July 5, 1932. L. DE FOREST 1,866,090

SOUND REPRODUCING DEVICE

Filed May 22, 1926 2 Sheets-Sheet 1

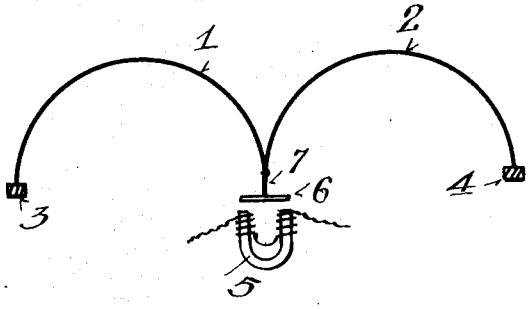


Fig. 1.

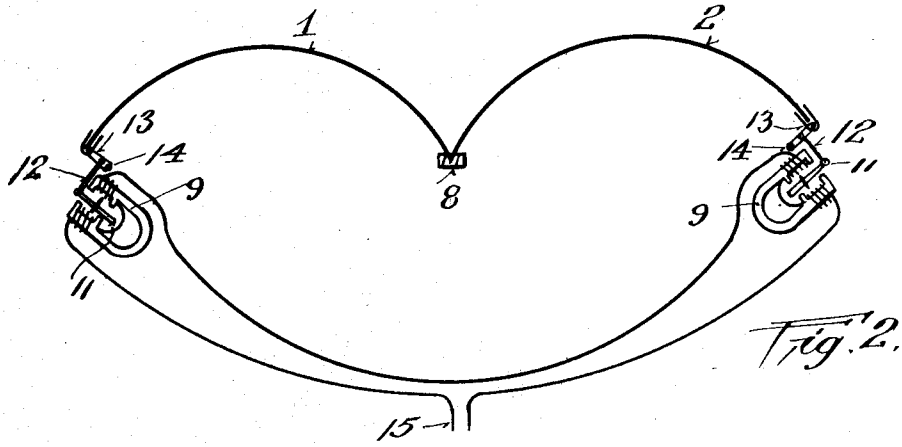


Fig. 2.

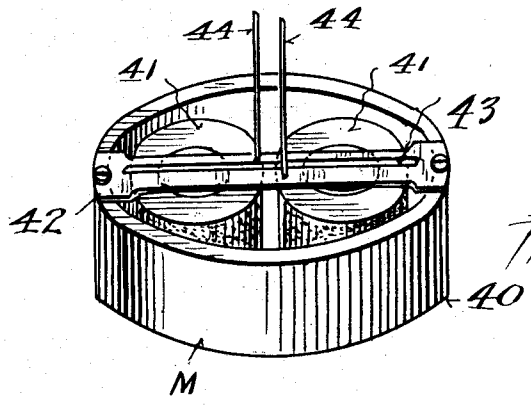


Fig. 9.

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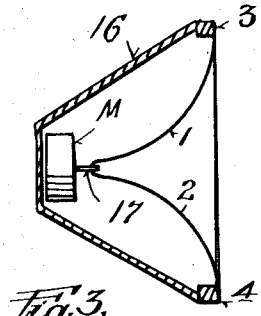


Fig. 3.

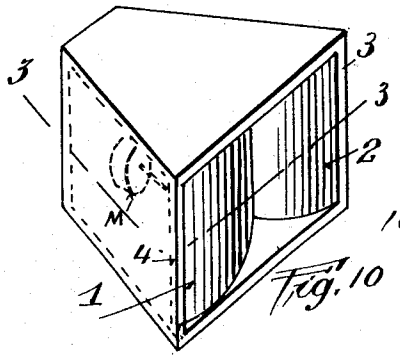


Fig. 10.

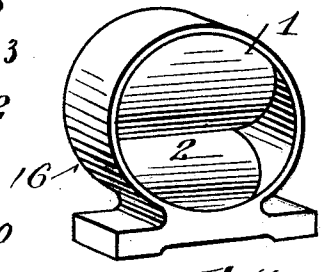


Fig. 11.

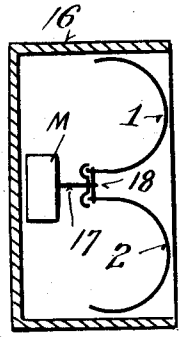


Fig. 4.

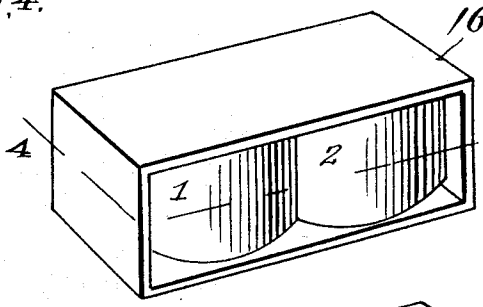


Fig. 12.

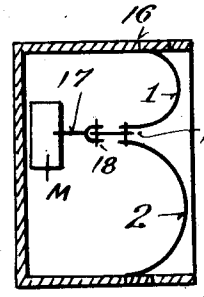


Fig. 5.

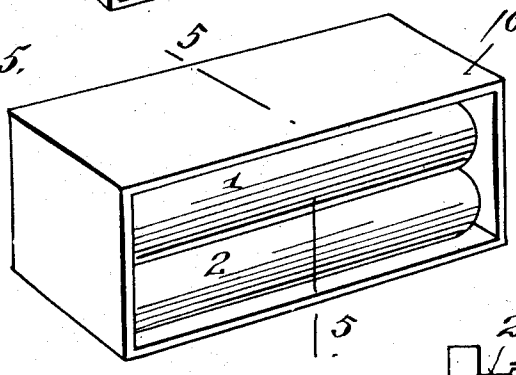


Fig. 13.

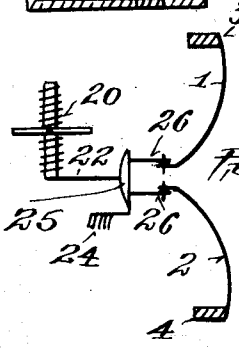


Fig. 6.

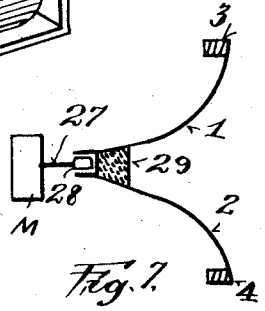


Fig. 7.

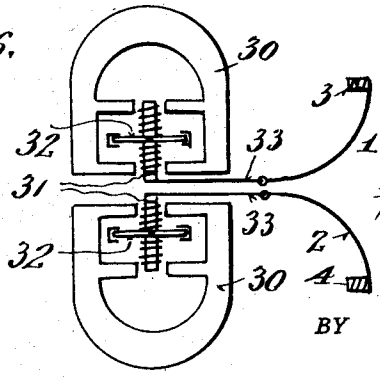


Fig. 8.

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Patented July 5, 1932 1,866,090

UNITED STATES PATENT OFFICE

LEE DE FOREST, OF NEW YORK, N. Y.

SOUND REPRODUCING DEVICE

Application filed May 22, 1926. Serial No. 110,880.

This invention relates broadly to sound reproducing devices such as phonographs and radio loud speakers.

One of the objects of this invention is the provision of a sound reproducing device comprising a plurality of membranes.

A further object of this invention is the construction of a device of this nature having a plurality of curved membranes of the same radii, but made of materials of different thickness.

A further object of the invention is the construction of a sound reproducing device having a plurality of membranes of different natural periods of vibration.

A still further object of this invention is the production of a loud speaker having more than one vibrating membrane, which are constructed with different radii.

Another object of this invention is the production of a loud speaker having a plurality of curved membranes arranged so as to produce a horn effect.

A still further object of this invention is the production of a loud speaker, consisting of a plurality of membranes adapted to be driven by one or more motive means.

A still further object of this invention is the construction of a sound reproducing device having a plurality of membranes arranged so as to produce no load on the stylus.

It is another object of this invention to produce a speaker unit with a plurality of membranes adapted to be arranged to provide a given amount of surface in a given amount of space.

These and many other objects result from the invention disclosed herein, as will appear more clearly in the following description.

This invention resides substantially in the construction, arrangement, combination, and relative location of parts, as will be clearly described below.

Referring to the drawings:

Fig. 1 illustrates one form of my invention, which comprises a plurality of membranes having the same radii, and driven by a single motive means.

Fig. 2 is a view of another modification illustrating two membranes subtending an angle less than 180° and driven by a plurality of motive means.

Fig. 3 is a cross sectional view of a modification of my invention, taken on the line 3—3 of Fig. 10.

Fig. 4 is a further modification taken on the line 4—4 of Fig. 12.

Fig. 5 is a still further modification of my invention, taken on the line 5—5 of Fig. 13.

Fig. 6 shows a still further modification of my invention.

Fig. 7 is a different embodiment of the principles of my invention.

Fig. 8 discloses a still further modification, in which each membrane is driven by its own motive means.

Fig. 9 is a perspective view of one form of motor adapted to drive the plurality of membranes.

Fig. 10 is a perspective view of one form of mounting for the sound reproducing device of this invention.

Figs. 11, 12 and 13 represent other forms in which the device may be embodied.

It has been found in actual practice, that in the production of a sound reproducing device for use in connection with phonographs, radio loud speakers, and public address speakers, considerable trouble is experienced in producing devices of this type which will cover the desired frequency range. In the type of sound reproducing apparatus now in common use, it has been practically impossible to embody in a single instrument, a vibrating membrane which is adapted to cover the range of frequencies ordinarily encountered in systems employing them.

While developing my sound reproducing device as disclosed in my Patent No. 1,560,502, of November 3, 1925, I discovered that it is possible to construct a loud speaker adapted to cover a wide range of frequencies, by employing a plurality of membranes driven by one or by a plurality of vibration producing units. I wish it to be understood at this point, that in referring to loud speakers, I intend to include all types of sound reproducing devices such as may be used in connection with phonographs, radio horns or speakers, and public address systems, which include

the field of talking motion pictures. I also contemplate within the meaning of the term, motive means, either mechanical, electromagnetic, or other suitable driving means.

In connection with the work mentioned above, I have discovered that by using a plurality of curved membranes of the same radii and of different thicknesses, or material, that a sound reproducing device can be constructed which will faithfully reproduce the high and low notes encountered in radio work, as well as those lying between these limits. I also discovered that by using curved membranes of different radii, the same results can be secured. The invention is not confined to any specific membrane materials. However, such materials as paper or suitably treated cloth are suggested.

Similar advantages result from using membranes of different curvatures, as well as by using membranes of the same curvature, but driving them from arms of different radii.

In Fig. 1, there is shown one embodiment of my invention, in which I employ the two curved membranes 1 and 2, which subtend an angle of 180°. The outer edges of these membranes are secured in supports 3 and 4, and the inner adjacent edges are secured together by any suitable means, as gluing, etc. An electro-magnetic motor 5 is shown for influencing a membrane, that is, which is secured tangentially to the adjacent abutting edges of the membrane by means of a stylus 7 which includes a keeper 6 for the poles of the motor 5. As I disclosed in my above mentioned patent, I have found that a sound reproduction of very clear quality is secured when the vibrations are imparted to the membranes tangentially.

The arrangement in Fig. 2 employs two curved membranes 1 and 2, secured rigidly together at their inner edges, in a rigid support 8. These membranes subtend an angle less than 180° and greater than 90°. Rigidly secured to the outer edges of these membranes, are the arms 13, pivoted at 14, and secured by means of the link or stylus 12 to the armatures 11 of the electro-magnetic motor means 9. The construction of these motors is not described herein, since they form no part of this invention, but are of the usual differential type well known in the art. In the arrangement shown in this figure, these motors are electrically connected together in series, by means of the wires 15. Here, as in the arrangement shown in Fig. 1, the vibrations are imparted tangentially to the members. Where the membranes are made of the same material, and have the same flexure, their rates of vibration may be made to differ by varying the point of application of the stylus 12 to the pivoted arm 14. Thus by this arrangement, one membrane can be adapted to handle the lower frequencies of vibration, and the other membrane the higher frequencies of vibration.

In the arrangement shown in Fig. 3, the two membranes 1 and 2 are curved to subtend an angle of 90°, and are rigidly secured at their outer edges in the frames 3 and 4. I have indicated generally at M, a motor secured to the back of the framework 16, which supports the members 3 and 4. The motor is connected to the two membranes by means of the styluses 17, in any suitable manner. I wish it to be understood at this point that while I have shown, for the purposes of illustration, two membranes, I intend to include under the term "a plurality of membranes", two or more, which in some cases might run up as high as ten membranes where a very high quality of reproduction is required.

In the arrangement of Fig. 4, the two membranes 1 and 2 are curved to subtend an angle of 180°, and are connected at their inner adjacent edges by means of the yoke 17 and motor M. In this arrangement, the space between the adjacent edges of the membranes is desirable since it prevents the locking of the air within the supporting casing 16, which might tend to produce undesirable effects on the quality of the sound reproduced.

I have shown at Fig. 5, an embodiment of my invention employing membranes 1 and 2 of different radii which may be made of the same or different material. The motor M is connected by means of the stylus 17 and yoke 18, through the link 19 to the inner adjacent edges of the membranes 1 and 2, by any suitable arrangement, such as riveting, gluing, etc.

The two curved membranes 1 and 2, of the device of Fig. 6, are secured at their outer edges to the rigid supports 3 and 4, and are connected at their inner adjacent edges by means of the two styluses 26, to the arm 25, which is resiliently secured to a fixed support 24. The armature 20 is shown diagrammatically, since it forms no part of this invention. The armature is connected by means of the stylus 22 to the arm 25. It will be noted that the arm 25, being pivoted to the styluses 26 at one end, vibrates about this point, and since the styluses 26 are located at different distances from the point of support, they will vibrate at different amplitudes, so that one membrane will vibrate at a lower rate of speed than the other. By means of this arrangement, a wide range of frequency may be readily covered. It will be readily apparent that more than two membranes can be used in such an arrangement, as well as with the other arrangements described above, where this is desired.

In the embodiments disclosed, I have discovered that a still further valuable result is secured by means of a plurality of mem-

branes, namely a horn effect; that is, the sound reproduced by the various membranes arranged as disclosed, is directed away from the membranes. In the forms shown in Figs. 6 and 8, where a space is left between the adjacent edges, the surrounding air is permitted free passage between the membranes and does not result in the formation of undesirable sounds. However, where the membranes are secured rigidly together, as in Figs. 1 and 2, I have found that they may be readily secured to a vibration transmitting element 28, which may be a bar of wood or other suitable material which is secured to the motor M by means of the stylus 27. In order to prevent the formation of undesirable sounds due to the formation of a closed air pocket, a damper element 29 is disposed between the membranes, as shown in Fig. 7. This membrane may be made of felt, cotton, or other suitable material.

In Fig. 8, is shown a modification similar to that of Fig. 2, in which a plurality of electro-magnetic motors 30, having their armatures 31 mounted on the reed element 32 and connected by means of the styluses 33 to the edges of the membranes 1 and 2. This figure shows more clearly, the differential type of motor referred to as being well-known in the art.

Where it is desired to use a plurality of membranes of the same curvature and constructed of the same material, a motor of the type shown in Fig. 9 may be employed, which comprises the casing 40, having mounted therein electro-magnets 41. Secured across the top of the casing 40, and adjacent the ends of the electro-magnets, is a strip of magnetic material 42, having a slot 43 extending longitudinally thereof and to one side of the center line. Styluses 44 are secured to the strip 42 on opposite sides of the slot. It will be evident that by placing the slot to one side of the center line, the portions of the strip to which the styluses are secured, are of different width and therefore of different natural periods of vibration. By applying this motor to the embodiments of my invention of the type shown in Figs. 3 to 8 inclusive, it is possible, where membranes of the same radii and construction are used, to impart to them different rates of vibration.

The illustrations in Figs. 10 to 13 inclusive, are merely shown as methods of mounting my sound reproducing device, and are given in the illustrative sense, to show the many forms to which it may be adapted.

It will also be evident that in the constructions of the types shown herein, no stress is imposed upon the stylus or styluses, since the membranes are arranged so that their tendency to flatten out is opposed. By this arrangement, therefore, no external load is applied to the motor means to affect its operation.

It will be evident from the drawings, that I intend operating a loud speaker, comprising a plurality of membranes, by means of a single or a plurality of motive means.

I am, of course, aware that many changes in the details of construction and arrangement of the elements of my invention will readily occur to those skilled in the art, and I do not, therefore, desire to be limited to the particular formations disclosed by way of illustration. For instance, the membranes may be made in many different forms, sizes, shapes, curvatures, etc., and of many different materials, without departing from the spirit of my invention. I therefore wish to be limited only as required by my appended claims.

What I seek to secure by United States Letters Patent is:

1. A sound reproducing device comprising a plurality of curved membranes having different radii of curvature, and a sound reproducing member tangentially attached to at least one of the marginal edges of each of the membranes, and a frame for supporting said membranes and said member.

2. A sound reproducing device comprising in combination a plurality of curved membranes of different natural periods of vibration and means for reproducing sound attached to said membranes to impart tangential vibrations thereto.

3. A sound reproducing device comprising in combination a plurality of membranes of different natural periods of vibration and a sound reproducing member attached to the marginal edges thereof.

4. A sound reproducing device comprising in combination a plurality of curved membranes of different natural periods of vibration arranged with adjacent edges and means for imparting different rates of vibrations to the adjacent edges thereof.

5. A sound reproducing device comprising in combination a plurality of curved membranes of different natural periods of vibration and a plurality of means for imparting sound vibrations thereto.

In testimony whereof I have hereunto set my hand on this 18th day of May, A. D., 1926.

LEE DE FOREST.