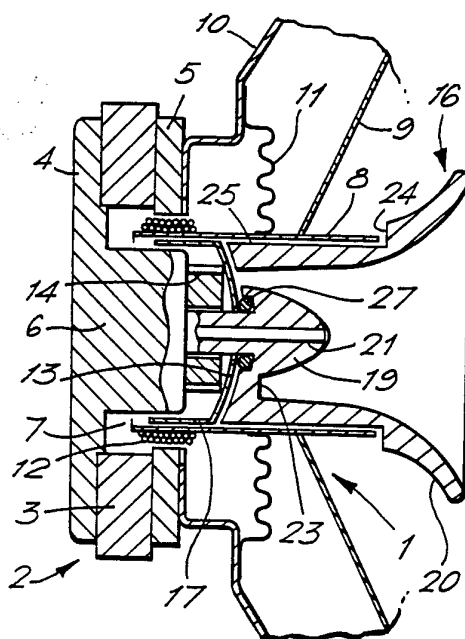




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(54) Title: LOUDSPEAKER**(57) Abstract**

A loudspeaker has a pole (6) and a surrounding magnet (3) which together define an annular gap (7). A voice coil (12) supported on a tubular former (8) is disposed within the gap (7) as is a conductive skirted dome (13). The dome (13) is supported upon an insulating gasket (14) providing three arcuate points of support and a phase plug (16) extends through a central opening (15) in the dome (13). The dome (13) and phase plug (16) are preferably separated by a second gasket (27) which may or may not be bonded to both and the phase plug (16) suitably includes an integral born (20) extending beyond the former (8).

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LOUDSPEAKER

This invention relates to a loudspeaker incorporating an inductively coupled tweeter particularly, but not necessarily only, for use in an automotive audio system.

A loudspeaker conventionally comprises a magnet assembly with an annular gap having a radial magnetic field within the gap. A voice coil is suspended in the magnetic field by means which permit it to be moved axially without touching the sides of the magnet assembly. The voice coil is wound on a rigid tube that is connected to a diaphragm, the outer edge of which is flexibly supported by a frame that is itself securely attached to a part of the magnet assembly. However, with this type of loudspeaker the frequency range of the sound produced is limited to low and medium frequency and, in order to reproduce high frequency sounds, it is proposed to incorporate an inductively coupled tweeter.

Inductively coupled tweeters in loudspeakers are known. For example, GB 545712 discloses an inductively coupled conductor in the form of a radiating dome positioned in the magnetic gap inside the main voice coil of a loudspeaker. The low and medium frequency sounds are radiated by a conventional cone, the high frequency sound is produced by the dome and is directionally controlled by a special horn fixed to the

centre pole.

In U.K. Patent No. 2118398 a similar arrangement is disclosed where a radiating dome is positioned over the central pole and supported by an annular suspension means. The dome is positioned within the tube or former supporting the voice coil and receives its energizing signals inductively from the voice coil. The dome is horn loaded by the same diaphragm as the voice coil, but reproduces high frequency sound.

More recent proposals are contained in European Published Applications 0344974 and 0344975. European Publication 0344974 is an improvement on the loudspeaker disclosed in GB Patent No.2118398 and includes a fixed element providing phase correction, which is supported by the pole through a hole in the dome. The radiating dome is supported by an annular flexible suspension on the pole face and also by another smaller flexible suspension on the underside of the phase correcting device. This provides two small sealed chambers. On the free end of the former there is a flared extension which is designed to provide a smooth acoustic impedance transition.

European Publication No. 0344975 discloses a similar electro acoustic transducer as disclosed in GB Patent No. 2188398 but is directed to the provision of an electrically insulating layer between the dome and the centre pole. This allows the annular gap to be of a

minimum clearance whilst eliminating short circuiting between the pole and the dome.

An object of the present invention is to provide an improved loudspeaker with an inductively coupled tweeter.

According to the present invention, there is provided a loudspeaker comprising a pole, a surrounding magnet defining an annular gap with the pole, a tubular former, a voice coil carried by the former and disposed within the annular gap, and a conductive skirted dome supported upon an insulated position or positions of support on the pole with the skirt disposed in the annular gap so as to be inductively coupled with the voice coil when the voice coil is energised.

Preferably the dome is supported upon three arcuate points of support. The three points of support may be provided by a gasket shaped to provide the arcuate points of support. The conductive dome suitably includes a central opening with a clearance to receive a phase plug attached to the pole by a stem passing through the opening. The underside of the phase plug may include a second gasket around its central supporting peg, to which the dome may or may not be bonded, to limit travel of the dome and to ensure that the skirt is always located in the annular magnetic gap. The reduction of support for the dome by using a pole face gasket having three arcuate points of support instead of a complete circle effectively reduces the suspended mass and improves performance of the tweeter.

The invention also includes a loudspeaker comprising a pole, a surrounding magnet defining an annular gap with the pole, a tubular former, a voice coil carried by the former and disposed within the

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annular gap, a conductive skirted dome having a central opening and being positioned on the pole with the skirt of the dome disposed in the annular gap so as to be inductively coupled with the voice coil when the voice coil is energised, a first insulating gasket disposed between the dome and the pole providing support for the dome, a phase plug attached to the pole by a stem passing through the central opening in the dome, a second gasket disposed between the dome and the underside of the phase plug, and a horn extending beyond the former.

According to another aspect of the invention there is provided a dome for forming an inductively coupled tweeter in a loudspeaker comprising an electrically conductive skirt and an insulated domed portion to generate high frequency sound. The insulated domed portion may be selected from a non-electrically conductive material such as paper or plastics material or an electrically conductive material such as aluminium but insulated from the skirt.

The invention will now be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic section of a loudspeaker in accordance with the invention;

Figure 2 is a plan view of the supporting gasket in Figure 1;

Figures 3a & 3b show respectively a plan view and side section of a preferred form of phase plug in accordance with the invention; and

Figure 4 is a diagrammatic section showing an embodiment of the invention including the phase plug of Figure 3.

In Figure 1 a loudspeaker 1 comprises a conventional back assembly 2 consisting of a magnet ring 3 having a yoke 4 and an annular front plate 5 bonded to the magnet ring 3. The yoke 4 includes a

cylindrical pole 6 extending through the openings defined by the annular plate 5 and the magnet ring 3 to define an annular gap 7. A hollow cylindrical former 8 is arranged to extend concentrically over a free end of the centre pole 6 and to lie partly within the annular gap 7 and a diaphragm 9 is bonded to the former. The former 8 and the diaphragm 9 are mounted to a fixed chassis 10 by means of a flexible suspension 11. A voice coil 12 is wound over the former and lies within the annular gap 7.

In order to reproduce high frequency sounds an inductively coupled tweeter is included which consists of an aluminium dome 13 supported within the gap 7 upon a gasket 14 providing three arcuate spaced positions of support. The dome 13 is inductively coupled to the voice coil 12 and includes a central aperture 15 through which a fixed phase plug 16 is mounted within the former 8.

The dome 13 is a one piece aluminium foil dome with a skirt 17 that is located in the annular magnetic gap 7 inside the main voice coil 12. The dome 13 is free to vibrate but is supported on the gasket 14 which is a compliant gasket bonded to the end face of pole 6. As can be seen from Figure 2, the gasket is of such a shape that it will make contact at approximately three equally spaced arcuate positions 18. The gasket suspension allows the dome 13 to float free with the minimum of support from the gasket 14.

In use, when an electrical signal is applied to the voice coil 12, forces are set up which move the former 8 and diaphragm 9 to produce low and medium frequency sound in accordance with the signal input. High frequency sound is produced by the dome 13 which, when the signal is applied to the voice coil 12, vibrates by virtue of the inductive

coupling to the skirt 17 of the dome. The sound is radiated by means of the dome surface between the phase plug 16 and the former 8. The phase plug is an established way of preventing radiation from the central part of the dome interfering with that from the edge.

By providing a supporting gasket with only three positions of support the attachment of mass is minimised which improves performance of the inductively coupled tweeter. The positions of support 18 defined by the outermost part of the gasket 14 are disposed radially inwardly of the edge of the pole 6. This arrangement supports the dome 13 just above the radius on the pole edge so that the dome 13 does not buzz or touch the pole in operation.

The dome 13 may be supported at more or less spaced positions and the positions need not be equally spaced. The dome may or may not be actually bonded to the gasket by self adhesive or other means. The gasket may be bonded or located concentrically on the face of the pole 6. If desired a second soft gasket (not shown in Figure 1) may be provided around the underside of the phase plug 16 to gently retain the dome 13 in the correct position touching either in a circle of contact or in several places only. The second gasket may or may not be bonded to the dome 13. If the second gasket is bonded to the dome 13 as well as to the underside of the phase plug 16 the gasket secures the dome 13 so that it is not free-floating but the material of the dome 13 allows it to flex in use.

The phase plug 16 suitably has an underside radius that is very similar to the dome 13 in order that it can fit closely although there may be a recess in the underside to locate the second soft gasket in position if provided. If desired the inside of the dome 13 or the

outside of the pole 6 may be insulated in accordance with normal established electrical practice with conductors adjacent to other metal parts to prevent the dome 13 shorting on the pole 6.

In one arrangement of the invention the former 8 may be provided with a conventional paper whizzer (not shown) for acoustical matching purposes to radiate the higher frequencies produced by the tweeter and voice coil.

The phase plug may include a separate or integral horn as shown in Figures 3a and 3b. In that arrangement the phase plug 16 includes a central phase correction portion 19 and a horn portion 20. The central portion 19 may have a centre hole 21 to allow fixture to the pole 6. The horn portion 20 is spaced from the central portion 19 to define a sound throat 22 and is fixed in position by three or more thin webs 23 connecting the horn portion 20 to the central portion 19. The horn portion 20 is flared outwardly and, on its outer surface, includes an annular shoulder 24 dimensioned to provide an annular rebate 25 which receives the moving free end of the former 8. The inner end surface 26 of the horn portion 20 is curved as shown to conform substantially with the curved surface of the dome 13. The arrangement is shown in section in Figure 4 with a second gasket 27 bonded to both the dome and underside of the phase plug.

In use, low and medium frequency sound is radiated by the diaphragm 9 and high frequency sound generated by the inductively coupled dome 13 is amplified and directionally controlled by the sound throat 22 of the horn portion 20. Because the outer surface of the horn portion 20 co-operates with the free end of the former 8 and the shoulder 24 will be aligned with the free end of the former 8 there is no sound passage

between the outer surface of the horn portion 20 and the former 8 so that the high frequency sound produced by the dome 13 is all directionally radiated by the flared surface of the horn portion 20. The horn portion 20 is not attached in any way to the former 8 and, being preferably integral with the phase correction portion 19, provides stable acoustical matching and reduced mass compared with a horn attached to the moving former 8.

Although in figures 3a and 3b the central portion 19 and horn portion 20 are shown as integrally moulded they may be separate if desired. The reduced line of support by using a 3-point suspension gasket on the pole face reduces the suspended mass and allows the dome to reproduce with a smoother frequency response and with improved sensitivity.

In the preferred arrangement the dome 13 is described as a one piece aluminium foil dome. However, in order to prevent the induced current from shorting across the dome, the skirt 17 may be conductive with a non-conductive paper or plastic curved top surface.

CLAIMS

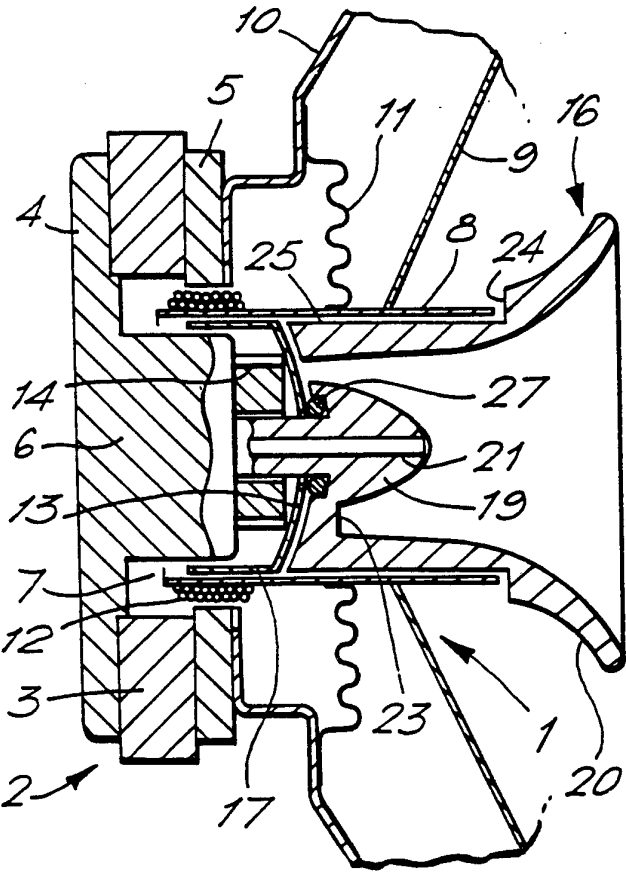
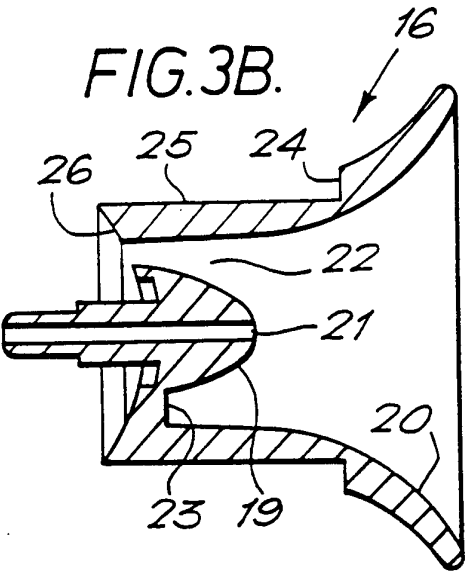
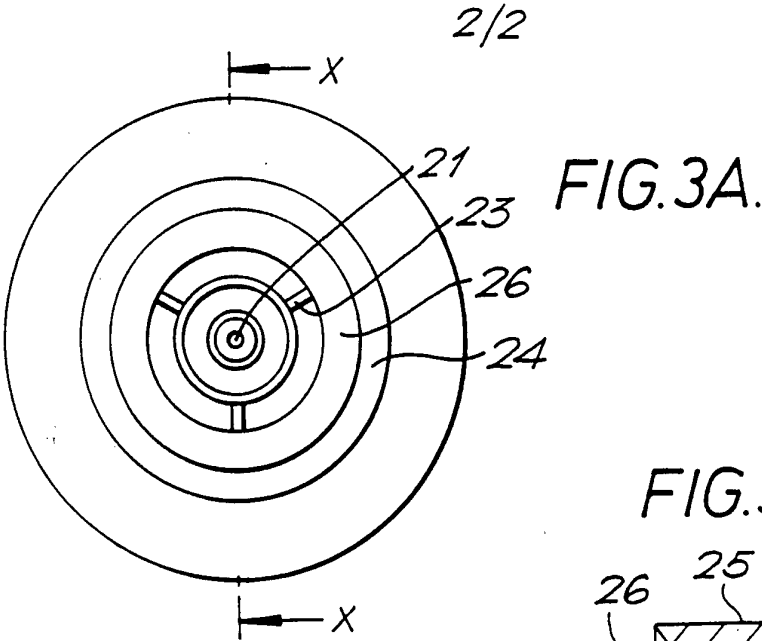
1. A loudspeaker comprising a pole, a surrounding magnet defining an annular gap with the pole, a tubular former, a voice coil carried by the former and disposed within the annular gap, and a conductive skirted dome supported upon an insulated position or positions of support on the pole with the skirt disposed in the annular gap so as to be inductively coupled with the voice coil when the voice coil is energised.
2. A loudspeaker according to claim 1 wherein the dome is supported upon three points of support.
3. A loudspeaker according to claim 2 wherein the three points of support are arcuate and are provided by a gasket shaped to provide the points of support.
4. A loudspeaker according to claim 3 wherein the gasket is secured to the inside of the dome.
5. A loudspeaker according to any one of the preceding claims wherein the dome is a one piece aluminium foil.
6. A loudspeaker according to any one of the preceding claims wherein the dome includes a central opening with a clearance to receive a phase plug attached to the pole by a stem passing through the opening.
7. A loudspeaker according to claim 6 including a second gasket disposed between the underside of the phase plug and the top of the dome.
8. A loudspeaker according to claim 7 wherein the second gasket is secured to both the phase plug and the dome to secure the dome in position.
9. A loudspeaker according to claim 6, 7 or 8 wherein the phase plug

includes a horn extending beyond the former and including an annular rebate for accommodating movement of the former.

10. A loudspeaker comprising a pole, a surrounding magnet defining an annular gap with the pole, a tubular former, a voice coil carried by the former and disposed within the annular gap, a conductive skirted dome having a central opening and being positioned on the pole with the skirt of the dome disposed in the annular gap so as to be inductively coupled with the voice coil when the voice coil is energised, a first insulating gasket disposed between the dome and the pole providing support for the dome, a phase plug attached to the pole by a stem passing through the central opening in the dome, a second gasket disposed between the dome and the underside of the phase plug, and a horn extending beyond the former.
11. A loudspeaker according to claim 10 wherein the first gasket provides three arcuate points of support.
12. A loudspeaker according to claim 10 or 11 wherein the second gasket is secured to both the dome and the phase plug.
13. A loudspeaker according to any one of claims 10 to 12 wherein the horn is integral with the phase plug.
14. A loudspeaker according to claim 13 wherein the horn is flared outwardly and includes a rebate in its outer surface to accommodate free movement of the former.
15. A dome for forming an inductively coupled tweeter in a loudspeaker comprising an electrically conductive skirt and an insulated domed portion to generate high frequency sound.
16. A dome according to claim 15 wherein the insulated domed portion is selected from; a non-electrically conductive material such as paper or

plastics material or an electrically conductive material such as aluminium but insulated from the skirt.

17. A dome according to claim 15 or 16 for a loudspeaker according to any one of claims 1 to 14.



INTERNATIONAL SEARCH REPORT

International Application No

PCT/GB 93/01509

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 H04R9/06 H04R1/24 H04R7/12 H04R7/20 H04R1/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 H04R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP,A,0 344 975 (ELIELI) 6 December 1989 cited in the application	1,15
A	see claims; figures	2,5,10, 16
A	EP,A,0 344 974 (ELIELI) 6 December 1989 cited in the application	1,6-10, 15
A	GB,A,2 118 398 (ELIELI) 26 October 1983 cited in the application	1,10,15
A	GB,A,2 122 453 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN) 11 January 1984 see page 2, line 128 - page 3, line 26; figures	2,10,11
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Further documents are listed in the continuation of box C.



Patent family members are listed in annex.

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Date of the actual completion of the international search

5 November 1993

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

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PCT/GB 93/01509

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

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