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(71) Applicant: **TANNOY LIMITED**
Canterbury Grove
West Norwood London SE27 OPW(GB)

(72) Inventor: **Rackham, Ronald Hastings**
21 Canterbury Grove
London SE27(GB)

(74) Representative: **Jennings, Guy Kenneth et al,**
GILL JENNINGS & EVERY 53-64 Chancery Lane
London WC2A 1HN(GB)

(54) **Moving coil loudspeakers.**

(57) Three separate co-axial transducer units 1, 2, 3 cover respectively high frequency, mid-frequency and low frequency bands. The unit 1 comprises a diaphragm 6 loaded by a horn 15 and the unit 3 comprises a cone 31. The unit 2 comprises a cone 22 carried by a chassis 21 formed along its rear surface with axially- and radially-extending annular portions 27, 28, the former being a close fit within a central opening of the front plate 12 of a magnetic assembly serving as part of both the high frequency and mid-frequency units, and the latter fitting against the face of the plate 12 where it is held by magnetic attraction. When the chassis 21 is fitted in position the portion 27 functions as a centring guide which facilitates manipulation in the presence of the magnetic field produced by the magnetic assembly.

EP 0 122 990 A1

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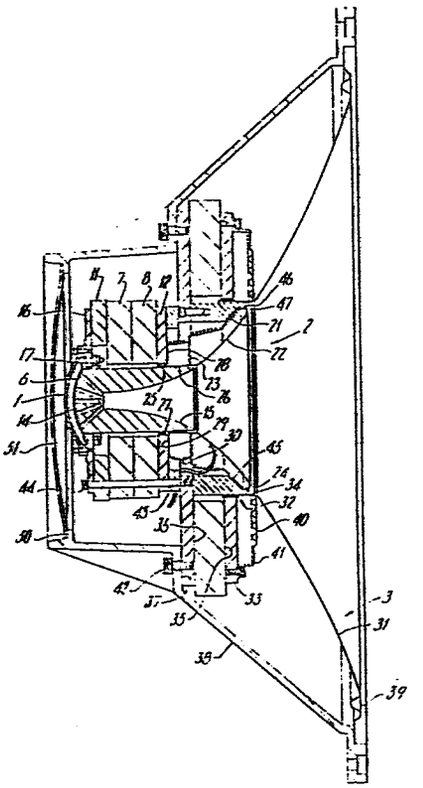
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Moving coil loudspeakers

Loudspeakers of the so-called "dual-concentric" type include a pair of co-axial voice coils, one of which drives a cone for reproduction of the lower frequencies, while the other drives a horn loaded high frequency diaphragm at the rear of the loudspeaker. The voice coils work in respective air gaps formed in annular rear and front plates forming part of a magnetic system which includes a ring magnet as illustrated, for example, in our patent specifications nos: 893,838 and 2,015,300. In loudspeakers of this type, the middle band of frequencies is reproduced by the over-lapping effect of the horn-loaded high frequency diaphragm operating near the lower limit of its frequency responsde and of the low frequency cone operating near the upper limit of its frequency response. As a result, the performance of the loudspeaker over this frequency band leaves room for improvement.

The invention is based on the principle of including an additional cone, designed to respond to the mid-frequency band, between the horn and the low frequency cone of a loudspeaker of this type, this being made possible, in accordance with the invention, by a construction comprising three

separate trandsucer units covering the three frequency bands and driven by respective co-axial voice coils, the low frequency unit comprising a cone at the front of the loudspeaker, the high frequency unit comprising a horn-loaded diaphragm at the rear of the loudspeaker and the mid-frequency unit comprising a cone carried by a chassis formed along its rear surface with axially- and radially-extending annular portions, the former being a close fit within a central opening of the front plate of a magnetic assembly serving as part of both the high frequency and mid-frequency units.

When the mid-frequency unit is being fitted in position it is inevitably subjected to a considerable magnetic attraction which adds to the difficulty of accurate centring. The provision of the axially extending annular portion largely overcomes this difficulty because the portion can be inserted in the central opening of the front plate while the remainder of the chassis is still spaced away from the front plate and the magnetic attraction is considerably below the maximum value which it reaches as the radially extending portion comes into contact with the front plate. During the remainder of the fitting movement the unit as a whole is guided by the co-operation between the outer surface of the axially extending portion and the surface of the central opening and thus remains accurately centred when it reaches its final position. As a result of this construction the low frequency cone may be

spaced away from the mouth of the horn to leave a gap for the insertion of the mid-frequency unit and the low frequency cone and its associated magnetic assembly may be fixed in position to the frame of the assembly prior to the fitting of the mid-frequency unit. The mid-frequency chassis is then fitted subsequently, being moved into position in an axial direction until the axially extending portion at the rear of the chassis engages the opening in the front plate as described above.

The components are preferably so designed that the magnetic attraction exerted on the chassis of the mid-frequency unit is sufficient to hold the unit in position without the need for any additional fixing. This has the further advantage that the unit can be pre-fabricated and then fitted in position as a self-contained entity. In some cases, however, bolts or other forms of fastener may be included to supplement the magnetic attraction without losing the main advantages of a construction in accordance with the invention which makes possible in practical terms the theoretical concept of what may be called a triple concentric loudspeaker, that is to say a loudspeaker in which the low and middle frequencies are reproduced by separate cones designed to produce their optimum performances over the frequency ranges in question and thus improving the overall performance of the loudspeaker as a whole.

As already described, the high frequency

diaphragm and the mid-frequency cone share a common magnetic system in the same manner as previous dual-concentric types of loudspeaker. The low frequency cone, however, requires an independent magnetic system and this is preferably fitted in front of the platform on the chassis provided for its support. This is in contrast to the normal practice adopted with cone-type loudspeakers when the magnetic assembly is mounted to the rear of the chassis platform. Front mounting in accordance with the present invention facilitates fitting of the mid-frequency cone in the space between the low frequency cone and the mouth of the horn and also assists in maintaining a relatively smooth contour at the junction between the two cones. A smooth contour is also maintained between the flare at the mouth of the horn and the mid-frequency cone in the same way as normally done between the cone and the horn of a dual-concentric loudspeaker.

The magnetic system for the low frequency cone needs to comprise a ring magnet with annular front and back plates in the usual way, the back plate being secured to the chassis platform so that the assembly as a whole is in front of the platform, as already described. In addition, the magnetic system needs to include a central annular pole piece extending from the back plate and co-operating with the edge of the central opening in the front plate to define the air gap for the voice

coil of the low frequency cone. This central pole piece will surround the chassis for the mid-frequency unit and may need to be shaped to conform with the latter.

The front edge of this pole piece will extend forwardly between the outer edge of the mid-frequency cone and the inner edge of the low frequency cone, and to provide a smooth transition between the two cones this front edge needs either to be relatively thin or to be shaped to form a smooth transition surface. The small annular gap left between the inner face of the pole piece and the chassis may conveniently be closed by an annular spacer of resilient material which helps to provide additional support for the mid-frequency chassis, excludes dust from the internal cavity and provides damping to the chassis to prevent unwanted acoustic output due to vibrations.

An example of a triple-concentric loudspeaker in accordance with the invention will now be described with reference to the accompanying drawing, which is a longitudinal sectional view.

The loudspeaker comprises three basic sections, namely a high frequency section 1, a mid-frequency section 2 and a low frequency section 3. The high frequency section 1 is driven by a diaphragm 6 which together with its associated magnetic system is very similar to that illustrated and described in our patent specification no: 2,015,300, and which will accordingly be described only relatively

briefly. It comprises a group of ring magnets 7, 8 and 11 fitted between annular rear and front plates 16 and 12 respectively. A central pole piece 14 has a hollow interior defining a horn 15 communicating with the diaphragm 6 and is fixed to an outer plate 16 by way of an integral flange 17.

The mid-frequency section 2 is in the form of a self-contained unit comprising a chassis 21 supporting a cone 22 by way of inner and outer suspensions 23 and 24 respectively. The chassis is made of material such as mild steel plate capable of supporting magnetic flux and provided with an outer protective coating. A voice coil 25 is carried by a former 26 which is of appreciable axial length so as to extend outside the front portion of the horn 15 as far as the suspension 23. The rear surface of the chassis 21 is formed with an axially extending portion 27 which forms a close fit within the central opening of the front plate 12 of the magnetic assembly and thus serves as a centring guide during assembly and centres the unit as a whole when assembly is complete. It also defines the radial width of the air gap. In addition the chassis includes a radially extending annular portion 28 which overlies the face of the front plate 12 and is held against it by magnetic attraction. A thin layer 29 of non-magnetic material is included between the portion 28 and the face of the plate 12 so as to reduce the force on the chassis, facilitate its removal when required

and provide damping. The outer surface of the chassis 21 may be fitted with acoustic resistance material 30 fitted over apertures in the side walls of the chassis to give damping.

The fitting in position of the mid-frequency unit 2 represents one of the final stages in the assembly of the loudspeaker and, in particular, is subsequent to the fitting of the magnetic assembly of the low frequency unit 3. The need for this arises from the relative shaping of the units 2 and 3 as will be explained in more detail.

The unit 3 comprises a low frequency cone 31 driven by a voice coil 32 working in an annular gap between the face of the central opening in an annular front plate 33 and the outer surface of an annular pole piece 34. The magnetic system includes in addition a ring magnet 35 and an annular back plate 36. This assembly is fixed to a platform 37 forming part of a main chassis 38 which supports an outer suspension 39 for the cone 31. Contrary to normal practice, the magnetic assembly is mounted on the front rather than the rear of the chassis platform 37 in order that the working air gap should be situated just to the rear of the outer suspension 24 for the mid-frequency cone, thus enabling the low frequency cone 31 to form a relatively smooth continuation of the mid-frequency cone 22. The inner suspension for the low frequency cone 31 is shown at 40 and is fixed along its outer edge to an angled annular bracket 41

which, in its turn, is fixed to the front plate 33. As mentioned above, the magnetic assembly comprising the parts 33, 34, 35 and 36 must be fitted in position prior to the fitting of the mid-frequency unit 2, but the low frequency cone assembly can be fitted after the mid-frequency unit and in production normally will be. Nevertheless, the fitting of this cone assembly does not interfere with the mid-frequency unit which can be removed, replaced and serviced as required without removal of the cone assembly.

The magnetic assembly is fixed to the chassis platform 37 by bolts, one of which is seen at 42, and which extend from the rear of the platform. These may pass through the magnet 35 and be screwed into tapped holes in the front plate 33. As illustrated, the plates 33 and 36 are attached to the magnet 35 by adhesive.

A non-magnetic spacer ring 43 is fitted between the edge of the opening in the back plate 36 and the front plate 12 of the magnetic assembly for the high and mid-frequency sections. This ring, which (although not shown as such) may conveniently be made up of three or more washers of specifically defined thickness, has the function of physically separating the two magnetic assemblies to accommodate the axial depth of the mid-frequency unit, The ring is fitted concentrically around fixing bolts, one of which is seen at 44, which hold the magnetic assembly for the high and mid-frequency units to

the plate 36. This arrangement allows free air movement between the cavity defined by the MF cone 22, LF pole 45, LF plate 36 and MF plate 12 and the air compliance volume defined by the air space contained by a rear cover 51 fitted to a rearward extension 50 of the main chassis. A domed shape is chosen for the cover 51 in preference to a flat disc to achieve rigidity and thus minimise resonances leading to unwanted acoustic radiation.

In order to bring the inner edge of the low frequency cone 31 close to the outer edge of the mid-frequency cone 22 and thus provide a smooth transition between the two, the low frequency magnetic system and in particular the central pole piece 34 needs to extend behind part of the mid-frequency chassis 21. Thus it will be seen that the forward edge of the pole piece 34 slopes outwardly at 45 to match the shape of the chassis 21 and that the inner side of the air gap is defined by a relatively thin extension 46 of the pole piece which fits just inside the outer suspension 24 for the mid-frequency cone 22. The narrow annular gap between the inner surface of the portion 46 and the chassis 21 is closed by a resilient bead 47 which gives slight additional support to the chassis 21 and also seals the gap to prevent access of dust to the associated cavity.

The relative shaping of the chassis 21 and the pole piece 34 means that part of the pole piece 34 lies behind part of the chassis 21 and that, in the assembled position, as shown, it is

impossible to remove the low frequency magnetic assembly without first removing the chassis 21. Conversely, it would be impossible to fit the low frequency magnetic assembly in position if the chassis were previously fitted.

Instead of making the extension 46 of the pole piece 34 relatively thin, as just described, in order to leave only a narrow gap between the inner edge of the cone 31 and the outer edge of the cone 22, the portion 46 may be made rather thicker and have its front surface shaped to form a smooth transition between the two cones. This not only provides a greater cross sectional area for the passage of magnetic flux, thus avoiding any risk of magnetic saturation, but also makes it possible to design the chassis 21 so that it does not extend in front of any part of the pole piece 34, thus providing greater freedom in the order of assembly of the components.

CLAIMS

1. A loudspeaker comprising transducer units covering respectively a low frequency band and a high frequency band and driven by respective co-axial voice coils, the low frequency unit comprising a cone at the front of the loudspeaker and the high frequency unit comprising a horn-loaded diaphragm at the rear of the loudspeaker, characterised by a mid-frequency unit, also driven by a co-axial voice coil and comprising a cone carried by a chassis formed along its rear surface with axially- and radially- extending annular portions, the former being a close fit within a central opening of the front plate of a magnetic assembly service as part of both the high frequency and mid-frequency units.

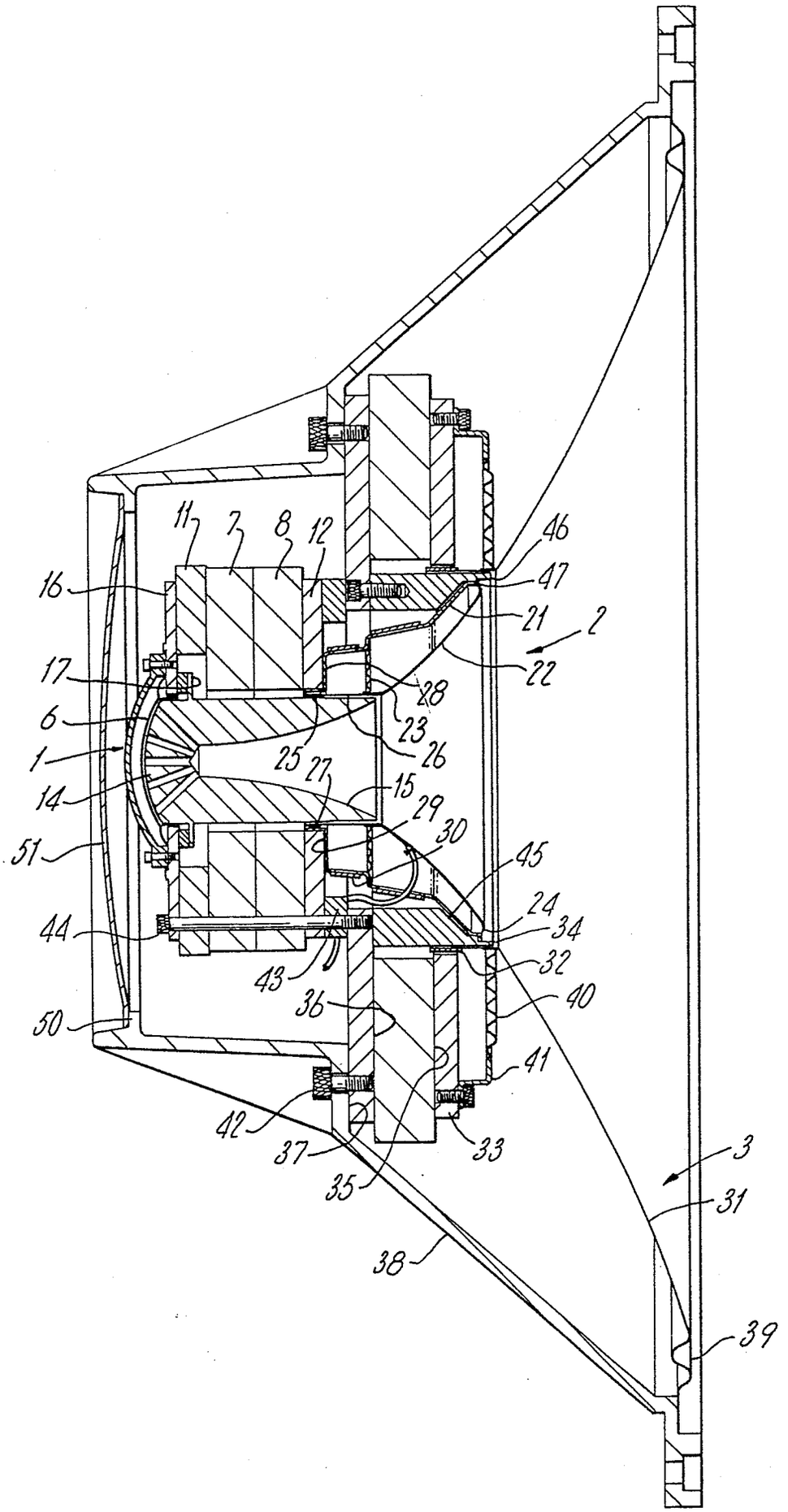
2. A loudspeaker according to claim 1 characterised in that the rear part of the chassis for the mid-frequency unit is formed of metal capable of supporting magnetic flux and is held in position solely by the magnetic attraction exerted by the magnetic assembly.

3. A loudspeaker according to claim 1 or claim 2 characterised in that the low frequency unit has a magnetic system fitted in front of a platform on a main chassis supporting all three units.

4. A loudspeaker according to claim 3 characterised in that the magnetic system of the low frequency unit includes a central annular pole piece surrounding the chassis for the mid-

frequency unit and terminating at its front edge in a portion which extends between a former for the low frequency voice coil and the outer extremity of the mid-frequency cone and is so shaped as to provide a smooth transition between the outer edge of the mid-frequency cone and the inner edge of the low frequency cone.

5. A loudspeaker according to claim 4 characterised in that the front edge portion of the annular pole piece is relatively thin so as to leave only a narrow gap between the two cones.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EUROPEAN SEARCH REPORT

0122990

Application number

EP 83 30 4297

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. ³)
Y	DE-A-2 819 548 (TANNOY PRODUCTS LTD.) * Page 6, line 3 - page 8, line 9; figures *	1	H 04 R 9/06 H 04 R 1/24
A		3	
Y	GB-A- 665 815 (MARCONI) * Page 2, line 74 - page 3, line 25; figure 4 *	1	
A		3,4	
A	GB-A- 701 395 (WHITELEY ELECTRICAL RADIO CO. LTD.) * Page 1, line 63 - page 2, line 74; figure *	1	TECHNICAL FIELDS SEARCHED (Int. Cl. ³)
A	US-A-3 462 559 (D.R. WILDER) * Column 3, line 24 - column 4, line 70; figure 1 *	2	H 04 R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	01-08-1984	MINNOYE G.W.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
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