

March 1, 1960

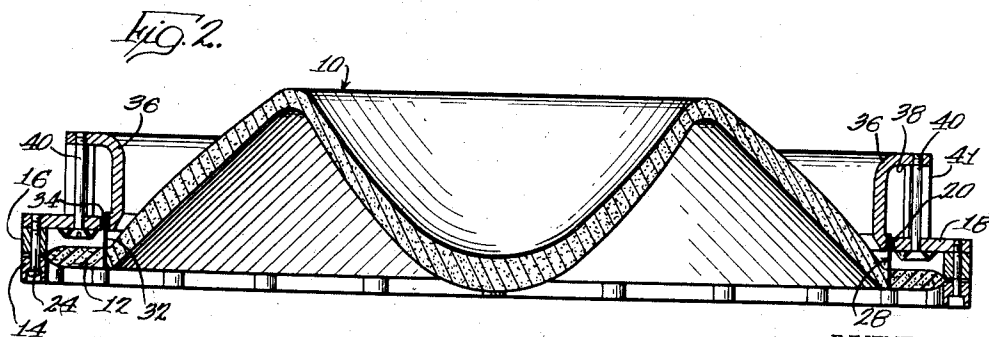
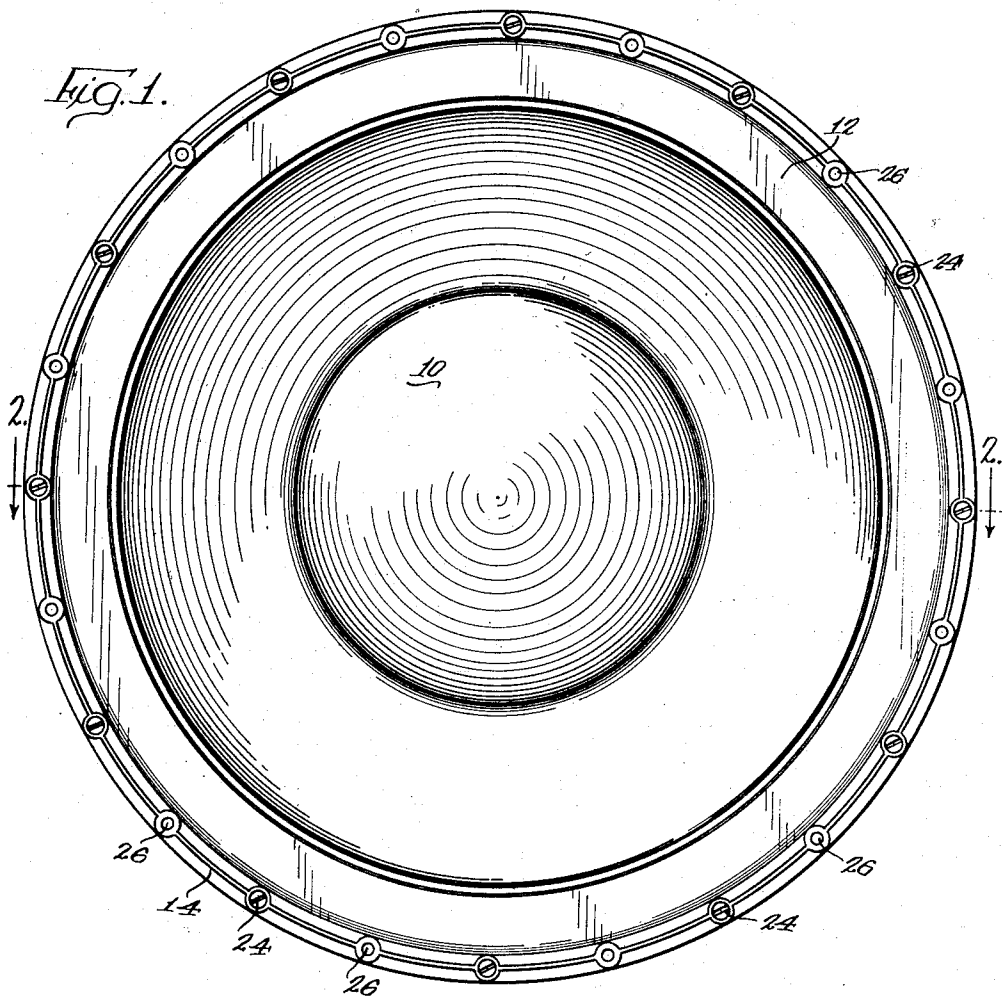
W. C. ROHN ET AL

2,926,741

SPEAKER

Filed April 28, 1958

2 Sheets-Sheet 1



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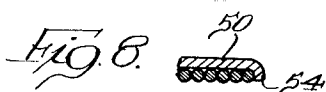
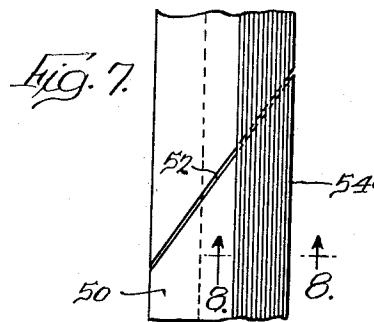
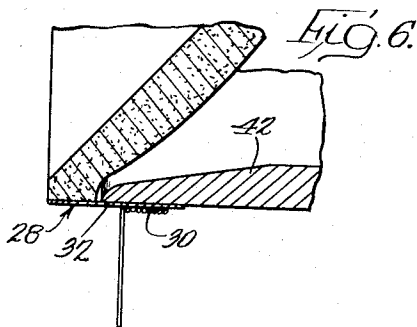
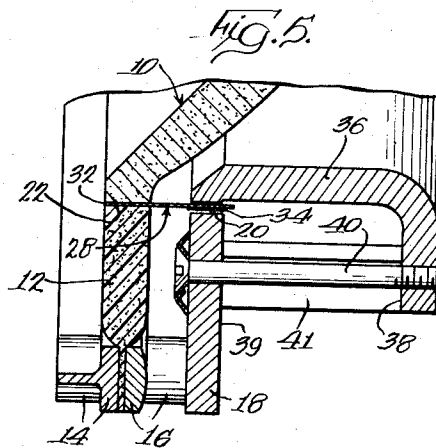
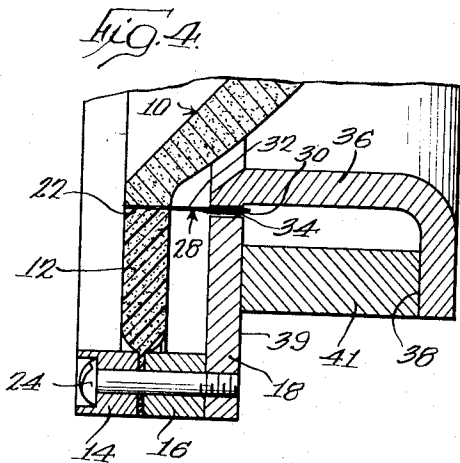
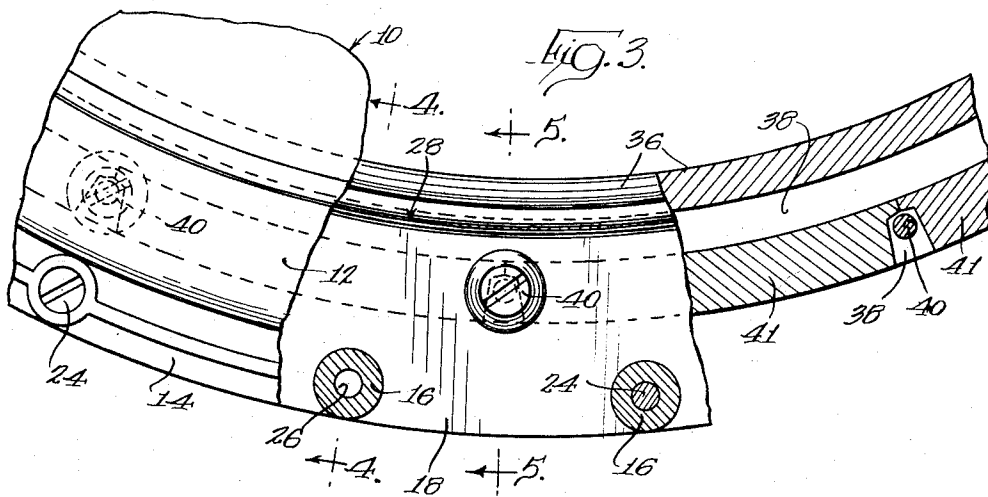
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SPEAKER

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2 Sheets-Sheet 2



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2,926,741

SPEAKER

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1 Claim. (Cl. 181—32)

The present invention relates to speakers of the type in which electrical energy representative of music, speech and the like, is converted into acoustical energy.

One of the objects of the present invention is to provide a novel speaker having a high fidelity of response together with high efficiency and high power output.

An additional object is to provide an improved speaker having the above characteristic and in which distortion introduced by the speaker is kept to an extremely low level.

Still another object is to provide an improved speaker particularly adapted for operation in the low frequency portion of the sound spectrum.

Yet another object is to provide a novel speaker having an excellent response with low distortion throughout a wide frequency range and in which the high frequency portion of the sound spectrum is much less directional in its characteristics than is usual.

Still another object is to provide a speaker having most or all of the above characteristics and which in addition may be supplied in large sizes while at the same time maintaining an extremely shallow front to back dimensional requirement.

Still another object is to provide a speaker of the vibratory cone or piston type, which is substantially without distortion, of the character which is usually introduced by acoustical shadows. Other objects and advantages will become apparent from the following description of a preferred embodiment of my invention which is illustrated in the accompanying drawings.

In the drawings, in which similar characters of reference refer to similar parts throughout the several views:

Fig. 1 is a front view of a speaker embodying features of the present invention;

Fig. 2 is a transverse medial sectional view through the speaker, which may be considered as taken in the direction of the arrow, along the line 2—2 of Fig. 1;

Fig. 3 is a fractional view drawn to larger scale of a portion of the speaker near the edge thereof with the view oriented as in Fig. 1, but with portions of the mechanism broken away so as to reveal the underlying structure;

Fig. 4 is a large scale fractional transverse sectional view through the rim portion of the speaker and may be considered as taken in the direction of the arrows substantially along the line 4—4 of Fig. 3;

Fig. 5 is a view similar to Fig. 4 but taken in a slightly different position along the speaker rim as indicated by the line 5—5 of Fig. 3;

Fig. 6 is a transverse fractional sectional view showing a portion of the speaker at one stage of its manufacture;

Fig. 7 may be considered as a fractional side view of a portion of a coil form which may be used in constructing the speaker of the present invention; and

Fig. 8 is a transverse sectional view of a detail, and may be considered as taken in the direction of the arrows along the line 8—8 of Fig. 7.

Speakers of the type to which the present invention relates are used for the reproduction of sound. Briefly, an

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undulating current is converted by the speaker to mechanical vibratory motion and, by acoustical coupling, this vibratory energy is transferred to the surrounding air mass.

Speakers of this type usually assume the form of a relatively stiff cone or piston formed of paper, pressed fiber, or a similar material which is supported at its edge by means of a flexible ring connected to a circumscribing framework. The flexible member, usually referred to as the hinge, may take the form of a separate element provided specifically for this purpose, or, more commonly, this element is formed simply by circumferentially corrugating the material of which the cone is formed so as to give it greater flexibility. The center of the cone is fixed to a voice coil which carries the undulating current, and this coil is located within a relatively strong magnetic field so that the coil moves inwardly and outwardly within the field as the intensity and polarity of the coil current varies, and this motion in turn is transferred to the cone at its center. The mechanical motion of the cone thus produced is transferred to the surrounding air mass by the acoustic coupling between the cone face and the air.

In the design of speakers of this general character there are several controlling limitations, many of which are mutually incompatible. Ordinary engineering in this field, therefore, consists in compromising the several design factors so as to achieve a reasonably effective balance. A speaker having the features of our invention, however, achieves a much higher than usual excellence, since some at least of the incompatible limiting factors may be eliminated from consideration, as will appear. As an example, it is known, among other things, that the magnetic field assembly should be relatively massive and rigidly supported so as to provide considerable flux and low vibration. This design characteristic in ordinary speakers is incompatible with the elimination of as much structure behind the cone as possible in order to reduce acoustic shadows. The present invention eliminates this problem completely.

The speaker of the present invention although it has good frequency response throughout the audible spectrum is particularly intended for use as an extremely high quality, low frequency transducer in a sound system. Such speakers are commonly referred to as "woofers." The embodiment shown is intended for efficient and smooth operation at high power levels and, as illustrated, is approximately 18 inches in overall diameter. In general, it consists of a vibratory cone or piston 10 connected at its periphery to a hinge ring 12 which projects radially outwardly. The outer edge portion of this hinge is clamped between a front ring at 14 and a back ring at 16, these two rings in turn being secured to an annular mild steel plate 18 near its outer edge. The plate 18 extends inwardly so that its inner edge 20 is located slightly outwardly of a position of alignment with the periphery 22 of the cone 10. The plate 18 and the rings 14 and 16 are secured together by several rather closely spaced, circumferentially arranged screws 24 which pass through the rings and are threaded into the plate 18.

The structure consisting of the rigidly bound together plate 18 and rings 14 and 16 constitute the mounting flange for the speaker so that the speaker can be secured to its baffle board by screws passed through holes 26 which in the embodiment shown are arranged so that the holes 26 alternate with the screws 24 around the periphery of the structure.

The voice coil, represented by the numeral 28, consists of a coil of wire indicated at 30 wound upon the rearward portion of a large diameter relatively short coil form 32. This coil form has a diameter equal to that of the piston 10 and is secured to the peripheral edge of the piston between the piston and hinge 12. The voice coil extends rearwardly of the piston so as to place the coil 30 wound thereon within a gap 34 in a magnetic circuit.

The magnetic structure forming this gap consists of the following. One pole at the gap is constituted by the inner edge 20 of the annular ring 18. The other pole piece at the other side of the gap is formed at the forward end of a mild steel ring 36 which, in section, is L-shaped.

The ring 36, from the pole end opposite the pole 20, extends substantially straight rearwardly of the structure and thence straight outwardly so as to provide a forward flat face 38 which is parallel to the rearward face 39 of the ring 18. These parallel flat faces in the present embodiment are spaced apart a distance of about one and one-half inches.

The two elements 36 and 18 are connected together by means of relatively long screws 40 which pass through the plate 18 and are threaded into the ring 36. Between each of these screw locations a magnetic slug 41 is positioned so that the slugs extend all the way around the structure in side-by-side relationship. The slugs are formed of cast Alnico 5 or equivalent material, and since they are clamped in place by endwise pressure applied between parallel faces, they need only to be ground to uniform length with parallel end surfaces.

More particularly, the cone or piston 10 is molded of styrofoam. This piston has considerable thickness and has relatively smooth faces with a cellular interior. It is therefore extremely light, while at the same time being extremely stiff. This stiffness is enhanced by giving the piston a compound parabolic contour with the central portion of the piston being folded forwardly so as to present a convex surface as is best seen in Fig. 2. Although the following dimensions need not be closely adhered to, the piston shown, which is representative, is about 15 inches in diameter. The diameter of the forwardly projecting portion at the center is about one-half the total piston diameter, and the total overall front to back dimension of the speaker is about 3¾ inches. The material in the cone is graduated in thickness so as to be thickest at the center and to thin out gradually as it approaches the folded portion. Outwardly of the fold, it gradually increases in thickness and then thins down somewhat just before reaching the short cylindrical portion at the periphery which is cemented to the voice coil form. As thus contoured, great strength and stiffness is obtained with minimum weight.

In addition to contributing considerably to the overall stiffness, folding the piston also contributes greatly to the angular dispersal of the high frequency sound radiated therefrom. This effect is brought about by the rather sharply curved forward surface of the dome at the center of the piston and is aided further by the conical, rather than parabolic, forward face on the portion outwardly of the fold. Although the forward face on the portion outwardly of the fold is conical, the back surface thereof is curved such that this section of the piston as a whole, in other words, along the centerline of the section, is substantially parabolic.

The periphery of the cone is molded so as to be substantially cylindrical and is secured to the voice coil form 28 by cementing. This coil form may be comprised of a strip of parchment paper. After the form is cemented to the piston, it is slid over the end of a coil winding arbor 42, see Fig. 6. Preferably in order to promote the subsequent separation of the coil form from the arbor 42, a thin layer, such as a one mil thickness, of polyethylene is interposed first between the arbor and the coil form. No. 27 copper wire, polyurethane coated, is suitable for the coil 30. Other sizes can, of course, be substituted, and the insulating material used is largely a matter of choice. This coil should be well cemented to the coil form, since under conditions of high power operation, the coil wire will be torn loose from the coil form if its adhesion thereto is poor. I prefer to accomplish the adhesion by coating the exterior surface of the coil form with a suitable adhesive, such as an epoxy resin, and then to wind the wire directly into the layer of adhesive.

The hinge 12 is preferably a ring die cut from a sheet of polyurethane foam which is approximately ¾ of an inch thick. This material is cellular in nature and although it is rather flexible, it has a very considerable resistance to stretching and resists taking a permanent set. The outer portion of the polyurethane foam hinge is clamped between the rings 14 and 16 as previously described, and therefore the material of the hinge at its periphery is squeezed flat with an accompanying collapse of the interior cellular structure. The result is that the hinge 12 has great resistance to transverse movement in any direction and the piston therefore is well maintained in a centered location relative to the framework and the magnetic gap, but the hinge has little resistance to bending, particularly at the pinched portion of the hinge which is just inwardly of the clamping rings. The piston therefore has great freedom of motion in an inwardly and outwardly direction but cannot move in any other direction.

Since the hinge maintains the cone 10 in precise alignment, the gap in the magnetic circuit within which the voice coil operates, may be quite small. This is important since it helps in establishing a high magnetic flux density at the gap. Although the large diameter parchment voice coil 28 could ordinarily expect to be subject to considerable deformation in use, we have found that once it is placed upon the arbor 42 and the wire coil 30 has been wound thereon and tightly cemented in place, the wire acts as a reinforcing element for the voice coil form so that thereafter the voice coil maintains its shape and dimensions quite precisely in spite of small changes which may take place in the diameter of the piston over a period of time.

If it is desired to use still higher flux densities, or less magnetic material in the circuit, or if for any reason an even smaller gap is desired and hence even more precise alignment and dimensional stability of the voice coil is called for, we have found that an excellent arrangement is to make the voice coil form from a strip of thin magnesium ribbon, as is illustrated in Fig. 7, in place of the parchment. This magnesium ribbon is cemented to the rim of the piston in the same manner as the parchment strip, excepting that the ends of the ribbon 50 should not touch each other. This is illustrated by the slight gap at 52. This gap prevents the coil form from acting as a single turn, short circuited coil within which a current would be induced during operation of the speaker. As shown in Fig. 7, the ends of the ribbon are skived, and although it would appear that the portion of the ribbon projecting beyond the edge of the piston would be comparatively weak, it has been found that once the wire 30 has been wound and cemented thereon, the wire acts as a sufficient bridge across the gap 52 to give the required rigidity.

If the speaker is to be used in very high power applications where the tendency of the alternating current in the coil 30 to strip the wire from the form is great enough to cause some failures in service, this can be rectified by rolling the extreme free edge of the magnesium ribbon 50 outwardly slightly to form a slightly hooked edge as at 54 in Fig. 8. By winding one of the turns against this hooked edge and the other turns in contact therewith and with each other, the resistance to stripping of the wire from the coil form is greatly increased.

It should be noted that the clamping ring 16 is cut away at the back as at 56 so as to provide large openings communicating between the atmosphere and the space behind the hinge 12. This is advisable since it prevents pressure variations in this space from having a damping action upon the piston.

Ordinarily in speaker construction the voice coil and the material forming the magnetic circuit are located directly behind the center of the cone and are supported from the rim by several arms or similar structure. This structure directly behind and close to the cone produces

acoustic shadows and reflections and introduces distortion which under some conditions may be quite serious. The difficulty is compounded by the fact that the arrangement for forming the magnetic circuit and magnetic gap must be very rigidly supported from the rim so that the forces tending to pull the voice coil into the magnetic gap will produce movement of the voice coil and cone only without causing substantial vibration in the elements of the magnetic circuit.

An important feature of this invention is that, as will be noted, the material forming the permanent magnet circuit is at the extreme periphery of the piston and no portion thereof projects inwardly beyond the edge of the piston more than a very small amount, of the order of $\frac{1}{4}$ to $\frac{3}{8}$ of an inch at most. Thus, the central hole through the speaker frame and magnetic circuit defined by the cylindrical portion 36 of the L-shaped ring is almost as large as the speaker piston. This substantially completely eliminates acoustical shadows and reflections. The distortion is therefore less and both sides of the speaker can be used for high quality sound radiation. Furthermore, the mechanism forming the magnetic circuit is extremely rigidly supported relative to the mounting flange.

Because of the folded nature of the piston, and because the magnetic material and the voice coil are not behind the center of the cone, the depth of the speaker from front to back is extremely shallow. This is an important advantage in mounting the speaker under certain commonly encountered conditions.

From the above description of the invention it will be appreciated that many worthwhile objectives have been accomplished which in the main are as follows. The piston is extremely light, yet extremely stiff. It is well centered and supported, but nevertheless because of the high degree of flexibility of the pinched portion of the hinge, the natural frequency of oscillation of the piston is low and therefore the speaker will respond properly down to the low end of the audible spectrum since throughout the frequency range of operation, the resonant frequency of oscillation of the piston is not reached.

Because the cone is well centered and because of the high degree of rigidity of the frame, a very small flux gap can be used, and it is possible to obtain extremely high flux densities, particularly since magnetic slugs may be used all the way around the periphery of the speaker, thereby enabling a large quantity of magnetic material to be inserted into the magnetic circuit without obstructing

the back of the piston. As previously discussed, the forward face of the piston disperses the sound, including the usually high directional high frequencies, over a wide angular range, and even under conditions where the speaker is wall mounted between two rooms the output of the speaker on the two sides is substantially the same, particularly in the lower frequency range, since there is no structure which can produce acoustic shadows on the back side of the speaker.

Furthermore, the speaker is so extremely thin from front to back, in spite of the fact that the example shown is an 18 inch speaker, that mounting in an ordinary wall with grills or other coverings on each side is entirely feasible.

It will be understood that the above specific description of a representative embodiment of our invention should not be considered as limitative, since variations may be made in the structure without departing from the scope or spirit of the invention, and that the scope of the invention is to be determined from the scope of the following claim.

Having described our invention, what we claim as new and useful and desire to protect by Letters Patent of the United States is:

A speaker piston formed of lightweight stiff cellular material having an appreciable thickness, said piston having a circular periphery, the material of said piston being formed to a contour such that a transverse medial section therethrough constitutes a compound parabola with the forward face of the outer portion of said piston being concave and the central portion thereof being reversely curved so as to be convex, said concave and convex portions being joined by a smoothly blended curve of small radius, and the thickness of said cellular material being greatest at the center and tapering to a thinner section where the central portion joins said small radius curve, and the thickness of said outer portion tapering from a thin section adjacent said small radius curve to a thicker intermediate section and thence to a thinner section adjacent said periphery.

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