MG1 and MG2, by two driving forces, or a first driving force which is generated by an interaction between a change of the magnetic flux in the conductor pattern portion 35a, and the magnetic field in the magnetic gap MG1, and a second driving force which is generated by an interaction between a change of the magnetic flux in the conductor pattern portion 35b, and the magnetic field in the magnetic gap MG2. As a result of the vibrations, a reproduced sound is generated and released.

[0058] In the speaker 25 of the embodiment, as shown in Fig. 7, the diaphragm 35 is realized by the very simple structure, and hence reduction of the weight, simplification of the production steps, and the like are enabled. Moreover, the frequency characteristics in the high frequency region can be largely improved by the reduction of the weight.

[0059] As shown in Fig. 6, the side ends of the diaphragm 35 where the conductor pattern portions 35a and 35b are formed are structured so as to be passed only one time through the magnetic gaps MG1 and MG2, respectively. Therefore, the interval of each of the magnetic gaps MG1 and MG2 can be set to be very small. According to the speaker 25 of the embodiment, namely, the intervals of the magnetic gaps MG1 and MG2 can be made smaller as compared with the first embodiment shown in Fig. 2 in which the polymeric resin film serving as the base material is folded and then inserted into the magnetic gap MG.

[0060] As shown in Fig. 6, the diaphragm 34 has a semicylindrical shape as a whole, and is shaped in a well-balanced manner so that unnecessary stress is not partially applied to the diaphragm. Consequently, a speaker of excellent directivity can be realized, and a faithful, distortionless, and clear sound can be reproduced in accordance with an audio signal.

[0061] The center portion of the diaphragm 34 which is used for generating a reproduced sound is not positioned in the magnetic circuit, but is in an open state. Therefore, it is possible to improve the sound pressure characteristics and the frequency characteristics.

[0062] Next, a third embodiment of the invention will be described with reference to Figs. 8 to 10. The embodiment is a high-frequency audio speaker of the structure which has the features of the speakers of the first and second embodiments.

[0063] Fig. 8 is a longitudinal section view showing the structure of the high-frequency audio speaker of the embodiment. The portions identical or corresponding to those of Figs. 2 and 6 are denoted by the same reference numerals.

[0064] Referring to the figure, the high-frequency audio speaker 36 comprises: two rectangular parallelepiped magnets 26 and 27; three yokes 28, 29, and 30 which are fixed so as to sandwich the poles of the magnets 26 and 27; a rectangular annular support member 20 which is substantially horizontally placed with respect to convex upper ends (magnetic poles) 31, 28a, 28b, and 32 of the yokes 28, 29, and 30; and a diaphragm 34 which is supported by the support member 20.

[0065] A magnetic circuit is formed by the magnets 26 and 27 and the yokes 28, 29, and 30. The pole 28a of the yoke 28 and the pole 31 of the yoke 29 are opposedly arranged with forming a predetermined interval therebetween, to form a first magnetic gap MG1, and the pole 28b of the yoke 28 and the pole 32 of the yoke 30 are opposedly arranged with forming a predetermined interval therebetween, to form a second magnetic gap MG2. The diaphragm 34 is disposed in a floating state in a gap 20a of the support member 20, and the first and second magnetic gaps MG1 and MG2.

[0066] The structure of the diaphragm 34 will be described in detail with reference to a plan view (development view) of Fig. 9.

[0067] As shown in Fig. 9, the diaphragm 34 is formed basically by a rectangular polymeric resin film which has relatively high heat resistance, and which is flexible and thin (in the embodiment, the thickness is set to be within a range of 10 to 50 μm), such as polyimide, or polyester, and has a structure in which a thin conductor pattern portion 35 made of copper, aluminum, or another metal material of high conductivity is formed integrally on the surface of the polymeric resin film by the printing technique.

[0068] The conductor pattern portion 35 is substantially axisymmetrical with respect to a center portion of the rectangular polymeric resin film (the portion indicated by the phantom broken line Q), and formed into a rectangular and helical shape.

[0069] The diaphragm is folded in two portions respectively indicated by phantom broken lines Qa and Qb which are separated from the phantom broken line Q by the same distance, whereby, as shown in Fig. 10, a conductor pattern portion 35a on the side of the phantom broken line Qa, and a conductor pattern portion 35b on the side of the phantom broken line Qb are directed to the outside. Furthermore, contacting faces ARa of the polymeric resin film corresponding to the conductor pattern portion 35a are bonded together, and contacting faces ARb of the polymeric resin film corresponding to the conductor pattern portion 35b are bonded together. As a result, formed is the diaphragm 34 in which portions 23a and 23b where the conductor pattern portions 35a and 35b have a flat plate-like shape, and an inner vibrating section 34c between the flat plate-like portions 23a and 23b, and outer vibrating sections 34a and 34b outside the flat plate-like portions 23a and 23b are curved with setting the flat plate-like portions 23a and 23b as borders.

[0070] In a state where the diaphragm 34 is placed in the gap 20a of the support member 20, the outer vibrating sections 34a and 34b are symmetrically fixed to the support member 20. The flat plate-like portion 23a corresponding to the conductor pattern portion 35a is inserted into the first magnetic gap MG1, the flat plate-like portion 23b corresponding to the conductor pattern portion 35b is inserted into the second magnetic gap MG2, and the support member 20 is then positioned and fixed to a case (not shown), thereby obtaining a structure in which, as shown in Fig. 8, the diaphragm 34 is set to a floating state, and the portion of the speaker 36 contributing to electroacoustic conversion is symmetrically structured.

[0071] In the thus structured speaker 36, when an audio signal is applied to the ends Sa and Sb of the conductor pattern 35, the whole diaphragm 34 is vibrated in a direction H which is perpendicular to the magnetic fields in the magnetic gaps MG1 and MG2, by two driving forces, or a first driving force which is generated by an interaction between a change of the magnetic flux in the conductor pattern portion 35a, and the magnetic field in the magnetic gap MG1, and a second driving force which is generated by an interaction between a change of the magnetic flux in the conductor pattern portion 35b, and the magnetic field in the magnetic gap

MG2. As a result of the vibrations, a reproduced sound is generated and released.

[0072] In the speaker 36 of the embodiment, since the diaphragm 34 has the three portions, i.e., the inner vibrating section 34c and the outer vibrating sections 34a and 34b as described above, the area contributing to sound reproduction can be substantially increased, and hence it is possible to realize a speaker of a high efficiency. In the same manner as the first and second embodiments, since the diaphragm 34 can be formed by the simple and light structure, the sound pressure characteristics and the frequency characteristics in the high-frequency bend can be improved.

[0073] Next, features of the speakers 16, 25, and 36 of the first to third embodiments will be described on the basis of results of experiments on the directional frequency characteristic shown Figs. 11 to 13.

[0074] Fig. 11 shows the directional frequency characteristic of the speaker 36, Fig. 12 shows that of the speaker 25, and Fig. 13 shows that of the speaker 16. In Figs. 11 to 13, the abscissa represents the logarithm of the frequency (logf), and the ordinate represents the sound pressure (dB).

[0075] In each of Figs. 11 to 13, the directional frequency characteristic indicated by the two-dot chain line shows characteristics at a directivity angle of 0° which were measured with setting a microphone in the direction (on the front axis) H shown in Fig. 2, 6, or 8, the directional frequency characteristic indicated by the one-dot chain line shows characteristics at a directivity angle of 15°, the directional frequency characteristic indicated by the broken line shows characteristics at a directivity angle of 30°, the directional frequency characteristic indicated by the dotted line shows characteristics at a directivity angle of 45°, and the directional frequency characteristic indicated by the solid line shows characteristics at a directivity angle of 60°.

[0076] Referring to Fig. 11, the speaker 36 of the third embodiment has a feature in which the sound pressure in the vicinity of the front (angle of 0° or 15°) is flat as a whole, and the sound pressure in a direction of an angle of 30° or more begins at a relatively low frequency to be lowered.

[0077] Referring to Fig. 12, the speaker 25 of the second embodiment has a feature in which dispersion of the sound pressure depending on the sound pressure is not observed, the sound pressure tends to be lowered as a whole as the frequency is higher, but the reduction tendency is relatively small and the directivity is excellent.

[0078] Referring to Fig. 13, in the speaker 16 of the first embodiment, the sound pressure in the vicinity of the front (angle of 0° or 15°) is flat as a whole, and that at an angle of 30° to 60° elongates to a relatively high frequency (the point T in the figure). Namely, the speaker 16 of the first embodiment has characteristics having both the features of the speakers 25 and 36 of the second and third embodiments.

[0079] In this way, the speakers 16, 25, and 36 of the first to third embodiments exert respective characteristic directional frequency characteristics. In a design of a speaker system or the like, therefore, a desired directional frequency characteristic can be obtained by suitably selectively employing the structures of the speakers. When the structures of the speakers are adequately combined with each other, it is possible to obtain a desired directional frequency characteristic.

[0080] As described above, the electroacoustic transducer of the invention comprises a thin diaphragm which is formed into a curved shape, and has a structure in which a thin linear conductor is formed integrally on the surface of the diaphragm, and only a region of the diaphragm where the conductor is formed is inserted into a magnetic gap of a magnetic circuit. Therefore, reduction of the weight of the diaphragm, and improvement of the efficiency of electroacoustic conversion due to the conductor and the magnetic gap can be enabled, so that it is possible to provide an electroacoustic transducer in which characteristics such as the sound pressure characteristics and the frequency characteristics in the high frequency region are excellent, and miniaturization, a high efficiency, and a low production cost can be realized.

Claims

1. An electroacoustic transducer comprising:

    a thin diaphragm which is formed into a curved shape; and
    a magnetic circuit having a magnetic gap,

    characterized in that:

    a thin linear conductor is formed integrally on a surface of the diaphragm, and
    only a region of the diaphragm where the conductor is formed is inserted into the magnetic gap of the magnetic circuit.

2. The electroacoustic transducer according to claim 1, **characterized in that** the conductor is formed in a center region of the diaphragm, and a flat-plate portion which is formed by folding and bonding the center region is inserted into the magnetic gap.

3. The electroacoustic transducer according to claim 1, **characterized in that**:

    an even number of magnetic gaps are provided;
    the conductor is formed to be substantially axisymmetrical with respect to the center region of the diaphragm; and
    an even number of portions of the conductor

which is substantially axisymmetrical with respect to the center region are inserted into the even number of magnetic gaps, respectively.

FIG.1

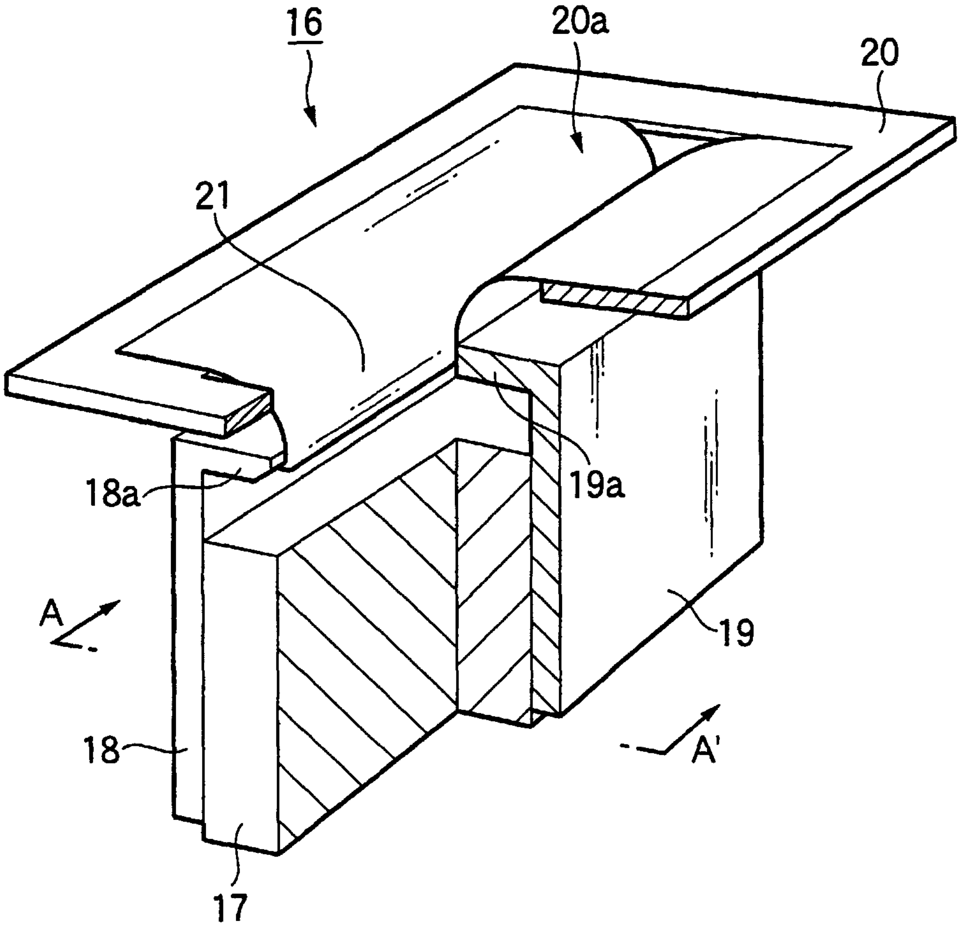


FIG.2

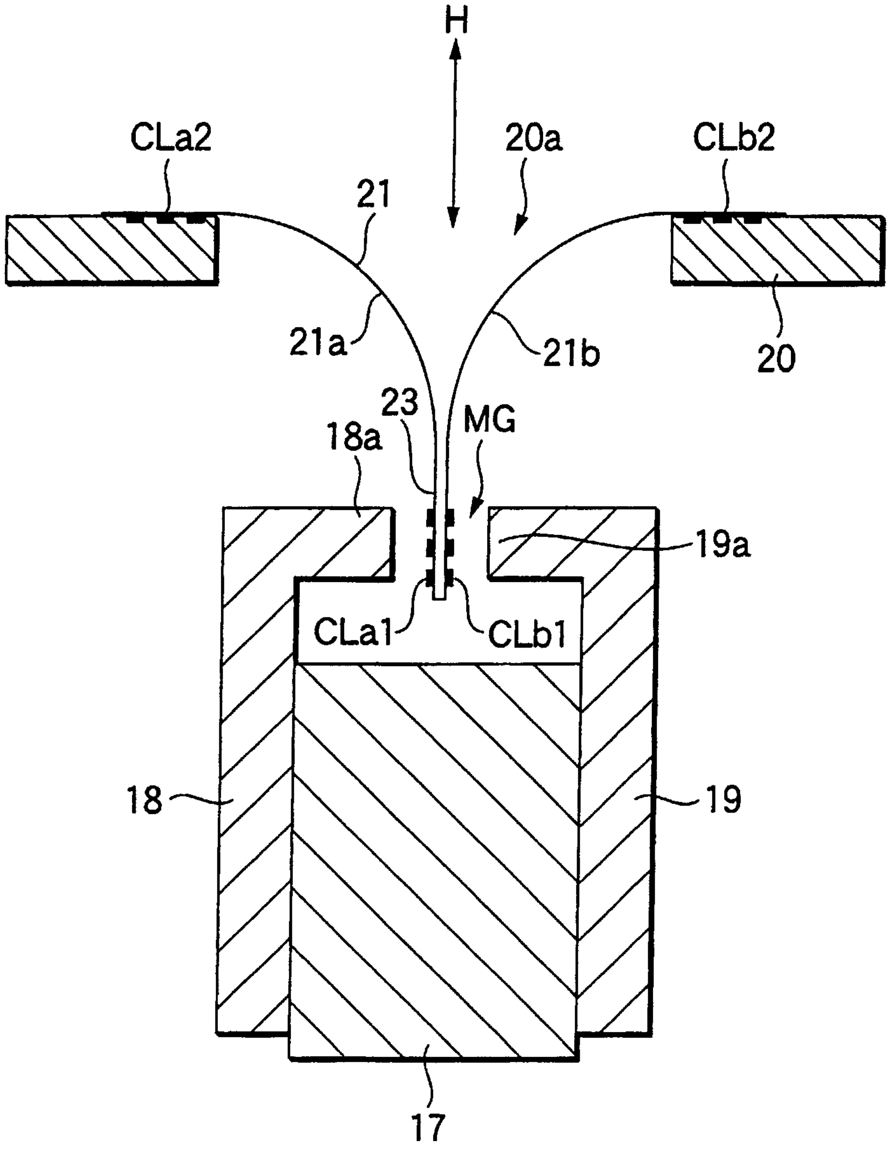


FIG.3

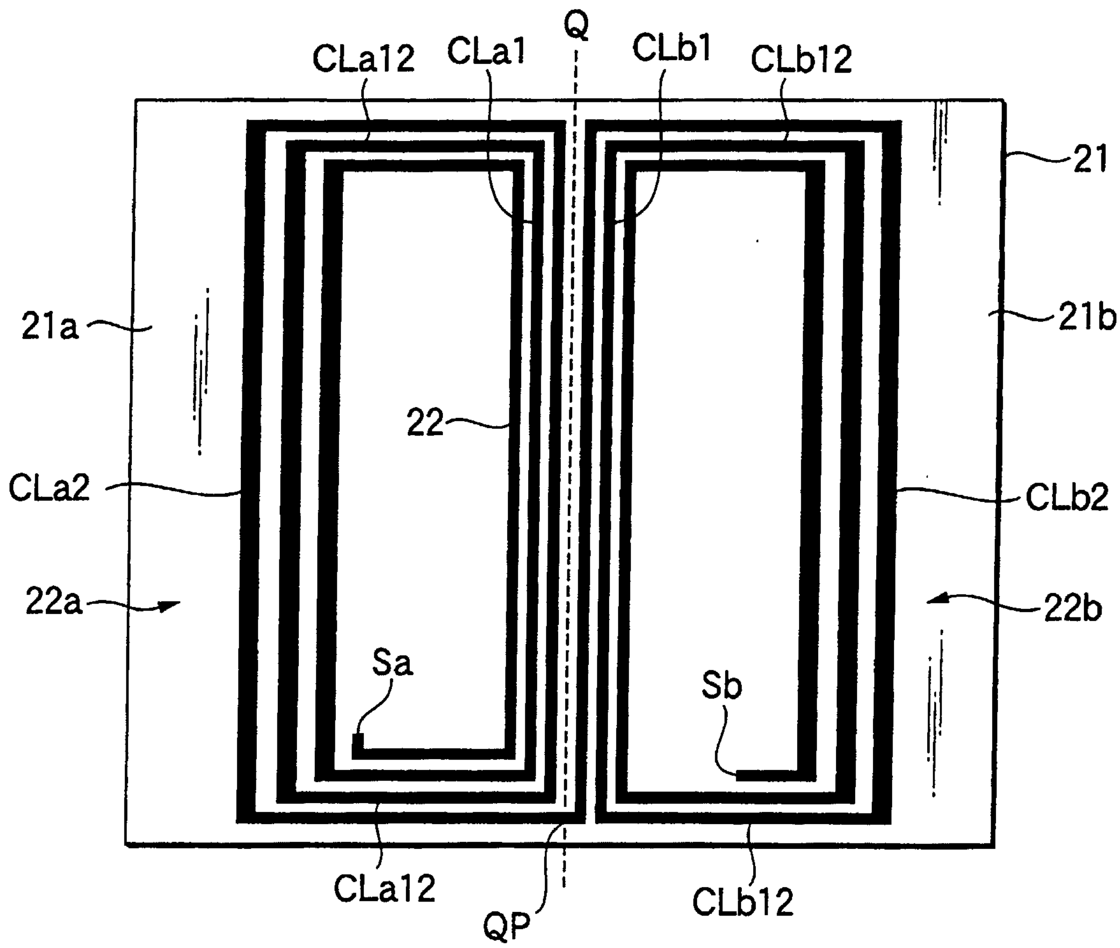

Q
CLa12
CLa1
CLb1
CLb12
21
21a
21b
22
CLa2
CLb2
22a
22b
Sa
Sb
CLa12
QP
CLb12

FIG.4

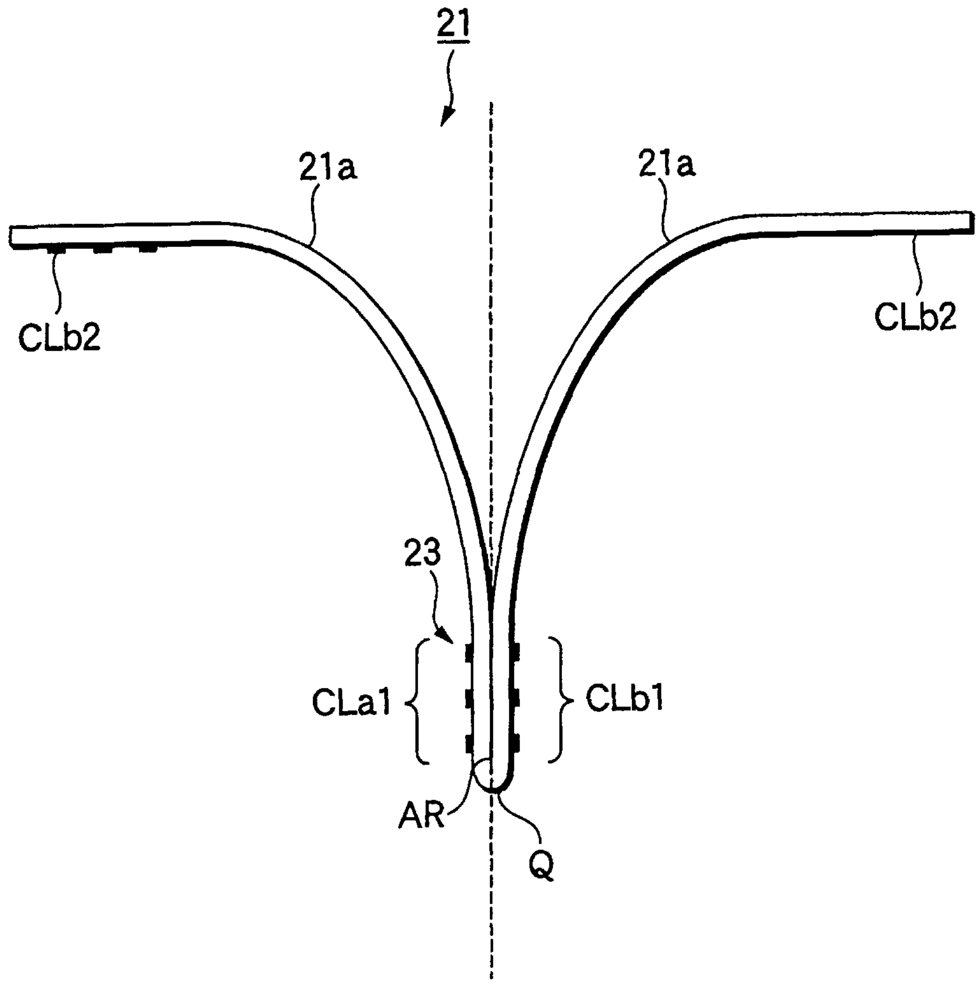


FIG.5

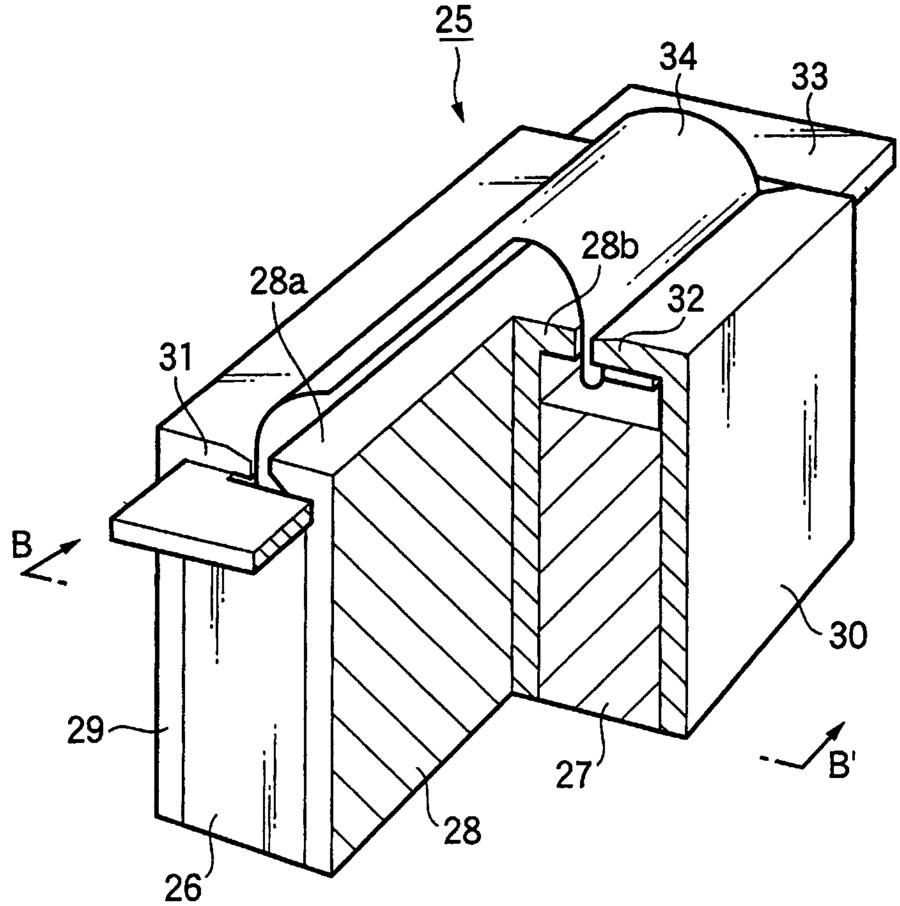


FIG.6

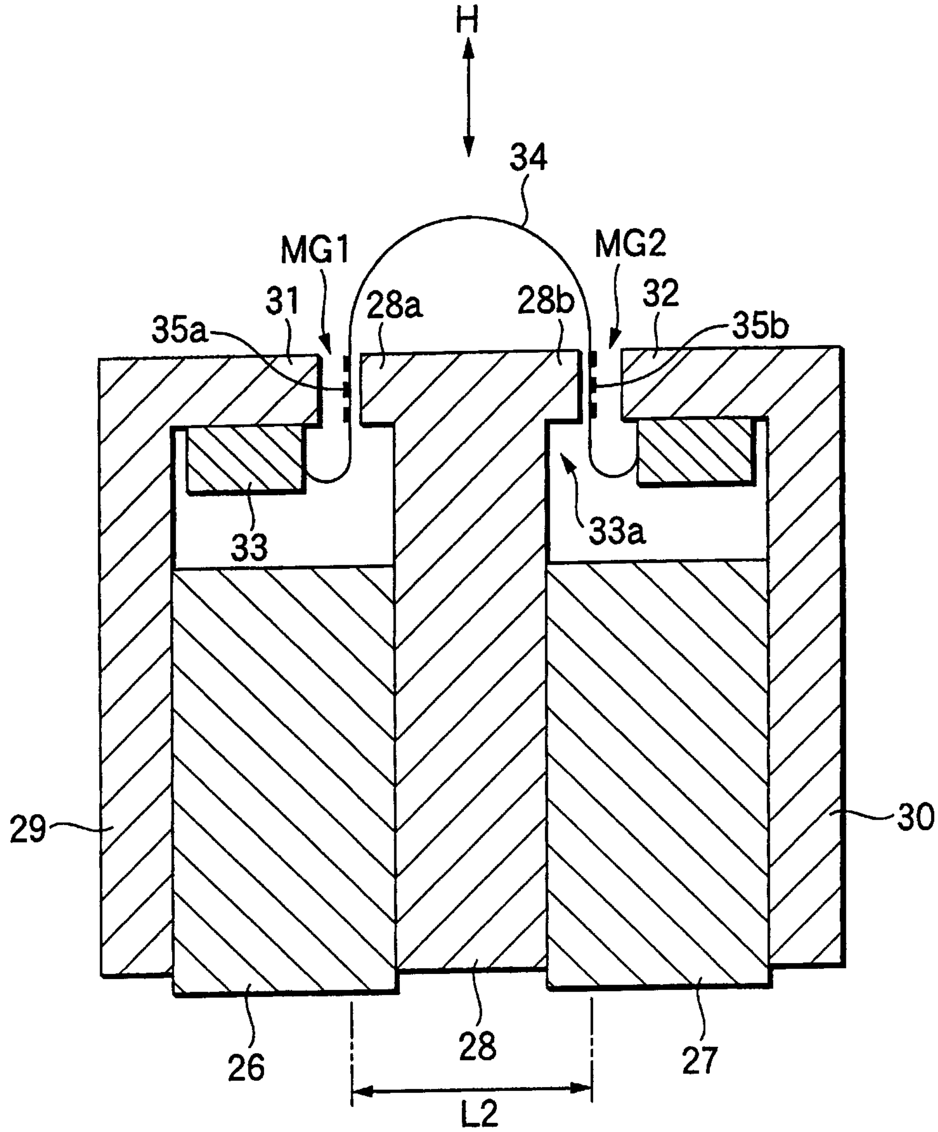


FIG.7

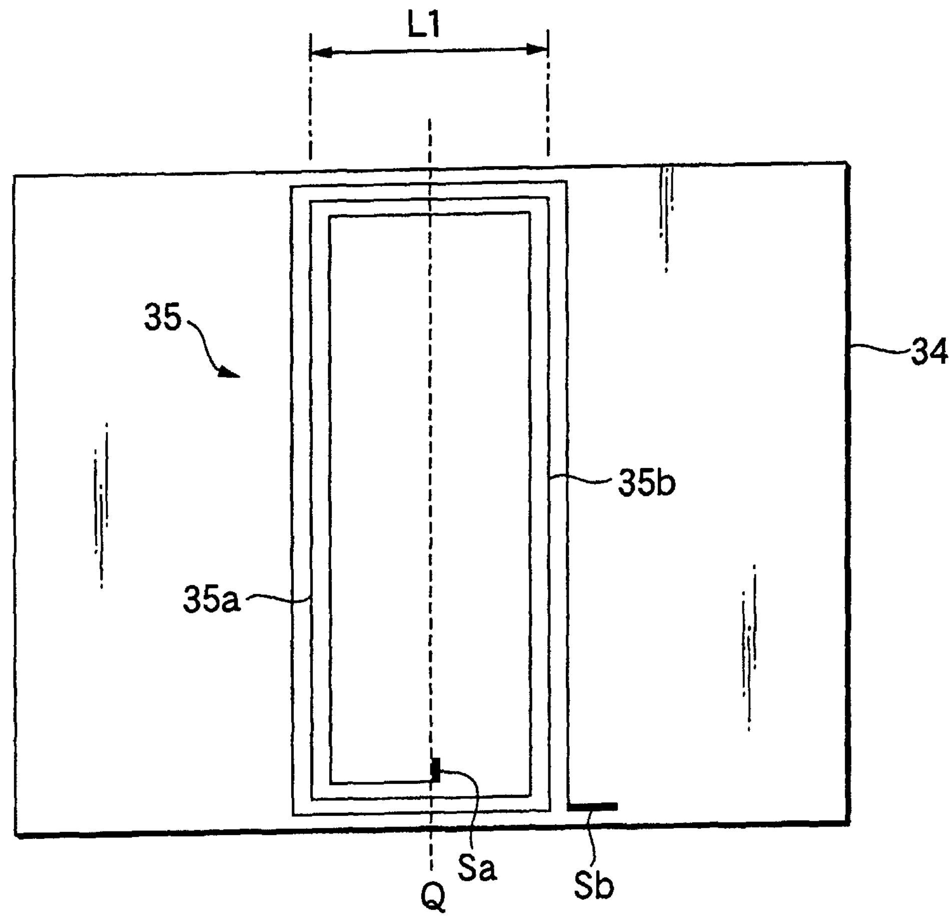


FIG.8

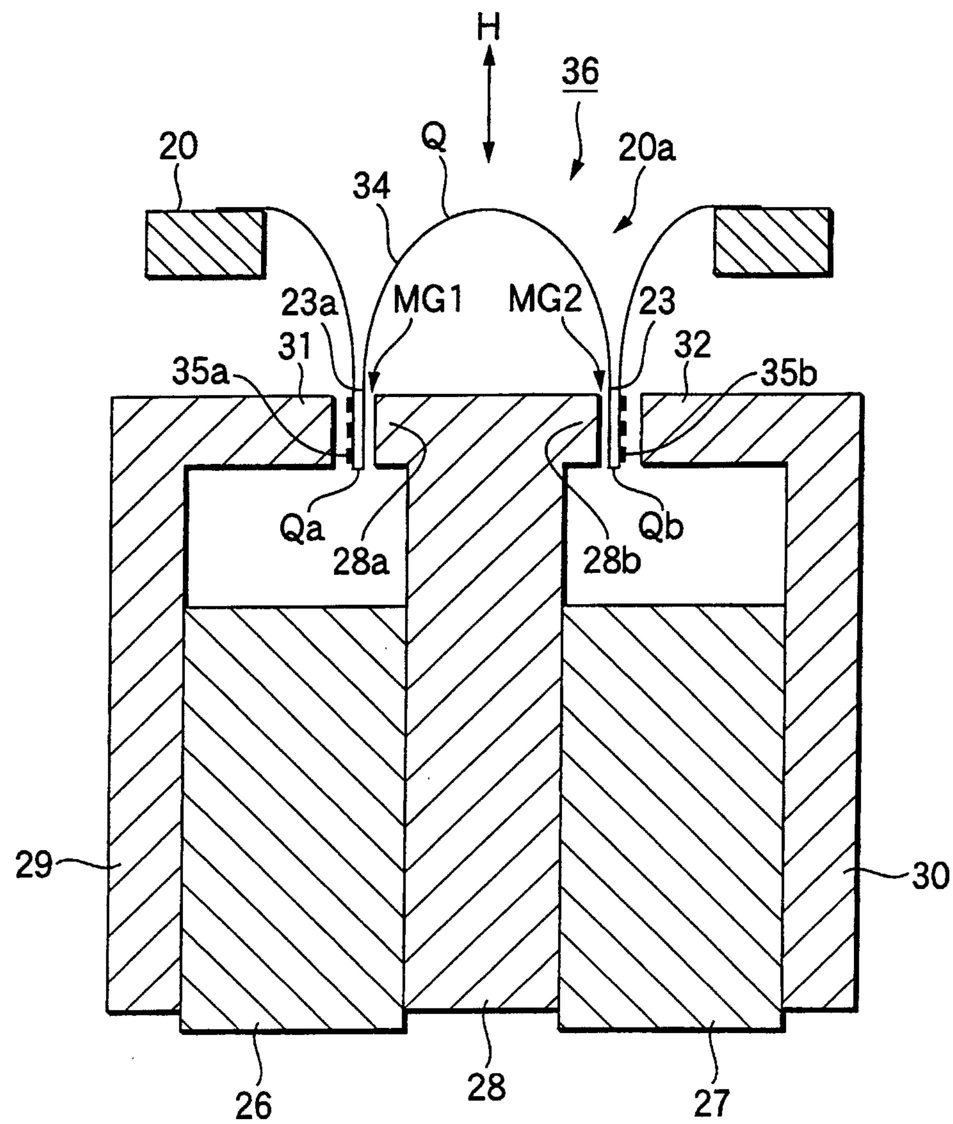

H
36
Q
20
20a
34
23a
MG1
MG2
23
31
32
35a
35b
Qa
28a
28b
Qb
29
30
26
28
27

FIG.9

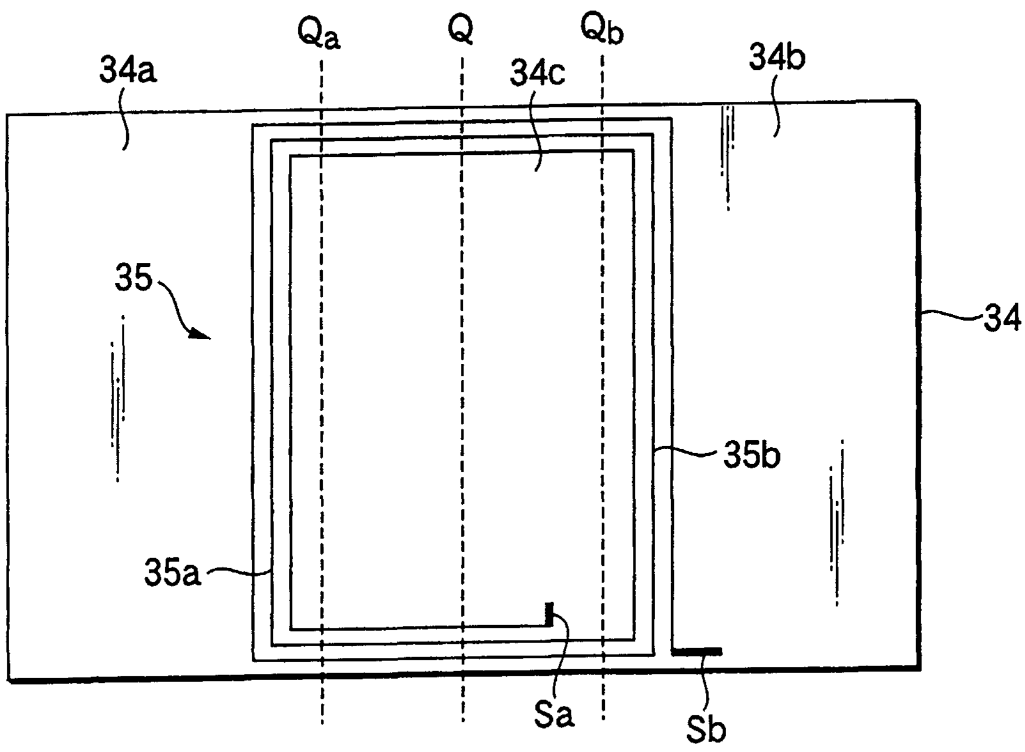


FIG.10

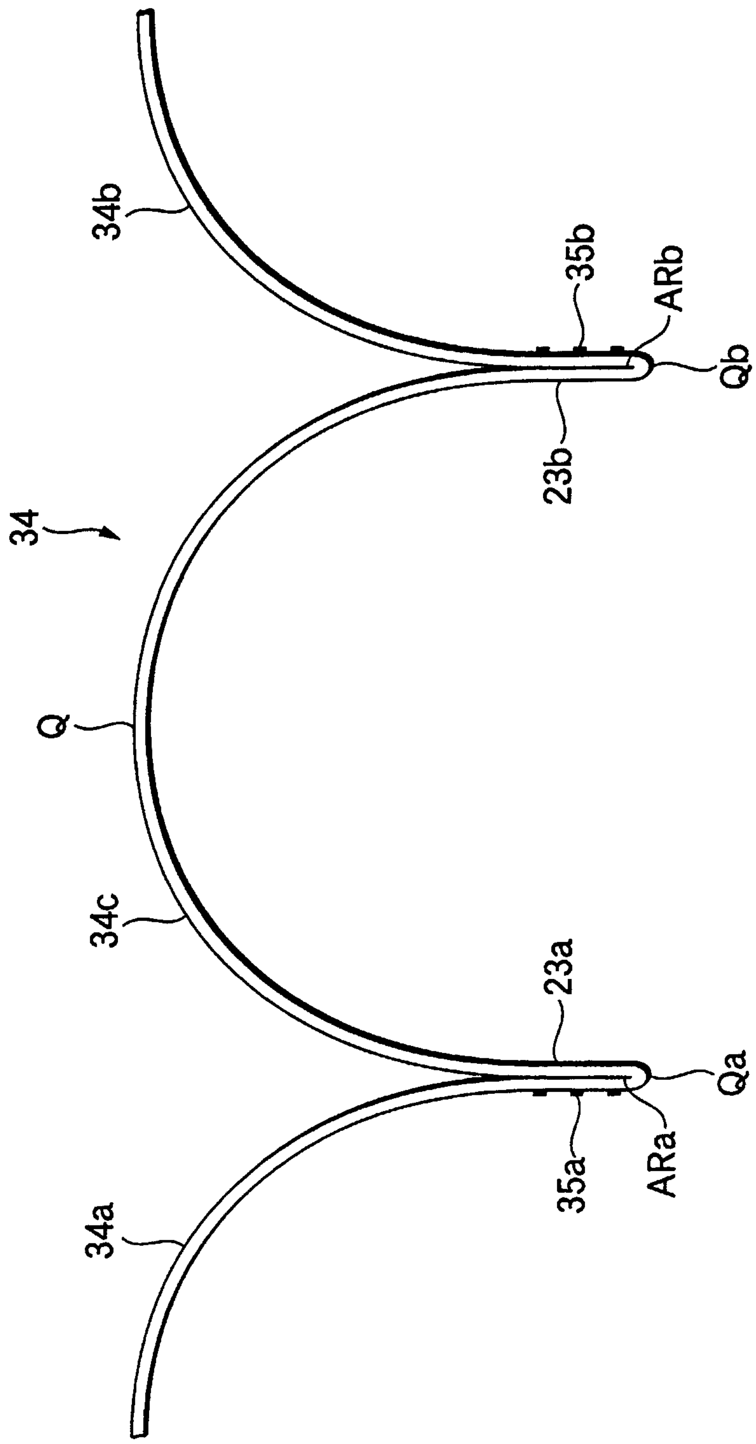


FIG.11

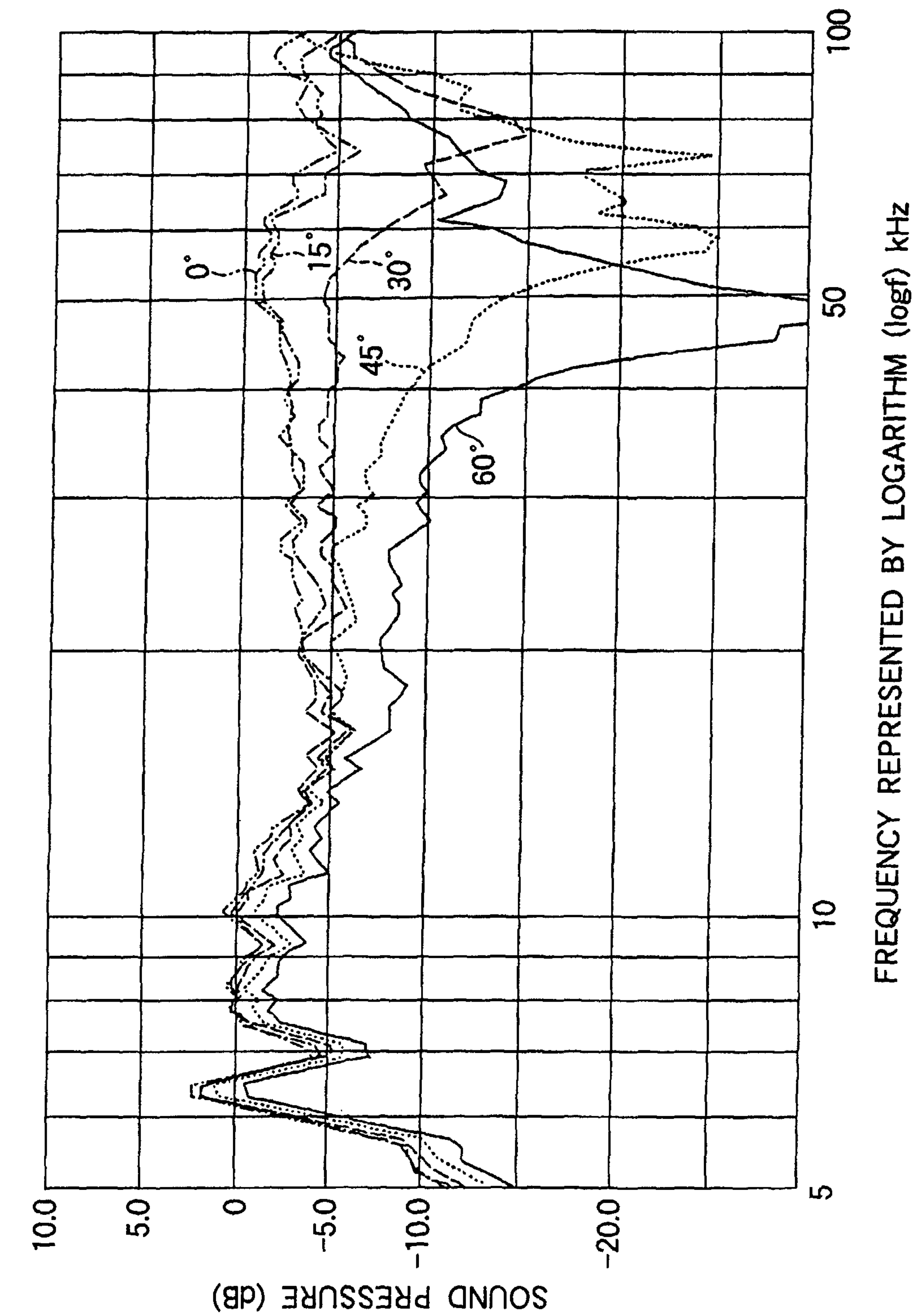

SOUND PRESSURE (dB)
10.0
5.0
0
-5.0
-10.0
-20.0
5
10
50
100
FREQUENCY REPRESENTED BY LOGARITHM (logf) kHz
0°
15°
30°
45°
60°

FIG.12

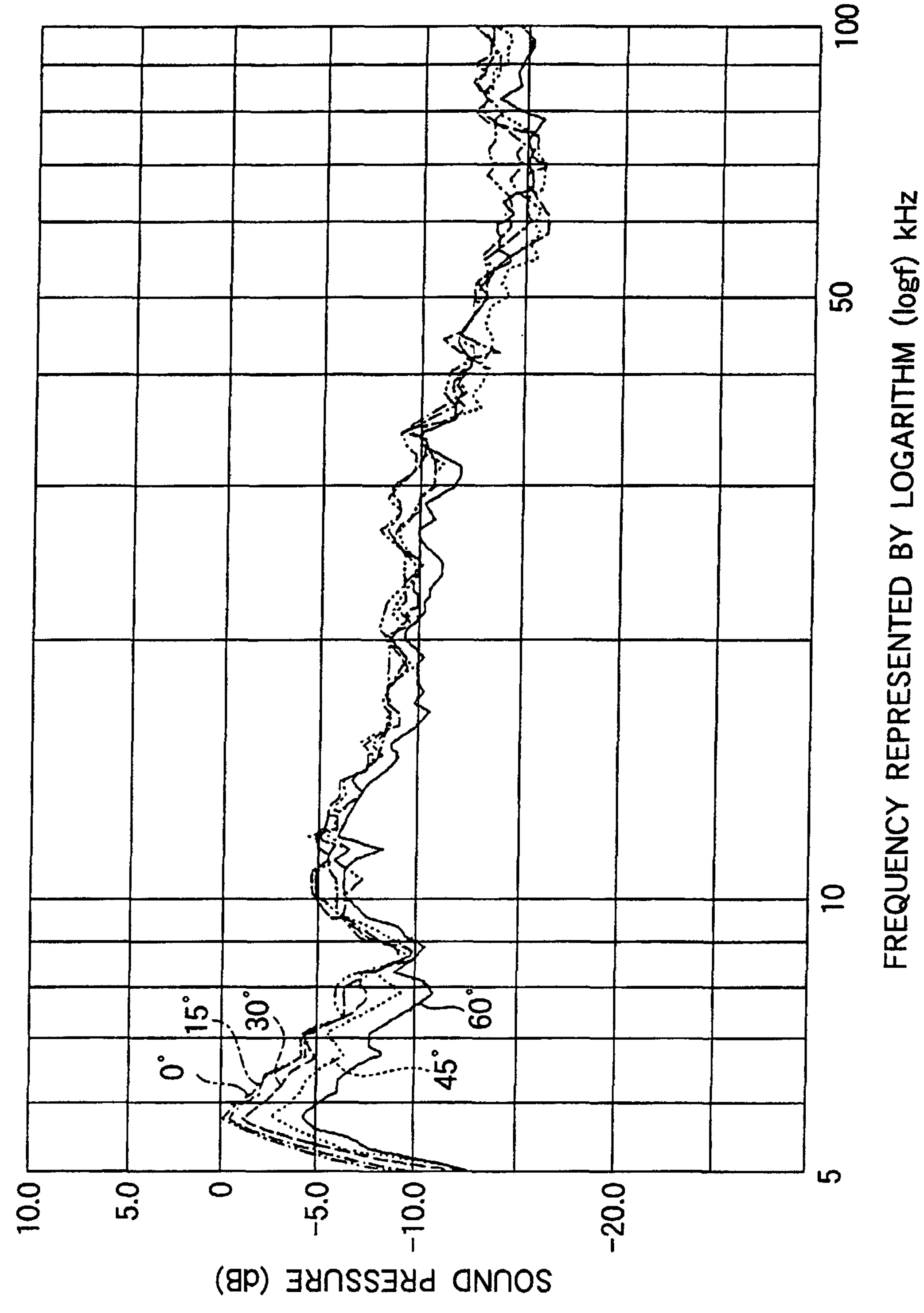
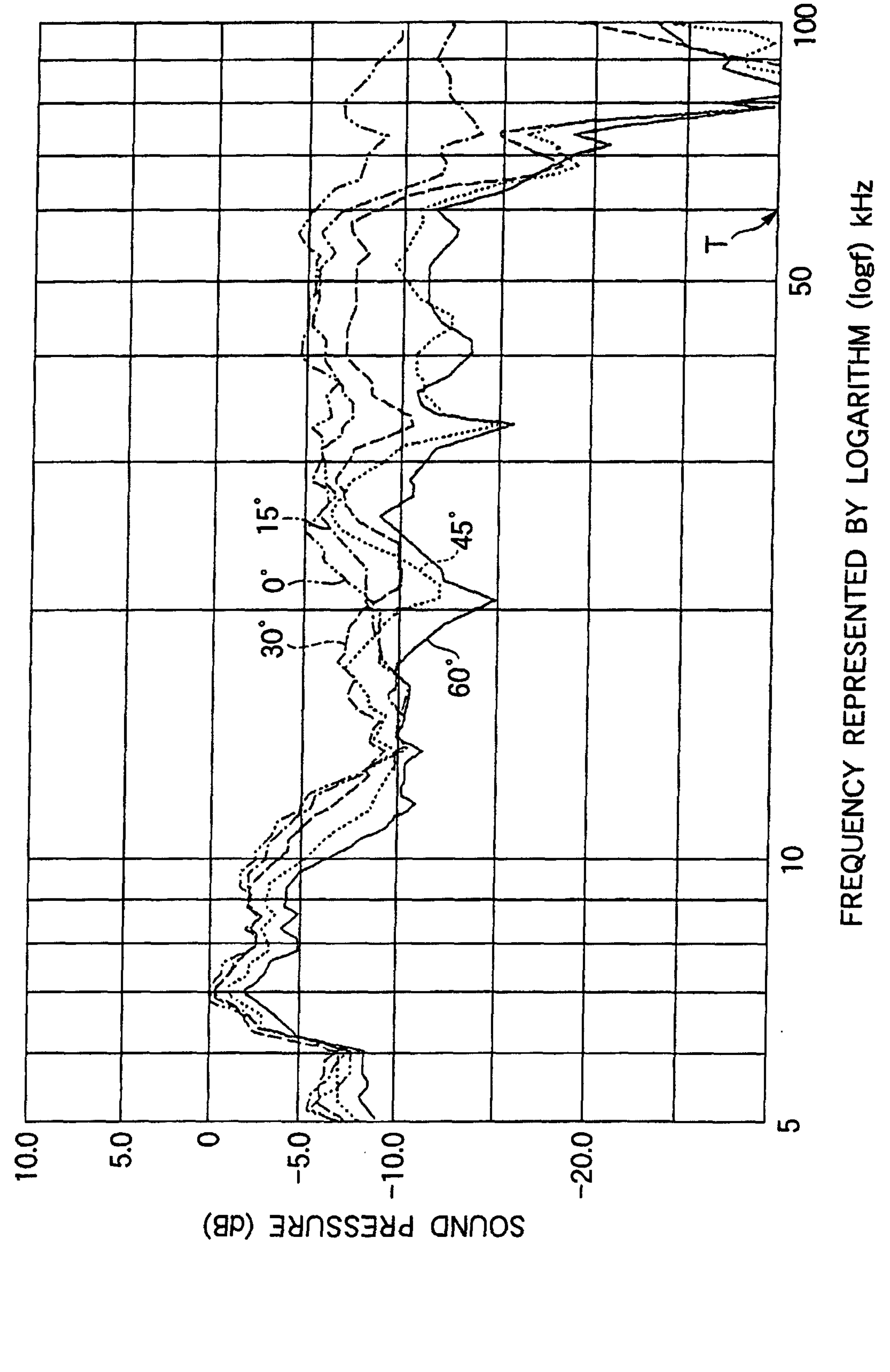

SOUND PRESSURE (dB)
10.0
5.0
0
-5.0
-10.0
-20.0
FREQUENCY REPRESENTED BY LOGARITHM (logf) kHz
5
10
50
100
0°
15°
30°
45°
60°

FIG.13



10.0
5.0
0
-5.0
-10.0
-20.0
SOUND PRESSURE (dB)
5
10
50
100
FREQUENCY REPRESENTED BY LOGARITHM (logf) kHz
0°
15°
30°
45°
60°
T

FIG.14

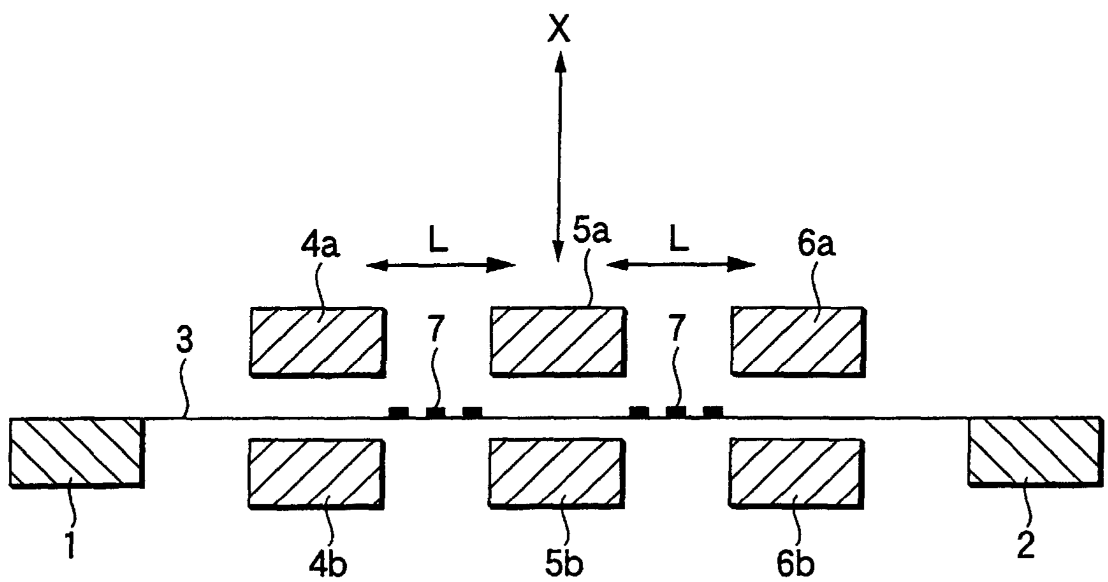


FIG.15