Oct. 27, 1964 A. F. PETRIE 3,154,173

LOUDSPEAKER CONE SUSPENSION

Original Filed Sept. 28, 1959

Fig. 1.

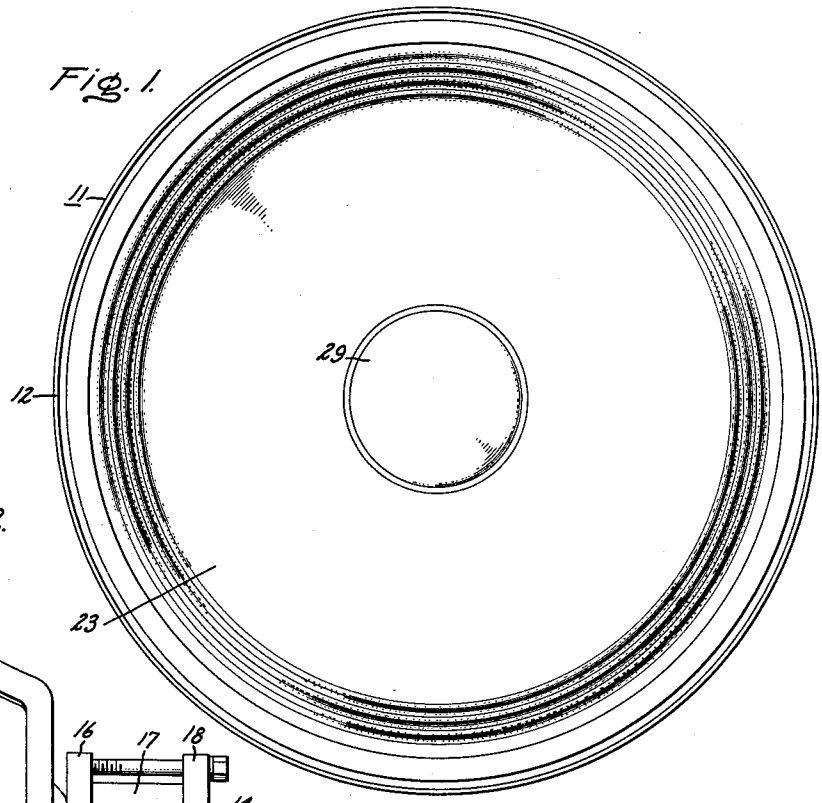


Fig. 2.

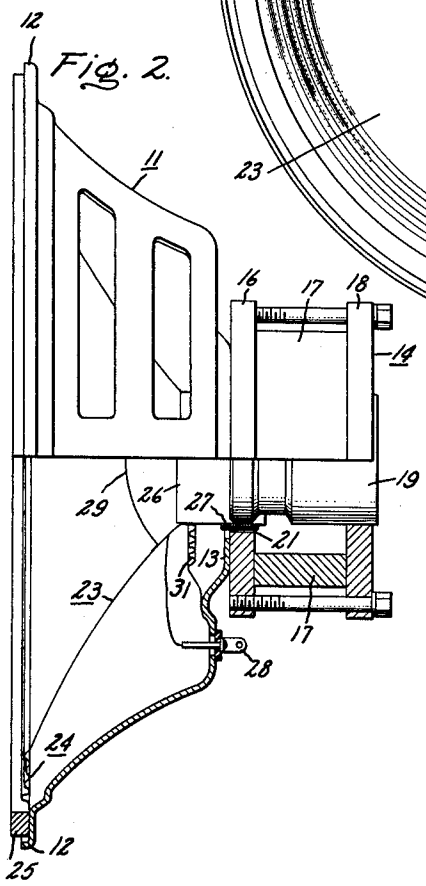


Fig. 4.

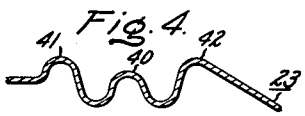


Fig. 5.

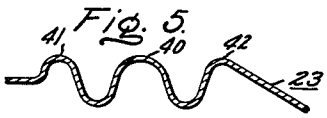


Fig. 6.

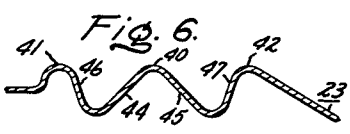
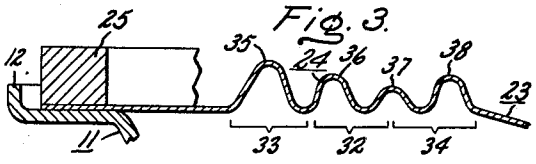


Fig. 3.



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LOUDSPEAKER CONE SUSPENSION

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Original application Sept. 28, 1959, Ser. No. 842,624, now Patent No. 3,072,213, dated Jan. 8, 1963. Divided and this application Nov. 19, 1962, Ser. No. 246,850

2 Claims. (Cl. 181—32)

This invention relates to loudspeakers, and particularly to cone suspension arrangements for supporting the cone of a loudspeaker.

This is a division from patent application Serial No. 842,624, filed September 28, 1959, and issued as Patent No. 3,072,213.

Loudspeakers employ a cone or diaphragm arranged to be vibrated in accordance with electrical signals, so as to convert the electrical energy into sound or acoustical energy. The cone or diaphragm must be suspended in a manner that will permit it to be vibrated along an axis. In a typical loudspeaker, the cone is supported at its outer rim by an arrangement of concentric corrugations arranged to permit the cone to vibrate axially but not laterally. A second suspension, of smaller size, is attached to the cone near the apex thereof.

The cone suspension must be designed carefully, because it affects the operation of the loudspeaker. For example, the suspension must be sufficiently "loose" or compliant so that the cone can vibrate freely to produce the desired sound waves. On the other hand, the suspension must have sufficient "stiffness" to insure that the cone excursions will be symmetrical with respect to a neutral position.

It has been found that an undesirable effect is caused by the conventional suspension system. This undesirable effect is caused by a resonant condition of the suspension, whereby one or both of the suspensions are driven into self-resonance by the vibrating cone. This self-resonance of the suspension system is more pronounced at certain frequencies of self-resonance. This self-resonance condition causes undesirable distortion of the sound output of the loudspeaker. There are believed to be other effects that cause further distortion, due to acoustical energy from the resonating suspension system traveling down the sides of the cone, thereby causing undesired extraneous vibrations in the cone. Although the distortion caused in a loudspeaker by the self-resonance of the suspension system is undesirable, hitherto there has been no satisfactory way known to reduce or minimize this undesirable effect.

An object of this invention is to provide an improved loudspeaker.

Another object is to provide a cone suspension which reduces or eliminates the above-mentioned undesirable distortion caused by self-resonance of the suspension system.

Still another object is to provide a cone suspension arrangement in which the frequency of self-resonance is raised, thereby minimizing the undesirable distortion effects of self-resonance. Other object will be apparent from the following disclosure and from the claims, and from the drawing in which:

FIG. 1 is a front view of a loudspeaker embodying the present invention;

FIG. 2 is a side view, partially broken away, of FIG. 1;

FIG. 3 is an enlarged detailed cross-sectional view of the cone suspension of the loudspeaker of FIGS. 1 and 2, and

FIGS. 4, 5, and 6 are detailed cross-sectional views of alternative cone suspensions in accordance with the present invention.

The invention comprises a loudspeaker cone suspension in the form of concentrically arranged corrugations of resilient material, these corrugations being so shaped and arranged that there is less material in the central region of the suspension than at the end regions of the suspension.

Now referring to FIGS. 1 and 2, there is shown a loudspeaker comprising a frame 11 having an outer rim 12, and an inner rim or flange 13 to which a magnet assembly 14 is attached. The magnet assembly 14 may comprise a front plate 16 attached to the flange 13, a cylindrical-shaped permanent magnet 17 having an end thereof positioned against the front plate 16, a rear plate 18 positioned against the other end of the permanent magnet 17, and a core 19 extending from the rear plate 18 and into an opening in the front plate 16. This structure provides a fixed radial magnetic field in an annular gap between the core 19 and the front plate 16.

A cone 23 is attached to the rim 12 by means of an outer suspension 24 which will be described in greater detail hereafter. Preferably, the cone 23 and suspension 24 are made from treated paper. The outer edge of the suspension 24 is cemented to the rim 12, and a gasket ring 25 is cemented thereover. A cylindrical voice-coil form 26 is attached to the cone 23 near the apex thereof, and extends into the gap 21. A voice-coil winding 27 is positioned on the form 26 at the gap 21, and the ends of this winding are brought out to a pair of terminals 28, of which only one is shown in the drawing. A dust cap 29 is attached to the cone 23 in front of the voice coil form 26, and an inner suspension 31 of impregnated cloth or other suitable material is positioned between the frame 11 and the voice coil form 26 or the cone 23 near the apex thereof.

When suitable electrical signals are applied to the terminals 28, these signals being supplied by an audio amplifier or other suitable source, these signals create an electrical field at the winding 27 which reacts with the magnetic field in the gap 21 so as to cause the cone 23 to vibrate in accordance with the electrical signals. This vibration of the cone 23 is in the direction of the axis thereof. The cone suspensions 24 and 31 insure that the cone will vibrate axially and not laterally.

Now considering the cone suspensions, which each comprise a sheet-like resilient material such as paper or cloth formed into a concentric arrangement of corrugations, I have found that the desired vibrations of the cone 23 cause certain undesired vibrations in the corrugations of the suspensions. Further, I have found that the centermost corrugations of the suspensions have a tendency to vibrate at self-resonant frequencies, and that this vibration of the centermost corrugations at self-resonant frequencies causes undesirable distortion of the sound produced by the loudspeaker. I have further found that this undesirable self-resonant condition of a suspension can be minimized, and the self-resonant frequencies can be raised to a value where they do not cause distortion, if the concentric corrugations of the suspension are arranged and proportioned so that their is relatively less suspension material in the central region of the suspension than at the end regions thereof. The invention is particularly important with respect to the outer suspension 24, and also may be used advantageously with respect to the inner suspension 31.

Now referring to FIG. 3, which is a cross-sectional view of a preferred embodiment of the cone suspension in accordance with the present invention, it will be seen that the outermost corrugation 35 is relatively the largest, the next corrugation 36 is relatively smaller, the following corrugation 37 is relatively the smallest, and the next and innermost corrugation 38 is relatively larger than the smallest corrugation 37. This arrangement provides relatively less material in the central region 32 of the sus-

pension than at the end regions 33 and 34 of the suspension, whereas the distribution of the material would be uniform if each corrugation was of identical size and shape. This arrangement reduces the tendency of the centermost corrugations 36 and 37 to vibrate at their own self-resonant frequencies, because these corrugations are relatively stiffer by the aforesaid construction. The aforesaid reduction of the amount of material at the centermost corrugations 36, 37 not only functions to reduce a tendency toward a self-resonant condition of these corrugations when vibrated at certain frequencies due to vibrations of the cone 23, but it also tends to raise the frequency of resonances of these center corrugations 36 and 37, thereby minimizing the disturbing effects of self-resonance. The same principle can be applied to a suspension having a greater or smaller number of corrugations.

FIG. 4 illustrates how a suspension system can be improved, in accordance with the invention, by making one or more of the centermost corrugations 40 a shorter height than the end corrugations 41 and 42, thus decreasing the amount of material in the center region of the suspension.

FIG. 5 illustrates how the centermost corrugation 40 can be given a relatively larger radius than that of the end-most corrugations 41 and 42, thereby reducing the amount of material at the center region of the suspension.

FIG. 6 illustrates an arrangement in which the sides 44, 45 of the centermost corrugation 40 are provided with more gradual slopes than are the sides 46, 47 of other corrugations of the arrangement thereby effectively reducing the amount of material in the centermost region of the suspension.

Any of the above-described arrangements for reducing the amount of material in the central region of a suspension can be combined together, and also can be applied to either or both of the outer suspension 24 and the inner suspension 31 of a loudspeaker.

From the foregoing it should readily be appreciated that I have provided a simple, economical and beneficial new design and construction for a loudspeaker suspensions, which, by providing relatively less material at the central corrugations than at the end corrugations of the suspension, causes a reduction in mass in this central

region, and thus I reduce the tendency for undesirable self-resonance to occur in the suspension system, and I also increase the frequency of any self-resonant condition. The new suspension arrangement of this invention greatly reduces or prevents a self-resonant condition of the suspension and thereby reduces or prevents an undesirable distortion effect which has plagued loudspeaker designers.

While preferred embodiments of the invention have been shown and described, various other embodiments and modifications will be apparent to those skilled in the art, but will fall within the scope of invention as defined in the following claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A loudspeaker cone suspension comprising resilient material shaped to provide at least three concentrically arranged symmetrical corrugations in the outermost region thereof, each of said corrugations including at least one substantially curved portion of a predetermined radius of curvature, the curved portions of the three corrugations facing in the same general direction, at least one of the intermediate corrugations having a curved portion of a radius of curvature which is greater than the radii of curvature of the end corrugations.

2. A loudspeaker cone comprising a conically shaped member of resilient material provided with at least three concentrically arranged substantially curved corrugations in the outermost region thereof, a first one of said corrugations being an outermost corrugation, a second one of said corrugations being an innermost corrugation, and a third one of said corrugations disposed between said first and second corrugations and having a radius of curvature which is greater than the radius of curvature of the first and second corrugations, thereby to raise the frequency of self-resonance for said corrugations.

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