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SOUND REPRODUCING DEVICE

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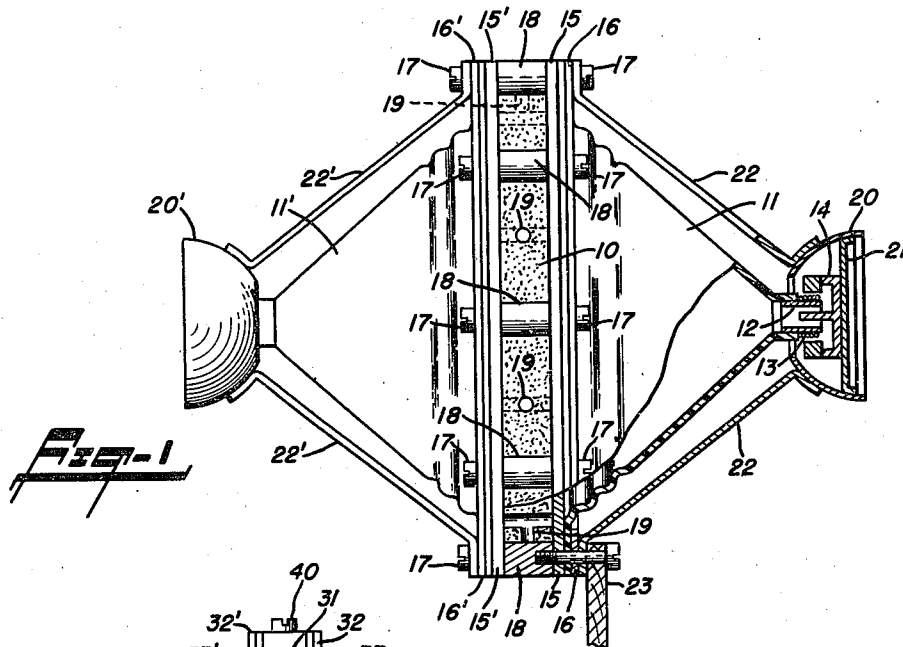


Fig. 1

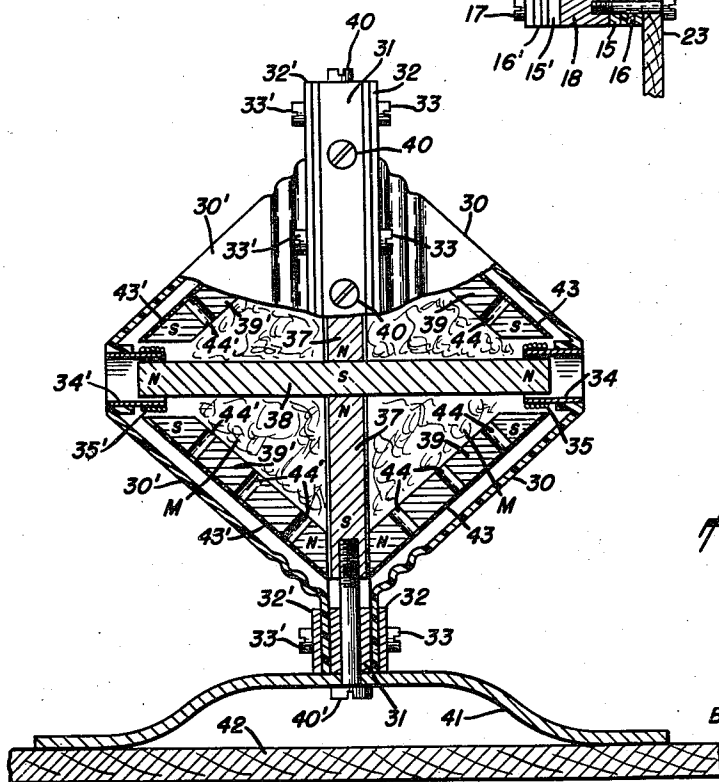


Fig. 2

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SOUND REPRODUCING DEVICE

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This invention relates to a sound reproducing device and more particularly to an electro-acoustic transducer of the type generally known as a cone loud speaker.

In a general sense, loud speakers are subject to distortion caused by their inability to radiate sounds of all audio frequencies equally in all directions and also by the fact that the sound radiations on opposite sides of the vibratory cone are of reverse phase.

Conical speakers conventionally use the concave side of the vibratory diaphragm as the forward, or desired, radiator. The cones vary in diameter from a few to twenty inches so that the dimension of the sound radiating surface is large compared to the wave length of the higher audible frequencies and small compared to wave length of the lower audible frequencies. Radiation theory discloses that a uniform, angular sound distribution, at a given frequency, requires a radiator whose dimensions are small relative to the wave length. Since a sound frequency of 10,000 cycles per second in air has a wave length of only about one (1) inch, a flat, or conical, radiator must have a dimension of the order of $\frac{1}{40}$ inch in order to act as an approximate point source for such sound frequency. If such a radiator be set in an infinite baffle, or if its reverse side radiations be completely absorbed, its radiation pattern would be approximately hemispherical. Obviously, such a minute-size radiator would be extremely inefficient at the lower audio frequencies because of its inadequate coupling to the air. If, on the other hand, a large radiator is used to increase radiation efficiency for the low frequencies then the radiator becomes highly directional for the high audio frequencies and there results an unequal angular sound distribution between the high and low frequency waves. Obviously, neither of the two dimensional extremes, above given, are practical.

The ideal radiator for uniform angular sound distribution at all frequencies would consist of a spherical diaphragm vibratorily enlarged and contracted in accordance with the electrical signal energy. This, however, involves many difficulties of a practical nature particularly the translation of a linear voice coil motion into a spherically-pulsing motion of the radiating surface.

The distortion produced by unequal angular sound distribution at different frequencies, by the conventional cone-type loud speaker responding to complex electrical waves having a wide frequency variation among their partial components, results in a narrow angle, or beam, concentration of the higher-frequency components along the axis of the cone, with a gradual spreading out of the angle for the lower frequency components. For example, a piano, or other harmonic-rich tone of say, 100 cycles per second reproduced by a conventional loud speaker, may have its 20th vibration partial (2000 cycles per second) concentrated within a radiation angle of about 30-50 angular degrees whereas the fundamental component may have its energy distributed over a solid angle of 180 degrees or more. The angular distribution of the other, intermediate frequency partials falls be-

tween these angular limits. Even if we assume that the entire electronic sound-transducer system is so distortion free as to impart to the speaker cone a wave motion that is completely faithful to all the partial vibration frequencies and the amplitudes of all such components, as exist in the original live tone to be reproduced, a conventional cone radiator cannot exactly reproduce the live tone. Along the cone axis the highest component frequencies will be much too strong because their energy is confined to a relatively narrow angle by the beaming action of such radiator. Similarly, the lowest component frequencies will be much too weak along the cone axis because their energy is spread over a much wider, solid angle. At a listening point angularly displaced from the cone axis, the higher frequency components will have a decreased sound level while the lower frequency components will have an increased sound level. Therefore, at no point in the cone's radiation field can one find the same relative amplitudes, among the partial components, as exist in the live, complex tone source. Since any alteration of the relative amplitudes of any of the components of a complex tone causes a change in tone quality, such conventional cone-type loud speakers cause a serious distortion of that tone quality, even though the entire transducer system, up to and including the cone motion, be completely free of distortion.

I have devised a practical solution to the problem by using two, coaxially-disposed cone diaphragms, or radiators, arranged front to front (convex sides facing outwardly) with means for absorbing their reverse side radiations. The two voice coils are phase-connected so that both cones move outwardly and inwardly together, in an approximation of a true, spherical radiator.

An object of this invention is the provision of a substantially non-directional sound-reproducing device having a substantially uniform spherical sound distribution pattern for all audio frequencies.

An object of this invention is the provision of a sound radiator including two cone-shaped vibratory diaphragms arranged front to front and operating in phase to simulate the expansion and contraction of a sphere and including means for absorbing the internal sound radiations.

An object of this invention is the provision of a sound-reproducing device comprising a pair of axially-aligned vibratory cones having juxtaposed bases, means for simultaneously vibrating both cones in opposite directions in response to electrical waves and sound-absorbing means disposed between the cones and adapted to absorb internal sound waves produced by vibrations of the cones.

These and other objects and advantages will become apparent from the following description when taken with the accompanying drawings illustrating several embodiments of the invention. It will be understood the drawings are for purposes of illustration and are not to be construed as defining the scope or limits of the invention, reference being had for the latter purpose to the appended claims.

In the drawings wherein like reference characters denote like parts in the several views:

Figure 1 is a side elevation, with parts in section, showing a sound reproducing device made in accordance with one embodiment of this invention; and

Figure 2 is a similar view of a device made in accordance with another embodiment of this invention.

Reference is now made to Figure 1 wherein there are shown two conventional permanent-type cone-type speakers mounted front to front with a disc 10, of felt or other good sound absorbing material, mounted between them. Each speaker comprises a vibratory diaphragm 11, 11' cemented to a tubular shell that carries the voice coil, as shown in the sectional view of the drawing wherein

the shell and voice coil are identified by the numerals 12, 13, respectively. The voice coil operates within a magnetic field established by a permanent (or other) magnet structure 14 as is well known in this art. The base of each diaphragm is secured between two metal rings 15, 16 and 15', 16' and the entire assembly is secured together by the screws 17 passing into threaded holes in the spacer bushings 18 that are disposed in spaced relationship along the periphery of the assembly. These spacer bushings have axial lengths substantially equal to the thickness of the sound-absorbing disc 10 thereby preventing excessive compression of the disc so that a desired degree of air breathing may prevail in the internal space between the two cones. In the event the disc 10 is made of a relatively dense material a plurality of breather holes 19 may be provided in the disc. In any case, the important consideration is to provide means for the movement of air in response to vibrations of the diaphragms while at the same time completely absorbing the internal sound radiations of the inner cone surfaces of each cone. The two voice coils may be connected in series or in parallel but they must be so phased that both diaphragms move outwardly and inwardly in unison. Since the convex sides of the cone diaphragms are relied upon for the external radiation of sound, the radiation effects approximate those of an expanding and contracting, or breathing sphere, even though the cone motions are linear along the cone axes.

In order to reduce the shadow effect of the permanent magnet structures for the high frequency sound components the individual motor structures are enclosed within the housings 20, 20'. Each magnet structure is secured to its associated housing by a suitable bracket 21 and the housings are supported from the central assembly by a number of relatively-thin metal studs 22, 22', one end of each stud being welded to the housing and the other end secured by the fastening screws 17.

The above assembly may be disposed within a suitable cabinet. Alternatively, the device may be supported on an upright post, or panel, 23, as shown. Since there is no external, reverse phase sound radiation no baffle board or enclosure of any kind is required.

The directional sound distribution characteristics of the device are shown by tests to be almost spherical for both high and low frequency waves. There is a small reduction in amplitude for both high and low frequency radiations at right angles to the cone axes and there is also a small amplitude reduction of the high frequencies along the cone axes due to the shadow effect of the permanent magnet structures. In order to eliminate the latter effect I provide a novel speaker assembly as shown in Figure 2.

Referring now to Figure 2, the base of each vibratory diaphragm 30, 30', is clamped between a central, metal ring 31 and the associated clamping rings 32, 32', by the screws 33. The apex of each diaphragm is turned inward and cemented to the associated coil shells 34, 34' that carry the voice coils 35, 35', respectively. My novel permanent magnet structure comprises four magnets including a centrally-disposed disc magnet 37 having a central hole therein and magnetized to form a north pole at the center and a south pole at the periphery, as indicated by the letters N and S. A cylindrical bar magnet 38 passes through the central hole in the disc magnet, said bar magnet being magnetized as indicated by the letters N and S, and the two magnets may be secured in fixed position relative to each other by a force fit or otherwise. Alternatively, a soft-iron bar may be substituted for the permanent magnet 38. The other members of the magnet structure comprise the cone-shaped permanent magnets 39, 39', each such magnet being spaced from the associated diaphragms 30, 30', respectively, and each being secured to the disc magnet 37 by any suitable means such as cement, bolts, or etc. As shown in the drawing, the cone-shaped magnets are magnetized to

provide a north pole at the base and a south pole at the apex. Inspection of the magnet structure will show that all magnets are arranged in series relationship (irrespective of their individual polarities, which may be reversed) to provide a maximum magnetic field intensity across the air gaps within which the voice coils 35, 35' operate. The entire magnet structure is supported by a plurality of radially-extending screws 40 passing through suitable holes in the ring 31 and into threaded holes in the disc magnet 37, the lower such screw 40' also serving to secure the entire loud speaker assembly to a suitable base 41 adapted for supporting the device on a flat surface such as the table top 42. In order to absorb the internal sound radiations of the diaphragms, the outer surfaces of the cone-shaped magnets 39, 39' are coated with suitable sound-absorbing members 43, 43', such as felt, and the internal space between the cone-shaped magnets and the disc magnet is filled with a suitable sound absorbing material M, as shown. Further, each of the cone-shaped magnets preferably are provided with a plurality of holes 44, 44', affording a transfer of air between the sound-absorbing material M, and the space formed between the vibratory diaphragm and the associated cone-shaped magnet. Alternatively, the cone-shaped magnets 39, 39', may be formed with spoke-like elements between the apex and the base to provide ample openings through which the internal sound radiations may flow to the sound absorbing material M. Air breathing between the two sides of the individual vibratory diaphragms occurs in the space between the inner walls of the voice coil shells and the end surfaces of the magnet bar 38. The electrical leads connected to the voice coils may be cemented to the outer cone surface and secured to terminals carried by a suitable insulator strip that is fastened to the device by the screw 33. While the magnet structure shown in Figure 2 is made up of four permanent magnet elements, namely, the disc magnet 37, bar magnet 38 and two cone-shaped magnets 39, 39', those skilled in this art will understand that certain of these elements may be made of magnetic material, such as soft-iron, provided the remaining permanent magnet element is capable of producing a sufficient magnetic flux density across the air gap within which the voice coil operates. Specifically, the disc 37 and cone-shaped elements 39, 39' can be made of soft-iron if the permanent magnet bar 38 is made of a material and size to produce sufficient flux in the air gaps between the bar ends and the apexes of the cone-shaped elements.

For purposes of clarity, the drawings do not show the conventional spiders employed to center the voice coil shells within the associated air gaps, various such spider arrangements being well known in the art. It is here also pointed out that the open end of the voice coil shell may be capped with a suitable non-porous member to promote high frequency sound radiations, as is also well known in this art.

Having now described my invention certain modifications in the individual components and their assembly will occur to those skilled in this art. Such modifications may be made without departing from the spirit and scope of the invention as set forth in the following claims.

I claim:

1. A sound reproducing device comprising a pair of axially aligned vibratory cones having juxtaposed bases, means securing the bases of the cones in fixed position relative to each other, electro-magnetic means for vibrating the cones toward and away from each other in unison said electro-magnetic means including individual voice coils mechanically coupled to the apexes of the respective cones, and sound-absorbing means, disposed between the two cones and exposed to the internal radiations from each, for substantially reducing the acoustical opposition exerted by the vibrations of each cone on those of the other.

2. The invention as recited in claim 1, wherein the

5

sound-absorbing means comprises a solid disc of sound-absorbing material disposed between the cone bases.

3. The invention as recited in claim 2, wherein the said electro-magnetic means includes individual permanent magnet structures having a magnetic flux gap within which the associated voice coil operates and including means supporting each magnet structure in fixed position relative to the cone bases.

4. A sound reproducing device comprising a supporting member; a pair of vibratory cones having their bases secured to opposite sides of the supporting member; electro-magnetic means for simultaneously vibrating the cones in opposite directions, said electro-magnetic means including individual voice coils secured to the apexes of the respective cones and magnetic structures magnetically coupled to the voice coils; means securing the magnetic structures to said supporting member; and sound-absorbing means, disposed between the two cones and exposed to the internal radiations from each, for substantially reducing the acoustical opposition exerted by the vibrations of each cone on those of the other.

5. The invention as recited in claim 4, wherein the sound-absorbing means comprises a solid disc of sound-absorbing material and said disc constitutes the said supporting member.

6. The invention as recited in claim 5, wherein the said magnetic structures are disposed outside of the cones and including a cylindrical housing disposed over each said structure.

7. The invention as recited in claim 4, wherein the said supporting member is a ring and the magnetic structures comprise a disc element of magnetic material disposed within the ring and having a central hole therein; a pair of cone-shaped elements of magnetic material having their bases abutting opposite surfaces of the disc magnet and axial holes in their apexes; and a bar element of magnetic material passing through the hole in the disc magnet and having each end disposed within a hole in the apex of one of the cone-shaped magnets, at least one of said elements being a permanent magnet.

8. A sound reproducing device comprising a mounting ring; a pair of vibratory cones having bases secured to opposite surfaces of the mounting ring; a disc magnet disposed within and supported from the said mounting ring and having a central hole therein; a pair of cone-shaped magnets spaced from the said cones, said cone-shaped magnets having their bases abutting opposite surfaces of the disc magnet and axial holes in their apexes;

6

a bar magnet passing through the hole in the disc magnet and having its ends extending into the holes in the cone-shaped magnets to form magnetic flux gaps; a voice coil secured to the apex of each cone and operative in a flux gap; and loose, sound absorbing material disposed in the space between the cone-shaped and disc magnets.

9. The invention as recited in claim 8 including a covering of sound-absorbing material on the outer surfaces of the cone-shaped magnets and wherein the said disc magnet is supported from the said mounting ring by means of screws passing through radial holes in the mounting ring into threaded holes in the peripheral surface of the disc magnet.

10. A sound-reproducing device comprising a pair of vibratory cones having respective apexes facing in opposite directions and respective base peripheries relatively closely adjacent each other; means closing the space between said base peripheries, whereby with said cones to define an enclosure substantially in the form of a base-to-base pair of cones; means actuable by sound-representing electric oscillations for vibrating said cones in phase opposition to each other, whereby substantial portions of said enclosure are caused to breathe oscillatorily to result externally of the enclosure in sound radiation substantially similar in phase in all outward directions; and sound-absorptive means, disposed within the enclosure and exposed to the internal radiations from each of said cones, for substantially reducing the acoustical opposition exerted by the vibrations of each cone on those of the other.

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