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MOVING COIL TRANSDUCER

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This invention relates to electro-acoustic transducers of the moving coil type, especially but not solely for use in telephone subscriber's apparatus.

Moving coil transducers are well known, and have been much used, especially for loudspeakers. With the advent of the so-called "electronic" telephone, i.e. one in which the subscriber's set includes electronic circuitry, it is convenient to use such transducers in telephones. Although the fact that they need amplifiers may be an apparent disadvantage, this is not so since the presence of electronic circuitry for other reasons means that the amplifier needed can be readily provided. Further the sound quality characteristics of moving coil transducers are better than for such existing devices as the carbon granules transducer. The existing transducers as currently used in telephones are relatively cheap so it is desirable to provide moving coil transducers which are compact and inexpensive.

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According to the invention there is provided an electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer

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periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central part of the diaphragm, wherein each of the two parts of the diaphragm
5 has a substantially cylindrical portion which extends into the air gap so that the coil is between the two cylindrical portions, and wherein both the outer portion and the central portion of the diaphragm drive the air when the transducer coil is current-driven or respond to
10 changes in air pressure when the transducer is used to respond to sound waves incident on its diaphragm.

According to another aspect of the invention, there is provided a method of making a moving coil transducer as set out in the preceding paragraph,
15 including providing a casing part for the transducer, which casing part has a circular reference datum formed therein, forming an annular coil locating rim in the outer periphery of the outer part of the diaphragm, using the reference datum to ensure that the rim is and remains
20 concentric with the datum, and assembling against the datum the magnet assembly which is circular such that the coil of the transducer is accurately located in the annular air gap.

According to another aspect of the invention,
25 there is provided an electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil
30 is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central
35 part of the diaphragm, wherein one of the pole pieces is a cylindrical member of a ferromagnetic material with a flat disc-like portion at one of its ends, which

disc-like portion supports one end of an annular magnet, wherein the other pole piece is a flat annular member of a ferromagnetic material attached to the other end of the magnet, its inner circular periphery with the outer periphery of the other end of the cylindrical portion of the first mentioned pole piece defining the air gap in which said coil is located, wherein each of the two parts of the diaphragm has a substantially cylindrical portion which extends into the air gap and is so arranged that the coil is supported between the two cylindrical portions, and wherein both the outer part and the central part of the diaphragm drive the air when the transducer coil is current-driven or respond to changes in air pressure when the transducer is used to respond to sound waves incident on its diaphragm.

According to the present invention, there is also provided an electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil, and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central part of the diaphragm, wherein one of the pole pieces is a disc of a ferromagnetic material with an upstanding ferromagnetic wall at its outer rim, wherein an annulus of a ferromagnetic material is mounted with its outer rim in magnetic contact with said wall, wherein a cylindrical magnet has one of its ends supported at the centre of the disc, wherein the other pole piece is a flat disc of a ferromagnetic material attached to the other end of the magnet, its outer circular periphery with the inner periphery of the annulus on said wall defining the air

gap in which said coil is located, and wherein each of the two parts of the diaphragm has a substantially cylindrical portion which extends into the air gap and is so arranged that the coil is supported between the two
5 cylindrical portions, and wherein both the outer part and the central part of the diaphragm drive the air when the transducer coil is current-driven or respond to changes in air pressure when the transducer is used to respond to
10 sound waves incident on the diaphragm.

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~~outer rim, wherein an annulus of a ferromagnetic material is mounted with its outer rim in magnetic contact with said wall, wherein a cylindrical magnet is supported at the centre of the disc, and wherein the other pole piece is a flat disc of a ferromagnetic material attached to the other end of the magnet, its outer circular periphery with the inner periphery of the annulus on said wall defining the air gap in which said coil is located.~~

10 An embodiment of the invention will now be described with reference to the accompanying drawings, in which Fig. 1, 2 and 3 each shows a cross-section of a moving coil transducer embodying the invention.

 The transducers described herein are so
15 designed that fully automated assembly can be achieved, and the assembly technique used ensures that the speech coil is accurately positioned in the air gap. The speech coil is wound on an aluminium former, which ensures accuracy of shape, and the aluminium also acts
20 as an electrical damper. The outer part of the diaphragm is formed in situ on the mounting ring, such that a nest into which the speech coil locates is accurately positioned with respect to the datum diameter on the mounting ring for the diaphragm. The same datum
25 also positions the outer pole piece of the magnetic assembly which reduces the build up of tolerances associated with conventional transducers.

 The formation of a nest as just mentioned provides a secure way to attach a speech coil to the
30 diaphragm, and also provides protection for the coil itself.

 The transducers described herein each have a two part diaphragm, which includes an aluminium coil former, so that automatic coil winding and termination
35 of the lead out wires can be achieved. It also permits the use of an assembly technique, which ensures accurate alignment of the coil to the pole gap (air gap)

and gives a positive means of attaching the coil to the diaphragm.

The first transducer to be described, see Fig. 1, has a rear cover 1 which is generally circular and has three upstanding pillars such as 2 in its middle which locate the inner pole 3, which is of magnetic material. This pole has a central hole to fit over the pillars 2 and a flat portion parallel to the rear cover. Secured to this flat portion is an annular magnet 5 so magnetised that its end faces are the poles. This magnet is made from one of the modern magnetic materials which can have high magnetic strength. To the upper face of the magnet there is secured a disc 6 of magnetic material, whose inner rim provides the outer pole. As can be seen from Fig. 1 the poles are so shaped as to provide an annular gap for the reception of the coil.

Also mounted on the rear cover, and ultrasonically welded to it, there is a support ring 7 of a non-magnetic material (like the rear cover) which has a mounting ring 8 integral with its upper end. This mounting ring is so dimensioned as to provide an annular face which locates on the upper face of the magnet. It also has an inner datum face which rests against the outer cylindrical rim of the pole piece 6. The mounting ring 8 has an annular region 9 for supporting the outer part of the diaphragm.

Mounted between the magnet 5 and the inner pole 3 there is a metallic ring 10 which forms a short-circuited turn, which minimises hum pick up when the transducer is in use. Between the pole 3 and the rear cover 1 there is an acoustic damper 11 of a fibrous material.

With the method of assembly indicated above it is found that the tolerances accumulate at the welded joint. This facilitates assembly with a low reject rate.

We now consider the diaphragm unit. This

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includes a two part diaphragm, the outer part being an annulus 11 of a suitable stiff insulating material or aluminium whose outer rim is secured to the annular region 9 of the support ring 7. The inner part of the part 11 is a bent down cylindrical portion 12 with an annular portion 13 at its lower end. The inner part 14 of the diaphragm is of aluminium, and is convex, except for a central concave region to provide adequate clearance within the transducer's front chamber. This inner part also has a cylindrical portion 16 bent down to and integral with an annular portion. The coil 18 fits between the bent down cylindrical portions as can be seen from Fig. 1, and is carried by the portion 16 of the diaphragm part 14. Further the inner diaphragm portion 16 with the coil fits accurately into the nest formed by the annular portion 13 of the diaphragm's outer part.

The leads from the winding, one of which is shown at 20, go from the ends of the winding of the coil 18 to two terminals one of which is shown at 21. Each of these terminals is fixed into a tunnel in the wall of the support ring 7.

The outer side, i.e. the side which faces the user, of the transducer, has a so-called spit guard 22, which is a thin flexible membrane, e.g. of polyethylene terephthalate fifteen microns thick. Outside of this there is the front cover 23, which has a ring, e.g. of twelve holes such as 24, for the ingress or egress of sound, dependent on whether the transducer (in its telephone application) is used as a transmitter or as a receiver. Behind these holes there is a mesh membrane 25, which may be of nylon, and which imparts acoustic damping to the transducer.

During the assembly of the transducer, the coil is wound on the cylindrical portion of the inner part of the diaphragm, and the result is then assembled to the magnet structure and casing in situ. The outer part of the diaphragm is, as already indicated, attached to the

raised part 9 of the mounting ring 8, and the recess 31 in that part 11 of the diaphragm is located by the diaphragm forming tool relative to the datum surface referred to above. Hence the coil is accurately located relative to that datum and therefore to the magnetic circuit. The magnetic circuit structure is also located by the outer diameter of the outer pole piece 6 relative to the datum surface, thus ensuring the accurate location of the coil in the gap. Thus the necessity for the use of an adhesive bonding of the coil to the diaphragm, as in many known transducers is avoided.

In certain cases, the short-circuited turn 10, and/or the spit guard 11, and possibly also the membrane 25, may not be needed, in which case whichever is not needed is not provided.

The transducer shown in Fig. 2 is similar in most respects to that shown in Fig. 1, so the description is confined to the points of difference. Whereas in Fig. 1 the damping arrangement include a disc of fibrous material at the rear of the inner pole, this is not so in Fig. 2. In this arrangement, the inside of the inner pole 40 has a stepped recess 41 into which is secured an annular damper 42 of a fibrous material. The upper edge of this recess is formed over as shown at 43 to secure the damper in place. Thus in this case we have a through-flow damper mounted within the inner pole.

The transducer shown in Fig. 3, while it uses the same method of constructing the diaphragm used in Figs. 1 and 2, differs from the other two transducers in a number of respects, as will be seen. Thus the magnet is a cylindrical magnet 50 located at the centre of an outer pole formed by a flat disc 51 and an outer wall 52. This outer pole is located to the rear cover 53 and the support ring 54 substantially as for the other two transducers.

Mounted on the outer wall 52 of the outer pole is a disc 55 whose inner cylindrical rim defines the

outside of the air gap. The inner side of the air gap is defined by the outer cylindrical rim of a disc-shaped pole piece 56 mounted on the upper end of the magnet.

5 In this transducer it will be noted that the only damping arrangement shown is the mesh 57 on the inside of the front cover 58. However, further damping arrangements, e.g. as in Fig. 1 or 2, can be added if these are needed.

10 The magnets used in the transducers described herein can be either ceramic magnets or metal magnets.

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CLAIMS:-

1. An electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central part of the diaphragm, wherein each of the two parts of the diaphragm has a substantially cylindrical portion which extends into the air gap so that the coil is between and supported by the two cylindrical portions, and wherein both the outer part and the central part of the diaphragm drive the air when the transducer coil is current-driven or respond to changes in air pressure when the transducer is used to respond to sound waves incident on its diaphragm.
2. An electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central part of the diaphragm, wherein one of the pole pieces is a cylindrical member of a ferromagnetic material with a flat disc-like portion at one of its ends, which disc-like portion supports one end of an annular magnet, wherein the other pole piece is a flat annular member of a ferromagnetic material attached to the other end of the magnet, its inner circular periphery with the outer



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periphery of the other end of the cylindrical portion of the first mentioned pole piece defining the air gap in which said coil is located, wherein each of the two parts of the diaphragm has a substantially cylindrical portion which extends into the air gap and is so arranged that the coil is supported between the two cylindrical portions, and wherein both the outer part and the central part of the diaphragm drive the air when the transducer coil is current-driven or respond to changes in air pressure when the transducer is used to respond to sound waves incident on its diaphragm.

3. A transducer as claimed in claim 2, wherein an annular acoustic damper is located between the rear face of the first mentioned pole piece and the rear cover portion of the transducer, the hole of the annulus being substantially concentric with the inside of the cylindrical member of that pole piece.

4. A transducer as claimed in claim 2, wherein the inside of the cylindrical member of the first-mentioned pole piece has a stepped recess on its inside at its front end, and wherein an annular damping ring is located in the recess.

5. A transducer as claimed in claim 4, and wherein the annular damper is held in place by a formed-over rim from the pole piece.

6. A transducer as claimed in claim 3, 4 or 5, and wherein the damper is a ring of a fibrous material.

7. A transducer as claimed in claim 2, 3, 4, 5 or 6, and wherein a generally cylindrical member of an electrically conductive material is located about the cylindrical member of the first pole piece, between that member and the magnet, such that that member forms a short-circuited turn.

8. A transducer as claimed in claim 2 or in any claim appendent thereto, and wherein the cylindrical member of the first pole piece is hollow and fits over



one or more upstanding pillars on the rear cover of the transducer.

9. A transducer as claimed in claim 1 or 2, wherein a casing within which the transducer is assembled has on its inside a circular reference datum region, wherein the outer periphery of the outer part of the diaphragm has an annular locating rim which co-operates with the reference datum region to ensure that the rim is correctly located concentric with the datum region, and wherein the magnet unit is circular and is assembled against the datum region, thus ensuring that the magnet unit and the diaphragm unit are correctly assembled with respect to each other.

10. An electro-acoustic transducer of the moving coil type, which includes a diaphragm unit including the diaphragm and a coil, and a magnet unit including a magnet and a plurality of pole pieces so located as to define an annular air gap in which the coil is located, wherein the diaphragm is made in two parts one of which is a substantially circular central part whose outer periphery supports the coil and the other of which is a substantially annular outer part which also supports the coil and is thereby attached to the central part of the diaphragm, wherein one of the pole pieces is a disc of a ferromagnetic material with an upstanding ferromagnetic wall at its outer rim, wherein an annulus of a ferromagnetic material is mounted with its outer rim in magnetic contact with said wall, wherein a cylindrical magnet has one of its ends supported at the centre of the disc, wherein the other pole piece is a flat disc of a ferromagnetic material attached to the other end of the magnet, its outer circular periphery with the inner periphery of the annulus on said wall defining the air gap in which said coil is located, and wherein each of the two parts of the diaphragm has a substantially cylindrical portion which extends into the air gap and is so arranged that the coil is supported between the two



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cylindrical portions, and wherein both the outer part and the central part of the diaphragm drive the air when the transducer coil is current-driven or respond to changes in air pressure when the transducer is used to respond to sound waves incident on the diaphragm.

11. A transducer as claimed in any one of the preceding claims, wherein the central circular part of the diaphragm is of a highly conductive material such as aluminium.

12. A transducer as claimed in claim 11, wherein the central part is domed outward with a shallow saucer-like recess at its middle.

13. A transducer as claimed in claim 11 or 12, wherein the outer annular part of the diaphragm is also made of a highly-conductive material such as aluminium.

14. A transducer as claimed in claim 2 or in claim 11, or in any claim appended thereto, and wherein each of the cylindrical portions of the two parts of the diaphragm has an annular portion at its inner end, which annular portions overlap.

15. A method of making a moving coil transducer, as claimed in claim 1, including providing a casing part for the transducer, which casing part has a circular reference datum formed therein, forming an annular coil locating rim in the outer periphery of the outer part of the diaphragm, using the reference datum to ensure that the rim is and remains concentric with the datum, and assembling against the datum the magnet assembly which is circular such that the coil of the transducer is accurately located in the annular air gap.

16. An electro-acoustic transducer of the moving coil type, substantially as described with reference to Fig. 1, Fig. 2 or Fig. 3 of the accompanying drawings.