April 5, 1932. A. F. SYKES 1,852,068

REPRODUCTION OF SOUND

Original Filed Nov. 16, 1920

Fig. 1.

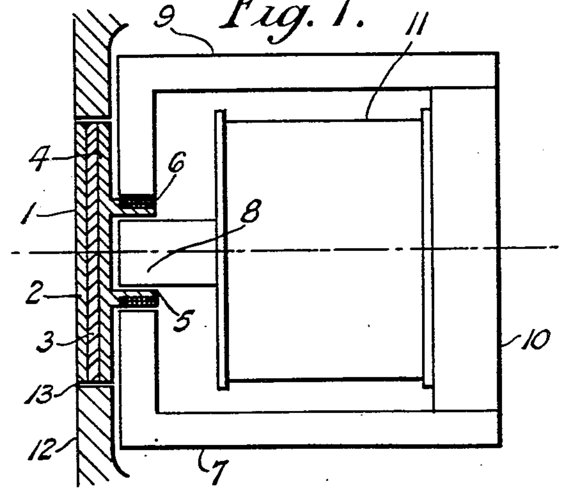


Fig. 2.

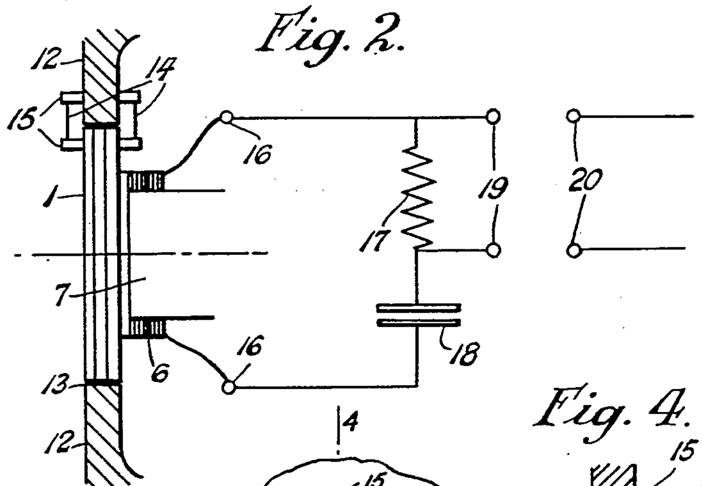
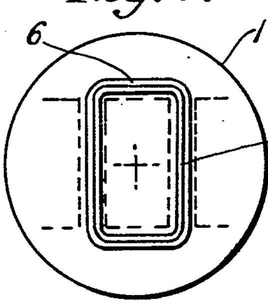


Fig. 3.



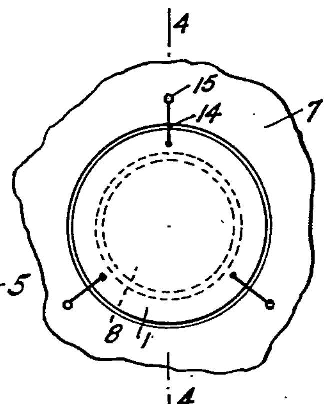
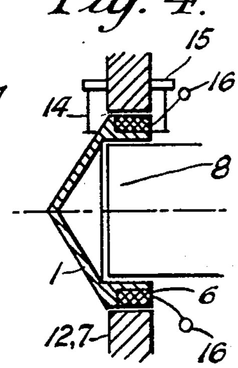


Fig. 5.

Fig. 4.



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Patented Apr. 5, 1932 1,852,068

UNITED STATES PATENT OFFICE

ADRIAN FRANCIS SYKES, OF NEW BARNET, ENGLAND, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RADIO CORPORATION OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

REPRODUCTION OF SOUND

Original application filed November 16, 1920, Serial No. 424,421, and in Great Britain November 18, 1919. Divided and this application filed June 11, 1928. Serial No. 284,587.

This application is a division of my patent application Serial Number 424,421, filed November 16, 1920 and in Great Britain November 18th 1919.

This invention relates to apparatus for the conversion of sound into equivalent variations of electric current or potential, and to the conversion of variations of electric current or derivatives thereof into mechanical vibrations.

The primary object of my invention is the reproduction of sound with improved fidelity in which tonal purity, definition and beauty are enhanced while disturbances, false tones and blasts are minimized, and in general in which defects usually attributed to the natural tones of diaphragms are eliminated. The objects of the invention are attained by providing an acoustic device which is nonresonant in nature. The acoustic device includes a mass which is either in fact or in effect devoid of tones, and a coil immersed in a magnetic field. The device may be used as a primary detector to derive electrical potentials from sound waves or vice versa.

In the detection of sound the sound vibrates a plain mass freely supported. To the mass is rigidly attached an electrical conductor immersed in a magnetic field—a winding or coil. The electrical conductor is immersed in a magnetic field so that when the conductor vibrates an electromotive force is induced. If this E. M. F. is differentiated electrically the result is a practically true replica of the wave of excess pressure.

If the primary detector or microphone is operated in the reverse direction, that is if electrical variations are supplied to the winding, the plain mass will set up sound vibrations.

I will now define what I mean by a plain mass. Consider a body of mass M to be acted upon by a force which causes it to vibrate in simple harmonic fashion, then if

s=amplitude of vibration
a=acceleration
t=time
f=frequency

the expression for the acceleration is:—

$$a=\frac{d^2s}{dt^2}=-4\pi^2f^2s$$

I define a plain mass as a body so supported and free from external or internal constraint that it would require a force of M times $4\pi^2f^2s$ to cause it to execute this vibration. A diaphragm of mass M does not in general for the purpose of this specification, constitute a plain mass since any tones it possesses require much less force of the same frequency or nearly the same frequency to excite to a given amplitude than corresponds to the above formula. For the purpose of this specification the reaction of the supports necessary to maintain the mass in position relative to the other apparatus is neglected since the constraint is trivial compared with the inertia of the mass itself. A body so supported is mass controlled in an acoustic sense as compared to being stiffness or spring controlled. A plain mass has now been described technically; it will be observed that it does not preclude a composite nature for the body employed.

Mathematically if the mass is acted upon by the pulsatory force of sound the amplitude of vibration to each harmonic is inversely proportional to the square of the frequency of the particular harmonic, and the maximum velocity attained is inversely proportional to the frequency, hence the E. M. F. generated in the coil falls uniformly as the frequency rises. If now this E. M. F. is applied to an apparatus capable of enlarging every harmonic in the proportion of its frequency the root mean square value of the current or potential so attained is a constant quantity. The harmonics referred to are harmonics of pressure on the body. At this stage it may be observed that without any modification the coil generates true electrical equivalents of the ordinate of particle displacement.

An apparatus with the property of enlarging every harmonic in proportion to its frequency, that is, of obtaining the electrical equivalent of mathematical differentiation, can be constructed in the following fashion. Let the E. M. F. generated in the detector coil be applied to the grid of a thermionic valve, or any distortionless electric relay, and let a small inductance be placed in the plate circuit; then the potential developed on the inductance will be the differential of the grid voltage. Care should, of course, be taken to avoid the use of any iron core in such fashion as to distort the result by the influence of hysteresis or eddy currents. A device of this nature cannot be loaded or in other words cannot supply more than a trivial amount of current without vitiating the conditions; it is the equivalent of a current transformer on open circuit and a valve so used is one used inefficiently or wastefully in the amplifying sense.

My invention is illustrated by the accompanying drawings. Figure 1 is an elevation in part section of a non-resonant detector. Figure 2 is a fragmentary view in part section of a non-resonant detector and a diagram of connections. Figure 3 is a rear elevation of a non-resonant sound detecting element with attached coil. Figure 4 is a fragmentary sectional view of a non resonant detector showing a variation in construction. Fig. 5 is a plan view of the modification illustrated in Fig. 4.

Figure 1 shows a plain mass 1 of composite construction built up from a disc of ebonite 2, a sheet of india rubber 3 and more ebonite 4 cemented together; a former or frame 5 carries a coil of wire 6 immersed in the field between the poles 7, 8 and 9, of the electromagnet 10 with a winding 11. The plain mass 1 is supported by ligaments, light springs or the like, in an aperture in a wall 12, shown in section, from which it is separated by a space 13 usually made very small.

The ligaments have such a small restoring force that the body 1 is mass controlled in an acoustic sense. To operate the apparatus sound is produced on the side of the wall remote from the electromagnet. A convenient arrangement is to make the wall 12 a division between two rooms, one the recording room and the other the instrument room. A horn or trumpet may if desired be used to concentrate the sound waves upon the mass 1.

Figure 2 is a fragmentary view in part section of the elevation of Figure 1. The ligaments 14 attached to projections 15 in the wall and plain mass respectively are shown supporting the mass. Terminals 16 receive wires from the coil 6. Across these terminals are placed a non-inductive resistance 17 and a condenser 18. Between the terminals 19 is felt the voltage variation across the non-inductive resistance 17. A number of valve relays in cascade are interposed between the terminals 19 and the terminals 20 so that the plate current in the last of the series is carried by the wires from the terminals 20 and this plate current is an enormous magnification and replica of the potential across the terminals 19; this plate current is caused directly or indirectly to operate a receiving or recording telephone.

Figure 3 is a view of the coil 6 wound on its former 5 at the rear of the plain mass 1. The poles 7, 8 and 9, of the electromagnet are indicated by dotted lines. Of course the former and coils move with and therefore add to the mass of the primary detector 1.

Figure 4 is a modification of the apparatus represented in Figure 1. Here the poles 7 and 8 of the electromagnet are of the peg and ring type, that is, the pole 7 encircles the pole 8 and the field is radial. In this construction the pole 7 is built into and forms part of the recording wall 12. The primary detector or plain mass 1 is of conical shape and made from ebonite; the coil 6 is wound on the periphery of the detector.

Divisible subject matter not claimed herein is claimed in my copending application Serial No. 30,605, filed May 15, 1925, entitled "Means for recording sound", now Letters Patent No. 1,743,251, granted January 14, 1930; in my Letters Patent No. 1,711,511, granted May 27, 1929, on an application Serial No. 424,421, filed November 16, 1920, entitled "Reproducing and recording of sound"; in my Letters Patent No. 1,639,713, dated August 23, 1927, entitled "Reproduction of sound"; and in my application Serial No. 319,299, filed November 14, 1928, for "reproduction of sound".

What I claim is:—

1. In means for reproducing sound, the combination of a conical vibration responsive member, a coil support bonded to a circumference on said conical member, a winding on said coil support adapted to carry telephonic currents or derivatives thereof, means for producing a magnetic field threading the said winding through a magnetic air gap, and means for suspending said conical vibration responsive member and attached coil support so that said winding is immersed in the said magnetic air gap, said vibration responsive member and said coil support being suspended so as to be without substantial restraint in an acoustic sense.

2. An acoustic device of the moving coil type comprising a conical diaphragm, a cylindrical member connected to said dia-

phragm, a coil on said cylindrical member, an electro-magnet system for providing an annular gap of magnetic flux, and means for suspending said diaphragm with said coil in said annular gap, said means having such a small restoring force that said diaphragm is mass controlled in an acoustic sense.

3. An acoustic device for the interconversion of sound waves and electrical energy comprising a conical diaphragm, a cylindrical member connected to said diaphragm, a winding on said cylindrical member, means for providing a magnetic field, said winding being immersed within said field, a supporting member spaced from said diaphragm, and resilient means connected between said diaphragm and said supporting member, said resilient means being of a different material from that of said diaphragm and providing a very small restoring force whereby said diaphragm is mass controlled in an acoustic sense and the natural period of vibration of said diaphragm is at a low frequency.

4. A device for the interconversion of sound waves and electrical variations comprising a conical diaphragm, a winding supported for movement with said conical diaphragm, a magnet system for providing a magnetic field in which said winding is immersed, a member spaced from said conical diaphragm, and flexible supporting means of different material from that of the diaphragm connected between said conical diaphragm and said member, said flexible supporting means having a restoring force which is trivial compared with the inertia of the diaphragm itself whereby said diaphragm is mass controlled in an acoustic sense over at least the greater portion of the audible frequency range.

5. An acoustic device comprising a conical diaphragm, means for producing a magnetic field, a winding secured to said diaphragm and immersed in said field, and supporting means having such a small restoring force that said diaphragm is mass controlled in an acoustic sense, connected to said diaphragm.

6. A vibratile system for an acoustic device comprising a substantially conical vibratile diaphragm, a coil supporting member secured thereto, a coil on said coil supporting member, and flexible means having such a low restoring force that said diaphragm is mass controlled in an acoustic sense over the larger portion of the audible frequency range, extending outwardly substantially from the peripheral edge of said diaphragm.

7. An acoustic device of the moving coil type comprising a non-planar vibratile diaphragm, a member secured to said diaphragm, a winding on said member, means for producing a magnetic field, and means for supporting said diaphragm, said means having such a small restoring force and offering such a minimum resistance to movement of said diaphragm that said diaphragm is mass controlled in an acoustic sense over at last the greater portion of the audible frequency range, said means supporting said diaphragm so that said winding is immersed in said magnetic field.

8. An acoustic device of the moving conductor type comprising a vibratile body, said vibratile body including substantially a conical portion and a cylindrical portion, a conductor on said cylindrical portion, a magnetic field for cooperating with said conductor, and flexible means for supporting said body so that said body is mass controlled in an acoustic sense over at least the larger part of the audible frequency range.

9. In a sound reproducer, an electrical system including an annular magnetic gap, a coil support arranged within said annular magnetic gap, a winding carried by said coil support, a conical shaped sound reproducing element connected to said coil support, and means for supporting the peripheral edge of said conical shaped sound reproducing element, said means comprising a stationary member spaced from the peripheral edge of said sound reproducing element and low restoring force means of more flexible material than the material of said sound reproducing element extending between said stationary member and the peripheral edge of said sound reproducing element.

In testimony that I claim the foregoing as my invention I have signed my name this 15th day of May, 1928.

ADRIAN FRANCIS SYKES.

CERTIFICATE OF CORRECTION.

Patent No. 1,852,068. April 5, 1932.

ADRIAN FRANCIS SYKES.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, line 104, for "No. 1,711,511" read No. 1,711,551; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of November, A. D. 1932.

M. J. Moore,
Acting Commissioner of Patents.

(Seal)