May 20, 1930. E. H. SMYTHE 1,759,328

SOUND REPRODUCER

Filed Aug. 17, 1926

Fig.1

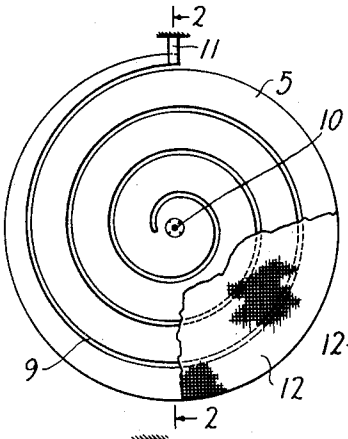


Fig.2

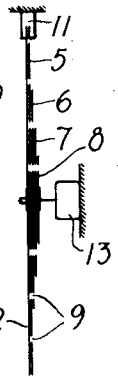


Fig.3

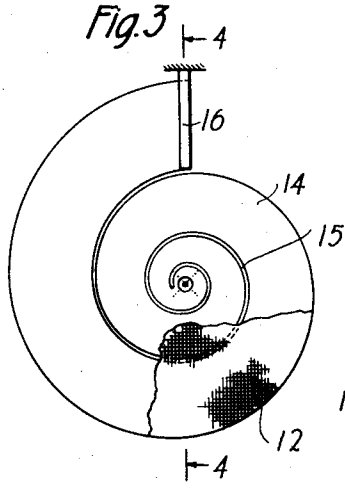


Fig.4

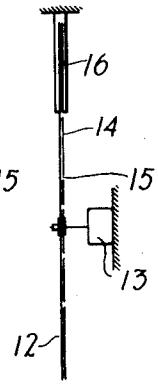


Fig.5

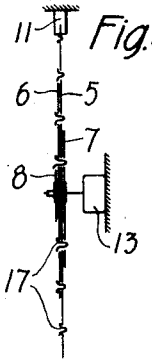


Fig.6

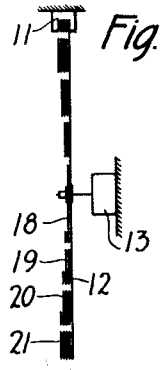


Fig.7

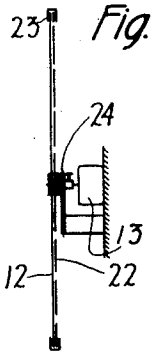


Fig.7a

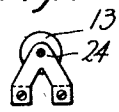


Fig.8

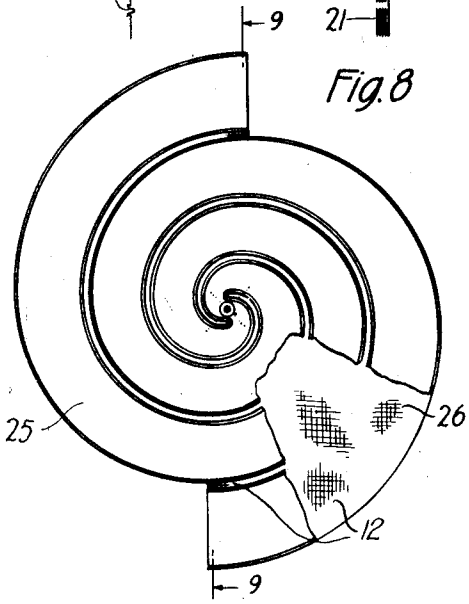
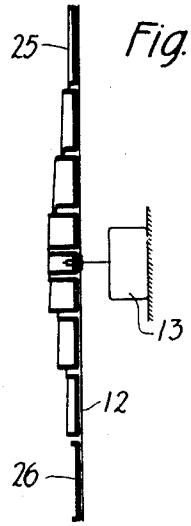


Fig.9



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1,759,328

UNITED STATES PATENT OFFICE

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SOUND REPRODUCER

Application filed August 17, 1926. Serial No. 129,732.

This invention relates to sound reproducers employing direct-acting diaphragms.

The principal object of the invention is to reproduce efficiently and faithfully all sounds within the audible range.

A related object of the invention is to increase the vibrant energy imparted to the air from a sound radiating surface.

A portion of the sound wave energy in direct-acting diaphragms is frequently dissipated in the form of so-called standing waves which are produced by interference between outgoing and reflected waves in the material of the diaphragm. These standing waves cause out-of-phase movements in closely adjacent portions of the diaphragm, and hence their energy is not radiated usefully. The reflection that causes such standing waves takes place principally at the periphery of the diaphragm because the energy is not completely attenuated in traversing the path between the driving point and the periphery.

This difficulty is largely overcome by means of this invention, which provides a direct-acting diaphragm in the form of a spiral extending from a central driving point to the periphery, and with the convolutions in edgewise relation with each other to form an extended surface substantially transverse to the direction of drive. This construction provides a much longer path for the vibrant energy than has heretofore been included within the space ordinarily permisible in direct-acting diaphragms. The distance between the driving point and the end of the spiral is sufficient to permit a gradual and more complete attenuation of the energy before the end of the spiral is reached, thus tending to prevent the setting up of standing waves in the diaphragm and to permit a greater part of the energy to be radiated.

In carrying out the invention, there are a number of factors which may be varied to produce any desired action with respect to frequency response. The mass and rigidity charactertistics may be controlled, for example, by constructing the diaphragm of tapered cross section, or of superposed discs of progressively varying diameter so that the thickness of the diaphragm varies between the driving point and the periphery. The mass and rigidity of the diaphragm may also be controlled by progressively varying the mass and stiffness characteristics of the disc, or the pitch of the spiral between the driving point and the periphery, or both.

The various features of the invention will be described in connection with the accompanying drawing, in which:

Fig. 1 is a plan view of a tapered cross-section spiral diaphragm of superposed layers of material, constructed in accordance with the invention;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a plan view of a diaphragm formed of a single layer of material, in which the pitch of the spiral is varied exponentially from the driving point to the support:

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 3;

Figs. 5 and 6 are sectional views illustrating different methods of forming the composite diaphragm to obtain different frequency response characteristics;

Fig. 7 is a sectional view of the spiral diaphragm having a modified form of support and a peripheral strengthening rib;

Fig. 7ª is a detail of the diaphragm support shown in Fig. 7;

Fig. 8 is a plan view of a diaphragm formed of two outwardly advancing spirals channeled to vary the mass and rigidity characteristics; and

Fig. 9 is a sectional view taken on the line 9—9 of Fig. 8.

Similar reference characters designate similar parts in the several views.

The diaphragm shown in Figs. 1 and 2 comprises a plurality of layers of material 5, 6, 7 and 8, such as thin wood veneer or blotting paper. The several layers may be in the form of discs of progressively decreasing diameter, the smaller discs being stacked on the disc 5 of greatest diameter. The discs may be glued together to give a high degree of transverse rigidity without adding greatly to the weight of the diaphragm.

A spiral slot 9 having a straight line increase in pitch is cut in the composite dia-

phragm, the center 10 of the diaphragm serving as the pole of the spiral. The spiral slot is preferably cut with a jig saw which will cut a slot wide enough to insure clearance between the edges of the several convolutions under operating conditions. The peripheral outline of the diaphragm is made circular by tapering down the last convolution to a narrow end which is secured to a supporting member 11. This construction gives the diaphragm a symmetrical appearance and also tends to avoid the reflection of energy at the end of the spiral. The flat surface of the diaphragm may be covered by a light flexible sheet 12, such as silk, to prevent air pressure short-circuiting between the front and back surfaces of the diaphragm by way of the spiral slot. The flexibility of the material 12 should be such that it will not permit any substantial radial transmission of energy across the convolutions of the spiral.

The diaphragm is driven at the center 10 by means of a motor element 13 of any suitable type, such as that disclosed and claimed in British Patent 260,946. Energy imparted to the center of the diaphragm traverses the spiral path and for the most part is radiated before the end of the last convolution is reached, thus substantially eliminating the resonance effect due to reflection losses.

The diaphragm illustrated in Figs. 3 and 4 comprises a single layer of material 14 in which the pitch of the spiral slot 15 is varied exponentially from the center to the outer edge to give the diaphragm progressively varying mass and rigidity characteristics from the center outwardly to the periphery. The last convolution of the spiral is terminated abruptly at its point of maximum breadth and is secured to a supporting member 16. This diaphragm may also be formed of a plurality of layers of material, the mass and rigidity of which will cooperate with the pitch of the spiral to give the diaphragm the desired frequency response characteristics. In a modified form the material of the single-layer spiral may be specially treated to produce a tapered variation of its mass and rigidity characteristics from center to periphery.

Fig. 5 illustrates a modification of the composite diaphragm shown in Figs. 1 and 2, having the smaller discs 6, 7 and 8 fastened alternately to opposite faces of the largest disc 5. In order to prevent air pressure short-circuiting between the opposite sides of the diaphragm and also to afford a slight frictional damping of the energy traversing the spiral path, a narrow strip of loosely felted material 17 is fastened to one side of the diaphragm in such a manner as to form a lip projecting into the spiral slot.

Fig. 6 illustrates a diaphragm the thickness of which is tapered from a maximum at the periphery to a minimum at the center. This diaphragm in the composite form of construction illustrated comprises a large disc 18 having a plurality of rings 19, 20 and 21 stacked on one of its faces, these rings having the same peripheral diameter as the large disc 18 but of progressively varying internal diameter. This construction may be varied as required to obtain different mass and rigidity characteristics. The pitch of the spiral may also be varied to secure the desired frequency response characteristics.

The diaphragm shown in Fig. 7 comprises a disc 22 having a spiral kerf which approaches but does not intersect the periphery of the disc. The periphery of the diaphragm is provided with a strengthening rib 23 of light stiff material such as duralumin. The diaphragm is supported solely at its central driving point by means of an elastic support such as the reed or leaf spring 24, shown in Figs. 7 and 7ª.

The diaphragm illustrated in Figs. 8 and 9 is formed of two similar outwardly advancing spirals 25 and 26 which are balanced about the central driving point. The spirals 25 and 26 are formed of similar channels or angles of constantly decreasing depth and increasing breadth from the center to the periphery, the channels or angles flattening out as the periphery is approached. This diaphragm may be supported at the outer end of each convolution in a manner similar to that shown in Fig. 1, or may be supported solely at its center as in the form illustrated in Figs. 7 and 7ª. The double spiral balanced construction is not limited to a diaphragm made up of channeled spirals, but may also be embodied in a diaphragm construction of a solid or composite disc of material merely by cutting two oppositely disposed and balanced spirals instead of one.

It will be understood that without departing from the broad spirit of the invention and under proper conditions the point of support and the point of application of the driving force to the spiral may be interchanged. The invention is also capable of other modifications and adaptations not specifically referred to but included within the scope of the appended claims.

What is claimed is:

1. A sound reproducer comprising a spiral diaphragm having its convolutions in edgewise relation, and means for imparting vibrations to an end of said spiral.

2. A sound reproducer comprising a spiral diaphragm, and a driving element connected to the pole of said spiral to impart vibrations to said diaphragm.

3. A sound reproducer comprising a direct acting diaphragm having a spiral slot extending from a point intermediate the center and the periphery outwardly, and means for imparting vibrations to said diaphragm.

4. A sound reproducer comprising a direct acting diaphragm having a spiral slot extending from the central portion to the periphery, means for supporting said diaphragm at the outer terminus of the spiral, and means for imparting vibrations to the center of said diaphragm.

5. A sound reproducer comprising a direct acting diaphragm having a spiral slot extending from near the center to the periphery, means for imparting vibrations to said diaphragm, and means for connecting adjacent edges of the spiral without permitting the radial transmission of energy across the convolutions of said spiral.

6. A sound reproducer comprising a direct acting diaphragm having a spiral slot extending from near the center to the periphery, means for imparting vibrations to said diaphragm, and a strip of light flexible material covering said spiral slot.

7. A sound reproducer comprising a flat spiral diaphragm, means for supporting said diaphragm at one end of the spiral, and means for driving said diaphragm at the other end of the spiral.

8. A sound reproducer comprising a spiral diaphragm, means for supporting said diaphragm at one end of the spiral, and means for driving the other end of the spiral in a direction perpendicular to a surface of said diaphragm.

9. A sound reproducer comprising a spiral diaphragm, means for supporting said diaphragm at the outer end of the spiral, and means for transmitting vibrations to said diaphragm at the pole of the spiral.

10. A sound reproducer comprising a spiral diaphragm having its outer convolution tapered to give the diaphragm a substantially circular periphery, means for supporting said diaphragm at the tapered end of the spiral, and means for transmitting vibrations to said diaphragm at the inner end of the spiral.

11. A sound reproducer comprising a spiral diaphragm having progressively varying mass and rigidity characteristics, and means for imparting vibrations to an end of said spiral.

12. A sound reproducer comprising a spiral diaphragm having progressively varying mass and rigidity characteristics, means for supporting said diaphragm at one end of the spiral, and means for driving said diaphragm at the other end of the spiral.

13. A sound reproducer comprising a large direct acting diaphragm the thickness of which varies progressively from the center to the periphery and having a spiral slot extending from the central portion to the periphery, and means for imparting vibrations to said diaphragm.

14. A sound reproducer comprising a composite spiral diaphragm formed of a plurality of layers of material of varying mass, and means for imparting vibrations to said diaphragm.

15. A sound reproducer comprising a composite diaphragm formed of a plurality of layers of material of progressively varying area and having a spiral slot extending from near the center to the periphery, and means for imparting vibrations to said diaphragm.

16. A sound reproducer comprising a composite diaphragm formed of a plurality of superposed discs of material of progressively decreasing diameter and having a spiral slot extending from the central portion to the periphery, means for supporting said diaphragm at the outer terminus of said spiral, and means for imparting vibrations to said diaphragm at the inner terminus of said spiral.

17. A sound reproducer comprising a diaphragm having a spiral slot extending from the central portion to the periphery, frictional damping means extending along said slot, and means for imparting vibrations to said diaphragm.

In witness whereof, I hereunto subscribe my name this 12th day of August, A. D. 1926.

EDWIN H. SMYTHE.