Feb. 23, 1943. D. H. CUNNINGHAM 2,312,238

DYNAMIC LOUD SPEAKER

Filed Jan. 27, 1938

Fig. 1.

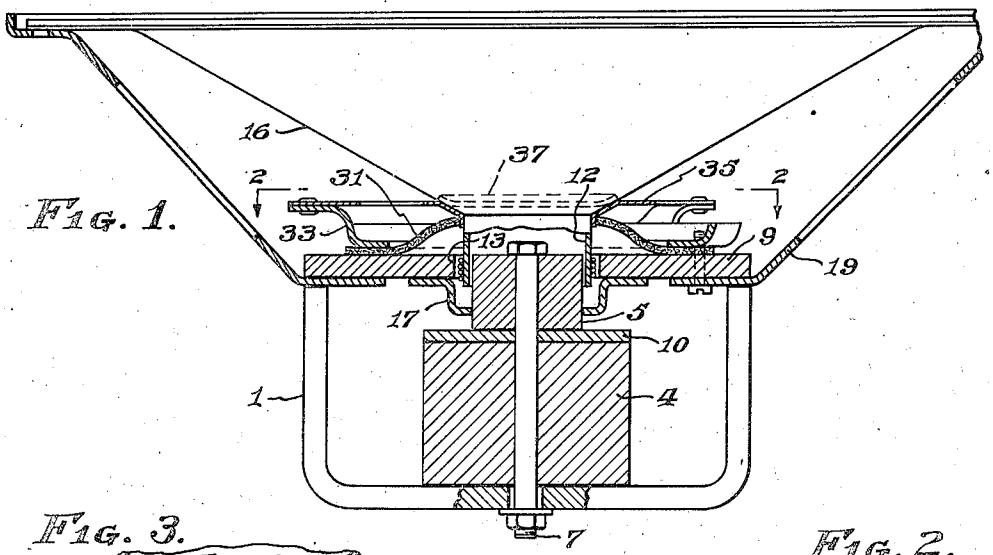


Fig. 3.

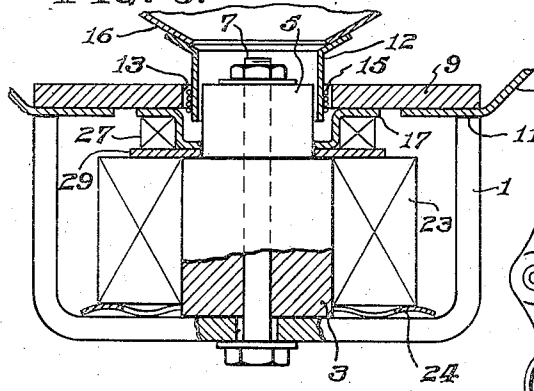


Fig. 2.

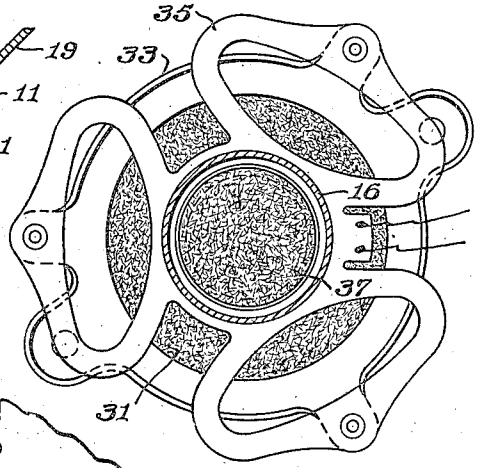


Fig. 4.

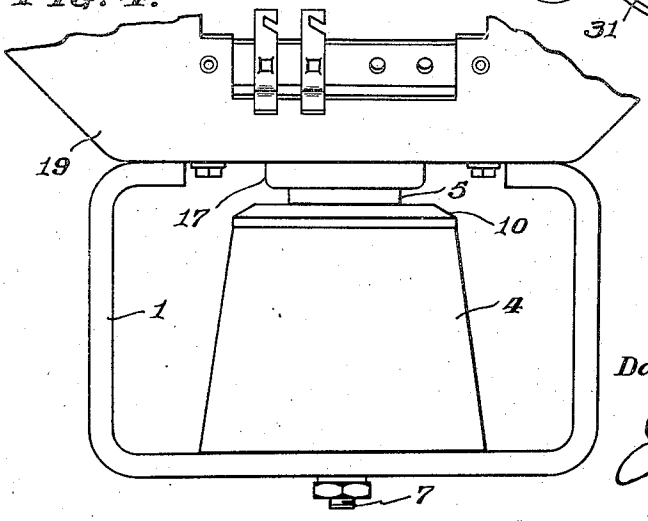
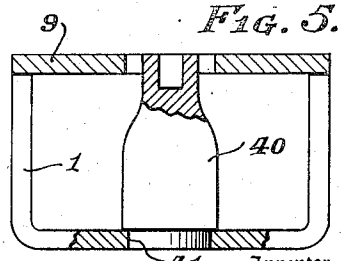


Fig. 5.



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UNITED STATES PATENT OFFICE

2,312,238

DYNAMIC LOUD-SPEAKER

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Application January 27, 1938, Serial No. 187,273

1 Claim. (Cl. 179—115.5)

My invention relates to sound transducers, and more particularly to the magnetic field structure and assembly of a dynamic loudspeaker.

An object of my invention is to provide a universal dynamic speaker assembly which is readily adapted in production to be assembled with either a central permanent magnet field element or an electromagnetic field element, as sub-assemblies, the main field yoke assembly being the same for both arrangements.

Another object of my invention is to provide a novel design of permanent magnet and magnetic circuit in a dynamic speaker for delivering magnetic flux of high density at the air gap, characterized by an efficient design of the magnet for minimizing cost of the magnet material and for using substantially the entire mass of the magnet at its optimum of performance in the storage of magnetic energy.

Another object of my invention is to provide a dynamic speaker of the permanent magnet type in which a high coercive force is produced with a minimum size and cost of magnet material.

In accordance with my invention, a novel and simplified magnet and accompanying fittings are made to conform to the space normally occupied by the field and coil and soft iron center core of the conventional electrodynamic loudspeaker, and are adapted to effectively replace said field coil and core bodily without changing the remainder of the speaker assembly.

In accordance with my invention, main field yoke assembly of a dynamic speaker has its elements permanently secured together, as by welding, and a sub-assembly, comprising either a field coil and core or a short central permanent magnet, is arranged to be attached to the main assembly, as well as to be removed therefrom for servicing, without dismembering the main assembly.

For a better understanding of my invention, reference should be had to the accompanying drawing wherein is shown, by way of illustration, certain embodiments of my invention.

In the drawing, where like reference numerals refer to like parts in the different figures,

Figure 1 is a side elevation, full size view, partly in section, of a permanent magnet dynamic speaker embodying my invention,

Figure 2 is a plan view, taken on the line 2—2 of Fig. 1, of a dust screen for keeping foreign particles out of the air gap, made in accordance with my invention,

Figure 3 is a side elevation, fragmentary view, full size, partly in section, of an electrodynamic loudspeaker embodying my invention,

Figure 4 is a side elevation view of fragmentary nature of a modification of the permanent magnet dynamic speaker of Fig. 1, embodying my invention in preferred form, and

Figure 5 is a side elevation view, reduced in scale, of a dynamic speaker permanent magnet of early design made under my instructions and in accordance with my invention.

Referring to Fig. 1, the magnetic field circuit of my dynamic loudspeaker comprises a yoke structure 1 having a U-shape, of a flat bar of magnetically permeable material, such as soft iron or mild steel, a mild steel pole plate 9 having an opening 13, and an inner cylindrical pole or core structure consisting of a short, stumpy base 4 of magnet material with ground polar plane surfaces at either end, and a pole piece or core end 5 of iron or mild steel, provided with a ground plane under surface, all of said surfaces being normal to the axis of the magnet and main lines of flux. This arrangement is made in accordance with the teachings of Gaubert et al. 1,991,738, February 19, 1935. The pole piece 5 projects into said opening 13 and forms with said pole plate an annular air gap for the voice coil. The material composing the core base 4 is homogeneous in nature throughout the magnet and is preferably of high coercive force, high energy storage material, such as an alloy of aluminum, nickel, cobalt, iron, and, in some cases, titanium, reference being made to patents of Ruder 1,947,274 and 1,968,569, and Faus 1,989,551, assigned to the General Electric Company; applications Serial Nos. 63,236, 63,237, 125,654 and 159,981, assigned to the Philips Company of Holland; and Mishima Patents 2,027,994 to 2,028,000, inclusive. The magnet is magnetized after assembly on the yoke assembly.

For the purpose of providing a more gradual transition between elements of different flux density, and a lower reluctance, from the permanent magnet 4 to the pole piece 5, respectively, a coupling element in the form of a steel washer 10, preferably with ground plane faces for effecting a low reluctance coupling, is interposed between the two in contact relation with the plane surfaces, and all three elements are removably clamped tightly together and to the base of the yoke 1 by means of a bolt 7, preferably of non-magnetic material, e. g., brass, and nut 8 which extend coaxially through a central bore in each. The purpose of the washer 10 is to provide a coupling between surfaces of different

areas, thereby preventing excessive concentration of flux in the magnet 4 at the area adjacent the pole piece 5. While the coupling element 10 may, in some form, be made integral with the pole piece 5, it is simpler and cheaper to make them separate. The various speaker elements are assembled in a manner similar to the corresponding elements in the electrodynamic speaker of Fig. 3, as described in greater detail in connection therewith. Such description of the assembly is similar to that appearing in the application of William F. Steers, Patent 2,286,123, issued June 9, 1942, where my invention was shown and described but not claimed, along with the invention of Steers, for purposes of illustration.

In order to exclude dust and magnetic particles from the magnetic air gap, a flexible cloth or felt sheet 31, formed by shaping or molding, is attached around the small end of the cone, or to the coil form, and anchored at its periphery to the pole plate 9 as by means of a frame 33 for supporting the centering spider 35. This flexible screen is independent of the flexible arm of the spider which supports the small end of the cone and the coil with respect to the axial motion of the latter, and does not materially limit the movement thereof. The inside of the cone opening is preferably closed by a cap 37 of either solid or porous material, respectively. This cap is cemented in place after assembly of the inner pole pieces. By varying the design of the materials used for dust screening with respect to porosity to air flow in and out of the confined air space, a variation of damping of the cone motion, and amplitude of vibration, may be obtained at frequencies around the natural resonance of the cone structure. The magnet end of the air gap is closed by means of centering ring 17.

Referring to Fig. 3, the electro-dynamic loudspeaker comprises a magnetic field structure formed by a U-shape yoke 1 of magnetically permeable material, such as soft iron or mild steel, an inner pole structure formed of similar material and including a core base 3 and a separate pole piece or core end 5, also of similar material. The core 3 has an upper polar plane surface, normal to its axis, in contact with the under plane surface of core end 5, and are fastened in place on the yoke 1 as by means of a bolt 7 that extends axially through a bore in the core 3 and end 5. An annular mild steel pole piece or yoke plate 9 is secured to the ends of yoke 1 by suitable means such as resistance welding, shown at 11. The plate is provided with a circular opening 13, concentric with the axis of said core base, and forms with the inner pole piece 5 a magnetic air gap in which a voice coil 15 and form 12, referred to as voice coil structure, secured to the small end of a frusto-conical diaphragm 16 is adapted to vibrate in an axial direction. A spacing or centering ring 17, of non-magnetic material, such as brass, is secured to the yoke plate, as by welding or other known method, and serves to accurately space the pole piece 5 and yoke plate opening 13 to form a uniform magnetic gap. The yoke plate is attached to the yoke by means of the interposition of the small end 19 of a diaphragm housing or dish-pan adapted to flexibly support the base of the diaphragm 16, a portion only of which has been shown. See Fig. 1 for full showing, the structures in Figs. 1 and 3 being similar except for the magnetizing elements.

A field coil 23 is shown around the inner pole for supplying the operating flux for the magnetic circuit of the speaker. This coil consists of many turns of small wire through which flows a unidirectional current derived ordinarily from a rectified alternating current, and containing fluctuations or unfiltered pulsations.

During manufacture the cone housing 19, yoke plate 9, and yoke 1 are fastened together by a single operation resistance welding process: Projections which are embossed into the cone housing between adjacent surfaces of the yoke and yoke plate, melt and solidify in union with the two magnet parts as a current and pressure is applied between the yoke plate and yoke. Hum neutralizing elements 27 and 29, made according to the above mentioned Steers Patent No. 2,286,123, issued June 9, 1942, are assembled over the side of the core end centering ring 17; the field coil 23, core 3 and resilient clamping washer 24 are pressed, as a single unit, into the yoke laterally from either open side of the yoke; the core end 5 is dropped into place, being centralized by the centering ring 17 to create a uniform air-gap with opening 13; the insertion of the core assembly bolt 7 through a hole in the yoke and through the central bore in the two core portions, and locking together with a nut 8, completes the magnet assembly. It will be noted that this process may be easily reversed and the assembly repeated by the service man if occasion arises where the field coil needs to be replaced.

Referring to Fig. 4, the efficiency of the magnet is improved by tapering from the base toward the air gap so that the flux density in planes normal to and along the axis of the magnet and lines of flux is substantially constant. This arrangement is particularly advantageous in cases of a large air gap which increases the leakage flux. There is always a substantial amount of leakage flux between the magnet and the surrounding structure such as the yoke and pole plate 9. The base portion of the magnet 4, for example, carries not only the useful air gap flux but the accumulated leakage flux picked up along the length of the magnet above this portion. In other words, there is more total flux in a given plane normal to the axis than in another given plane nearer the top of the frusto-conical magnet. The length of the magnet is of the order of the diameter, a relation that is characteristic of the alloys mentioned above. By reason of the reduced length, the leakage flux is relatively not great.

The link washer 10 is shown as tapered, but I have found that this shape is not important, the difference between a tapered washer and a straight sided one, as in Fig. 1, being negligible. The size and shape of the magnet are such that the maximum flux is delivered at the air gap for a given amount of material which is quite expensive. The uniform density is a value equal to the density when optimum energy obtainable for the magnetic material is used.

Each elementary segment of the magnet throughout its volume is, therefore, magnetized at a flux density substantially equal to that which, by measurement from the demagnetization characteristic of the material, obtains when maximum energy is stored in the magnet.

This novel design provides a magnet of most economical construction required to produce a given performance or delivery of useful flux at the air gap.

While I have shown a frusto-conical shape of

magnet, the sides of the magnet may be curved, but I find that the shape shown is very practical. Fig. 5 shows a curved magnet of cobalt steel, the magnet and pole piece being integral. Here the base of the magnet was fastened in the yoke by means of a ground surface 41 forced into a hole in the yoke base.

I claim as my invention:

In the process of manufacturing a dynamic loudspeaker having a U-shaped yoke, a yoke plate, a diaphragm and a voice coil, and a diaphragm support housing, the steps which comprise forming a circular opening in said yoke plate for receiving said voice coil, assembling said yoke, yoke plate, diaphragm and diaphragm housing in aligned position and permanently securing them together into a unitary permanent assembly, producing two species of magnetizing field elements including permanent magnet cores with end pieces and electro-magnetic windings with soft iron cores and end pieces, respectively, selecting either species of said field elements and assembling the selected species of field element into said permanent assembly in coaxial relation with said opening by inserting the core of the selected species laterally into said permanent assembly into operating position on said yoke and inserting one of said end pieces axially through said opening onto the upper end of said core in concentric relation within said opening, and removably clamping said selected field element to said yoke without disturbing said unitary permanent assembly.

DAVID H. CUNNINGHAM.