June 19, 1934. O. CHRISTENSON 1,963,075

DEVICE FOR PRODUCING SOUND

Filed May 14, 1932

Fig. 1.

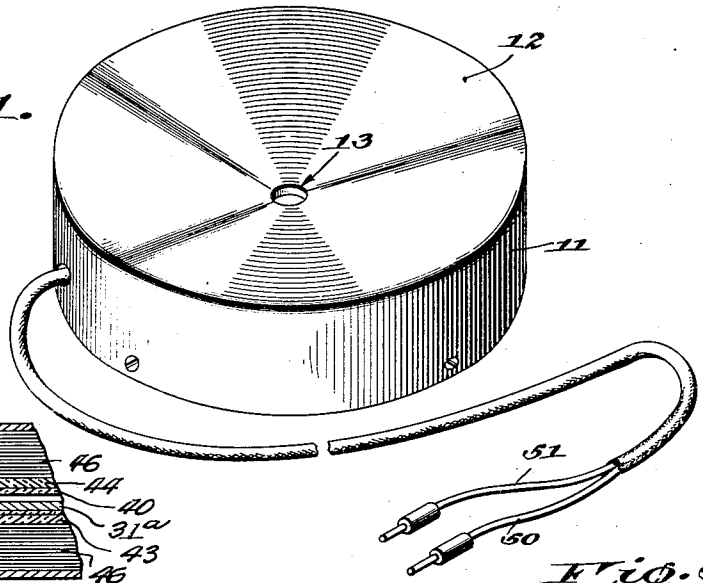


Fig. 6

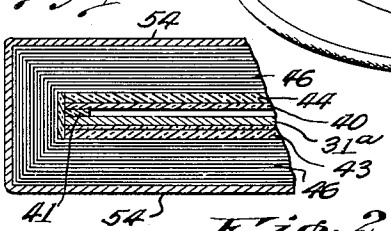


Fig. 5.

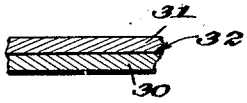


Fig. 2.

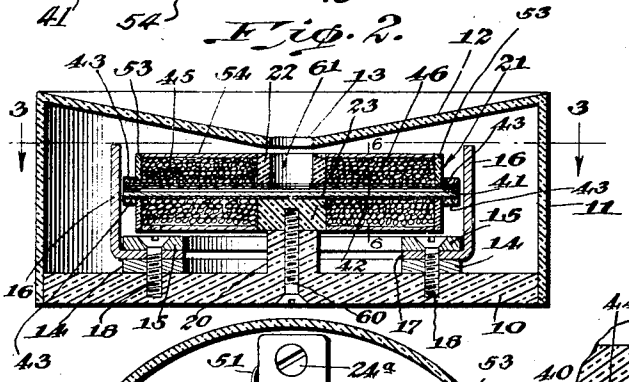
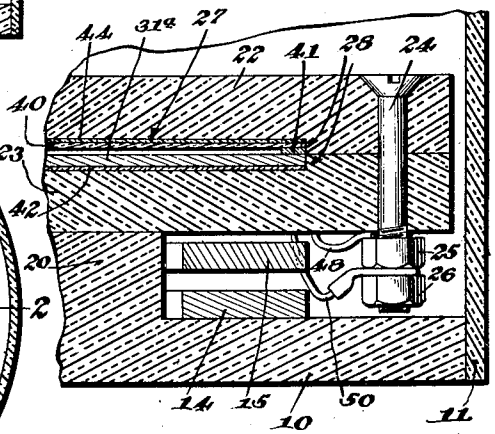


Fig. 4.



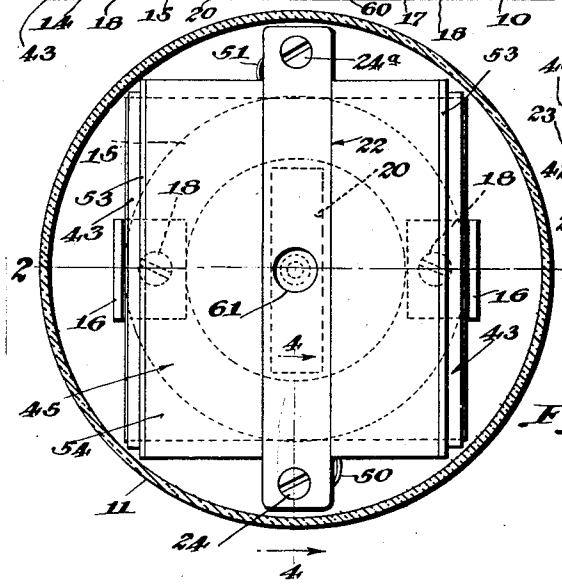


Fig. 3.

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1,963,075

DEVICE FOR PRODUCING SOUND

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Application May 14, 1932, Serial No. 611,411

12 Claims. (Cl. 179—110)

This invention relates to a device for producing sound.

An object of the invention is the provision of a device for the reproduction of sound and which may be employed either as a receiver for telephones or for radios, in which a plate is employed formed of two sheets of thin metal having different co-efficients of expansion, with the sheets being secured together at a predetermined temperature so that when the plate is cooled the sheets will be under a compressive and tensile stress, such a plate being subject to changes caused by magneto-striction.

Another object of the invention is the provision of a sound-reproducing device based on the magnetostriction principle in which a plate is formed of two sheets of thin metal and secured together at a predetermined temperature so that when the plate is cooled the sheets of material will be under a compressive and tensile stress so that when a current is passed through a coil embracing the plate the acoustically modulated current is converted into sound energy by means of the magnetostrictive vibrations with the efficiency of the device being increased by the compressive stress and the polarizing field on one of the sheets of metal.

A further object of the invention is the provision of a sound reproducing device in which a plate is formed of a thin sheet of nickel secured, in any approved manner, to a thin metal plate having a co-efficient of thermal expansion which is greater than the co-efficient of expansion of the nickel so that the nickel is maintained under a permanent compressive stress which is utilized to increase the magnetostrictive effect in the nickel when varying currents are passed through a coil embracing the plate for the purpose of producing sound waves.

This invention will be best understood from a consideration of the following detailed description, in view of the accompanying drawing forming a part of the specification; nevertheless, it is to be understood that the invention is not confined to the disclosure, being susceptible of such changes and modifications which shall define no material departure from the salient features of the invention as expressed in the appended claims.

In the drawing:

Figure 1 is a view in perspective of a device constructed in accordance with the principles of my invention,

Figure 2 is a transverse vertical section taken along the line 2—2 of Figure 3,

Figure 3 is a horizontal section taken along the line 3—3 of Figure 2,

Figure 4 is an enlarged fragmentary vertical section taken along the line 4—4 of Fig. 3, and

Figure 5 is an enlarged fragmentary vertical section of the composite plate employed in the receiver.

Fig. 6 is a fragmentary vertical section taken at a right angle to the section shown in Fig. 2.

Referring more particularly to the drawing, 10 designates a base member formed of any well known insulating material and this is neatly fitted within one end of a cylinder 11 also formed of insulating material.

The outer end of the cylinder is provided with a closure 12 which is concave and has a central opening 13 for the emission of sound.

The cover 12 may be formed integrally with the cylinder 11 or may be made separately and connected thereto.

A pair of metal rings 14 and 15 are located concentrically upon the base 10 and pole pieces 16 having inturned portions 17 are located between the rings 14 and 15. The rings and the pole pieces 16 through the inturned portions or flanges 17 are secured to the base member by means of screws 18. The rings 14 and 15 and likewise the poles 16 are formed of a metal which may be magnetized.

The rings 14 and 15 are of magnetic steel and are permanently magnetized across a diameter in line with the pole pieces 16 which are formed of soft iron so that the magnetic field extends between the two pole pieces for the purpose of establishing a polarizing field on the nickel plate.

Disposed diametrically of the base member 10 is a raised portion 20 formed integrally with the base member and, therefore, consists of insulating material. This raised portion forms a support for the unit, generally designated by the numeral 21.

A pair of bars 22 and 23 extend diametrically of the base member 10 or the cylindrical member 11 and are connected together at their ends by means of bolts 24 having nuts 25, 26 threaded on the projecting ends thereof. The inner portions of the bars 22 and 23 are cut away, as shown at 27, to provide a space for a purpose which will be presently explained. The cutting away from the central portion of the bars provides raised portions 28 at the ends of the bars which are in contact with each other in order to form the space between said bars.

A metal plate, shown in an enlarged view in Fig. 5, is formed of two thin sheets of metal such as zinc, indicated at 30, and a sheet formed of nickel, indicated at 31. These plates have their

adjacent faces, as shown at 32, secured together by means of soldering. The nickel plate is approximately .01 of an inch in thickness while the zinc plate is approximately .15 of an inch in thickness. Pure nickel is employed of dead soft temper. Any appreciable variation from the thickness of the nickel will result in a decrease in sensitivity of the device.

The nickel plate and zinc plate are tinned on one side with solder and placed together with their tinned surfaces in contact between steel plates which are in turn placed between the jaws of a vice. The whole is then heated in any approved manner until the solder on the surfaces of the plates is melted. The plates are then pressed tightly together and allowed to cool before removal from the vice.

Any metal, alloy, or material having a linear coefficient of expansion greater than that of nickel may be used to subject the nickel plate to permanent compressive stress and among such metals and non-metals having the largest coefficients of expansion are zinc, aluminum, lead, tin and porcelain. Lead and tin, however, will not give good results because of their low melting points and low tensile strength. Porcelain may be used but due to the difficulty of securing the nickel plate to the porcelain plate the porcelain is somewhat impractical for the purpose. It has been found, however, that aluminum and especially zinc give satisfactory results. A zinc plate soldered to the nickel plate with solder having a melting point of about 450 degrees Fr. will subject the nickel to a degree of compressive stress in which condition its susceptibility and magnetostrictive effect are greatest.

A thin sheet of insulating material, as shown at 40, is placed upon the surface of the nickel but spaced therefrom a distance approximately a thirty-second of an inch. It will be appreciated that this distance may be varied, depending upon the size and the condition under which the plate is employed. The sheet 40 may be of any well known insulating material, but mica is preferable. This sheet is spaced from the nickel sheet by means of strips 41 located adjacent the edge of the sheet 40 and the metal plate 31a.

A second sheet of insulating material is shown at 42 and is located in flat contact with the zinc surface of the plate 31a. This sheet may be lacquered and cemented to the outer face of the plate 31a.

On the outer face of the sheet 40 is applied a thin piece of insulating material 44. The sheets 42 and 44 may be a strip of paper wrapped around the plate 31a and the insulating strip 40 and cemented in place.

A pair of coils of wire, shown at 45 and 46, embrace the opposite sides of the plate 31a are wound around said plate and are disposed upon opposite sides of the bars 22 and 23. These coils are provided in the form of winding of #44 B. & S. gauge enamel insulated copper wire. Both coils are wound in the same direction, each coil being simply a continuation of the other. In winding, the following procedure is employed: The assembly is placed in the winding machine and the end of the wire from the spool supply is passed through an opening in one of the bars 22 or 23 and temporarily secured in place. The wire is then wrapped around one section upon one side of the bars 22 and 23 until this section is secured. The assembly is then turned around in the winding machine so that it will revolve in the opposite direction. The end of the wire from the spool supply is joined to that end of the first coil which was temporarily secured in place before commencing the winding. The remaining section is then filled with the winding.

By winding in this manner the difference of potential between the bottom layers of the coils is at a minimum, thereby minimizing the possibility of a break-down of the insulating cover over the zinc nickel plate 31a. The construction has an additional advantage in that both terminals of the winding are brought out at the upper surface of the winding. One terminal is connected, as shown at 48, to the bolt 24 by means of a nut 25. The other end of the winding is connected to the bolt 24a. A wire 50 is connected to the bolt 24 by means of the nuts 25 and 26 while a wire 51 is connected in a similar manner to the bolt 24a. The wires 51 and 50 are the lead-in wires from the instrument.

As shown more particularly in Fig. 2 a flat strip 53 of insulating material is located on each end of the plate 31a and has an elongated opening which neatly receives the ends of the plate 31a and the associated strips 41, 42, and 44. Thin bars or strips 43 are cemented to the projecting ends of the strips 42 and 44 at the opposite sides of the plate 31a for holding the strips 53 in place. The strips 42, 44, 53 and 43 are secured in position before the wire is wound around the plate.

Tape 53a formed of insulating material is wound around the exterior of the coils and cemented in position by a suitable lacquer.

A bolt 60 is threaded through the base member 10, the raised portion 20 and the lower bar 23 for holding the member 21 in position as a unit and slightly spaced above the magnetic ring 15.

The bar 22 is provided with a passage 61 which is adapted to align with the passage 13.

The nickel employed in the manufacture of the upper layer of the plate 31a, as shown at 31, has been refined and annealed in vacuum, in hydrogen, or by other efficient method. It is to be noted that the removal of harmful impurities from the nickel and annealing it to the softest temper obtainable greatly increases the permeability and magnetostrictive effect and thereby the sensitivity of the receiver. The receiver may be connected in the ordinary circuits and used for the same purpose as any other type of receiver and for best results it should be wound to match the impedance of the output or supply circuit.

In the present construction the nickel plate acts in place of a diaphragm and is actuated by magnetostrictive forces which generate vibrations in the plate proportional in amplitude or intensity to the receiver current variations. The electrical energy of the speech currents is converted into sound energy through magnetostrictive vibrations. It is probable that diaphragm resonance effects such as are inherent in receivers having mechanically vibrating diaphragms are absent in this receiver and that it therefore has more uniform frequency response characteristics.

If a thin nickel plate is placed within a helix traversed by a direct current the plate through the action of magnetostriction will contract in a direction parallel with the magnetic field, set up within the helix and expand in a direction perpendicular to the field. If the current passing through the coil were an acoustically modulated current, speech or musical sounds it represents would be reproduced by the nickel plate impressing its changes or rather its dimensional

changes on the air. Only the changes caused by magnetostriction in the thickness of the nickel plate serve a useful purpose in the receiver. The plate is prevented from increasing or decreasing in length or width because it is held securely against such movements.

The plate may be bent on a curvature of large radius so that a strain is set up in the crystalline structure of the metal and therefore the magnitude of its magnetostriction is increased and the plate becomes more sensitive to the increased magnetic field.

The alloy known as invar has the smallest coefficient of linear expansion of any metal or alloy known at the present time. Therefore, if a plate formed of invar is secured to a plate formed of any other metal or alloy by the method described in the specification it will result in setting up a permanent tensile stress in the metal or alloy. In actual construction it has been found that by using nickel-iron alloys with invar a tensile stress is set up in the diaphragm. The degrees of tensile stress are controlled by the use of solders and brazing alloys of high and low melting points. Preferably thin platinite was used in setting up a sheet of invar. The longitudinal magnetostriction effect in platinite is greater than in any other metal or alloy, although a diaphragm made from this combination is not quite as sensitive as diaphragms made from nickel-zinc.

I claim:

1. A sound reproducing device comprising a housing having an opening in one face, a permanent magnet fixed to an opposite face within said housing, a sound reproducing plate spaced from the magnet, a coil of wire around said plate, means for insulating the coil from said plate, the plate being formed of two sheets of metal having different co-efficients of expansion and secured together under such a temperature that one of the sheets will be always under a compressive stress so that the last-mentioned sheet will be sensitive to an impressed magnetic field created when a current is passed through the coil, and means for connecting the ends of the coil with an output current.

2. A sound reproducing device comprising a housing having an opening in one face, a permanent magnet fixed to an opposite face within said housing, a pair of diametrically disposed spaced bars secured to the last-mentioned face, a sound reproducing plate located between the bars formed of a pair of sheets of metal having different co-efficients of expansion and secured together under such a temperature that when the plate is cooled one of the sheets will be under a compressive stress, a sheet of insulating material located in contact with one face, a sheet of insulating material disposed at the opposite face of the plate and spaced therefrom, a coil of wire embracing the sheets of insulating material, insulating material enclosing the coil, means for connecting the ends of the coil with an output current.

3. A sound reproducing device comprising a base, a permanent magnet fixed to said base, a pair of bars formed of insulating material and provided with a longitudinal slot therebetween, a plate located within the slot formed of a pair of sheets of metal having different co-efficients of expansion and secured together under such a temperature that when the plate is cooled one of the sheets will be under a compressive stress, insulating material at opposite sides of the plate, a coil of wire embracing the last-mentioned insulating material, and binding posts to which the ends of the coil are connected.

4. A sound reproducing device comprising a base, a permanent magnet fixed to said base, a pair of bars formed of insulating material and provided with a longitudinal slot therebetween, a plate located within the slot formed of a pair of sheets of metal having different co-efficients of expansion and secured together under such a temperature that when the plate is cooled one of the sheets will be under a compressive stress, insulating material at opposite sides of the plate, a coil of wire embracing the last-mentioned insulating material, binding posts to which the ends of the coil are connected, means for securing together the bars and for clamping the last-mentioned insulating material and plate rigidly in position.

5. A sound reproducing device comprising a base, a plate supported on the base, formed of a pair of sheets of metal having different co-efficients of expansion and secured together under such a temperature that when the plate is cooled one of the sheets will be under a compressive stress, insulating material at opposite faces of the plate, a coil of wire embracing the plate, the insulating material being located between the coil and the plate, means for connecting the ends of the coil with an output circuit, and means for creating a magnetic flux in the neighborhood of the plate.

6. A sound reproducing device comprising a base, a plate supported on the base, formed of a pair of sheets of metal having different co-efficients of expansion and secured together under such a temperature that when the plate is cooled one of the sheets will be under a compressive stress, insulating material at opposite faces of the plate, a coil of wire embracing the plate, the insulating material being located between the coil and the plate, means for connecting the ends of the coil with an output circuit, means for creating a magnetic flux in the neighborhood of the plate, bars for clamping the insulating material and plate in position, portions of the coil being disposed upon opposite sides of the bars.

7. In a sound reproducing device, a plate formed of a magnetostrictive metal which is under a compressive stress directed along the plane of the plate, a coil of wire embracing the plate and adapted to have a current passed therethrough, and means for maintaining the plate in a magnetized state.

8. In a sound reproducing device, a plate formed of magnetostrictive metal which is under tensile stress, a coil of wire embracing the plate and adapted to have a current passed therethrough, and means for maintaining the plate in a magnetized state.

9. In a sound reproducing device, a plate formed of magnetostrictive metal which is under compressive stress directed along the plane of the plate, and a coil of wire adjacent to the plate adapted to have a current passed therethrough, and means for maintaining the plate in a magnetized state.

10. In a sound reproducing device, a plate formed of magnetostrictive metal which is under tensile stress, a coil of wire adjacent the plate adapted to have a current passed therethrough, and means for maintaining the plate in a magnetized state.

11. In a sound reproducing device, a plate formed of magnetostrictive metal, a second plate

formed of a material having a coefficient of expansion which is different from that of the first mentioned plate, means for securing the plates together at such a temperature that when they are cooled the first mentioned plate will be under permanent stress, a coil of wire embracing the composite plate and adapted to have a current passed therethrough, and means for maintaining the magnetic portion of the composite plate in a magnetized state.

12. In a sound reproducing device, a plate formed of magnetostrictive metal, a second plate formed of a material having a coefficient of expansion which is different from that of the first mentioned plate, the two plates being secured together at such temperatures that when they are cooled the first mentioned plate will be under stress, a coil of wire adjacent the composite plate adapted to have a current passed therethrough, and means for maintaining the magnetic portion of the composite plate in a magnetized state.

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