(12) UK Patent Application (19) GB (11) 2490931 (13) A

(43) Date of A Publication 21.11.2012

(21) Application No: 1108373.0

(22) Date of Filing: 19.05.2011

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(51) INT CL:
H04R 19/02 (2006.01) ***H04R 19/04*** (2006.01)

(56) Documents Cited:
WO 2002/019764 A1 **WO 1998/035529 A2**

(58) Field of Search:
INT CL **H04R**
Other: **WPI, EPODOC**

(54) Title of the Invention: **Electrostatic transducer**
Abstract Title: **Electrostatic acoustic transducer**

(57) The electrostatic transducer comprises an electrically conductive first layer 1, a flexible insulating second layer 2 disposed over the first layer, and a flexible electrically conductive third layer 3 disposed over the second layer (2). The first layer 1 is provided with an array of through apertures 5 each having an inlet 6 facing the second layer 2 and an outlet 7. The apertures 5 have walls with inwardly directed portions which have conductive surfaces.
In response to signals applied to the first and third layers 1, 3, portions of the second and third layers 2, 3 are displaced towards the outlets 7 of the apertures 5 by electrostatic forces. Since the wall portions of the apertures are conductive this enhances the electrostatic force acting on the corresponding portions of the third layer 3.

Figure 1

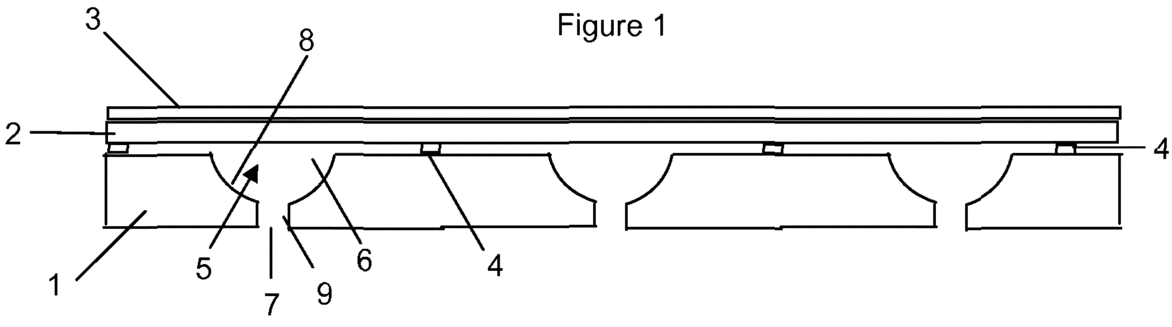

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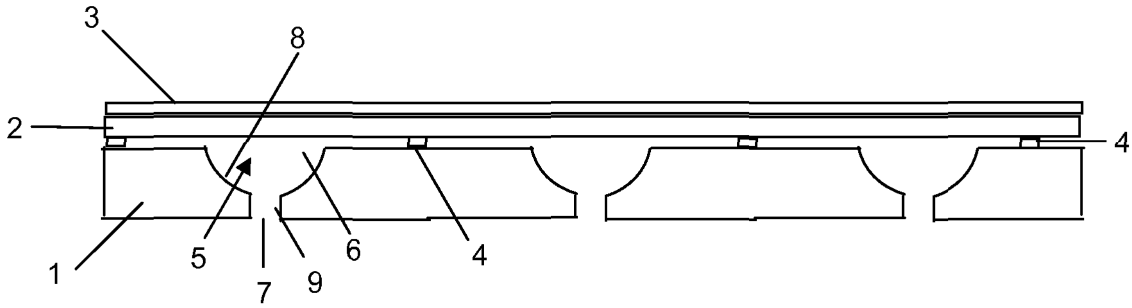
Figure 1



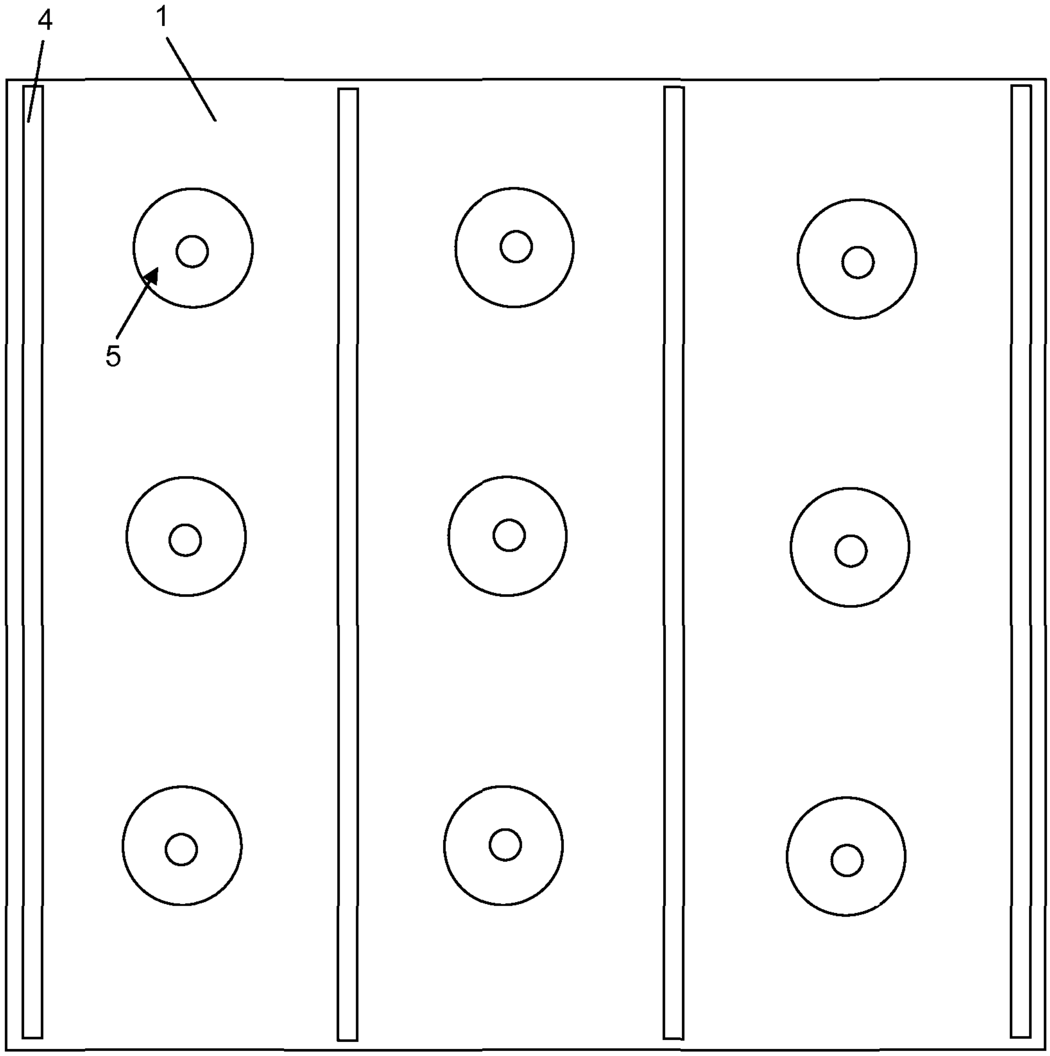


Figure 2

Figure 3

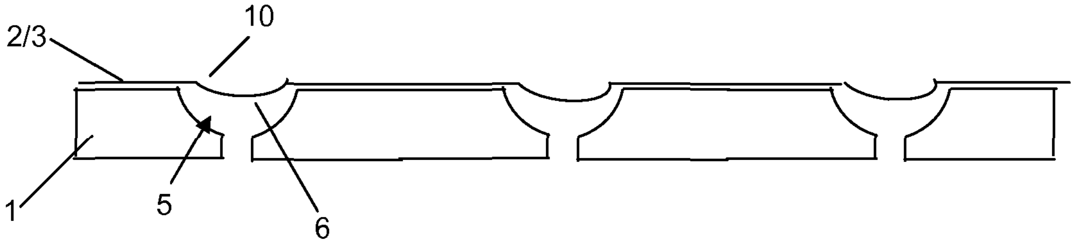


Figure 4

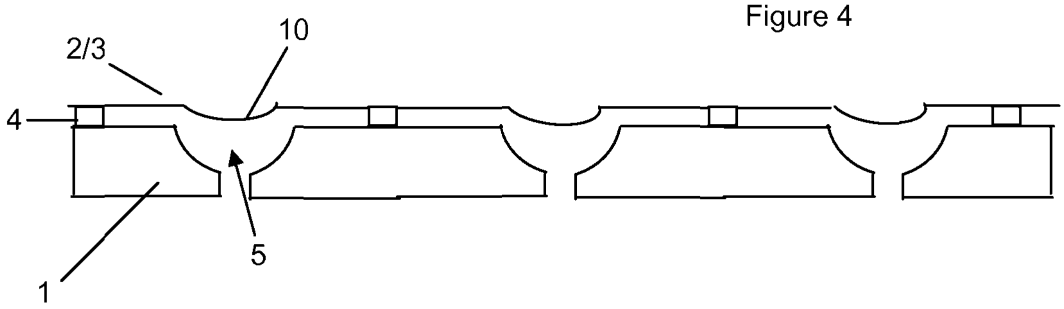
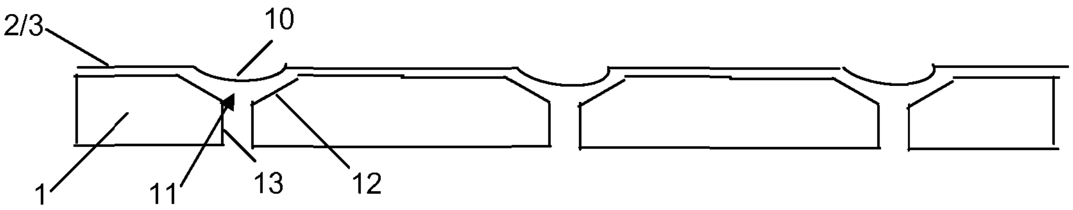


Figure 5



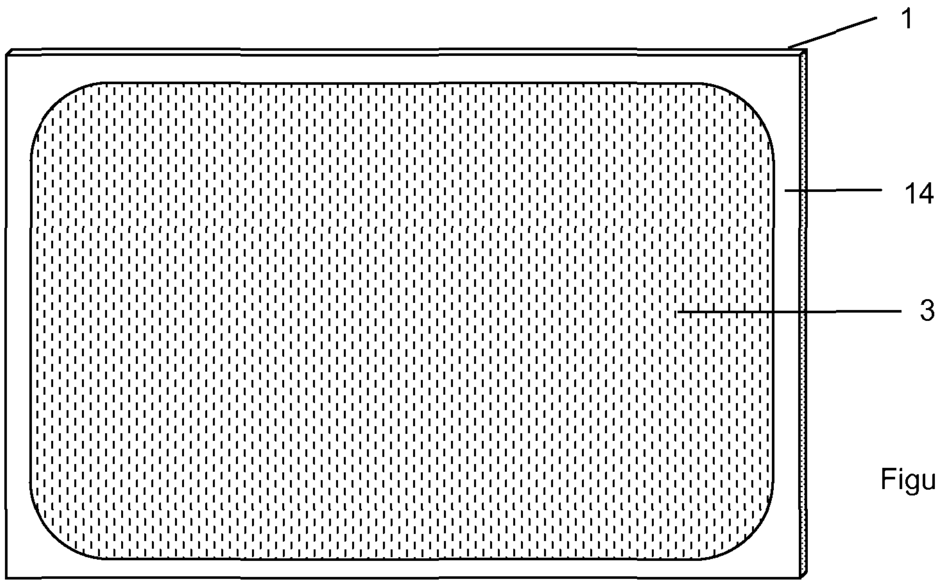


Figure 6

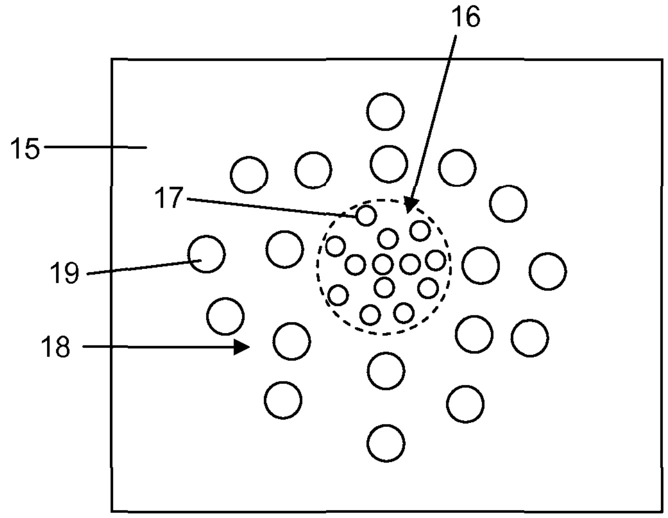


Figure 7

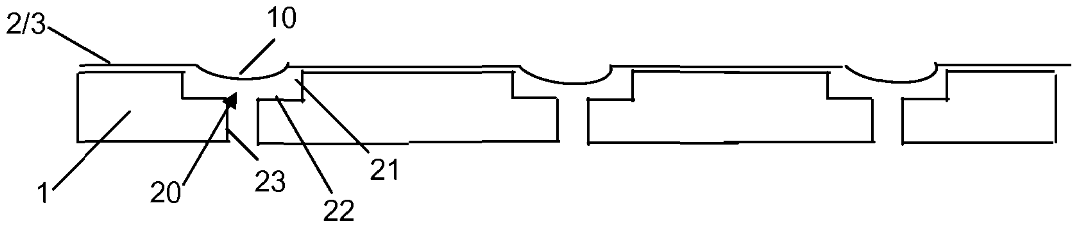


Figure 8

Electrostatic Transducer

This invention relates to an electrostatic transducer and is particularly but not exclusively concerned with a loudspeaker suitable for reproducing audio signals.

A traditional electrostatic loudspeaker comprises a conductive membrane disposed between two perforated conductive backplates to form a capacitor. A DC bias is applied to the membrane and an AC signal voltage is applied to the two backplates. Voltages of hundreds or even thousands of volts may be required. The signals cause a force to be exerted on the charged membrane, which moves to drive the air on either side of it.

In US 7095864, there is disclosed an electrostatic loudspeaker comprising a multilayer panel. An electrically insulating layer is sandwiched between two electrically conducting outer layers. The insulating layer has circular pits on one of its sides. It is said that when a DC bias is applied across the two conducting layers, portions of one of the layers are drawn onto the insulating layer to form small drumskins across the pits. When an AC signal is applied, the drumskins resonate, and parts of that conducting layer vibrate to produce the required sound.

In WO 2007/077438 there is disclosed an further type of electrostatic loudspeaker comprising a multilayer panel. An electrically insulating layer is sandwiched between two electrically conducting outer layers. In this arrangement, one of the outer conducting layers is perforated and, for example, may be a woven wire mesh providing apertures with a size of typically 0.11 mm.

In US 2009/0304212 there is disclosed an electrostatic loudspeaker comprising a conductive backplate provided with an array of vent holes and an array of spacers. Over this is positioned a membrane comprising a dielectric and a conductive film. The space between the backplate and the membrane is about 0.1 mm and it is said that a low voltage supplied to the conductive backplate and the conductive film will push the membrane to produce audio.

One problem with electrostatic loudspeakers of this type is obtaining sufficient displacement of the membrane. In US 7095864, for example, the apertures provide room for the "drumskins" to vibrate. However, the electrostatic field strength rapidly falls off towards the centre of the hole.

Viewed from one aspect, the present invention provides an electrostatic transducer comprising an electrically conductive first layer, a flexible insulating second layer disposed over the first layer, and a flexible electrically conductive third layer disposed over the second layer, wherein the first layer is provided with an array of through apertures each having an inlet facing the second layer and an outlet; characterised in that in response to signals applied to the first and third layers, the second and third layers have portions which are displaced towards the outlets of the apertures by electrostatic forces, and the apertures have walls with inwardly directed portions which have conductive surfaces.

In this manner, as portions of the second and third layers move towards the outlets of the apertures, they move closer to the inwardly directed wall portions of the apertures. As these wall portions are conductive, this enhances the electrostatic force acting on these portions of the electrically conductive third layer.

The wall portions may converge towards the aperture outlet. Converging walls may be straight, so as to define an aperture in the shape of a portion of a cone. Alternatively they may be curved, or there may be a combination of curved and straight portions. Adjacent to the outlet of an aperture, there may be a portion where the walls do not converge and there may be a straight bore or conceivably they could diverge in this region. Curved walls could be convex but in a preferred embodiment they are concave.

Alternatively, the aperture may be stepped, for example having a relatively wide portion of generally constant size for a certain depth, and then having an inwardly directed wall portion which is provided with a narrower bore to the outlet of the aperture. In this arrangement, the conductive portions may be provided on the inwardly directed wall portion and optionally also on the side wall of the relatively wide portion.

The inwardly directed portions of the walls may be entirely conductive or may have a number of conductive portions. For example, if the first layer is made from a conductive mesh with small diameter holes, the mesh may be shaped so that if forms flat portions from which depressions descend. In that case both the flat portions and the walls of the apertures would have small diameter holes across their surfaces. However, the opening to one of the depressions would be considerably wider and define the inlet to an aperture in accordance with the invention; and a number of the mesh holes at the base of the depression would constitute the outlet in accordance with the invention (although a separate outlet could be provided, additionally or alternatively).

Preferably the inwardly directed portions of the aperture walls are in electrical communication with the remainder of the first layer. This will naturally be the case if the first layer is formed from a conductive mesh that is shaped to define the apertures, or if the first layer is formed from a sheet of metal that is shaped to define the apertures, or for example if the first layer is moulded from a conductive polymer. In one form of the invention, the first layer is a sheet of a polymeric material which is non conductive and has the apertures formed in it, and then the surface of the first layer, including the walls of the apertures, is provided with a conductive coating.

The shape of the inlet of the apertures, viewed in plan view, may be circular, elliptical or any other chosen shape.

In some embodiment of the invention it is preferred that the apertures are of a considerably larger size than the spaces in a mesh such as is used in WO 2007/077438. For example, in some embodiments the aperture may have a minimum dimension of the inlet of the aperture (which in the case of a circular inlet would be the diameter, or in the case of an elliptical aperture its minor axis) no less than about 0.5 mm.

With apertures of a suitable size, there may be advantageous effects even if the apertures do not have inwardly directed wall portions, provided that the walls are provided with conductive portions. Thus, the apertures may be substantially larger than those that it would be practicable to provide with a mesh such as that in WO 2007/077438, given that a widely spaced mesh would provide a small conductive surface overall. Wide apertures would normally mean a sharp reduction in the electrostatic field towards the centre of the aperture. However, by making the walls of the apertures conductive the field in the region of the apertures may be enhanced.

Thus, viewed from another aspect of the invention, there is provided an electrostatic transducer comprising an electrically conductive first layer, a flexible insulating second layer disposed over the first layer, and a flexible electrically conductive third layer disposed over the second layer, wherein the first layer is provided with an array of through apertures each having an inlet facing the second layer and an outlet; characterised in that in response to signals applied to the first and third layers, the second and third layers have portions which are displaced towards the outlets of the apertures by electrostatic forces, the apertures have inlets with a minimum dimension of at least about 0.5 mm, and the walls of the apertures have conductive surfaces.

In some embodiments of either aspect of the invention the minimum dimension of the inlet of the aperture (which in the case of a circular inlet would be the diameter, or in the case of an elliptical aperture its minor axis) may be no less than about 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm, 16 mm, 17 mm, 18 mm, 19 mm or 20 mm.

In some embodiments of either aspect of the invention the maximum dimension of the inlet of the aperture (which in the case of a circular inlet would be the diameter, or in the case of an elliptical aperture its major axis) may be no greater than about 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm 16 mm, 17 mm, 18 mm, 19 mm, or 20 mm.

In some embodiments of either aspect of the invention the dimension of the inlet of the aperture may be in a range whose lower figure is chosen from about 0.5 mm 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm 16 mm, 17 mm, 18 mm, 19 mm or 20 mm; and whose upper figure is a larger figure chosen from about 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm, 15 mm 16 mm, 17 mm, 18 mm, 19 mm, 20 mm or 25 mm.

In embodiments of either aspect of the invention, the apertures may have all substantially the same inlet dimension, or there may be a combination of two or more dimensions. For example, there could be one region, such as an inner region, which may have apertures of one dimension or range of dimensions, and one or more other regions, such as one or more outer regions with apertures of another dimension or range of dimensions. Within a region there may be a mixture of apertures of two or more different dimensions

The depth of the apertures will match the thickness of the first layer. The thickness of the first layer could be in a range whose lower figure is chosen from about 0.5 mm 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm or about 10 mm; and whose upper figure is a larger figure chosen from about 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm or about 15 mm.

In embodiments with apertures with converging wall portions, the convergent region of the apertures may occupy less than the thickness of the first layer and terminate in a simple bore.

The convergent region of the apertures, or in the case of stepped apertures the region before the step, could occupy a depth in a range whose lower figure is chosen from about 0.5 mm 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm or about 10 mm; and whose upper figure is a larger figure chosen from about 0.75 mm, 1 mm, 1.25 mm, 1.5 mm, 1.75 mm, 2 mm, 2.25 mm, 2.5 mm, 2.75 mm, 3 mm, 3.25 mm, 3.5 mm, 3.75 mm, 4 mm, 4.25 mm, 4.5 mm, 4.75 mm, 5 mm, 5.25 mm, 5.5 mm, 5.75 mm, 6 mm, 6.25 mm, 6.5 mm, 6.75 mm, 7 mm, 7.25 mm, 7.5 mm, 7.75 mm, 8 mm, 38.25 mm, 8.5 mm, 8.75 mm, 9 mm, 9.25 mm, 9.5 mm, 9.75 mm, 10 mm, 11 mm, 12 mm, 13 mm, 14 mm or about 15 mm.

In some arrangements in accordance with either aspect of the invention the second layer is attached to the first layer at spaced positions, for example by means of adhesive. In some arrangements the second layer is free from attachment to the first layer. In some arrangements the second layer is free from attachment to the first layer over substantially all of the area of the second layer. In some arrangements the second layer is free from attachment to the first layer over at least a major part of the area of the second layer.

In some arrangements in accordance with either aspect of the invention, the second layer is attached to the third layer at spaced positions, for example by means of adhesive. In some arrangements the second layer is free from attachment to the third layer. In some arrangements the second layer is free from attachment to the third layer over substantially all of the area of the second layer. In some arrangements the second layer is free from attachment to the third layer over at least a major part of the area of the second layer. In some arrangements, spacers are provided between the second and third layers.

In some arrangements in accordance with either aspect of the invention, the third layer is not separate from the second layer, but formed by a conductive layer applied to the side of the second layer facing away from the first layer. For example, the second layer may comprise an insulating polymer film which has been metallised on one side.

The first layer may be rigid, semi rigid or flexible. It may for example be of a polymer sheet to which a conductive layer has been applied.

In some embodiments of either aspect of the invention, the first and / or second layer may be provided with spacers separating the first and second layers. These spacers allow greater freedom of movement of the second and third layers. The spacers could for example be in the form of, preferably parallel, strips positioned across the first or second layer, or individual spacers - which could be arranged in straight lines but need not be so . For ease of positioning, each strip or arrangement of individual spacers may be positioned in the spaces between the apertures. A grid of strips or lines of spacers may be provided. For ease of positioning, the strips or individual spacers may be placed on the first layer.

The spacers may have a thickness of between about 15 to about 25 microns (0.015 mm to 0.025 mm) , preferably between 20 to 25 microns. However, spacers of other thickness may be used, such as strips or other spacers with a thickness of up to 30 microns, 40 microns, 50 microns, 60 microns, 70 microns, 80 microns, 90 microns 100 microns, 110 microns, 120 microns, 130 microns, 140 microns or 150 microns, for example.

In the case of strips, these may have a width of about 0.5 mm or about 1 mm, or about 1.5 mm, or about 2 mm, or about 2.5 mm, or about 3 mm. The strips may have a width in the range of about 0.5 mm to about 3 mm, preferably about 1 mm to about 2.5 mm, preferably about 1 mm to about 2 mm.

The spacers may be of a conductive material or an insulating material, such as Mylar™.

In use of a transducer as set out above as a loudspeaker, a bias voltage may be applied across the first and third layers, and an alternating signal voltage also across those layers. The voltages could be of any desired value, depending on loudspeaker size, total harmonic distortion specified and the output required.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings, in which:

Figure 1 is a diagrammatic section through a transducer in accordance with one embodiment of the invention;

Figure 2 is a plan view of part of the transducer;

Figure 3 is a diagram showing deflection of components of the transducer in one embodiment;

Figure 4 is a diagram showing deflection of components of the transducer in another embodiment;

Figure 5 shows an alternative arrangement to that of Figure 1;

Figure 6 is a diagrammatic view of a complete loudspeaker in accordance with the invention;

Figure 7 is a diagrammatic view showing, by way of example only, one possible arrangement of apertures in an embodiment of the invention; and

Figure 8 shows an alternative arrangement to those of Figures 1 and 5.

As shown in Figure 1 loudspeaker comprises a first layer, or backplane, 1 with a thickness of about 3 mm. This is made of an insulating polymer which has been provided with a conductive layer (not shown) on its upper surface. Over this layer is a flexible layer of an insulating polymer film 2, and over that is a conductive layer 3. The conductive layer 3 and the insulating layer 2 could be separate layers but in this invention conductive layer 3 is in the form of metallisation applied to the outer surface of insulating layer 2 to provide a film with a total thickness of about 12 microns although in some embodiments film thicknesses of about 6 microns may be used. Insulating strips 4 of Mylar™ are positioned between layers 1 and 2. These strips are between 1 and 2 mm wide, and between about 20 and 25 microns thick.

The backplane 1 is provided with an array of through apertures 5. Each of these has an inlet 6 facing the insulating layer 2, and an outlet 7. The upper part 8 of each aperture is curved and concave and thus provides converging walls. This upper part 8 is also provided with a conductive layer which is connected to the layer on the upper surface of the backplane. The lower part of the aperture is in the form of a simple, parallel sided, bore 9. In this embodiment the aperture inlets are circular with a diameter of 12 mm.

As can be seen from Figure 2, the insulating strips are provided between the apertures 5.

The drawings are not to scale, and only a portion of a transducer is illustrated so as to explain the principles involved.

In one arrangement in accordance with this embodiment there is a regular array of circular apertures.

With reference to Figure 3, a DC bias voltage of say 200 to 400 volts can be applied between the conductive portions of the backplane 1 and the outer layer 3. An alternating signal of about 200 volts is also applied across the backplanes 1 and the outer layer 3. The effect is that the film which provides layers 2 and 3 moves towards and away from the backplane as a result of electrostatic forces. In areas over the apertures 5, the film 2 / 3 can form bulges 10. As shown they project towards the backplane 1, in the region of apertures 5, but they can also project away from the backplane. In this embodiment, when projecting towards the film the bulges 10 can project into the apertures 5.

In the embodiment of Figure 4, insulating spacer strips 4 are used and whilst bulges form on the film 2 / 3 projecting towards and away from the backplane, in this embodiment when projecting towards the backplane they do not project into the apertures 5. However, in another embodiment even with the use of spacers the bulges may project into the apertures.

In the embodiment of Figure 5, the backplane 1 is provided with modified apertures 11. These have straight converging walls 12, which provide a shallower converging part of the aperture. The walls 12 are conductive. The lower part 13 leading to the outlet of the aperture is therefore longer than in the previous arrangements.

Figure 6 shows a loudspeaker incorporating the invention. The back plane 1 is overlaid with the insulating and conductive layers 2 / 3 - which in this case are a provided by a single sheet of metallised polymer film - and a frame 14 is provided to keep these layers relatively taut over the apertured backplane. The whole assembly may be about 3 mm thick. In alternative arrangements, the backplane may be more flexible and the assembly will be thinner.

Figure 7 shows a modified backplane 15 which is provided with an inner region 16 with apertures 17 of a relatively small size, and an outer region 18 with apertures 19 of a relatively large size. With such an arrangement the frequency responses or other characteristics of the two regions could be different, making one region more suitable for low or high frequencies than the other.

Figure 8 shows a further embodiment in which the backplane 1 is provided with modified apertures 20. These have an upper portion with straight side wall 21, which terminates in an inwardly directed step 22. A lower part 23 leads to the outlet of the aperture. At least the step 22 is conductive, and preferably the upper portion side wall 21.

There is thus provided a compact, inexpensive thin loudspeaker with improved audio performance.

CLAIMS

1. An electrostatic transducer comprising an electrically conductive first layer, a flexible insulating second layer disposed over the first layer, and a flexible electrically conductive third layer disposed over the second layer, wherein the first layer is provided with an array of through apertures each having an inlet facing the second layer and an outlet; wherein in response to signals applied to the first and third layers, the second and third layers have portions which are displaced towards the outlets of the apertures by electrostatic forces acting between the first layer and the third layer, the apertures have inlets with a minimum dimension of at least about 0.5 mm, and the walls of the apertures have conductive surfaces.

2. An electrostatic transducer as claimed in claim 1, wherein the apertures have inlets with a minimum dimension of at least about 5 mm.

3. An electrostatic transducer as claimed in claim 2, wherein the apertures have inlets with a minimum dimension of at least about 10 mm.

4. An electrostatic transducer as claimed in claim 1, 2 or 3 wherein the apertures have walls with inwardly directed portions.

5. An electrostatic transducer as claimed in claim 4, wherein the apertures have walls which converge towards their outlets.

6. An electrostatic transducer as claimed in claim 5, wherein the convergent walls of the apertures occupy less than the thickness of the first layer and terminate in a non-converging bore.

7. An electrostatic transducer as claimed in claim 4 or 5, wherein the convergent walls are concave.

8. An electrostatic transducer as claimed in claim 4, wherein the apertures are provided with an inwardly directed step part way between the inlet and the outlet, and terminate in a bore extending from the step.

9. An electrostatic transducer as claimed in any preceding claim, wherein the conductive surfaces of the apertures are integral with an electrically conductive layer on the surface of the first layer facing the second layer.

10. An electrostatic transducer as claimed in any preceding claim, wherein the second layer is a film of polymer and the third layer comprises a conductive surface layer applied to the side of the film remote from the first layer.

11. An electrostatic transducer as claimed in any preceding claim, wherein the second and third layers are held taut.

12. An electrostatic transducer as claimed in any preceding claim, wherein spacers are disposed between the first and second layers.

13. An electrostatic transducer as claimed in claim 10, wherein the spacers are in the form of strips or lines of individual spacers, arranged at intervals across the surface of the first layer.

14. An electrostatic transducer as claimed in any preceding claim, in the form of a loudspeaker, with means for providing a bias voltage and a signal voltage between the first and third layers.

15. An electrostatic transducer comprising an electrically conductive first layer, a flexible insulating second layer disposed over the first layer, and a flexible electrically conductive third layer disposed over the second layer, wherein the first layer is provided with an array of through apertures each having an inlet facing the second layer and an outlet; wherein in response to signals applied to the first and third layers, the second and third layers have portions which are displaced towards the outlets of the apertures by electrostatic forces, and the apertures have walls with inwardly directed portions which have conductive surfaces.

16. An electrostatic transducer as claimed in claim 15, wherein the inwardly directed portions are portions which converge towards the outlets of the apertures.

17. An electrostatic transducer as claimed in claim 15, wherein the inwardly directed portions are provided by steps in the apertures.

Application No: GB1108373.0 **Examiner:** Peter Easterfield
Claims searched: 1 to 17 **Date of search:** 8 June 2011

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	WO 02/19764 A1 (WARWICK UNIVERSITY)
A	-	WO 98/35529 A2 (SRI)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

H04R

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
H04R	0019/02	01/01/2006
H04R	0019/04	01/01/2006