Dec. 1, 1942. D. H. CUNNINGHAM 2,303,989

SIGNAL TRANSLATING APPARATUS

Filed March 1, 1941

FIG. 1.

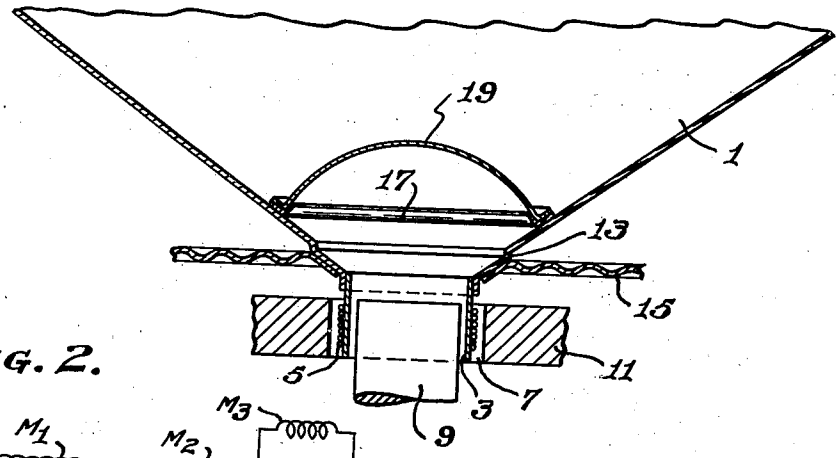


FIG. 2.

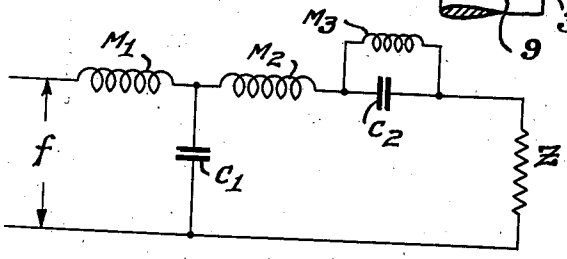
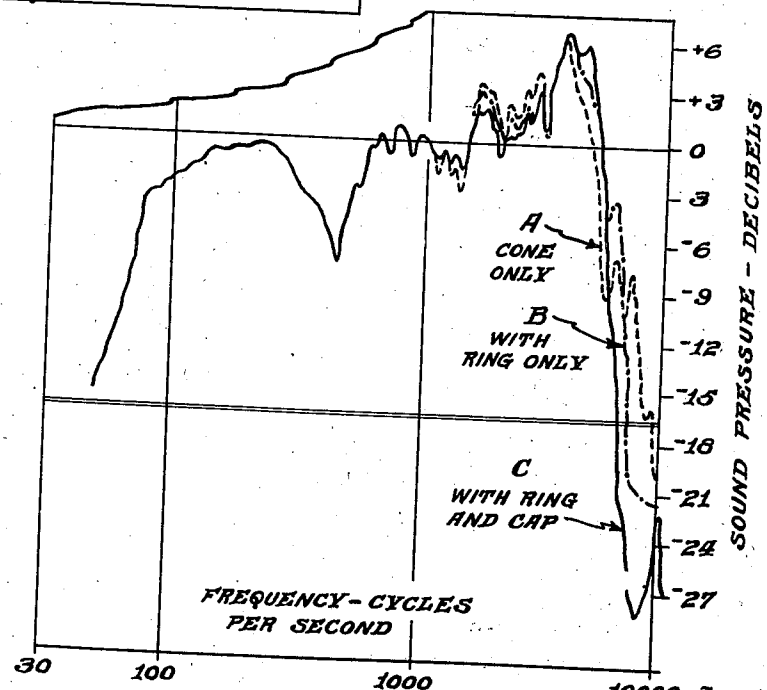


FIG. 3.



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UNITED STATES PATENT OFFICE

2,303,989

SIGNAL TRANSLATING APPARATUS

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Application March 1, 1941, Serial No. 381,213

6 Claims. (Cl. 179—115.5)

This invention relates to signal translating apparatus and more particularly to a loudspeaker, the present invention being an improvement over that disclosed in the Carlisle Patent No. 2,007,750, of July 9, 1935.

In the aforesaid patent, there is disclosed a loudspeaker of the electrodynamic type in which a mechanical filter is incorporated for controlling the high frequency response. This filter consists essentially of a compliant connection between the voice coil form and the diaphragm and, in some instances, also includes a mass secured to some part of the system, the arrangement being such as to provide a predetermined cut-off at the higher frequencies.

While an arrangement such as disclosed by Carlisle is very satisfactory for most practical purposes, there are some cases in which a sharper cut-off is desirable, and the primary object of my invention is to provide a loudspeaker which will accomplish this purpose.

More particularly, it is an object of my invention to provide, in an electromechanical loudspeaker, an improved mechanical filter by means of which more precise control of the high frequency response may be obtained than was heretofore possible.

Another object of my invention is to provide an improved acoustic filter which is extremely simple in construction, which is highly efficient in use, and which is exceedingly inexpensive in cost.

It is also an object of my invention to provide an improved mechanical filter for loudspeakers as aforesaid which may be applied readily to many existing loudspeaker diaphragms.

According to my invention, the diaphragm, such as the frusto-conical diaphragms commonly in use, is provided with a circumferential corrugation or the like adjacent its smaller end or base to constitute a compliance therein, a driving coil being wound on a coil form secured to said smaller base in conventional manner. On a diameter greater than the corrugation, I secure to the front surface of the cone a metallic ring which constitutes a mass, the corrugation in the diaphragm being located between the driving coil and the ring, and the three being preferably in concentric relation. Thus far, the system is, effectively, quite similar to that disclosed by Carlisle in the above-identified patent. My improvement consists in the addition of a cap to the aforesaid ring, the cap being made of a paper, Celluloid, or any other material which possesses relatively great inherent compliance in a direction axially of the cone. The mass of the cap and its compliance form a shunt resonant mechanical trap which provides an extremely sharp cut-off heretofore made possible only by relatively expensive electrical filters, so far as I am aware, whereas the cost of my improved filter is at most only a few cents. In addition to its acoustic function, the cap may also serve as a dust cap in conventional manner.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description of one embodiment thereof, when read in connection with the accompanying drawing, in which

Figure 1 is a fragmentary sectional view of an electrodynamic loudspeaker formed according to my present invention,

Figure 2 is a wiring diagram of an electric circuit equivalent to the acoustic system shown in Figure 1, and

Figure 3 is a response curve showing the response of my improved loudspeaker as compared with the responses of (1) a conventional loudspeaker and (2) a loudspeaker of the type disclosed in the above-noted Carlisle patent.

Referring more particularly to the drawing, wherein similar reference characters designate corresponding parts throughout, there is shown, in Figure 1, a frusto-conical diaphragm 1 to the smaller end of which is secured a cylindrical form 3 on which a driving coil 5 is wound, the coil 5 being disposed in the air gap 7 between a central pole piece 9 and an outer pole piece 11 of a suitable magnet system. The diaphragm 1 is formed adjacent its smaller end with a circumferential corrugation or the like 13 which constitutes a compliant coupling between the coil 5 and the major portion of the diaphragm, a centering suspension 15 of well known form being secured to the diaphragm 1 preferably between the compliance 13 and the coil 5.

Secured to the front surface of the diaphragm 1 on a diameter greater than that of the corrugation or compliance 13 and preferably in concentric relation to the corrugation 13 and the coil 5 is a ring 17 of metal or any other suitable material constituting a mass which loads the diaphragm 1. The ring 17 may be made of aluminum, steel, copper, hard rubber, Bakelite, or any other similar material having substantial mass, and it is secured to the diaphragm 1 by a suitable adhesive in a position such that the com-

pliance 13 is located between it and the coil 5. To the ring 17 is secured a cap member 19 of a material which is fairly light and has relatively great inherent compliance, particularly in a direction axially of the cone. Such materials as paper, Celluloid, cellulose acetate, linen impregnated or coated with a thin coating of a suitable resin, or the like, may be found suitable, but I preferably employ a soft paper having a thickness of the order of 6 to 10 mils. This paper may be of the same type, for example, as is used for the diaphragm 1, but not necessarily of the same thickness, being usually thinner than the diaphragm. The cap 19 may be dome-shaped, as shown, or of any other shape, it being essential, however, that it should be compliant. If necessary, the cap 19 may even be formed with one or more corrugations to make it sufficiently compliant.

By reference to the equivalent electrical wiring diagram of Figure 2, a clearer understanding of the nature and operation of my improved loudspeaker may be had. In this diagram, the voltage across the line corresponds to the driving force f derived from the coil 5, and the series connected inductors M_1 and M_2 correspond, respectively, to the mechanical impedances due to the mass of the coil 5 and the mass of the ring 17. The capacitor C_1 shunted across the line between the inductors M_1 and M_2 represents the compliance of the corrugation 13, the line being terminated by the resistor Z which represents the mechanical impedance of the cone 1. Thus far, the system is quite similar to that represented in Figure 6 of the above-noted Carlisle patent. The addition of the compliant cap 19 introduces into the system, in series with the inductors M_1 and M_2 and the resistor Z, the shunt resonant circuit consisting of an inductor M_3 and a capacitor C_2, the inductor M_3 corresponding to the mechanical impedance due to the effective mass of the cap 19 and the capacitor C_2 representing the effective distributed compliance thereof. By proper selection of the values of M_3 and C_2 for a particular frequency, the impedance across the shunt resonant circuit can be made to be maximum at that frequency and thereby sharp cut-off obtained.

The response curve of Figure 3 shows, by comparison, the advantages of my improved loudspeaker over those of the prior art. In this figure, the dotted curve A shows the response of a conventional loudspeaker cone having neither the ring 17 nor the cap 19 thereon. The dot and dash line curve B shows the response of a loudspeaker such as shown in Figure 7 of the Carlisle patent, that is, one having a mass similar to the ring 17 secured thereto. It will be noted from curve B that the cut-off of such a loudspeaker is sharper and the attenuation greater than in a loudspeaker having a diaphragm which is not loaded by a mass. Finally, the solid curve C shows the effect of adding the compliant cap 19 to the system, and it will be seen from this curve that not only is the high frequency response below cut-off extended somewhat, but the cut-off is also considerably sharper and the attenuation much greater than with either of the loudspeakers to which the curves A and B apply.

From the foregoing description, it will be apparent that I have provided an improved loudspeaker having the advantages heretofore noted. It will also undoubtedly be apparent to those skilled in the art that, although I have shown and described my invention as applied to a loudspeaker of the electrodynamic type and one employing a cone diaphragm, my improved filter is equally well applicable to loudspeakers employing other types of driving motors, such as magnetic, condenser, piezoelectric, and the like, as well as to diaphragms of any other form. Also, instead of forming one or more corrugations 13 in the diaphragm 1 to give it compliance between the coil 5 and the ring 17, it is obvious that the diaphragm may be made of a material which will have sufficient inherent distributed compliance in this region for the required purpose. Other similar changes will, no doubt, readily suggest themselves to those skilled in the art. I, therefore, desire that my invention shall not be limited except insofar as is made necessary by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In a loudspeaker, the combination of a diaphragm, driving member therefor, a mass secured to said diaphragm, said diaphragm having compliance therein between said driving member and said mass, and a cap member secured to said mass, said cap member being made of a material having relatively great inherent compliance.

2. In a loudspeaker, the combination of a diaphragm, a driving member therefor, an annular member constituting a mass secured to said diaphragm concentrically with and in spaced relation to said driving member, said diaphragm having compliance therein between said driving member and said annular member, and a cap secured to said annular member, said cap being made of a material having relatively great inherent compliance.

3. In a loudspeaker of the electrodynamic type, the combination of a diaphragm, a driving coil therefor, an annular member constituting a mass secured to said diaphragm concentrically with and in spaced relation to said coil, said diaphragm having compliance therein between said coil and said annular member, and a cap member secured to said annular member, said cap member being made of a light-weight material having relatively great inherent compliance.

4. In a loudspeaker of the electrodynamic type, the combination of a diaphragm, a driving coil therefor, a metallic ring constituting a mass secured to said diaphragm concentrically with and in spaced relation to said coil, said diaphragm having compliance therein between said coil and said ring, and a paper cap secured to said ring, said cap having relatively great inherent compliance.

5. In a loudspeaker of the electrodynamic type, the combination of a frusto-conical diaphragm, a coil form secured thereto at its smaller end, a driving coil for said diaphragm carried by said form, said diaphragm having a circumferential corrugation or the like therein in proximity to said smaller end and constituting a compliance, a ring of greater diameter than said compliance and constituting a mass secured to said diaphragm concentrically with said compliance and said coil, and a cap member secured to said ring, said cap member being made of a material having relatively great inherent compliance.

6. The invention set forth in claim 5 characterized in that the mass of said cap member and the compliance thereof provide a shunt resonant mechanical trap which imparts a sharp cut-off to said loudspeaker.

DAVID H. CUNNINGHAM.