April 29, 1930. LE ROY W. STAUNTON 1,756,838

SOUND REPRODUCING APPARATUS

Filed July 3, 1926

Fig. 1

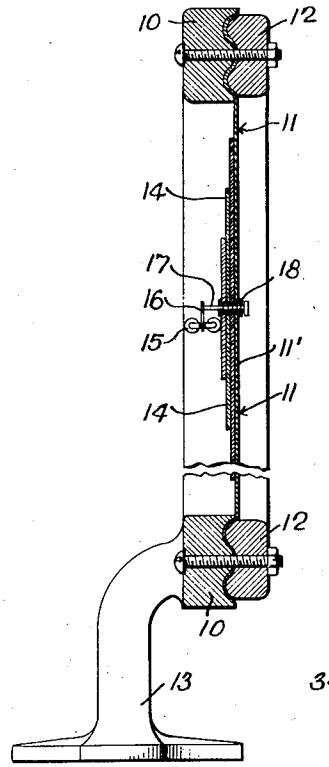


Fig. 2

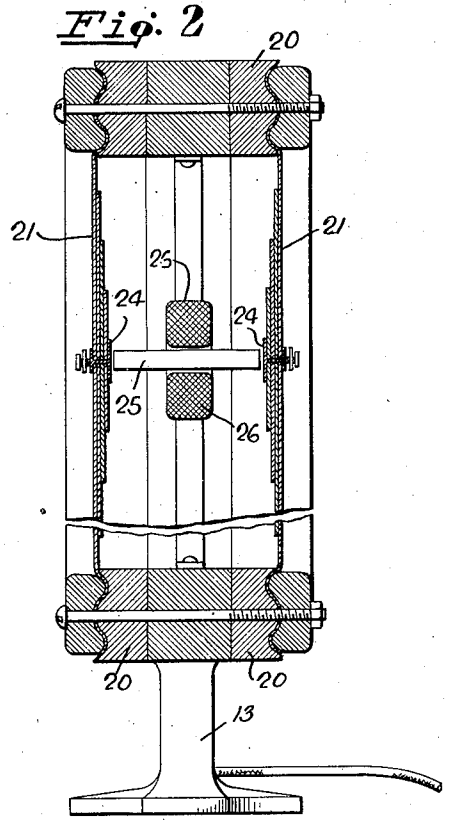


Fig. 4

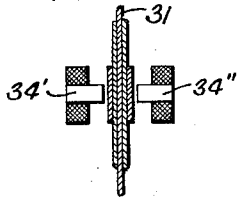


Fig. 3

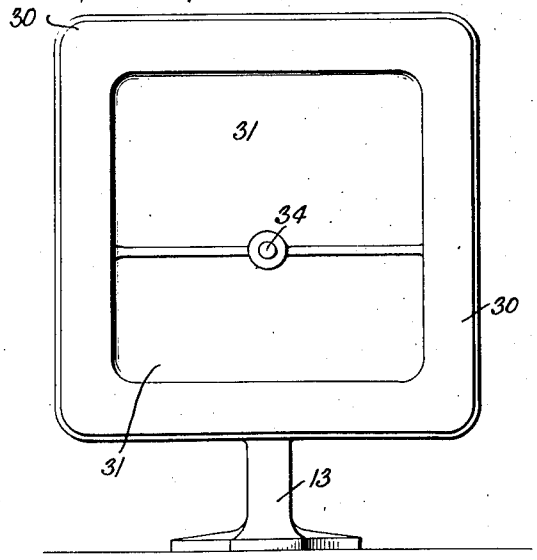
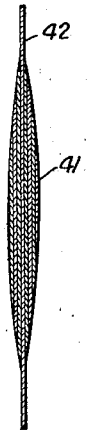


Fig. 5



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UNITED STATES PATENT OFFICE

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SOUND-REPRODUCING APPARATUS

Application filed July 3, 1926. Serial No. 120,414.

This invention relates to sound-reproducing apparatuses and particularly to apparatuses which employ diaphragms adapted to be actuated in response to a sound-controlled electric current for setting up vibrations in the free air. Such apparatus is adapted to be used, for example, as a loud speaker in conjunction with radio receiving sets.

The object of the invention is generally to provide an improved type of electrically actuated sound-reproducing device which is efficient, economical and readily manufactured.

More specifically an object is to provide a loud-speaker for use with radio receiving sets, actuated by audio frequency currents without undue amplification, and adapted for setting a body of free air into vibration with sufficient amplitude to produce sounds of normal audibility without the aid of resonators and utilize sheet diaphragms so that they may be made into disk types of loud speakers when desired.

Other objects of the invention will in part be obvious and will in part appear hereinafter.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts, which will be exemplified in the constructions hereinafter set forth and the scope of the application of which will be indicated in the claims.

For a fuller understanding of the nature and objects of the invention reference should be had to the following detailed description taken in connection with the accompanying drawing, in which:

Fig. 1 shows a vertical cross-section of a sound-reproducing device constructed in accordance with the invention;

Fig. 2 shows a similar cross-section of a modified form thereof;

Fig. 3 is a front elevation of another modified form;

Fig. 4 is a fragmentary view showing a detail thereof; and

Fig. 5 is a detailed view of a modified form of diaphragm suitable for use in loud speakers, constructed in accordance with the present invention.

Referring now to the drawing, and particularly to Fig. 1, 10 denotes a frame or other suitable support which is constructed to be relatively non-resonant to the sounds reproduced by the sound-producing element, here shown as diaphragm 11 clamped between the support 10 and a clamping ring 12, the latter being bolted or otherwise secured to the support 10. The support 10, for convenience, is shown as mounted on a pedestal 13; it will be understood, however, that the frame 10 may be supported in any convenient manner and may be built into radio receiving sets if desired.

The diaphragm 11 is shown as a laminated structure composed of a basic sheet 11′, whose edges extend to and are secured in the frame 10, and a plurality of superposed sheets or layers 14 of successively decreasing diameter as the centre is approached. The layers 14 are adhesively secured to the basic sheet 11′ and to each other, so as to form a unitary diaphragm structure of gradually increasing thickness toward the centre. A polarized relay is shown at 15 mounted in the frame 10 having its vibrating arm 16 positively connected through the rod 17 for "driving" or vibrating the diaphragm. The rod 17, as indicated, is preferably adjustably secured in a threaded sleeve 18 which is secured in and passes through all the laminations of the diaphragm.

It is thus seen that, when the relay 15 is connected to be traversed by a sound-controlled electric current, for example the current from an audio-stage of a radio receiving set, the diaphragm 11 will be driven or forced into vibration in response to the variations in the sound-controlled current. The diaphragm in consequence is set into vibration at a frequency corresponding to the sound-produced variations of the current.

In order that this construction shall be adapted for reproducing the vibrations of the original sound so as to have an amplitude of normal audibility, the diaphragm 11, in accordance with the present invention is of sheet material and has such elastic properties that the centre of the diaphragm or point from which the diaphragm is driven is ap-

proximately always a loop, while the edges of the diaphragm are a node, for the average frequency of audible sounds. This requires that the diaphragm itself should have a diameter equal to approximately one-half the average wave-length, whereby the radius is approximately one quarter of the average wave-length. In this way a relatively large active sound-producing surface is provided for setting a relatively large volume of free air into a state of vibration with an amplitude sufficient to reproduce directly sounds of normal audibility.

The elasticity of the diaphragm is made to be such as to avoid undulations being set up that would have nodes at points in the diaphragm other than the edges; since such nodal points would represent an annulus of inactive surface, while in addition, the portions of the surface at each side of the annulus are in opposite phases and will in consequence still further reduce the active area of the diaphragm and the consequent ampliture of the sound which it is desired to reproduce. The sheet material, suitable for the construction of the diaphragm 11 at present generally available, are the relatively thin and stiff sheet materials, such as sheet metal, sheet fibre, parchment paper, parchment and the like; these however, in their normal state, do not possess the proper elasticity.

It has been ascertained that the required degree of elasticity can be imparted by giving the diaphragm material a permanent stress, which is mainly internal but may be partly external. Sheet metal, for example, sheet steel, may be given a permanent stress of the character desired by heating the sheet substantially uniformly until it has expanded substantially uniformly over its entire surface. The expanded sheet, while hot, is then placed over a die or other support which is the shape of the frame 10 on which the diaphragm is to be mounted; when on the die, the sheet is drawn and cooled. When cooled in the drawn condition it will have a permanent internal stress, which may be added to externally when placed in the frame of the loud speaker.

Parchment paper has been found to be well adapted to the taking up of a permanent internal stress by wetting, stretching, and drying the same; this may be accomplished, for example, by stretching the parchment, when thoroughly wet, substantially uniformly in all directions upon a frame and drying the same while under the stretching tension. The material when dry is found to be permanently internally stressed, is stiff, and has different elastic properties than originally, and when put in the frame 10 may be further externally stressed by the tension employed by the supporting frame. It is convenient, however, in the practice of the present invention to employ the frame itself in the process of manufacture as the stretching means for parchment paper, when it is the material of the diaphragm, since the laminated diaphragm may be placed therein while wet, and clamped in place.

By thus permanently stressing the diaphragm material the desired elasticity results, and a disk type of loud speaker in consequence is provided which sets up sounds of normal audibility directly in the free air. A loud speaker thus constructed has nodes substantially only about its periphery. This is evidenced in tests by the fact that the diaphragm when permanently stressed and properly in place can be cut loose from the frame about its edges and still reproduce sound in the manner desired. When the diaphragm is of parchment or other similar relatively cellular material, the desired elasticity may be attained by coating the same with a material which, when dry, imparts stiffness without flabbiness so that the desired elasticity results. A suitable coating material is a varnish which does not have an oil base, for example, a cellulose varnish such as is now frequently used for varnishing the fuselage and the like of airplanes.

A construction adapted for the production of a large volume of sound is shown in Fig. 2. Here a pair of diaphragms 21 are mounted in the frame 20 back to back. In this instance the central lamination 24 of the diaphragms is of magnetic material, for example, an iron disk; and is adjustably secured substantially at the centre of the diaphragm. These magnetic laminations are adapted to be disposed a proper distance from the pole piece 25 of the actuating electromagnetic winding 26.

While the magnetic lamination 24 is centrally disposed on the exterior of the back side of each of the diaphragms 21, the magnetic material for actuation in this arrangement is not necessarily so disposed and can be disposed at any point within the diaphragm construction. It has also been ascertained that while the diaphragms will in general be constructed as circular that other shapes may be equally well employed, for example, elliptical and relatively square and oblong shapes. In Fig. 3 a loud speaker is shown in which a relatively square diaphragm 31 is shown as mounted in a frame 30. The connection for the driver is indicated at 34. This point, as shown is not the central point of the diaphragm 31. In this instance the driver is purposely connected at a point somewhat off centre, since it is found that the driver may be connected at points somewhat to one side of the centre with advantageous results in certain instances. The apparent reason for this is that such an eccentric position of the driver permits the setting up of certain overtones which are not disadvantageous.

While the drivers shown for the diaphragms in Figs. 1 and 2 are adapted to apply power for vibrating the same from only one side, it is frequently advantageous to provide for a balanced driving effect. To this end the driver 34 is preferably divided into two parts 34′ and 34″ and placed on the opposite sides of the diaphragm 31, as indicated in Fig. 4, the windings being electrically so arranged that their driving effects are 180° out of phase, whereby there is produced a balanced driving effect on the two opposite sides of the diaphragm.

While the result of the present invention, it has been ascertained, depends substantially entirely upon the elastic properties imparted by stressing the diaphragm material, still, in order that it may be set into vibration from a relatively central point so that substantially the whole of its surface is active and the central point a loop and the edges thereof a node, it should be constructed so that the vibration-wave travels with uniform velocity from the centre to the edges, and to this end should have its mass decreased radially. The mass is consequently greatest at the centre and is gradually decreased outwardly. This arrangement is attained in substantially any convenient manner. The diaphragm 11 in Fig. 1 is shown as achieving this construction by having adhesively secured the laminations of successively decreasing diameters to the basic sheet 11′. Yet this result may be secured by securing the laminations on both sides. A convenient manner of accomplishing this is shown in Fig. 5 where a cross-section of the laminated diaphragm is shown at 41 where the diaphragm is substantially lens-shaped, the central sheet, however, being extended to form a rim 42 about the circumference.

Since certain changes may be made in the above construction and different embodiments of the invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a diaphragm mounted in a state of relatively high permanent internal stress on said support, said diaphragm being a composite laminated structure comprising superposed layers of sheet material, the successive layers to be adhesively secured and of successively decreasing diameters toward the centre, and means arranged to vibrate said diaphragm, whereby vibrations are produced in said diaphragm of sufficient amplitude for reproducing sound of normal audibility directly in the surrounding free air independently of resonators.

2. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a diaphragm mounted in a state of relatively high permanent internal stress on said support and stressed externally, said stresses being of a character adapted to impart a resiliency sufficient to enable it to reproduce sounds of normal audibility directly in the surrounding free air, said diaphragm being composed of superposed laminations of successively decreasing diameters toward the centre, said laminations being secured together so as to produce a relatively unitary diaphragm construction, and means arranged for vibrating said diaphragm so as to have its centre substantially always a loop and its periphery always a node.

3. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a diaphragm mounted in a state of relatively high permanent internal stress on said support, and stressed externally, said stresses being adapted to impart an elasticity such that the diaphragm when having a diameter of approximately half a wavelength of the average audible sound-wave, will set up vibrations in the surrounding free air of sufficient amplitude for normal audibility without the aid of resonators, said diaphragm being composed of superposed laminations of successively decreasing diameters toward the centre, said laminations being secured together so as to produce a relatively unitary diaphragm construction, and means arranged for vibrating said diaphragm so as to have its centre substantially always a loop and its periphery always a node.

4. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a laminated diaphragm mounted in a state of relatively high permanent internal stress on said support, and stressed externally, such stresses being of a character adapted to impart an elasticity to said diaphragm such as to enable it to reproduce sounds of normal audibility directly in the surrounding free air and having a structure of greater mass at the centre and decreasing outwardly toward the edges so as to propagate sound therein with a uniform velocity in substantially all radial directions from said centre, and means arranged to vibrate said diaphragm and to drive it from a point substantially at said centre.

5. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a laminated diaphragm mounted in a state of relatively high permanent internal stress on said support, and stressed externally, such stresses being of a character adapted to impart an elasticity to said diaphragm such as to enable it to reproduce sounds of normal audibility directly in

the surrounding free air and having a structure of greater mass at the centre and decreasing outwardly toward the edges so as to propagate sound therein with a uniform velocity in substantially all radial directions from said centre, and means arranged to provide a balanced driving effect for said diaphragm connected to drive the same substantially from said centre.

6. In sound-reproducing apparatus, the combination with a substantially non-resonant support, of a laminated diaphragm mounted in a state of relatively high permanent internal stress on said support, and stressed externally, such stresses being of a character adapted to impart an elasticity to said diaphragm such as to enable it to reproduce sounds of normal audibility directly in the surrounding free air and having a structure of greater mass at the centre and decreasing outwardly toward the edges so as to propagate sound therein with a uniform velocity in substantially all radial directions from said centre, and means arranged to drive said diaphragm from a point adapted to produce unobjectionable overtones.

In testimony whereof I affix my signature.

LE ROY W. STAUNTON.