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AN ELECTROACOUSTIC TRANSDUCER AND A METHOD OF MANU-
FACTURING AN ELECTROACOUSTIC TRANSDUCER

The present invention relates to an electroacoustic transducer and a method of manufacturing an electro-
5 acoustic transducer.

Various types of miniature electroacoustic transducers such as microphones are known. For example, an electroacoustic microphone as shown in
10 Figures 1 and 2 is known. The electroacoustic microphone shown in Figures 1 and 2 is provided with an electrically conductive generally cylindrical casing 10, having an open window 12 for receiving sound. Disposed in casing 10 is a base 14 having a recess 16 in the side facing open window 12 of casing 10
15 and a through-hole 18 in the centre. A stationary electrode 20 is secured in recess 16 of base 14. Stationary electrode 20 is prepared by forming a film 22 of plastics material on a metal plate 24 and processing film 22 to form an electret film with
20 a conventional charging. An electrically conductive diaphragm 26 is mounted parallel with open window 12 of casing 10 and stationary electrode 20, with the periphery of diaphragm 26 clamped between an insulating spacer 28 mounted on stationary electrode
25 20 and an electrically conductive ring 30 secured to the inner wall of casing 10. Diaphragm 26 is made of, for example, a metal film or a film of

plastics material coated with a metal film and having a thickness of several microns. Metal plate 24 of stationary electrode 20 has a protruding pin 32 which penetrates through-hole 18 of base 14. Protruding pin 32 of stationary electrode 20 and casing 10 work as signal output terminals to be coupled to an external circuit (not shown).

The electroacoustic microphone shown in Figures 1 and 2 is, however, complicated in structure and there still remain certain problems from the stand-points of its operational characteristics, cost, size, manufacturing process etc.

According to the present invention from one aspect, there is provided an electroacoustic transducer comprising:

a base plate made of electrically insulating material; and

a stationary electrode formed on one side of said base plate, said stationary electrode being made of electrically conductive material, wherein the transducer further comprises:

an annular support formed on said one side of said base plate and surrounding said stationary electrode, said annular support being made of an electrically conductive material which is the same as the electrically conductive material of which said stationary electrode is made and extending higher than said stationary electrode from said base plate;

an electrically conductive diaphragm secured on said annular support and facing said stationary electrode;

a first terminal formed on the other side of said base plate, said first terminal being made of electrically conductive material;

first circuit means electrically connecting said stationary electrode to said first terminal and penetrating said insulating base plate;

5 a second terminal formed on said other side of said insulating base plate, said second terminal being made of electrically conductive material which is the same as the electrically conductive material of which said first terminal is made; and

10 second circuit means electrically connecting said annular support to said second terminal.

According to the present invention from another aspect, there is provided a method of manufacturing an electroacoustic transducer, wherein it comprises the steps of:

15 providing a substantially level base plate made of electrically insulating material with a layer, of substantially uniform thickness, of electrically conductive material applied on one side of said insulating base plate;

20 forming a stationary electrode and an annular support surrounding said stationary electrode on said one side of said base plate, by selectively removing a portion of said electrically conductive layer within an area on said base plate to leave
25 said stationary electrode and said annular support;
reducing the thickness of said stationary electrode above said insulating base plate compared with said annular support; and

30 thereafter applying an electrically conductive diaphragm on said annular support and facing said stationary electrode.

The present invention will now be described, by way of example, with reference to Figures 3 to 8 of the accompanying drawings, in which:-

35 Figure 3 is a cross-sectional view showing a preferred embodiment of an electroacoustic transducer according to the present invention;

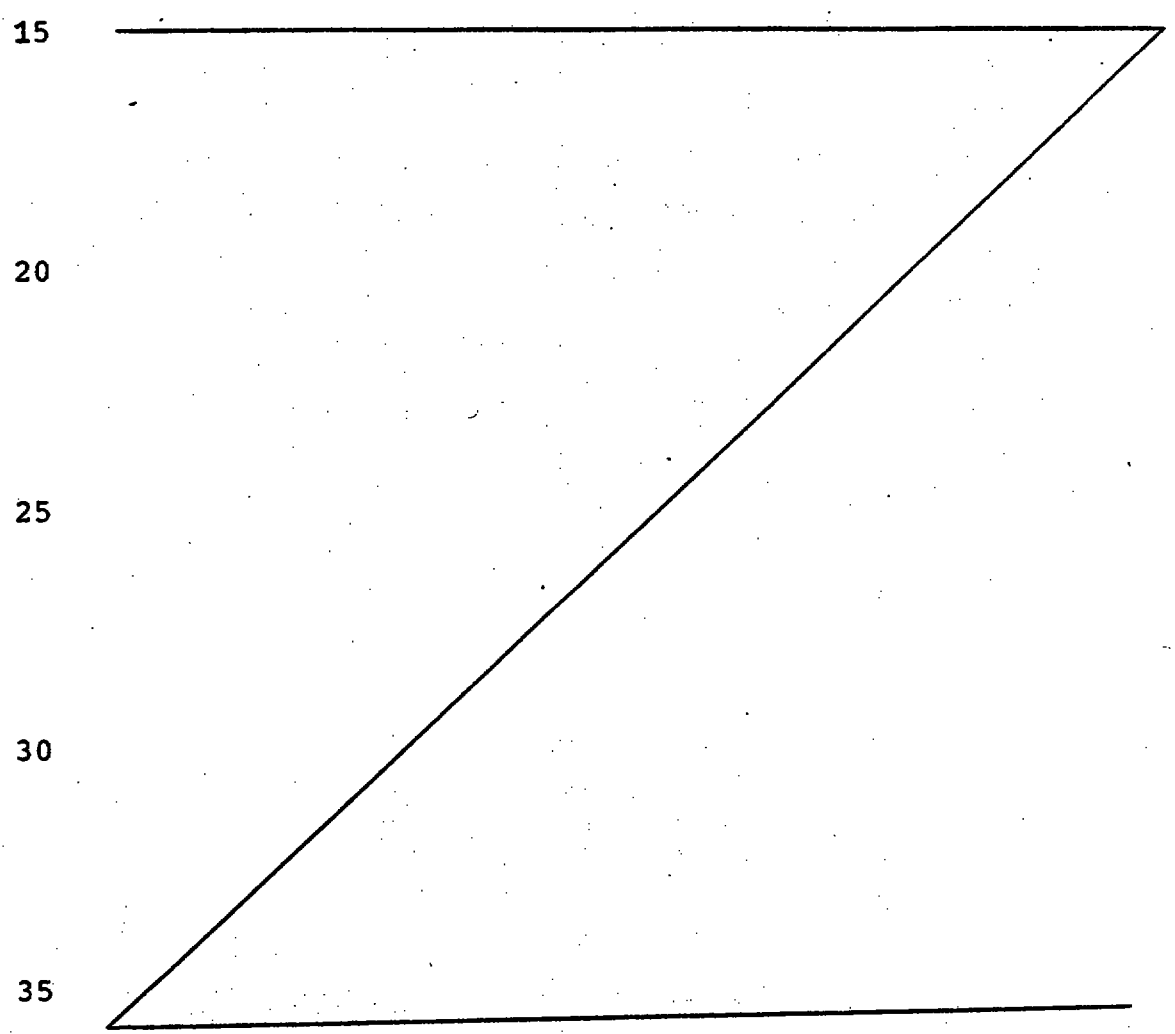
Figure 4 is a cross-sectional view of the electroacoustic transducer shown in Figure 3, taken along a line A-A;

5 Figure 5 is a cross-sectional view showing another embodiment of the present invention;

Figures 6(a) to 6(d) are cross-sectional views showing steps in the manufacture of the electroacoustic transducer shown in Figure 3;

10 Figure 7 is a cross-sectional view showing a plurality of electroacoustic transducers manufactured in accordance with an example of the present invention; and

Figure 8 is a plan view showing electroacoustic transducers according to Figure 7.



Throughout the drawings, like reference numerals or letters are used to designate like or equivalent elements.

Referring first to Figures 3 and 4, a base plate 40 is made of electrically insulating material like fibre-glass. On one side of base plate 40, a stationary electrode 42 made of electrically conductive material like copper is secured. Base plate 40 has a thickness of about 1 millimetre and stationary electrode 42 has a thickness of about less than 1 millimetre and a diameter of about 4.5 to 8.5 millimetres. An electret film 44 is secured on the top of stationary electrode 42. Electret film 44 has the same diameter as stationary electrode 42 and a thickness of several microns to several tens of microns. An annular support 46 made of the same electrically conductive material as stationary electrode 42 is secured on the same side of base plate 40 and surrounding stationary electrode 42. Annular support 46 has an outer diameter of about 6 to 10 millimetres, an inner diameter of about 5 to 9 millimetres and a thickness of about 1 millimetre, being thicker than the total thickness of stationary electrode 42 and electret film 44 by about several microns or several tens of microns.

A first terminal 48 made of an electrically conductive material such as copper is secured on the other side of base plate 40 and facing stationary electrode 42. First terminal 48 and stationary electrode 42 are electrically connected to each other via a first conductor 50 made of electrically conductive paste which fills a first through-hole 52 passing through stationary electrode 42, base plate 40 and first terminal 48 together at the centres thereof. A second terminal 54 made of the same conductive material as first terminal 48 is secured on the other side of base plate 40 and facing

annular support 46. Second terminal 54 and annular support 46 are electrically connected to each other via a second conductor 56 made of the same electrically conductive paste as first conductor 50 and filling a second through-hole 58 passing through base plate 40 and second terminal 54 together at a location adjacent the outer periphery of annular support 46. First and second terminals 48 and 54 have the same thickness, of about several tens of microns to several hundreds of microns.

An electrically conductive diaphragm 60 having a film base 60a of plastics material and a metal layer 60b coated on film base 60a is secured on the top of annular support 46. Diaphragm 60 is arranged in parallel with electret film 44 on stationary electrode 42 and has an air gap with a thickness of about several microns or several tens of microns between itself and electret film 44. A cylindrical casing 62 made of an electrically conductive material such as copper or aluminium is mounted on base plate 40 and covers annular support 46 and diaphragm 60. Casing 62 has two legs 64, 64 extending downwards from the bottom end of casing 62 and passing through base plate 40 and connected to second terminal 54 on the other side of base plate 40. Casing 62 has an open window 66 in its top and facing diaphragm 60. Cylindrical wall 68 of casing 62 has a diameter of about 8 to 12 millimetres and a thickness of about several hundreds of microns.

Figure 5 illustrates another embodiment of an electroacoustic transducer according to the present invention. The modified embodiment shown in Figure 5 corresponds to the first embodiment shown in Figures 3 and 4 except that an impedance transforming device 70 is substituted for first conductor 50; a metal plate 72 substituted for second conductor 56 connects annular support 46 and second terminal 54 and passes

across the periphery of base plate 40; and casing 62 is omitted.

Figures 6(a) to 6(d) illustrate steps for manufacturing the electroacoustic transducer shown in Figures 3 and 4. As shown in Figure 6(a), raw material 80 providing insulating base plate 40 has first and second metal foils or leaves 82 and 84, for example copper foils, respectively applied on different sides of the base plate. First metal foil 82 on one side of the base plate has the same thickness as annular support 46 shown in Figure 3. Second metal foil 84 on the other side of the base plate has the same thickness as first and second terminals 48 and 54 shown in Figure 3.

Referring to Figure 6(b), first metal foil 82 is processed by a first etching operation to leave only a round disc portion providing stationary electrode 42 and an annular portion providing annular support 46. Second metal foil 84 is processed by a second etching operation like the first etching operation to leave only a round disc portion providing first terminal 48 and an annular portion providing second terminal 54. The first and second etching operations could occur at the same time or at different times. In connection with the above, areas of first and second metal foils 82 and 84 except the portions providing stationary electrode 42, annular support 46 and first and second terminals 48 and 54 are entirely removed.

Stationary electrode 42 on the one side of base plate 40 is then processed by a third etching operation like the first and second etching operations to decrease the thickness of stationary electrode 42 so that it is thinner than annular support 46 by a prescribed dimension of several microns or several tens of microns. The prescribed dimension is determined by the etching operation time, etc.

Referring to Figure 6(c), electret film 44 is applied on stationary electrode 42 after the third etching operation. Electret film 44 is prepared by charging a stable electric charge on a film of plastics material before or after its application on stationary electrode 42. Although charging the stable electric charge on the film is able to be made according to various conventional methods, electret film 44 in this embodiment is preferably made in accordance with the method described in U.S. Patent Specification No. 4,356,049.

As shown in Figure 6(d), first and second through-holes 52 and 58 are formed in base plate 40. First through-hole 52 penetrates electret film 44, stationary electrode 42, base plate 40 and first terminal 48 together. Second through-hole 58 penetrates annular support 46, base plate 40 and second terminal 54 together. Then, first and second through-holes 52 and 58 are filled with electrically conductive paste to provide first and second conductors 50 and 56. The first conductor 50 connects stationary electrode 42 to first terminal 48 and the second conductor 56 connects annular support 46 to second terminal 54. After the filling with paste in first and second through-holes 52 and 58, electrically conductive diaphragm 60 is fixed at its periphery on annular support 46. Diaphragm 60 is arranged in parallel with electret film 44 on stationary electrode 42 with the prescribed air gap between it and electret film 44.

Referring now to Figures 7 and 8, a modified version of the above method for mass production of electroacoustic transducers will be described. Figures 7 and 8 illustrate only a final step for manufacturing the acoustic transducers, the steps prior to Figures 7 and 8 being equivalent to the steps shown in Figures 6(a) to 6(d). According to

the modified method, a plurality of electroacoustic transducers 90 are formed on a single rectangular wafer 92 made of insulating material like fibre-glass. Wafer 92 provides a plurality of electroacoustic transducer base plate regions aligned lengthwise and crosswise with other. On each base plate region, a stationary electrode 42, an annular support 46, first and second terminals 48 and 54, etc. are formed in accordance to the steps of Figures 6(a) to 6(d). Then, a single rectangular diaphragm sheet 94 having a film base 94a of plastics material and a metal layer 94b coated on the film base 94a is applied across all of the plurality of electroacoustic transducers 90 and then fixed to the respective annular supports 46. Sheet 94 is then trimmed away to leave portions facing the annular supports 46 and stationary electrodes 42 to provide respective diaphragms 60. The electroacoustic transducers 90 are separated from each other by regions 96 of rectangular wafer 92, which regions 96 are provided with perforations 98 or V-shape grooves 100 for easy breaking apart of the transducers 90. Perforations 98 or V-shape grooves 100 are able to be made at any time before or after applying diaphragm sheet 94. The electroacoustic transducers 90 are then separated from each other by breaking at the regions 96.

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CLAIMS

1. A method of manufacturing an electroacoustic transducer, wherein it comprises the steps of:

5 providing a substantially level base plate made of electrically insulating material with a layer, of substantially uniform thickness, of electrically conductive material applied on one side of said insulating base plate;

10 forming a stationary electrode and an annular support surrounding said stationary electrode on said one side of said base plate, by selectively removing a portion of said electrically conductive layer within an area on said base plate to leave said stationary electrode and said annular support;

15 reducing the thickness of said stationary electrode above said insulating base plate compared with said annular support; and

20 thereafter applying an electrically conductive diaphragm on said annular support and facing said stationary electrode.

2. A method according to claim 1, which further comprises the steps of:

25 providing a plurality of such electroacoustic transducers on a single such insulating base plate, said transducers being separated from each other by connecting regions made for easy breaking; and

30 separating said plurality of electroacoustic transducers from each other by breaking at said connecting regions, the forming step comprising the step of forming a plurality of such stationary electrodes and such annular supports on respective regions of said base plate, and the applying step comprising the step of applying a single diaphragm sheet on to the plurality of annular supports prior to the
35 separating step.

3. A method according to claim 2, wherein said single insulating base plate has another layer of electrically conductive material, applied on the



28. other side of the insulating base plate, and the method further comprises, prior to the application of said single diaphragm sheet, the steps of:

forming a plurality of first terminals and
5 second terminals on said other side of said insulating base plate within respective electroacoustic transducer regions of said base plate, the second forming step comprising selectively removing portions of said
10 electrically conductive layer on said other side of said insulating base plate within areas on said other side to leave said first and second terminals;

providing first and second through-holes within said respective electroacoustic transducer regions, said first through-holes reaching at their respective
15 ends to said stationary electrodes and said first terminals in the respective electroacoustic transducer regions and said second through-holes reaching at their respective ends to said annular supports and said second terminals in the respective electroacoustic
20 transducer regions; and

electrically connecting said stationary electrodes and said annular supports to said first and second terminals respectively in said respective electroacoustic transducer regions through first
25 and second circuit means respectively passing through said first and second through-holes.

4. A method according to claim 2 or 3, wherein said connecting regions have perforations.

30 5. A method according to claim 2 or 3, wherein said connecting regions have V-shaped grooves.

6. A method of manufacturing an electroacoustic transducer, substantially as herein described with reference to Figures 3 to 8 of the accompanying drawings.

35 7. An electroacoustic transducer comprising:
a base plate made of electrically insulating material; and



a stationary electrode formed on one side of said base plate, said stationary electrode being made of electrically conductive material, wherein the transducer further comprises:

5 an annular support formed on said one side of said base plate and surrounding said stationary electrode, said annular support being made of an electrically conductive material which is the same as the electrically conductive material of which
10 said stationary electrode is made and extending higher than said stationary electrode from said base plate;

 an electrically conductive diaphragm secured on said annular support and facing said stationary electrode;

15 a first terminal formed on the other side of said base plate, said first terminal being made of electrically conductive material;

 first circuit means electrically connecting said stationary electrode to said first terminal
20 and penetrating said insulating base plate;

 a second terminal formed on said other side of said insulating base plate, said second terminal being made of electrically conductive material which is the same as the electrically conductive material
25 of which said first terminal is made; and

 second circuit means electrically connecting said annular support to said second terminal.

8. An electroacoustic transducer according to claim 7, wherein said first and second terminals
30 are opposite said stationary electrode and said annular support respectively.

9. An electroacoustic transducer according to claim 7 or 8, wherein said second terminal is annular and surrounds said first terminal.

35 10. An electroacoustic transducer according to any of claims 7 to 9, wherein said first and second terminals are made of electrically conductive



material which is the same as the electrically conductive material of which said stationary electrode and said annular support are made.

5 11. An electroacoustic transducer according to any of claims 7 to 10, wherein it further comprises:
an electrically conductive casing mounted on said insulating base plate and housing said stationary electrode, said annular support and said diaphragm, said casing being electrically connected to said
10 second terminal and defining an open window facing said diaphragm.

12. An electroacoustic transducer according to any of claims 7 to 11, wherein said first and second circuit means are respectively conductors.

15 13. An electroacoustic transducer according to any of claims 7 to 10, wherein said first circuit means is an impedance transforming device and said second circuit means is a conductor.

20 14. An electroacoustic transducer according to any of claims 7 to 13, which further comprises an electret applied on said stationary electrode and spaced from said diaphragm.

25 15. An electroacoustic transducer, substantially as herein described with reference to Figures 3 to 8 of the accompanying drawings.

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