Oct. 1, 1929. A. L. THURAS 1,729,806

ELECTRODYNAMIC DEVICE

Filed April 26, 1928

FIG. 1.

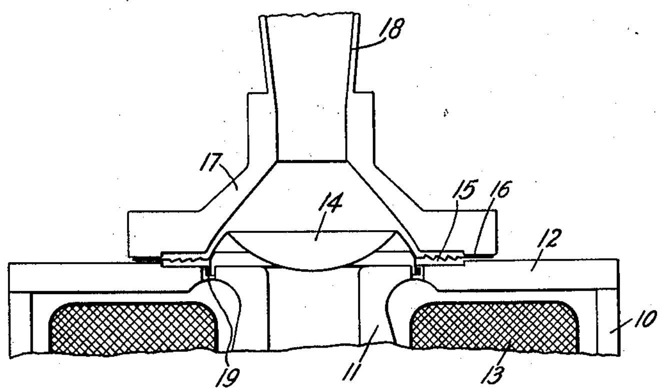


FIG. 2.

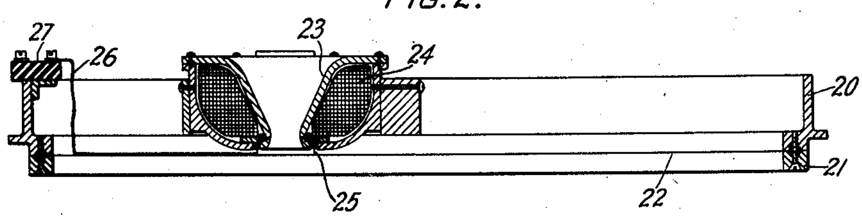


FIG. 3.

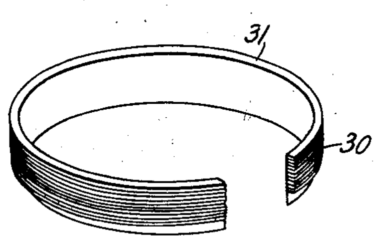
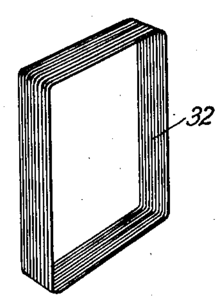


FIG. 4.



INVENTOR
ALBERT L. THURAS
BY
Walter C. Kiesel
ATTORNEY

Patented Oct. 1, 1929 **1,729,806**

UNITED STATES PATENT OFFICE

ALBERT L. THURAS, OF NEW YORK, N. Y., ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

ELECTRODYNAMIC DEVICE

Application filed April 26, 1928. Serial No. 273,082.

This invention relates to electrodynamic devices and more particularly to the movable element of such devices.

An object of the invention is to increase the efficiency of electrodynamic devices which are employed as the driving systems of acoustic devices.

A more specific object of the invention is to increase the sensitivity, operating efficiency and current carrying capacity of movable elements in the magnetic field of electrodynamic devices.

In accordance with the broad aspect of the invention, a movable element or coil operating in the magnetic field of an electrodynamic device is formed of a metallic material having its mass, specific gravity and specific resistance lower than other materials heretofore used for such purposes. More specifically the movable element is formed of beryllium or as it is sometimes called glucinum, which has a specific gravity of 1.9 and a specific resistance of 7.3 ohms per mil foot. The element or coil may also be formed of an alloy in which beryllium or glucinum forms the greater part. This material is particularly adaptable for use as the driving coil for the vibrating element of an acoustic membrane or diaphragm. The proper proportioning of the weight of the coil and the vibrating element will result in a sound radiator having a larger area per unit mass than other driving systems heretofore used. These characteristics in conjunction with the low specific resistance of the coil increase the efficiency of the driving system of an acoustic vibrating device and also increase the current carrying capacity of the driving coil.

In one of the preferred forms of the invention, a diaphragm and sound chamber, such as the structure disclosed and claimed in the copending application of E. C. Wente, Serial No. 127,023, filed August 4, 1926, is coupled to a movable coil which is positioned in the magnetic field between the pole pieces of an electromagnet and is formed of a conductor composed of beryllium or glucinum, or an alloy thereof. The coil is attached to the diaphragm and is movable therewith.

The invention is also applicable to the moving element of measuring apparatus such as galvanometers, oscillographs, light valves or other electrical apparatus in which it is desired to employ a movable element having small mass and low resistance.

A more detailed description of the invention follows and is illustrated in the accompanying drawing, in which:

Fig. 1 is a diagrammatic view of an acoustic device embodying the movable coil element in accordance with this invention;

Fig. 2 is a cross-sectional view of a large sound radiator acting directly in air in which the movable coil is attached to the large radiating surface;

Fig. 3 is a perspective view showing the detailed construction of a movable coil made in accordance with this invention which may be applied to the devices shown in Figs. 1 and 2; and,

Fig. 4 is a perspective view of a modified form of coil which may be employed as the movable unit of a galvanometer or other electrodynamic device.

Referring to Fig. 1 the acoustic device consists of a magnetic structure having an annular core member 10 in which the central tubular member 11 forms one of the poles of the magnetic structure and the apertured disc member 12 forms the other pole. These members are arranged in position to provide an annular air gap between the opposing poles in which the winding 13 is located. A vibratile member or diaphragm having a dished rigid portion 14, a resilient annular portion 15, and a supporting rim 16 is arranged above the magnetic core and supported on the disc member 12 by the housing 17 which carries the horn 18. The diaphragm is preferably made of thin duralumin or beryllium although light metallic materials and even fibrous materials may be used. A moving coil 19 is positioned within the annular air gap between the poles of the magnetic structure and is attached to and movable with the dished portion 14 of the diaphragm. A more detailed description of the structural features of this device is disclosed in the application of E. C. Wente hereinbefore mentioned.

The movable coil 19 attached to the dished portion 14 of the diaphragm and movable in the magnetic field of the magnetic structure 10 is one of the major elements which determine the efficiency of the device for converting electrical energy into acoustic energy. In a device such as shown in the drawing, the vibrating diaphragm should be as light and stiff as possible and it is also necessary that the movable coil should be formed of material having light mass to improve the sensitivity of the moving system. In accordance with this invention this is accomplished by forming the movable coil of a conducting element such as beryllium or glucinum. This element forms a desirable material for such use since it has certain characteristics which are of considerable importance in the application of moving coil systems to electrodynamic devices. For instance, the specific gravity of this metallic element is considerably lower than aluminum, being approximately 1.9 and the resistance is also low being approximately 7.3 ohms per mil foot. This material has other properties which are of great importance, such as high resistivity to corrosion and high melting point. It will be seen that for a given area per unit mass a longer coil can be produced having the same resistance as aluminum. The benefit derived from having a longer coil attached to the diaphragm will be the greater effective force that the magnetic field can apply to the coil which is movable therein, and consequently the variations of electric current passing through the coil can be converted more efficiently into sound variations. The moving coil 19 may also be formed of a suitable alloy in which beryllium or glucinum forms a major portion. For instance, the beryllium may be alloyed with a certain percentage of aluminum to render the material more ductile for forming into wire or tape.

The efficiency of an acoustic device is the ratio of the acoustic power output to the total power input. The acoustic power output of the device is limited by the electrical impedance inherent in the moving system. This impedance is determined by the resistance of the movable coil and the motional impedance of the diaphragm when vibrating. The resistance component of this motional impedance when multiplied by the square of the current gives the power that is generated by the motion of the diaphragm. The motional impedance of the moving coil vibrating system is substantially a pure resistance. It will be seen therefore that the efficiency may be increased by a reduction of the specific resistance of the movable coil or by increasing the motional resistance of the vibrating system.

In a movable coil acoustic device such as is shown in Fig. 1 in which the coil is formed of low specific resistance material, such as beryllium, the output efficiency may be more clearly understood by the following representative expressions.

The electrical resistance of the vibrating system is represented by

$$R_o+R_m \quad (1)$$

in which R_o is the resistance of the movable coil and R_m is the motional resistance of the coil and diaphragm in motion. The power input is represented by

$$I^2(R_o+R_m) \quad (2)$$

and the power output will be represented by

$$I^2R_m \quad (3)$$

The efficiency of the acoustic device will therefore be the ratio of power output to power input and may be represented by

$$\frac{I^2R_m}{I^2(R_o+R_m)}=\frac{R_m}{R_o+R_m}=\text{efficiency} \quad (4)$$

It will readily be seen that if R_o is large the efficiency will be materially decreased whereas if R_o is low, the efficiency approaches more nearly unit.

The motional resistance R_m is represented by the expression

$$R_m=\frac{(Bl)^2 10^{-9}}{R} \quad (5)$$

where B represents average flux density of current, l represents length of wire in the movable coil, and R represents radiation resistance.

When the coil is formed of beryllium or an alloy thereof which is of relatively light mass, the length of the conductor in the coil may be materially increased, thereby increasing the value of motional resistance and causing a corresponding increase in the radiation efficiency of the vibrating system.

The sound radiator shown in Fig. 2 comprises a ring frame member 20, and a clamping ring 21 between which is supported a large sound radiating surface 22 such as a light metallic diaphragm. A magnetic unit is arranged on one side of the diaphragm and comprises a hollow core member 23 having a winding 24, the walls of the core forming opposite poles having an annular gap therebetween adjacent the surface of the diaphragm 22. A movable coil 25 formed of a metallic element or conductor of beryllium of glucinum or an alloy thereof, is attached to the diaphragm surface 22 and connected by a lead wire 26 to the terminal post 27. The coil 25 is movable in the magnetic field between the poles of the magnetic structure 23. This structure is disclosed and claimed in an application of V. A. Schlenker Serial No. 190,484, filed May 11, 1927.

The movable coil described in Figs. 1 and 2 is shown more in detail in Fig. 3 and comprises a conducting element 30 in the form of a flat ribbon which is wound edgewise with adjacent turns insulated from each other and formed into a self-supporting coil having a fabric lining 31 which is attached to a diaphragm surface by the projecting upper edge.

Fig. 4 shows another form of movable coil made in accordance with this invention in which the coil is formed into a rectangular self-supporting structure and is suitable to function as the moving coil of an oscillograph or galvanometer measuring system. In this arrangement the coil may be formed of wire comprising beryllium or glucinum or an alloy in which this metal forms more than 50%.

The moving coil structure of this invention is applicable to other types of electrodynamic devices in which it is desirable to have an element of light mass and low specific resistance in order to produce a coil which is sensitive to changes in magnetic flux in the magnetic field of an electrical device. Because of its low specific resistance such an element can carry more current without burning up.

It is to be understood that the invention is not to be limited to the specific structures described above, since various modifications may be made without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. An electrodynamic device comprising a movable current carrying element of beryllium.

2. A movable element for an electrodynamic device, composed of a metallic conductor having a specific gravity less than 2 and a specific resistance less than 8.

3. A movable element for an electrodynamic device composed of a metal having its mass, specific gravity and specific resistance less than aluminum.

4. A movable coil for an electrodynamic device composed of a metal in which the product of mass and resistance is approximately 1/3 of aluminum.

5. A coil for a vibratile member having a conductor composed of beryllium.

6. A coil for a vibratile member composed of a conducting alloy in which beryllium forms a major portion.

7. In an electrodynamic device, an electromagnet comprising a core, a winding therefor, and a coil movable in the magnetic field of said electromagnet, said coil being of low specific resistance and composed of a conducting material in which beryllium forms more than 50%.

8. An acoustic device comprising a vibratile member, a coil connected thereto, said coil being composed of a conducting element of beryllium, and pole pieces exerting a magnetic force on said coil.

In witness whereof, I hereunto subscribe my name this 25th day of April, 1928.

ALBERT L. THURAS.