April 17, 1951 C. E. STEVENS 2,549,139

CONE DIAPHRAGM FOR LOUD-SPEAKERS

Filed June 17, 1947

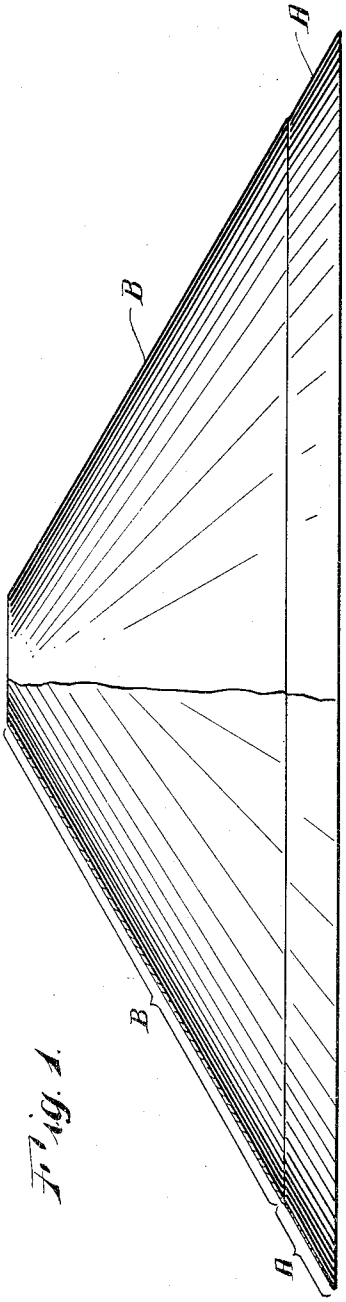


Fig. 1.

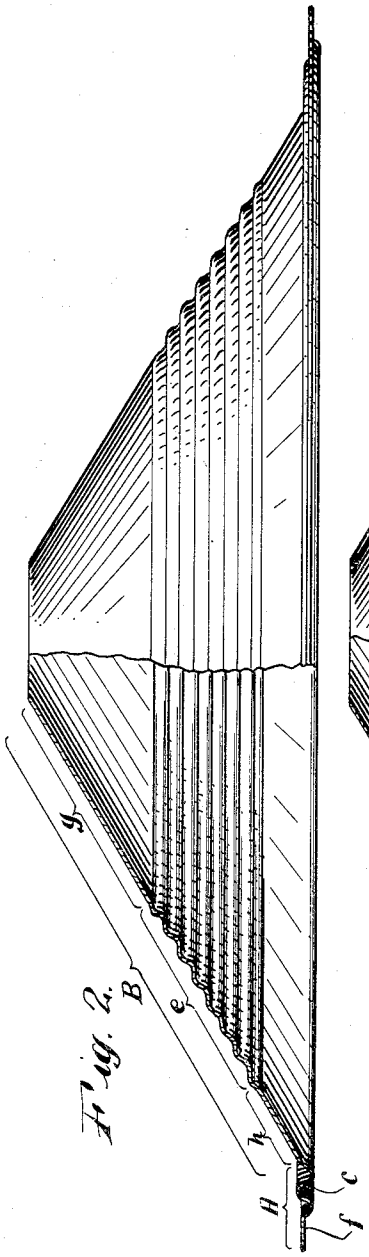


Fig. 2.

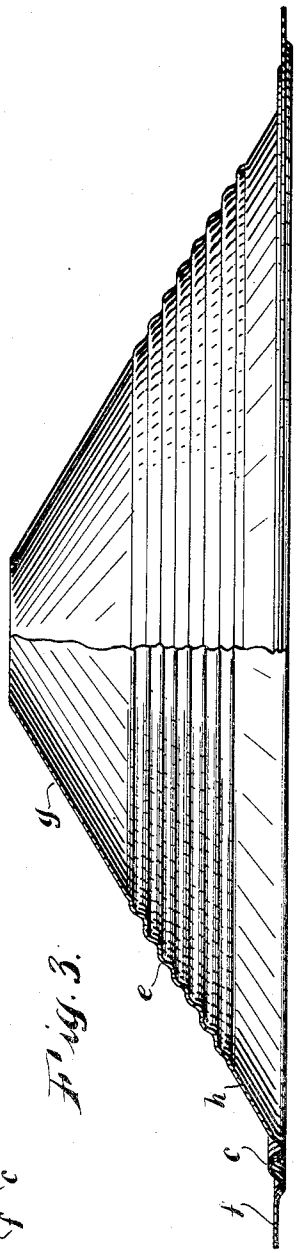


Fig. 3.

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Patented Apr. 17, 1951

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UNITED STATES PATENT OFFICE

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CONE DIAPHRAGM FOR LOUD-SPEAKERS

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Application June 17, 1947, Serial No. 755,046

3 Claims. (Cl. 181—32)

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This invention relates to cone diaphragms for radio loud-speaker units and to a method of producing the same. The object of the invention is to provide a one-piece cone diaphragm having a plurality of contiguous sectioned parts comprised of the same material with each said part being formed specially to respond to vibrations in one of the frequency ranges commonly referred to by those skilled in the art as the high, low and medium ranges within the broad range of audio frequency to be covered by said diaphragm, namely, 60 to 10,000 cycles.

Another object is to provide a one-piece cone diaphragm for radio loud-speakers having a plurality of contiguous sections each formed specially to obtain a high responsivity and high fidelity of tone reproduction in said part for a selected range of frequencies covering a range from very low to very high.

Still another object is to provide an improved cone speaker diaphragm for radio loud-speaker units characterized by a frequency response range as high as 10,000 cycles to as low as 60 cycles and by high sensitivity.

Other objects will be apparent as the invention is more fully hereinafter disclosed.

In accordance with these objects I have discovered that the frequency response range of the one-piece, cast, cone diaphragm product formed in accordance with the method and apparatus disclosed in Stevens Patent No. 2,411,066 dated November 12, 1946, which patent is assigned to the same assignee as the present invention, is materially increased and improved by corrugating an annular area in the lower half of the cast cone body but spaced above the relatively thin corrugated peripheral edge portion of said body, to increase the compliance and responsivity of the body to vibrations in the medium or intermediate frequency range and by compacting or compressing the upper half of said cast cone body to a thickness materially less than the cast thickness of the lower half of the said body to increase the sensitivity and responsivity of the body to vibrations lying in the high range of frequencies, the uncorrugated portion of the lower half of the cast cone body providing responsivity to frequencies in the low range of frequencies and the corrugated relatively thin sectioned edge portion of the cast cone body providing the necessary flexibility and vibration dampening properties to the finished cone speaker.

The present invention is adapted to wide modification without essential departure therefrom, as one skilled in the art will recognize from the following specific embodiment disclosure thereof.

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In the manufacture of one-piece, cast, cone diaphragm bodies in accordance with the invention of the above identified Stevens patent, a cone-shaped body having a peripheral and annular edge section of materially less thickness than that of the cone body is obtained, which edge section is corrugated into a plurality of reverse bends in the area adjacent the thicker body section leaving an outwardly extending fin edge section having a width adapting the same to be secured in a vibration-free joint to an annular support member of the radio loud-speaker unit surrounding the vibrating voice coil of the loud-speaker to which the cone apex is fixedly secured.

The corrugated thin section of the cone diaphragm dampens the cone vibrations and prevents the same from passing to the annular support member.

The particular type and kind of paper pulp employed in the forming, by the casting method of said prior patent, of the cast cone diaphragm, controls or regulates the over-all frequency range responsivity of the cone diaphragm. Many different types and kinds of paper pulp mixtures may be employed. With any given paper pulp mixture, the responsivity of the cast cone diaphragm varies with variation in cone thickness and the sensitivity range varies with variation in the density of the cone at any given thickness. It is, therefore, believed apparent that where it is desired, as in the case of cone diaphragms for radio loud-speaker units to provide a cone diaphragm uniformly responsive and sensitive to vibrations within the wide range of 60 to 10,000 cycles, it is extremely difficult to attain that result in a cast body of uniform thickness and density from apex to peripheral edge. The provision of a peripheral edge section of relatively thin section as compared to the body part, corrugated to impart flexibility to the section and to leave an extending annular fin of thin section to be fixedly secured to the annular cone support member, markedly improves the responsivity of the body to vibrations in the low frequency range and effectively dampens the cone vibrations from passing to the support member.

The frequency range of responsivity of such a cast cone body (with corrugated thinner annular edge section) depends upon the composition, thickness and density of the body. Of the many different types and kinds of paper pulp available for use in the cast-forming of the cone body by the method of said prior patent a mixture known in the art as a soft beaten, long fiber, hydrated

Krafft pulp has been found to provide the best and widest responsivity range. With this type of pulp a cone body having a thickness (as cast) of .016 to .017 inch has an effective responsivity range of from 60 to 6000 cycles.

I have discovered that by compressing the apex area of the cone body for an extended distance downwardly from the apex the sensitivity of the cone to vibrations of all frequencies in the range 60 to 6000 cycles is markedly increased and that the responsivity range of the cone may be increased to as high as 10,000 cycles.

I have further found that by corrugating a part of the uncompressed area of the cone below the compressed, higher density apex area, the responsivity and sensitivity of the cone to vibrations in the middle or intermediate range of frequencies is augmented or improved to such an extent that the overall responsivity and sensitivity of the cone diaphragm to all frequencies within the range 60–6000 cycles is made more uniform and acceptable for use with radio loudspeaker units of the vibrating voice coil type.

As one specific embodiment of the present invention, but not as a limitation thereof, I will describe the same as it has been adapted to the treating of one-piece cone diaphragms, formed by the method of the Stevens patent, above identified, comprised of the specific and preferred paper pulp composition above identified.

Before further disclosure of this specific embodiment, reference should be made to the accompanying drawings wherein:

Fig. 1 shows, partly in section, a one-piece cone diaphragm of the type and kind formed by the casting method and apparatus of the Stevens patent, above identified;

Fig. 2 shows, partly in section, the one-piece cone diaphragm of Fig. 1 as shaped and molded in the first step of the present invention; and

Fig. 3 shows, partly in section, the one-piece cone diaphragm of Fig. 2 after treatment in accordance with the second step of the present invention.

Referring to Fig. 1, the one-piece cast diaphragm illustrated is of the type known generally in the art as a 10 inch cone, which is the diameter across the base of the cone. The cone height is normally about 2¼ inches from base to flattened, or cut-off, apex. The cut-off apex is normally provided to provide for the use of a cone-shaped plug member adapted at its apex to be secured to the end of a vibrating voice coil and about its periphery to the cut-off edge of the cone apex.

In the "as-cast" condition shown in Fig. 1, the width of the thinner sectioned peripheral edge part A of the cone approximates ¾ inch and the width of the body part or cone area B from the inner edge of part A to the cut-off apex thereof approximates 4¼ inches.

After removal from the casting form, the cone body is placed in a forming die wherein it is shaped or molded, without material compaction, in a manner and by means old and well known in the art, to the shape and configuration indicated and shown in Fig. 2. In this step of the present invention, the thinner sectioned part A is corrugated over a part, approximating ½ of its width, in the area *c* next adjacent the thicker cone body part, and provided with a plurality of semi-circular reverse bends imparting to the part A in this area *c* a high degree of flexibility and leaving a peripheral fin extension *f* thereon extending in the plane of the cone base of thin section for vibration-free attachment to an annular support member commonly provided for mounting the cone diaphragm in a radio loud-speaker device.

At the same time the lower half of the body part B also is corrugated over an extended width downwardly from the upper uncorrugated apex area in a plurality of reverse bends substantially semi-circular in contour, the total number of such corrugations being widely variable without essential departure from the present invention but in no case covering the entire lower half of the cone body B.

The corrugations *e* in the lower half of cone body B improves markedly the compliance of and the responsivity of the diaphragm to vibration frequencies in the intermediate range of frequencies. The uncorrugated area *h* of the lower half of body part B appears necessary to retain therein full responsivity in the lower range of frequencies. In general, I have found that with the specific composition and thickness of cast cone body involved, the width of uncorrugated part *h* should approximate ¾ inch and the width of corrugated part *e* should approximate 1½ inches for best results as to responsivity in the lower and middle ranges of frequencies.

The uncorrugated upper area *g* has a fairly good responsivity to vibrations in the range of frequencies above the middle range and up to 6000 cycles but its sensitivity is relatively low. Various expediencies have heretofore been employed to increase the sensitivity, such as, for example, the use of various stiffening agents, such as shellac and resins, applied to the surface of the cone to overcome the normal reluctance of the cast fiber structure to pick up the voice coil vibrations promptly.

I have found that by compressing or compacting this area *g* between co-operating male and female dies, in a manner which is, per se, old and well known in the art, to thereby increase the density of the part *g* relative to that of parts *e* and *h*, the sensitivity of the cone diaphragm is increased markedly and materially and at the same time the responsivity range is increased from a high of 6000 cycles to as high as 10,000 cycles which is about the maximum frequency for audibility required in such cone diaphragms.

The extent to which the density of part *g* is increased by such compaction may be varied widely without essential departure from the invention. I have found that generally with the specific fiber composition employed in the cast cone body above noted, a reduction in thickness in the upper half of the cone body from 25% to 35% produces excellent results on both sensitivity and responsivity. That is to say, that with an original thickness of .016 to .017 inch in the part *g*, compaction of the part to a thickness of from .010 to .012 inch provides excellent sensitivity and raises the responsivity range of the cone body from about 6000 up to 10,000 cycles.

It is believed that the smoothing of the surface of the area including part *g* as a result of the pressure applied thereto during compressing, or compacting, this area to lesser thickness and higher density results in the increase in the responsivity range and that the stiffening of the part *g* as a result of such compaction to lesser thickness results in the increase in the sensitivity of the cone diaphragm.

The final cone diaphragm product is shown in Fig. 3. The several contiguous parts *f*, *c*, *h*, *e*

and *g* thereof, each comprised of the same material and forming a one-piece cone body, are appropriately identified with the relative thicknesses and widths of each closely approximated as to scale as hereinabove disclosed in the specific embodiment given.

It is believed apparent from the above disclosure that with different paper pulp compositions used in cast-forming the cone body, the initial thickness and density of body parts A and B thereof may be varied widely without essential departure from the invention as may also the relative widths of contiguous parts *f*, *c*, *h*, *e*, and *g* thereof, and the extent of compaction applied to part *g*. It is believed well within the expected skill of one skilled in the art to so correlate the same to obtain the improved result of the present invention from the disclosure hereinabove given, and all such modifications, variations and departures from the present invention are contemplated as may fall within the scope of the following claims.

What I claim is:

1. A cone-shaped diaphragm for a radio loud-speaker unit of the vibrating voice coil type, said diaphragm consisting of a one-piece cone-shaped body consisting of substantially the same fibrous material throughout, said body having a plurality of contiguous annular areas with each said area formed specially to have a high responsivity to a desired range of vibration frequencies within the broad range of frequencies from about 60 to about 10,000 cycles, and said areas consisting of an apex area extending over about the upper half of the cone body, an intermediate annular area extending over the upper part of the lower half of said cone body, an annular area covering the lower part of the lower half of said cone body, and a peripheral edge area, the said apex area having a lesser thickness and a higher density than the thickness and density of the lower half of the said cone body, the intermediate annular area of the lower half of the said cone body being corrugated into a plurality of reverse bends but otherwise being of the same density and thickness as the uncorrugated annular area in the lower half of said cone body, and said peripheral edge area being of the same density but of lesser thickness than the lower half of said cone body being corrugated in the annular area next adjacent the cone body and having a peripheral fin extension thereon.

2. A radio loud-speaker cone diaphragm characterized by having a high responsivity to low, intermediate and high frequency vibrations over the range of frequencies from about 60 to 10,000 cycles and a relatively high sensitivity to all frequencies, said diaphragm comprising a one-piece cone-shaped body consisting of substantially the same fibrous material throughout, the upper half of the said body having a lesser thickness and a higher density than the lower half of the said body and the lower half of the said body being corrugated into a plurality of reverse bends over an extended area materially less than the entire area leaving the area next adjacent the cone edge uncorrugated, said cone edge being provided with a fin extension of the same density as the lower half of the cone but of lesser thickness corrugated in a plurality of reverse bends in the area next adjacent the cone edge, said fin extension lying in the plane of the base of the cone body.

3. In a radio loud-speaker cone diaphragm, the improvement which comprises a one-piece cone-shaped body provided with four contiguous annular areas, each shaped specially to impart specific properties to the cone body, said areas comprising an apex area extending over about the upper half of the cone body, an uncorrugated edge area extending over a part of the lower half of the cone body upwardly from the cone edge, an intermediate corrugated annular area lying between the edge area and the apex area, and a peripheral fin extension corrugated in the area next adjacent the said edge area, said fin extension area lying in the plane of the base of the cone body, the density of said fin extension approximating that of the lower half of the said cone body but the thickness thereof being materially less than the thickness of the lower half of the said cone body and the density of the said apex area being considerably greater and the thickness of said apex area being considerably less than the density and thickness of the said lower half of said cone body, the entire cone body and fin extension consisting of substantially the same fibrous material.

CLIFFORD E. STEVENS.

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