Sept. 16, 1930. J. V. L. HOGAN 1,776,223

ACOUSTIC DEVICE

Filed Jan. 30, 1926

Fig. 1.

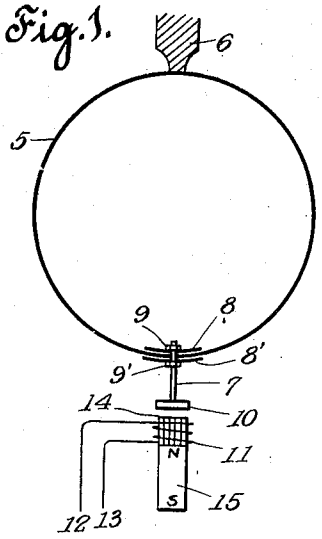


Fig. 2.

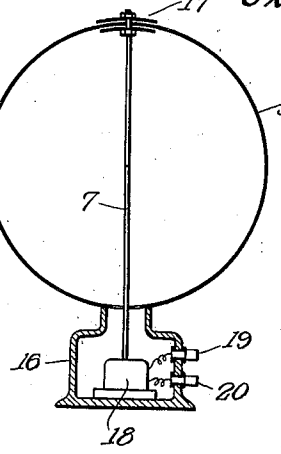


Fig. 3.

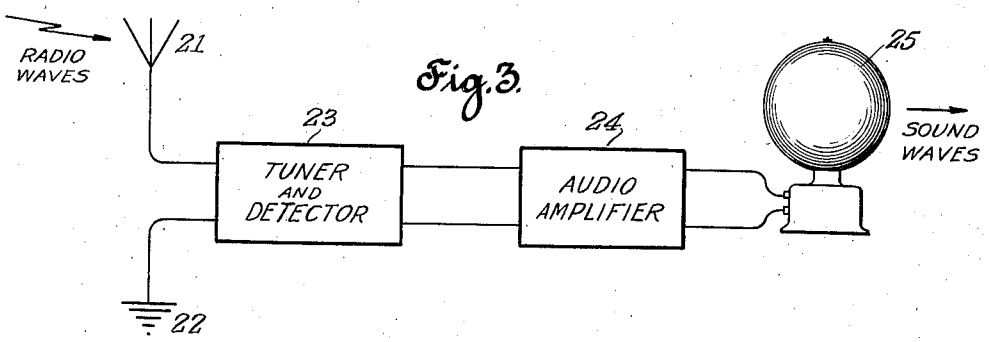
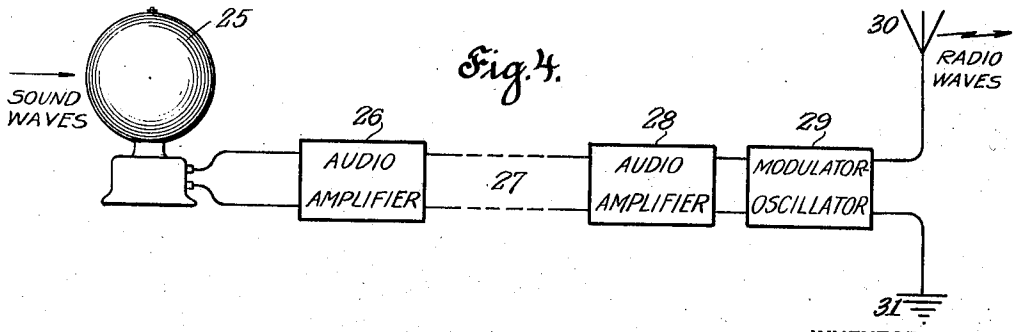


Fig. 4.



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UNITED STATES PATENT OFFICE

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ACOUSTIC DEVICE

Application filed January 30, 1926. Serial No. 85,069.

This invention relates to the transfer of mechanical vibrations from one medium to another, and more particularly to the conversion of sound energy. It has for its primary object to improve the efficiency of such energy-transfer throughout a wide band of acoustic frequencies, whereby the fidelity of transformation of complex or simple sounds having a great variety of frequencies may be improved. Further objects are to attain a high degree of uniformity of space distribution of the effects involved, and to produce a device both simple in manufacture and simple and reliable in use.

One of the largest uses for such a device is as a reproducer or so-called "loud speaker" for the conversion of audio frequency electric currents into mechanical vibrations in a relatively dense medium, such as an iron armature, and the transfer of these vibrations to a less dense medium such as air. Another use is as a so-called "pick up" or telephone transmitter device, in which air waves of sound frequencies are caused to produce similar mechanical vibrations in a relatively dense medium and these vibrations act in the system to produce or cause electric currents having similar variation frequencies. Such electric currents may be used for a variety of purposes, such as (1) the operation of a telephone receiver or other reproducer, (2) the modulation of ultra-audible electric currents in a radio or "carrier current" line telephone system, or (3) the operation of a phonograph-record cutting device for the recording of sound or other vibrations.

Bearing in mind the various uses of such vibration-transfer devices as that which I have invented, together with the fact that much the same criteria of excellence apply to the performance of the system in any of its uses, the discussion of this invention may be simplified by considering the structure from the viewpoint of converting audio frequency currents to sound waves in air. This is the function of the "loud-speaker" so largely used in connection with radio telephone receiving apparatus.

I have discovered that in order to convert electric currents into equivalent sound waves with the highest degree of effectiveness, both as to quality of reproduction and volume of tone, the following criteria should be met:

(1) The efficiency of the reproducer, measured by the ratio of sound wave energy produced to electric wave energy applied at any instant should be a maximum.

(2) The efficiency as above defined should be a constant quantity as a function of frequency throughout the useful sound range of say 25 to 10000 cycles.

(3) The efficiency, and the relation between the efficiencies at various frequencies, should remain constant as the amplitude of vibration varies.

(4) Provision should be made for free vibration of the moving system through the maximum amplitude desired.

(5) The distribution of the sound effect should be as nearly spherical as possible.

As to the first criterion set forth above, one of the greatest problems has been to apply the mechanical forces produced by the (usually magnetic) action of the varying currents in such a way as to vibrate effectively a large volume of air. A small diaphragm may be loaded to act upon relatively great masses of air by the use of a megaphonic horn, but such practice violates the second requirement above for the reason that the horn or equivalent sound passage in general introduces conditions that prevent a uniform efficiency over a wide band of acoustic frequencies.

The second criterion is of the maximum importance, for upon it depends the fidelity of reproduction or conversion of sounds covering the audible range. To attain substantial perfection of conversion the relations of effective inertia, mechanical restoring force and mechanical damping should be so chosen that operation at no one frequency within the operating range is favored (in the production of response) above any other frequency in that range. Preferably the mechanical periods introduced by inertia and restoring force should be lower than 1/25 second or higher than 1/10000 second, or their effects should be minimized by high damping in the vibrating system. Such high damping may be introduced, where required, by the work

performed by the device and this usually will contribute to increasing its efficiency. Otherwise it may be introduced artificially, as by friction or mechanical hysteresis.

The third criterion is also important, since unless it is met there will be a difference in the fidelity of production of or response to sound waves having different intensities.

The fourth criterion needs no extended discussion, since it is simply a design requirement that prevents the production, by the device itself, of foreign noises such as buzzes or scratches when operating at high amplitudes.

The fifth criterion is of great importance, having a direct bearing upon the practical value of the device. Horn type reproducers have a substantially conical sound distribution, the diameter of the section of the cone being relatively small compared to the distance of the section from the diaphragm. Other reproducers of the prior art, utilizing enlarged plane or conical diaphragms, also have distribution patterns that are in general conical, though the section-diameter distance ratio is greater than in the cases where horns are used. With all these prior art reproducers, however, there are large volumes of the surrounding space where the sound effect is a minimum,—as for instance in the plane of the enlarged diaphragm or cone or behind the orifice of the horn.

By my invention I can combine the five controlling criteria of a perfect sound or vibration converting device in such a way that they are more fully attained than in any prior art device of which I have knowledge.

The invention may be understood from the following description taken in connection with the drawing, in which

Fig. 1 shows, partially in section, a simple embodiment containing the invention.

Fig. 2 shows in section a preferred structure.

Fig. 3 illustrates the device used as a reproducer of received radio signals.

Fig. 4 illustrates the device used as a "pick-up" for radio telephonic transmission.

Referring specifically to Fig. 1, the element 5 is a relatively flexible or resilient and substantially complete sphere of celluloid, paper or other suitable material. This surface is preferably substantially homogeneous in structure, although when some materials such as paper are used the sphere may be constructed of gored sections united in "orange peel" fashion and preferably with the joints or overlaps between gores running longitudinally from pole to pole. It is supported at one pole by a relatively rigid or fixed member 6 and at the antipodal pole carries a link 7 suitably attached (as by means of a pair of cup-shaped washers 8—8′ and clamp nuts 9—9′). The link or drive-rod 7 extends to a magnetic armature 10 which is arranged to act upon or be acted upon by an electro-magnetic system including the coil 11 with terminals 12, 13, the pole piece 14 (which is preferably laminated) and the polarizing magnet 15.

It will be understood that the structure of Fig. 1 is not complete in detail, but that the drawing is intended to illustrate certain special features of the invention. In practice a number of modifications are desirable, such as the substitution of a bipolar polarized magnetic system with pivoted armature or a driving coil suspended so as to move in an annular space across which exists a radial magnetic field for the simple system shown.

In operating the device as a reproducer the alternating or pulsating currents representing the sounds to be generated are applied to the coil 11 via its terminals 12—13. The polarizing magnet 15 acting upon the armature 10 places the "speaking sphere" 5 under a definite initial axial stress tending to elongate the sphere into a prolate spheroidal form having its major axis through the poles at 6 and 7. When varying currents pass through the winding the magnetic stress acting on the sphere through the drive-rod 7 is varied in accordance with the current changes, and the body 5 is therefore caused to vibrate as its polar extremity attached to 7 is moved axially. These vibrations tend to change the body 5 from an approximately true sphere to a prolate spheroid of varying length, or if a magnetic system producing compression upon the sphere is used the forms assumed in action may include that of an oblate spheroid. The changes of form produced by the driving current result in substantially similar and equal movements of the surface of the sphere, such movements having a substantial radial component and resulting in a movement of air molecules in contact with the surface to produce the desired sound waves which pass off in all directions.

In using the device as a sound "pick-up" the reverse cycle of operations takes place. Sound waves impinging upon the surface of the sphere from any direction cause it to move, the motions resulting in an axial motion of the push rod 7 and consequent variations in the air gap between armature 10 and pole-piece 14. These variations produce corresponding alternating electromotive forces in the coil 11, and current conveying such variations may be led away by means of terminals 12—13.

It will be observed that the production of sound by this device involves a symmetrical operation and that the generated sound waves may be expected to pass outward from the sphere in all directions with substantially uniform or at least an extremely wide effective distribution. When used as a "pick-up", however, sound waves are often applied

from a single direction, so tending to cause an unsymmetrical movement of the sphere. In such cases it may be noted that the pick-up from certain directions (and in particular along the axial line) may be somewhat more efficient than that from other directions. This feature may be utilized by turning the sphere as desired, and in the interception of complex multiple sound waves (as in orchestral music) may be availed of for equalizing or controlling the electrical response to sound waves from various points or directions.

It will be understood that the movements referred to, and the consequent changes of form of the vibrating sphere, may be very minute in magnitude. Effective sound waves of large intensity may be generated by (or may result in) motions that are almost of microscopic size.

In Fig. 2 the sphere 5 is supported at one pole by the pedestal 16, a hole in the sphere being cut to permit the push-rod 7 to extend to the antipodal pole at 17. The lower end of the push-rod is attached to the electromagnetic system 18, whose driving coil terminals are brought out to the insulated binding posts 19 and 20. The operation of the device in this form is as described in connection with Fig. 1. For the magnetic system I prefer the moving coil type above referred to.

Fig. 3 shows a receiving antenna and ground system 21—22 passing through a tuner and detector 23, whose output is connected to an audio amplifier 24. The audio frequency electric power delivered from the amplifier passes to the reproducer 25, which may be of the form shown in Fig. 1 or Fig. 2.

Fig. 4 shows the device 25 operating as a pick-up, in which case its terminals may be connected to an audio amplifier 26. The output of this amplifier may be conveyed electrically as desired, by means of line wires 27, to a radio telephone transmitting station comprising audio amplifier 28 and modulator-oscillator 29. The modulated radio frequency currents produced by 29 may be led to a radiating antenna-ground system 30—31, from which radio waves are transmitted.

Although I have shown and described the vibrating surface of my acoustic device as a sphere, I wish it understood that the surface need not be mathematically or even practically spherical in order to obtain many of the advantages of the invention. An oblate or a prolate spheroid, for instance, may be satisfactorily used and other variations in form which do not depart from the spirit of the invention as expressed in the appended claims will occur to the user. In general the vibrating body is preferably a substantially closed envelope with respect to the main active surfaces, though it will be understood that orifices may be provided for entrance of the drive-rod, insertion of the magnetic driving unit, provision of pressure nodes to minimize air-chamber resonant periods where they occur at disturbing frequencies, etc. Neither do I wish to be understood as limiting my invention to the specific forms shown, for many modifications of structure as to the supporting and driving mechanism may obviously be made. For example the push-rod 7 may be replaced by a practically inertialess filament under tension, or may be shortened by placing the magnetic system 18 partly or entirely within the surface 5. The magnetic system may be centrally supported within the sphere, and the vibrating surface suspended upon two oppositely-acting drive-rods so that mechanical vibrations are applied directly and in opposing directions to both antipodal polar points. Where the reproduction of phonographically recorded sounds is desired the mechanical vibrations caused by the record may be applied directly to the push-rod or its equivalent without the interposition in the system of electro-mechanical means.

What I claim is:

1. An acoustic device comprising a substantially spherical non-metallic wall of paper-like material, the polar dimension of which is adapted to increase and decrease simultaneously with equatorial contraction and expansion in combination with a support at one point of said wall and an electromagnetic system comprising a movable element connected mechanically to another point of said wall in combination with a support for said device at one pole thereof and vibrating means connected to the opposite pole.

2. An acoustic device comprising a substantially spherical wall of inelastic material having substantially uniform thickness and flexibility in combination with a support at one point of said wall and an electromagnetic system comprising a movable element connected mechanically to another point of said wall in combination with a support for said device at one pole thereof and vibrating means connected to the opposite pole.

3. An acoustic device comprising a substantially spherical homogeneous body deformable as a whole in combination with a support at one point of said body and an electromagnetic system comprising a movable element connected mechanically to another point of said body in combination with a support for said device at one pole thereof and vibrating means connected to the opposite pole.

4. An acoustic device comprising an approximately spherical body formed entirely of non-magnetic material in combination with a support at one point of said body and an electromagnetic system comprising a movable element connected mechanically to another point of said body in combination with a support for said device at one pole

thereof and vibrating means connected to the opposite pole.

5. A hollow spherical acoustic device of non-metallic inelastic material subjected to balanced internal and external air pressures in combination with a support at one point and an electromagnetic system comprising a movable element connected mechanically to another point in combination with a support for said device at one pole thereof and vibrating means connected to the opposite pole.

6. A hollow approximately spherical acoustic device composed of segmental areas of non-metallic material of approximately uniform thickness united along polar great circles in combination with a support at one point and an electromagnetic system comprising a movable element connected mechanically to another point in combination with a support for said device at one pole thereof and vibrating means connected to the opposite pole.

7. A hollow approximately spherical acoustic device equatorially deformable, means for supporting said device at one pole, and means for applying power axially at the opposite pole to increase and decrease its polar dimension, said means comprising a support for said spherical device and an electromagnetic system mechanically connected to said device.

8. An acoustic device comprising a substantially spherical wall, mechanical connections thereto at substantially diametric portions thereof, said wall being supported by said mechanical connections only, whereby said wall is capable of free movement at all points remote from said connections.

JOHN V. L. HOGAN.