Jan. 8, 1963 A. F. PETRIE 3,072,213

LOUDSPEAKER CONE SUSPENSION

Filed Sept. 28, 1959

Fig. 1.

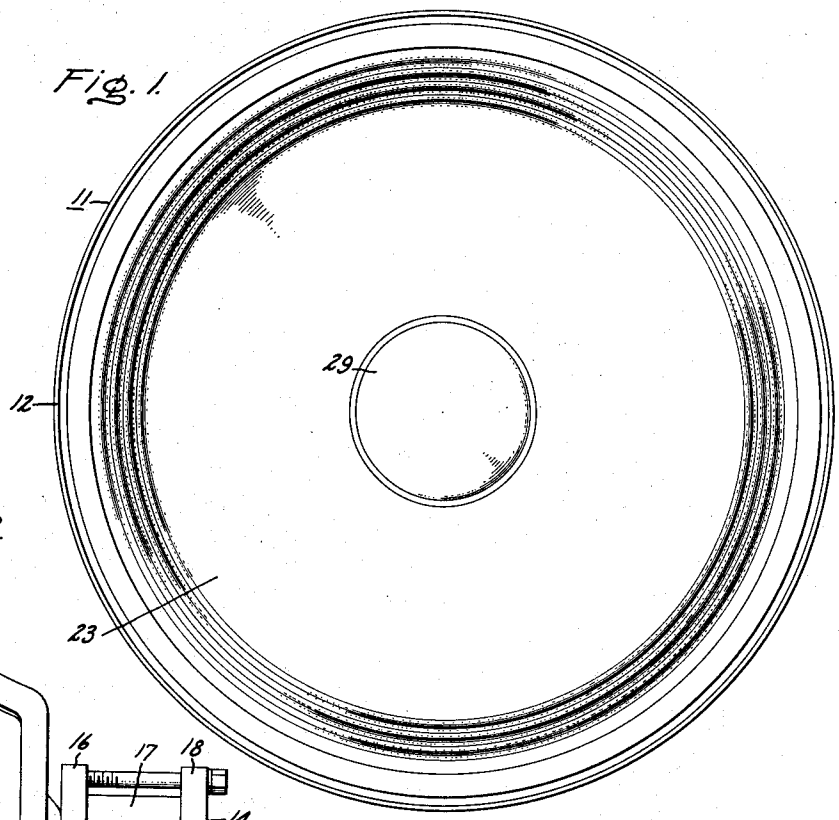


Fig. 2.

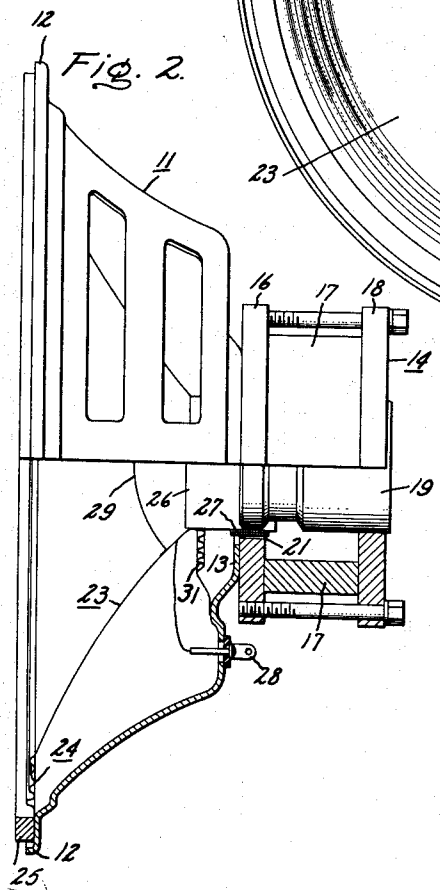


Fig. 4.

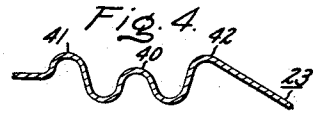


Fig. 5.

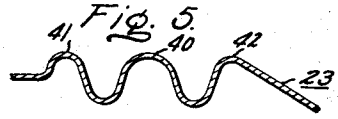


Fig. 6.

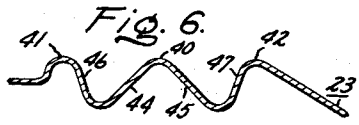
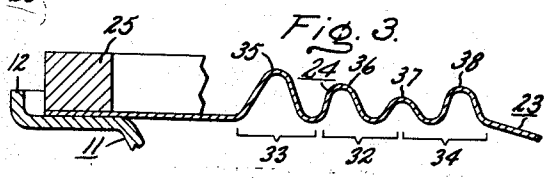


Fig. 3.



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United States Patent Office 3,072,213 Patented Jan. 8, 1963

3,072,213

LOUDSPEAKER CONE SUSPENSION

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Filed Sept. 28, 1959, Ser. No. 842,624
3 Claims. (Cl. 181—32)

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

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 is 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 objects 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 there 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 other 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 suspension 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 rendered 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 towards a self-resonant condition of these corrugations when vibrated at certain frequencies due to vibrations of the cone **23**, but it also tends to arise 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 endmost 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 suspension, 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 as 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 a material having four or more concentrically arranged corrugations, said corrugations being of successively decreasing size from the outermost corrugation toward the innermost corrugation, said innermost corrugation being larger than the adjacent corrugation.

2. A loudspeaker cone comprising a conically shaped member provided with a plurality of concentrically arranged corrugations in the outermost region thereof, said corrugation being of successively decreasing size from the outermost corrugation toward the innermost corrugation, said innermost corrogation being larger than the adjacent corrugation.

3. A loudspeaker construction comprising a frame having an annular portion, a conically shaped cone member provided with a plurality of concentrically arranged corrugations in the outermost region thereof, and means attaching the outermost edge of said cone member to said annular portion of the frame, said corrugation being of successively decreasing size from the outermost corrugation toward the innermost corrugation, said innermost corrugation being larger than the adjacent corrugation.

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