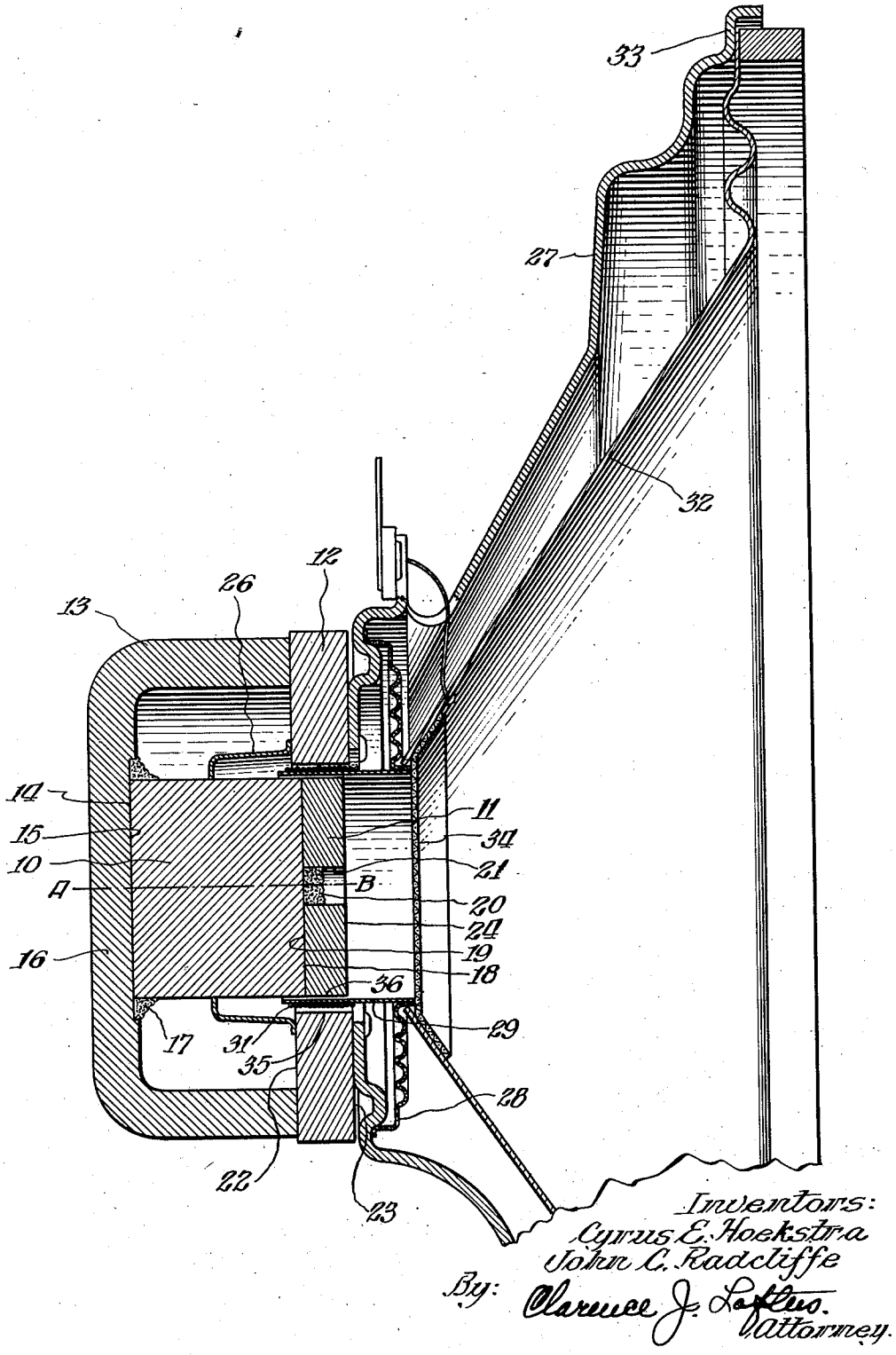
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LOUD-SPEAKER ASSEMBLY

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LOUD-SPEAKER ASSEMBLY

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1

The present invention relates to electromechanical transducers, and its teachings are particularly useful in the production of permanent magnet radio speakers of the moving voice coil type.

It is the general aim of the invention to provide an improved structure for the magnetic circuit of a loud speaker, whereby the efficiency of the magnetic circuit employed is increased substantially above the maximum efficiency possible with those previously used. In furtherance of the general aim, it is the primary object of the invention to provide a magnetic circuit for a moving voice coil speaker, wherein a maximum percentage of the magnetic flux threading the magnet is caused to thread the voice coil air gap.

In the prior art practice it has been a commonly proposed expedient to provide an annular air gap for the voice coil by inserting one end of a cylindrical bar magnet directly into an aperture in a soft iron pole plate and completing the circuit by a return yoke from the remote end of the magnet to the plate. It has been learned, however, that even with the most powerful permanent magnet alloys presently available, the utilization of a single cylindrical bar magnet of the same diameter as the voice coil fails to provide the desired flux density at the air gap, even when the end of the permanent magnet is extended directly into the voice coil aperture, and the pole plate and the flux return path of the circuit are formed of the best grade of soft magnetic materials. It has, therefore, become common practice to employ permanent magnets of considerably larger diameter than the diameter of the voice coil, so that the increased cross sectional area of the magnet provides more lines of force across the air gap. Tapered magnets have been suggested, but it has been a more common expedient to employ a permanent magnet in the form of an enlarged slug housed within the speaker yoke, and provided with a tapered or flanged pole piece extending into the office coil. Fairly satisfactory results may be obtained by such structures, but they are inefficient in utilization of the flux of the permanent magnet, and consequently require magnets of considerably larger diameter than the voice coil in order to bring about the desired degree of flux density in the gap in which the voice coil moves.

The present teachings depart from prior practice by providing, in combination with a pole plate and return circuit of magnetically permeable material, an alloy permanent magnet and a magnetically soft pole piece of unique dimensional relations found to give a marked increase

2

in efficiency of the circuit and to provide increased flux density in the air gap with any given weight of permanent magnet material. It has been found by actual test that whereas in a conventional speaker it is possible to get only about one-third of the magnetic flux of the magnet to thread the air gap, with the present invention about two-thirds of the flux will thread the gap. This is due to the fact that the permanent magnet employed, while of small diameter and extending into the voice coil, is not itself used as the pole piece. Instead, it is provided with a pole piece of magnetically permeable soft iron, mild steel or similar magnetic material, with the pole piece thinner than the pole plate at the air gap and located between its opposite faces.

This arrangement takes full advantage of the inherent magnetic characteristics of alloys such as "Alnico V" and "Alnico VI," in which the grain is oriented in its heat treatment by holding it in a magnetic field during one of its cooling cycles so that its magnetic properties are greater along its axis than in any other direction. That is, its properties are extremely directional in nature. Thus, if the magnet is used as the pole piece, the lines of force extending across the air gap are perpendicular to the magnetic axis of the magnet, and the field is comparatively weak. In the present teachings, this is avoided by the use of a pole piece of soft iron, which not only reduces the weight of expensive magnetic alloy required, but results in an important gain in flux density in the gap, particularly when the pole piece is dimensioned and positioned in the specific manner here disclosed. In short, the present applicants have discovered that by providing a magnetically permeable pole plate and concentric pole piece which is substantially thinner than the pole plate and wholly within the aperture, it is possible to obtain such an efficient concentration of lines of force across the gap that it is entirely feasible to utilize a simple, cylindrical permanent magnet of diameter smaller than the voice coil.

A preferred embodiment of the invention is illustrated in the drawing of this specification wherein a radio speaker comprising a present commercial application of these teachings is illustrated. The single feature of the drawing is a fragmental cross sectional view through the speaker assembly.

The magnetic circuit of the speaker in which the novelty of the present invention resides includes a cylindrical magnet 10, a pole piece 11, a pole plate 12 and a yoke or "pot" 13. The magnet 10 is an aluminum-nickel-cobalt-iron alloy, which is precipitation hardened and manufac-

tured by a process wherein its grain is oriented during its heat treatment by holding it in an intense magnetic field as it cools. This is an alloy commonly employed in speaker magnets and widely sold in the trade under the name of "Alnico V." The pole piece 11, pole plate 12 and yoke 13 are of what is ordinarily termed "soft iron" in the art, the term as used here including all equivalent magnetically soft material. Excellent results are obtained by the use of S. A. E. 1010 (or lower carbon) hot rolled steel, though steel or iron of other carbon content may be employed, as may other magnetic materials such as sintered powdered iron shapes.

The magnetic axis of the magnet 10 extends along the line A—B, which is concentric with the cylindrical walls of the magnet and with the other operating parts of the speaker. The rear face surface 14 of the magnet is ground smooth and is seated flat against a flat face 15 on the inside of the back wall 16 of the yoke 13. The magnet is held in position by any convenient means, as by solder 17. The forward face 18 of the magnet is in flat surface contact with the back face 19 of the pole piece 11, and these two parts are preferably secured together by solder 20 introduced through a central opening 21. The pole plate 12 is of considerably greater thickness than the pole piece 11, so that its inside face 22 lies in a plane offset from and spaced rearwardly of the back face 19 of the pole piece, while its outside face 23 lies in a plane offset from and spaced forwardly of the front face 24 of the pole piece.

In practice, excellent results are accomplished by utilizing, for a 1" voice coil speaker, .250 iron for the pole plate, with the pole piece formed of .170 thickness. The front face of the pole piece lies about .020 behind the front face 23 of the pole plate. The back face of the pole piece is spaced forwardly from the pole plate face 22 about .060.

In the process of manufacture the plate 12 and yoke 13 may be joined in any conventional way or, if desired, these parts may be formed as a single integral piece. As shown, the pole piece and magnet are soldered in position and are preferably magnetized during the soldering operation, so that the abutting face surfaces at each end of the magnet are held in intimate surface contact to give minimum magnetic reluctance at these joints. The soldering operation may conveniently be accomplished by inserting a non-magnetic ring gauge in the air gap and fusing the solder 17 and 20 simultaneously by heat supplied by a hot plate.

Before assembly, a dust guard 26 is inserted as shown. The speaker is completed by attaching a basket 27 in the usual manner and mounting the spider 28 and voice coil form 29 on which the voice coil windings 31 are carried. The speaker cone 32 is mounted on the outer rim 33 of the basket with its apex joined to the voice coil form and spider in the usual manner. A dust cap 34 may also be secured in position as shown to prevent entry of dirt and magnetic particles into the voice coil air gap.

From the foregoing it will be seen that the teachings of this disclosure provide two magnetic poles of novel form, which coact to provide maximum flux density in an annular air gap. The outer magnetic pole consists of an internal cylindrical surface 35 extending between parallel annular edges at the rear and front faces 22 and 23 of the plate 12. The inside pole consists

of the thin disc 11, which has a cylindrical pole surface 36 extending between annular edges at the front and back face surfaces 24 and 19. This structure departs from prior practice in several well defined particulars, primarily in that (1) the pole piece is wholly within the voice coil aperture; (2) the pole piece is spaced rearwardly of the front face and forwardly of the rear face of the plate; and (3) the magnet 10 extends substantially to (or somewhat beyond) the rear face 22 of the plate. It has been learned that by these expedients the efficiency of the magnetic circuit is improved to a marked extent. Instead of having the magnetic flux in the air gap approximating only one-third of the flux threading the magnet (as is usual with conventional speakers), approximately two-thirds of the total flux threads in the air gap. This improvement in performance arises from the specific positional relationships of the parts shown, in which the magnetically soft pole piece 11 is formed of metal substantially thinner than the pole plate 12, with its surfaces both at the front and rear being offset inwardly from the faces of the pole plate, rather than flush or protruding as in prior teachings. The permanent magnet 10 may extend slightly into the aperture of the pole plate, but does not itself function as the pole piece. Rather, it energizes the permeable magnetic material of the pole piece 11, so that the highly directional magnetic characteristic of the permanent magnet alloy is utilized to its fullest extent, the lines of force passing from the magnet to the pole piece in the direction of the magnetic axis rather than at right angles thereto. The magnet diameter is smaller than the voice coil, and extends into the pole plate aperture sufficiently to support the pole piece in correct position therein.

Having thus described the invention, what we claim as new and desire to secure by United States Letters Patent is:

1. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said face surfaces; a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surfaces; said pole piece being concentric with the voice coil aperture and of thickness less than the pole plate; the pole piece being positioned wholly within the voice coil aperture; with the front face surface of the pole piece spaced rearwardly from the front face of the pole plate and the rear face surface of the pole piece spaced forwardly from the rear face of said pole plate; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a cylindrical permanent magnet of diameter less than the diameter of the voice coil aperture; said magnet extending from the back plate of the return yoke into the aperture, and abutting the back face surface of the pole piece.

2. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein

terminating in parallel annular front and back pole plate edges at said face surfaces; a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surface; said pole piece being concentric with the voice coil aperture and wholly within the voice coil aperture; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a cylindrical permanent magnet of diameter less than the diameter of the voice coil aperture; said magnet extending from the back plate of the return yoke and abutting the back face surface of the pole piece.

3. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said face surfaces; a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surfaces; said pole piece being concentric with the voice coil aperture and of thickness less than the pole plate; the pole piece being positioned wholly within the voice coil aperture; with the front face surface of the pole piece spaced rearwardly from the front face of the pole plate and the rear face surface of the pole piece spaced forwardly from the rear face of said pole plate; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a permanent magnet of aluminum-nickel-cobalt-iron alloy; said magnet having parallel flat rear and forward pole faces, with the rear pole face abutting the back plate of the return yoke and the forward pole face extending beyond the rear face of the pole plate, into the aperture, and abutting the back face surface of the pole piece.

4. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said face surfaces; a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surfaces; said pole piece being concentric with the voice coil aperture and positioned wholly within the voice coil aperture; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a permanent magnet of aluminum-nickel-cobalt-iron alloy; said magnet having parallel flat rear and forward pole faces, with the rear pole face abutting the back plate of the return yoke and the forward pole face abutting the back face surface of the pole piece.

5. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back

pole plate edges; a magnetically soft iron pole piece of circular shape having an external cylindrical pole surface terminating in parallel annular front and back edges; said pole piece being concentric with the voice coil aperture and of thickness less than the pole plate; the pole piece being positioned wholly within the voice coil aperture; with the front edge of the pole piece spaced rearwardly from the front edge of the pole plate and the rear edge of the pole piece spaced forwardly from the rear edge of said pole plate; a return yoke of magnetically soft iron, and a magnetic generator comprising a cylindrical permanent aluminum-nickel-cobalt-iron alloy magnet of diameter less than the diameter of the voice coil aperture; said magnet extending from the return yoke into the aperture, and to the pole piece.

6. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said face surfaces; a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surfaces; said pole piece being concentric with the voice coil aperture and positioned within the voice coil aperture with the rear face surface of the pole piece spaced forwardly from the rear face of said pole plate; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a cylindrical permanent aluminum-nickel-cobalt-iron alloy magnet of diameter less than the diameter of the voice coil aperture; said magnet having parallel flat rear and forward pole faces, with the rear pole face abutting the back plate of the return yoke and the forward pole face extending beyond the rear face of the pole plate, into the aperture, and abutting the back face surface of the pole piece.

7. In a magnetic circuit for a transducer, the sub-combination of a pole plate of magnetically soft iron having a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges; with a magnetically soft iron pole piece of circular shape having an external cylindrical pole surface terminating in parallel annular front and back edges; said pole piece being concentric with the voice coil aperture and of thickness less than the pole plate; and positioned wholly within the aperture with the front edge of the pole piece spaced rearwardly from the front edge of the pole plate and the rear edge of the pole piece spaced forwardly from the rear face of said pole plate.

8. In a magnetic circuit for a transducer, the sub-combination of a pole plate of magnetically soft iron having relatively flat front and back face surfaces and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said face surfaces; with a magnetically soft iron pole piece comprising a circular disc having flat parallel front and back face surfaces and an external cylindrical pole surface terminating in parallel annular edges at said face surfaces; said pole piece being concentric with the voice coil aperture and of thickness less

than the pole plate; and positioned wholly within the aperture with the front face surface of the pole piece spaced rearwardly from the front face of the pole plate and the rear face surface of the pole piece spaced forwardly from the rear face of said pole plate.

9. A magnetic circuit for a transducer comprising, in combination, a pole plate of magnetically soft iron having relatively flat front and back face surfaces, and a voice coil aperture with an internal cylindrical pole surface therein terminating in parallel annular front and back pole plate edges at said surfaces; a magnetically soft iron pole piece comprising a circular disc having an external cylindrical pole surface terminating in parallel annular edges at said face surfaces, said pole piece being concentric with the voice coil aperture and positioned in the voice coil aperture; a return yoke of magnetically soft iron including a back plate parallel with and spaced from said pole plate, and a magnetic generator comprising a permanent magnet of aluminum-nickel-cobalt-iron alloy,

said magnet having parallel flat rear and forward pole faces, with the rear pole face abutting the back plate of the return yoke, and the forward pole face extending substantially to the rear face of the pole plate and abutting the back face surface of the pole piece.

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