June 7, 1955 F. R. SIAS 2,710,376

MAGNETIC ARMATURE MIRROR FOR GALVANOMETERS

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Fig. 1.

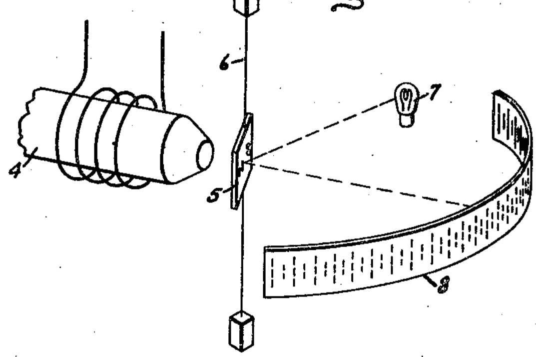


Fig. 2.

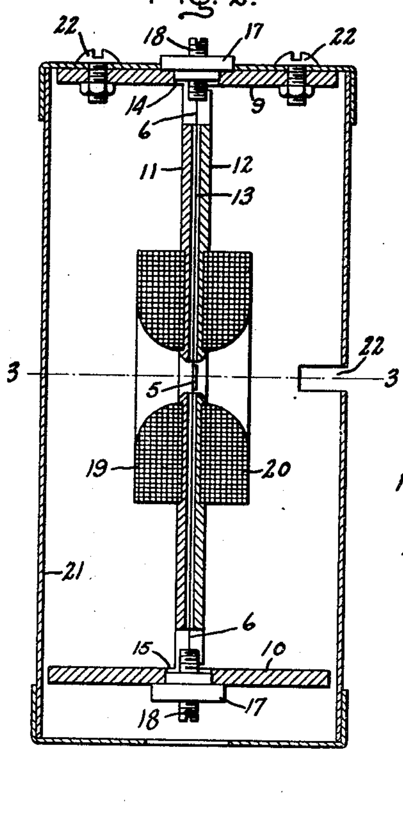
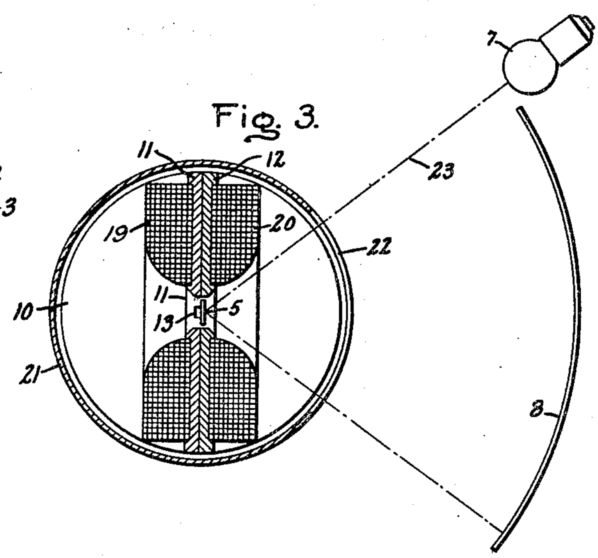


Fig. 3.



Inventor:
Frederick R. Sias,
by Russell A. Warner
His Attorney.

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MAGNETIC ARMATURE MIRROR FOR GALVANOMETERS

Frederick R. Sias, Lynnfield Center, Mass., assignor to General Electric Company, a corporation of New York

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1 Claim. (Cl. 324—97)

My invention relates to galvanometers and particularly to magnetic armatures therefor which also serve as mirrors so as to be used with a light ray system to indicate or record the armature deflection, and it is an important object of my invention to increase greatly the sensitivity of mirror type magnetic armature galvanometers as heretofore built.

The features of my invention which are believed to be novel and patentable will be pointed out in the claims appended hereto. For a better understanding of my invention reference is made in the following description to the accompanying drawing in which Fig. 1 represents a schematic embodiment of my invention. Fig. 2 represents a vertical cross section through approximately the center of a suspension type galvanometer containing my magnetic armature mirror in the air gap and illustrating a shape of the stationary coils that permits the armature to be utilized as a mirror in a light ray indicating system, and Fig. 3 is a sectional plan view through the center of the coils (axis 3—3, Fig. 2) of such a galvanometer.

In Fig. 1, I have schematicaly indicated the more essential parts of a mirror type galvanometer embodying my invention where **4** represents a stationary electromagnet for producing a field proportional to the strength of the current or voltage to be measured, **5** represents a magnetic armature suspended by a torsional wire **6**, with the armature within the influence of the field produced by the electromagnet. In this case the magnetic armature is relatively thin and flat having a surface which is polished or otherwise made reflecting so as to be used as a mirror as well as an armature. At **7** there is represented a light source which directs a ray of light onto the mirrored suface of armature **5**, and the ray is reflected onto a stationary translucent scale **8**, such that as the armature is turned in response to the field, the measurement movement of the mirror is indicated by the light ray moving over the scale **8**.

Heretofore, it has been the usual practice in this type of galvanometer to provide a mirror on the suspension which is separate from the armature and which is located well above or below the armature. Such separate armature and mirror arrangements considerably increase the mass of the moving system as compared to my single armature and mirror system. It has been found that the watts input to a galvanometer to give a constant torque to weight of the moving system is proportional to the square of the moving system weight. It is evident, therefore, that if a separate mirror is attached to the moving system whose weight equals that of the magnet, the power input will be four times that required to move the magnet alone. Hence, by providing a magnet armature which is also a mirror, I have completely eliminated the weight of a separate mirror and greatly increased the sensitivity. I have found that utilizing the armature as a mirror does not compromise the armature design. The armature may be in the form of a thin, circular disk having a mirror surface at least on one side. In such design the mass of the moving system is located at the point where the torque is applied, and there can be no lag or lack of exact synchronism between the movement of the armature and mirror, and the length of the suspension may be reduced to the requirements of the unitary armature and mirror system .

One difficulty is encountered in employing a unitary armature and mirror in galvanometers as heretofore constructed since in a well designed galvanometer of the type under consideration, the armature should be located in the air gap of a stationary electromagnet or energizing coil system, and which in previous designs largely hid the armature from view such that if the armature were used as a mirror, no satisfactory light ray reflecting system could be employed. A design of shielded coil system shown in Figs. 2 and 3 eliminates this difficulty.

As best shown in Fig. 3, I provide a symmetrical, well shielded coil system for producing a concentrated flux in an armature air gap, while at the same time allowing for a beam of light to strike the armature and be reflected over an arc of the order of 60 degrees as the armature is deflected, so as to be read on an external scale with good visibility.

Referring to Figs. 2 and 3, I have provided a framework of nonmagnetic material, such as brass, comprising horizontal, circular top and bottom plates **9** and **10** interconnected by a central, vertical, divided partition comprising plates **11** and **12** which extends across the diameters of plates **9** and **10** and between them. The circular end plates and the vertical partition plates are joined together into a rigid framework. The circular end plates **9** and **10** may be made integral with one of the sections **11**, for example, of the partition and the other section **12** of the partition may be removably secured to section **11** as by small brass machine screws, for reasons to be explained. The sections of the partitions **11** and **12** as assembled lie face to face against each other but each has a vertical groove cut on its inner face down its center, so that when assembled, these grooves form a central, vertical channel opening **13** through the center of the partition from top to bottom in line with central and larger openings **14** and **15** in the circular end plates **9** and **10**. This channel **13** is to provide space for and to protect the suspension wire **6**, secured between fastening and tensioning means contained in the openings at **14** and **15**. These suspension wire fastening and tensioning means may comprise stepped collars **17**, the smaller diameter portions of which fit into the openings **14** and **15** with the larger diameter portion on the outside and through which are threaded screws **18**, the suspension wire **6** being secured to the inner ends of such screws as shown in Fig. 2. The partition parts **11** and **12** have central cutouts at top, bottom, and center to allow room for the screws **18** and the armature **5** which is mounted on the suspension wire **6** about midway between its ends. By means of the screws **18** the exact position of the mirror armature **5** may be adjusted and the tension of the suspension wire may be adjusted. By making one section **12** of the partition removable, the suspension wire **6** and the mirror armature **5** may be assembled in place and adjusted before the removable plate **12** is secured in place.

Circular depressions are cut in the outer faces of the partition with the armature as a center to form seats for the coils **19** and **20** and to reduce the thickness of the partition between the coils. These coils will generally be connected in series and may be considered as a single winding producing a flux in the same direction in the armature gap along the axis 3—3, Fig. 2. The coils may also be connected in parallel either to add their fluxes or in opposition to provide a ratio galvanometer. The coils are securely fastened to the partition by adhesive and otherwise as necessary.

To provide a flux return path about the winding and to protect the galvanometer from outside magnetic influence, I mount the galvanometer as thus assembled on its supporting frame in a magnetic container **21** made of some high permeability magnetic material. The container **21** is fastened to the galvanometer framework as by means of the bolts at **22**. Openings are provided at the centers of the container ends to provide access to the screws **18**.

Also there is an arc-shaped slit **22** cut in one side of the container opposite the armature **5** to provide for the passage of a light ray **23** from the exterior light source **7** to the armature **5** and out again to the scale **8**.

It will be understood that the armature **5** is a thin, circular disk of permanent magnetic material polarized across a diameter at right angles to its axis of rotation or to the axis of the suspension wire, and that the side of the armature towards the light source **7** has a good mirror surface. If the armature has a zero torque position, such as represented in Fig. 3, it may be caused to deflect counterclockwise when the winding comprising coils **19** and **20** is energized in the proper direction. The deflection is restrained by the torsion wire **6** and the deflection is proportional to the current in the winding.

It will be noted that the contour of the inner side of the coils and coil support is made such as to leave generally cone-shaped free areas adjacent the armature with the armature located at the apex of such cones such that the armature is visible from the light source and any part of scale **8**. Thus there is a free viewing angle of the order of 60 degrees outward from the armature. While it is unnecessary to provide such free viewing area to the left of the armature as viewed in Fig. 3, there is no material sacrifice in making the coils alike and symmetrical instead of making the inner contour of coil **19** of a uniform, small diameter. Hence, the same coil form may be used for both coils. A deflection angle of 60 degrees of the light beam as reflected from the armature is easily obtained.

A considerable advantage is obtained by providing the unitary armature and mirror in reducing the total weight of the moving system and thereby increasing the sensitivity of the galvanometer. Also, the weight of such moving system is largely and symmetrically concentrated at the center of the suspension and at the point of the application of torque. Hence, the deflection indication is truly representative of the armature deflection and there can be no lag between the armature and mirror movements. The problem of mounting a separate armature and mirror combination on the suspension wire in their proper relation is absent. The over-all length of the suspension may be reduced and the over-all size of the galvanometer may be reduced accordingly as compared to a galvanometer having separate armatures and mirrors spaced apart on the suspension wire. The length, diameter, and weight of the suspension wire may be reduced by using my invention and all of which contributes to increased sensitivity.

As is well known, the deflection characteristics of a galvanometer may be modified and adjusted by shaping the field flux pattern, changing the size, shape and material of the armature, adjusting the tension of the wire, including impedance in the exciting circuit and the like, and such expediencies known to the prior art may be used quite generally without interference with the invention described. Where the galvanometer is used for direct current purposes the magnetic armature may be a thin permanent magnet, preferably of thin circular shape polarized parallel to its plane along an axis at right angles to its axis of rotation and suspended at its center midway between the pole pieces.

The mirror thereon may be made by simply polishing one of its flat surfaces. Many suitable permanent magnetic materials will take a high reflecting polish but some are better than others in this respect. Since the mirrors may be made very thin as compared to their diameters, high coercivity is not particularly important. The armatures are preferably made as thin as possible and still strong enough to resist breaking where light weight and high sensitivity are desired. The thickness referred to here may be compared to that of thin paper. Tungsten

steel will make a satisfactory permanent magnet, polished mirror armature of thin paper thickness. A permanent magnet alloy material of aluminum, nickel, iron, and cobalt, and also one of iron, cobalt and vanadium will take a high mirror polish and are suitable for such mirror armatures. In case the galvanometer is to be used for alternating current purposes it will often be desirable to use a magnetic armature which is not polarized and here it is more likely that the material, such as iron, will not take a satisfactory mirror polish. In all cases where the material will not take a satisfactory mirror surface, one side may be plated with a thin film of aluminum, or silver, or chromium to provide a mirror surface. While a circular-shaped armature has been mentioned, other symmetrical shapes such as ellipses and rectangular-shaped armatures may be used. The armature need be no longer than the size of a mirror that will give a sufficient light spot on the scale used. For illustration purposes a mirror armature thicker and larger than will ordinarily be necessary has been indicated.

While the invention has been described as used in a suspension type of galvanometer, it is obvious that other ways of pivoting and supporting the armature may be used in various types of instruments. For instance, in Fig. 1, if the electromagnet be removed, the device may be used as a reflecting compass.

In accordance with the provisions of the Patent Statutes I have described the principle of operation of my invention, together with the apparatus which I now consider to represent the best embodiment thereof, but I desire to have it understood that the apparatus shown is only illustrative and that the invention may be carried out by other means.

What I claim as new and desire to secure by Letters Patent of the United States, is:

A galvanometer comprising a nonmagnetic framework having upper and lower end plates secured in parallel spaced relation by a partition, said partition comprising a pair of flat plates detachably secured together face to face and extending between and at right angles to said end plates, the inner faces of said partition plates having aligned grooves to provide a channel therethrough between said end plates, a torsion wire extending through said channel and adjustably secured under tension between said end plates, an armature opening through said partition midway between said end plates and in alignment with said torsion wire, a paper thin magnetic armature having a mirror surface secured on said wire in said armature opening, a pair of coils about said armature opening secured to and spaced apart by said partition and forming a winding for producing the field flux of said galvanometer through said armature, the inner periphery of said coils and frame adjacent said armature opening being formed to provide generally cone-shaped free spaces of not less than 60 degrees diverging laterally in opposite directions from said armature, a cylindrical container of high permeability magnetic material enclosing said galvanometer parts and forming a magnetic circuit for the field flux of said galvanometer about the outside of said coils and a magnetic shield for said galvanometer, a sector-shaped opening in said container opposite said armature, and a light source and a scale external to said container positioned so that light from said source may pass to said mirror armature and be reflected onto said scale through the sector-shaped opening in said container and the cone-shaped free space adjacent said armature over the normal deflection range of said armature.

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