Feb. 19, 1929. 1,702,650

C. F. HINDLE

GALVANOMETER

Filed May 13, 1924 2 Sheets-Sheet 1

Fig. 1.

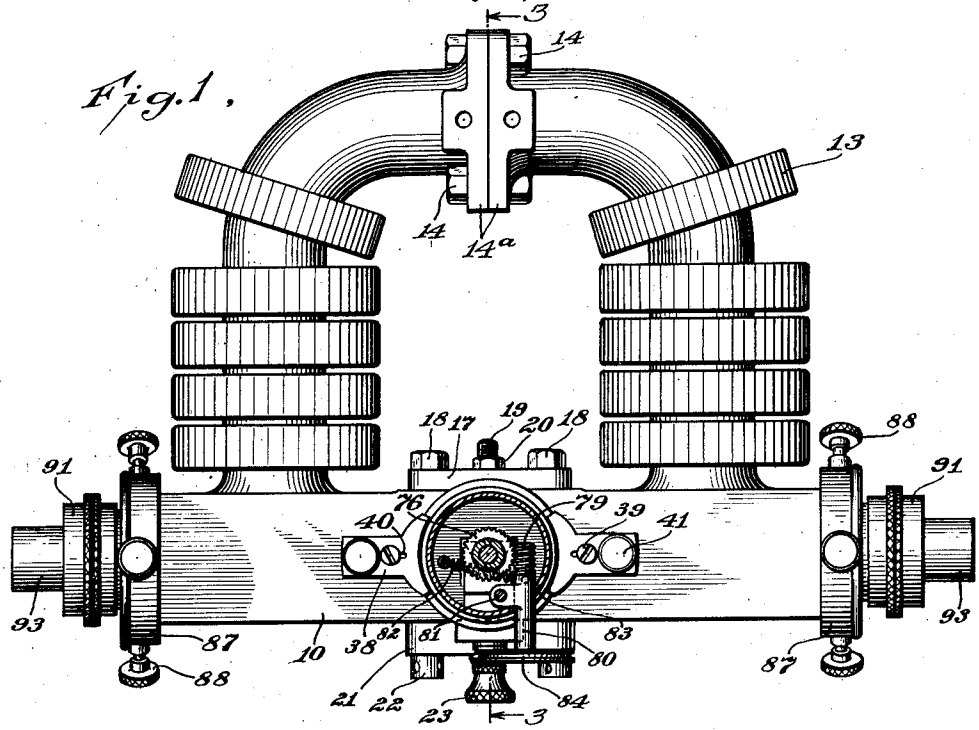
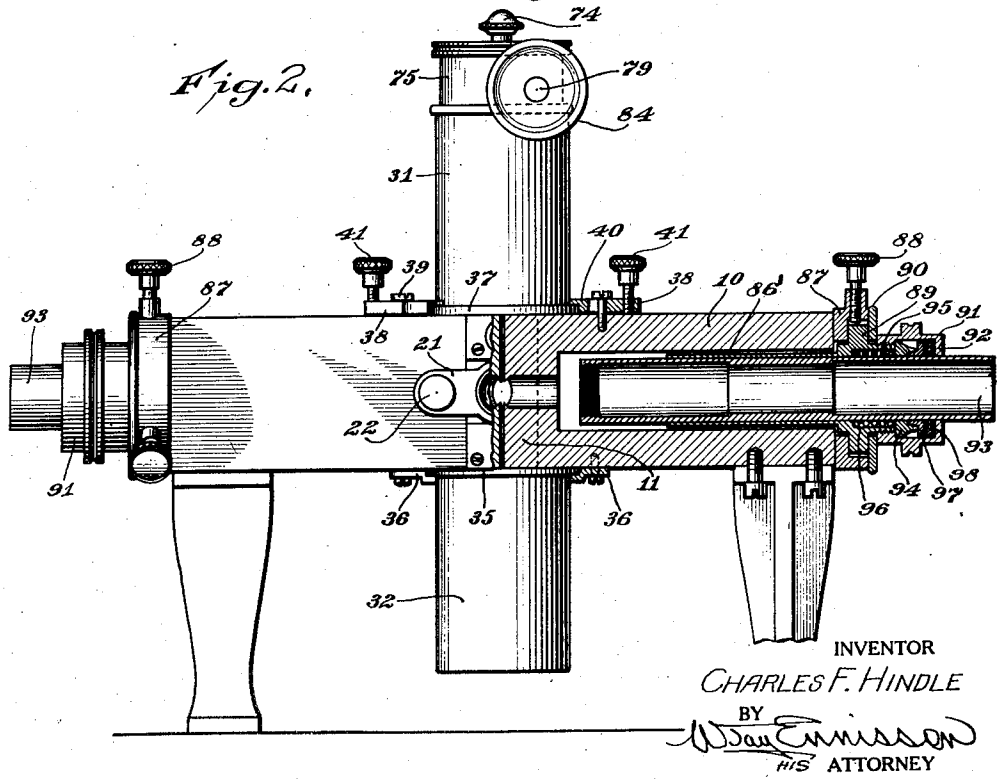


Fig. 2.



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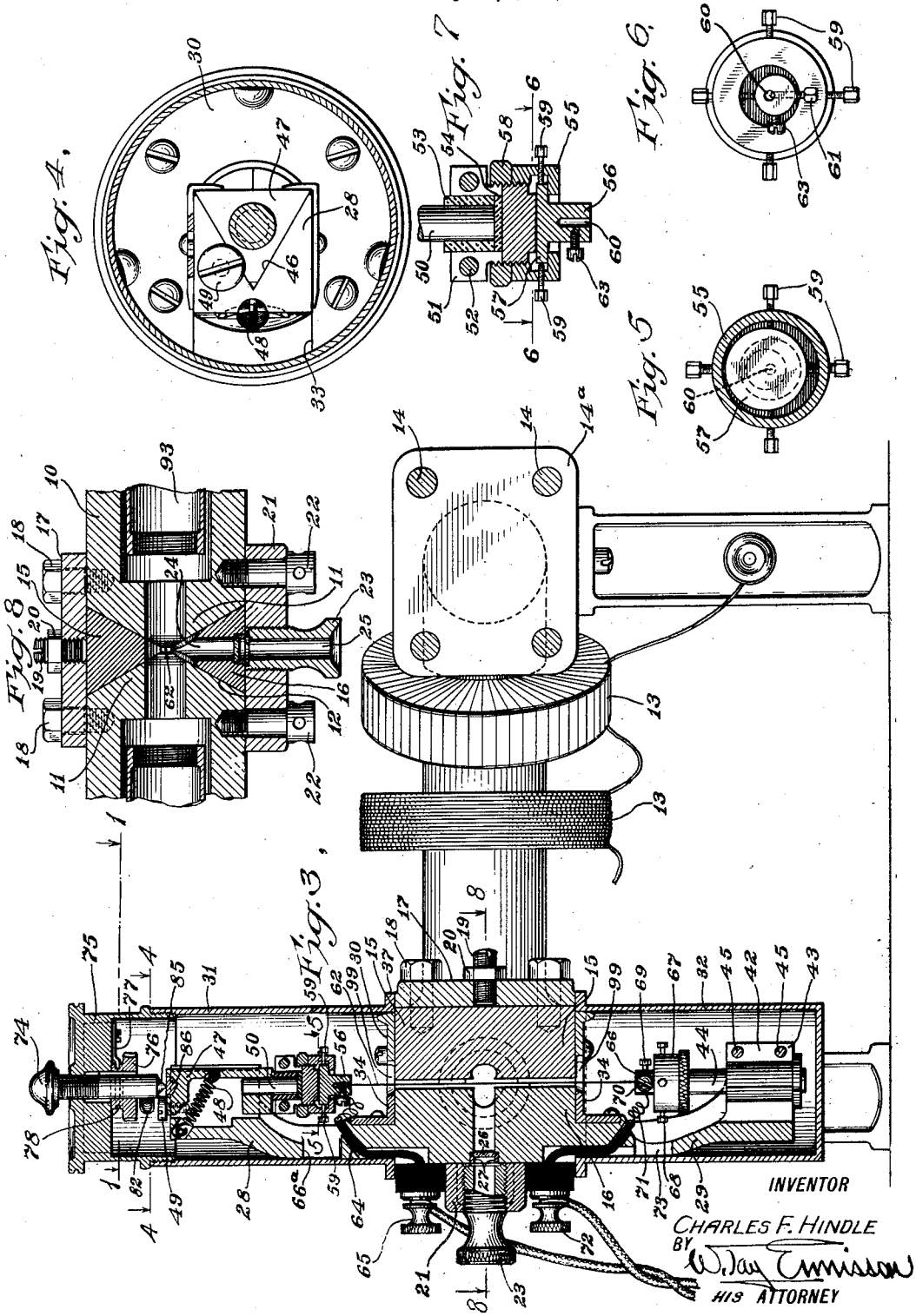

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UNITED STATES PATENT OFFICE.

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GALVANOMETER.

Application filed May 13, 1924. Serial No. 712,973.

This invention relates to string galvanometers, and particularly is in the nature of an improvement upon the type of instrument disclosed and claimed in United States Patent No. 1,416,824 issued May 23, 1922. In prior types of string galvanometers, the replacement of the strings of electro-conductive material and proper alignment and positioning of the string is very difficult and uncertain, for the reason that the adjustable parts are difficult of convenient access and the adjustments and replacement must frequently be effected by persons who are unfamiliar with and relatively unskilled in matters pertaining to delicate, accurate, scientific instruments. It has also been difficult to ascertain the alignment and condition of the string while within the instrument without disassembling a portion of the instrument. To use strings of different properties, several instruments were required, one for each string.

An object of the invention is to provide an improved string galvanometer with which the mounting, alignment, and adjustment of the string may be made exteriorly of the instrument, such as by skilled artisans at the factory, and applied by any one whether skilled or not without danger of injury to the string or a disturbance of its adjustment; with which strings are readily changeable so that with one instrument, a number of strings of different qualities may be kept in mounted and adjusted condition and quickly interchanged in active position as desired for use; with which the condition of the string while within the instrument may be readily determined by direct observation without opening the chamber in which the string is disposed; which has all the advantages of the prior instruments; and which is exceptionally simple, compact, efficient, durable, convenient, light in weight, and relatively inexpensive. Various other objects and advantages will appear from the following description of an embodiment of the invention, and the novel features will be particularly pointed out in the appended claims.

In the accompanying drawings:

Fig. 1 is a sectional plan of the instrument, the section being taken approximately along the line 1—1 of Fig. 3;

Fig. 2 is a front elevation of the instrument with a portion broken away to show the interior details;

Fig. 3 is a sectional elevation of the same, with the section taken approximately along the line 3—3 of Fig. 1;

Fig. 4 is a sectional plan of a portion of the instrument, with the section taken approximately along the line 4—4 of Fig. 3;

Fig. 5 is a sectional plan of a portion of the same, taken approximately along the line 5—5 of Figs. 3 and 7;

Fig. 6 is a bottom plan of the parts shown in Fig. 5;

Fig. 7 is a sectional elevation of the same; and

Fig. 8 is a sectional plan of a portion of the instrument, the section being taken approximately along the line 8—8 of Fig. 3.

Referring to the illustrated embodiment of the invention, the core 10 of the electromagnet is nearly a complete ring, the polar ends 11 being bevelled from opposite sides and spaced slightly apart so as to provide V-shaped channels 12 along opposite sides between the polar ends and concentrate the magnetic flux as far as possible in the convergent polar tips. Any desired number of magnetizing coils 13 may be provided upon the core intermediate of its ends and connected to any suitable source of current. The core is preferably divided midway of its ends (Figs. 1 and 3) and connected by bolts or screws 14 which pass through abutting flanges 14^a on the core section ends.

A pair of V-shaped wedges 15 and 16 (Figs. 3 and 8) of non-magnetic metal or other suitable material are disposed in the V-shaped grooves or channels 12 on opposite sides of the pole pieces so as to form a continuation of the core section except between the unbeveled portions of the pole pieces. The wedge 15 is confined within its channel by a strap 17 of non-magnetic material which is secured to the polar ends by suitable means such as by screws 18. A screw 19 threaded through the strap 17 bears against the wedge 15 and wedges it into its channel, the screw being held in adjusted positions by a lock nut 20.

The wedge 16 is confined within its channel by a strap 21 (Figs. 3 and 8) of non-magnetic material which connects the pole pieces, being secured to the pole pieces by

screws 22. A tubular screw 23 is threaded through the strap 21 so as to press the wedge 16 into its channel. The wedge 16 is provided with a passage 24, aligned with the passage 25 in the tubular screw 23, so that the chamber or space between the pole pieces may be observed through the aligned passages. A magnifying lens 26 is secured by a ring 27 within the passage 24 of wedge 16 so as to prevent the movement of air and dust along the passages and to provide an enlarged image of anything within the space between the pole pieces. The lens is countersunk far enough for protection against injury from screw 23.

The wedge 16 is provided with extensions 28 and 29 from both ends, preferably being integral extensions. Plates 30 (Figs. 3 and 4) of non-magnetic material are secured by screws to the upper and lower abutting faces of the abutting polar ends to bridge the same and form positioning flanges for protecting shells 31 and 32 which have open ends fitting over the same. The plates 30 have corresponding slots 33 running in a direction transversely of the core, into which angular guide fingers 34 secured to the wedge 16, slide when the wedge is inserted between the poles, and before the shells 31 and 32 are applied. The shells 31 and 32 fit over the wedge 16 and prevent its withdrawal from its channel, but this is not required since other ample securing means is available.

The shell 32 may have at its upper open end a peripheral external flange 35 (Fig. 2) with slots (not shown) therein, and lugs 36 on the under face of the core underlie the flange and hold it against the core. The shell is removed by rotating it until the slots of the flange align with the lugs and then it may be dropped, the lugs passing through the slots. The shell 31 has an external peripheral flange 37 upon its lower open end and lugs 38 (Fig. 2) secured by screws 39 upon the poles overlie the flange and secure it to the core. The apertures 40 in the lugs 38 through which the screws 39 pass are slots enabling a limited sliding of the lugs to engage or release the flange of the shell, movement being prevented when the lugs are clamped by tightening of the screws. Screws 41 may be threaded through the outer ends of the lugs 38 and by pressure upon the pole pieces, rock the lugs to force the flange 37 more firmly against the core.

The lower end 29 of the wedge 16 is extended laterally and slit as at 42, the two arms 43 formed by the slit being clamped toward one another and around a pin 44 by screws 45. The pin 44 can therefore be secured in different vertical positions upon the wedge.

The upper end extension 28 of the wedge 16 is provided in one face with a longitudinally extending slot or channel 46 of V-shape (see Fig. 4), and a triangular element 47 is slidable vertically in said channel. A spring 48 (Figs. 3 and 4) connected between the element 47 and the upper extension 28 of the wedge 16 serves to pull the element 47 upwardly along the channel and also hold it snugly within the channel. A screw 49 is threaded into the upper end of the extension 28 with its head overlying the channel so as to limit the upward movement of element 47 to an extent dependent upon the adjusted position of the screw. The purpose of this adjustment will hereinafter appear.

A pin 50 is secured in any suitable manner so as to depend from the lower end of the triangular element 47 and enters a slit sleeve or connecting element 51 (Fig. 7), the sections of which are brought together about the pin 50 by screws or bolts 52. An insulating bushing 53 surrounds the lower end of the pin 50 and a disc 54 of insulating material is interposed beneath the end of the pin so that the slit sleeve or clamping element 51 will be insulated from the pin 50. A ring 55 is threaded upon the lower end of the clamping element 51 and an anchorage element 56 having a flanged head 57 passes through the ring with the head 57 clamped between the inner face of the ring and the lower end of the clamping element 51. A lock nut 58 may also be threaded upon the lower end of the clamping element 51 for locking the ring 55 in position. Preferably the ring 55 is threaded upon the lower end of the clamping element to such an extent that the anchorage element 56 is given some play for lateral adjustment and is locked in this position by the lock nut 58. A number of screws 59 are threaded through the ring 55 so as to engage laterally against the head 57 of the anchorage element and by relative adjustments of the screws 59 the anchorage element may be shifted laterally within the ring. The lower end of the anchorage element is preferably cylindrical and is provided with a recess 60 eccentrically disposed and a screw 61 is threaded through the thick wall of the cylindrical end and into the recess 60 for clamping therein one end of a string element or member 62. By having the recess 60 eccentrically disposed in the cylindrical end a greater body of metal is available through which the screw 61 may be inserted in order to prevent stripping of the threads. A set screw 63 may be threaded laterally into the cylindrical end of the anchorage element for the attachment of a current conductor 64 leading therefrom and passing through an aperture in the upper extension 28 of the wedge 16 to a binding post 65 provided upon the outer face of the wedge 16. The upper end 28 may be provided with an aperture 66ª through which access may be had to such of the screws 59 as may be disposed adjacent the upper end 28.

Upon the upper end of the pin 44 an anchorage element 66 is adjustably secured in a

ring 67 similar to the ring 55 and the anchorage element 66 is laterally adjustable in the ring by the screws 68 corresponding to the screws 59. The anchorage element 66 is provided in its upper end with a recess into which the lower end of the string or member 62 extends, the string or element being secured in the recess by the set screw 69. The set screw 70 on the anchorage element 66 provides means for attachment of one end of a conductor 71 which passes through an aperture in the lower extension 29 of the wedge 16 to a terminal post 72 provided upon the outer face of the wedge 16. The lower extension 29 may also have an aperture 73 similar to the aperture 66 to provide access to the set screw 68 for adjusting laterally the anchorage element 66 of the lower end of the string member.

A screw 74 is threaded through the cap 75 closing the upper end of the shell 31 and is keyed to a worm wheel 76 which is mounted thereon against the inner face of the cap 75. A spring 77 secured to the cap has a forked end running in an annular groove 78 in a hub of the worm wheel for permitting rotation of the worm wheel and holding it against the inner face of the cap. A screw 79 is rotatably mounted in a sleeve 80 which is pivoted at 81 to the cap so as to carry a worm screw provided upon the inner end of the shaft 79 into and out of meshing engagement with the worm wheel 76. A spring 82 may be connected between the sleeve 80 and a suitable part of the cap for normally and yieldingly urging the sleeve in a direction to carry the worm gear on the shaft 79 into engagement with the worm gear 76. The cap is provided with a slot 83 to permit of the limited oscillation of the sleeve 80. The outer end of the shaft 79 is provided with an operating button 84 by means of which it may be manipulated. By manipulation of this button 84 when the worm screw is meshing with the worm wheel the screw 74 may be given a vertical movement through the cap. The screw at its lower end is provided with the point 85 bearing upon a hardened insert 86 provided in the upper end of the triangular element 47. Thus when the button 84 is manipulated in one direction, the screw 74 will be operated downwardly and will depress the triangular element 47 along the V-shaped guideway 46 and against the action of the spring 48. This downward movement lowers the anchorage element 56 and loosens the string member 62. When the button 84 is operated in the reverse direction it will lift the screw 74 and progressively release the triangular element 47 which then moves upwardly under the action of the spring 48 so as to elevate the anchorage element 56 and tension the string member 62. The screw 49 limits the upward movement of the triangular element 47 beyond the position in which it gives the string 62 a maximum safe tension, even though the button 84 is operated further in the same direction. In case the button 84 is operated to lower the anchorage element of the string so that the parts thereof engage with other parts and obstruct further movement, the spring 82 will yield and allow slippage to occur between the worm wheel 76 and the worm screw upon the shaft 79.

The string member 62 is of electro-conducting material and is preferably a gilded quartz string. When the current is passed through the string, it will be deflected laterally of the flux path to an extent proportional to the strength of the field in which it is placed. The lateral deflection of the string will be indicated by means to be hereinafter explained.

The polar ends 11 of the core 10 are provided with aligned passages or apertures 86′ which run in the direction of the lines of force passing between the polar ends. These passages intersect with the small space between the ends of the poles in which the string 62 is disposed so that lateral movement of the string in a magnetic field may be observed or detected through these aligned passages. Rings 87 are provided upon the core at the outer ends of the passages 86′ and carry a plurality of screws 88 which extend radially of the passages 86′. A bushing 89 is disposed within each passage 86′ and the portion within the passage is of smaller diameter than the passage so as to be capable of lateral adjustment therein. The screws 88 at their inner ends bear upon the periphery of the bushing 89 so that by relative adjustments of the screws 88 the bushing may be adjusted laterally in its passage 86′ to a limited extent. A ring flange 90 may be secured against the ring 87 so as to confine an annular boss upon the bushing 89 against the ring 87 with provision for lateral adjustment of the bushing in the passage 86′. The outer end of the bushing 89 is externally threaded and the sleeve 91 is threaded thereon. The sleeve 91 has an inturned flange 92 through which the optical tube 93 passes, the tube 93 having slidable engagement in the bushing 89. A ring 94 is fixed to the periphery of the optical tube and is disposed between the flange 92 and the outer end of the bushing 89. A helical spring 95 surrounds the optical tube 93 between the ring 94 and an internal annular wall 96 in the inner passage of the bushing 89 so as constantly to urge the ring 94 and the optical tube outwardly through the bushing. A bearing ring 97 is slightly telescopic with the ring 94 and is threaded therein and a suitable anti-friction bearing such as a roller bearing 98 is interposed between the bearing ring 97 and the inner face of the flange 92 so that the sleeve 91 may be freely rotated without undue friction caused by the relatively stronger ring 94. This construction and mounting of the optical tube is provided in

both polar ends of the core and the details of but one end are consequently described. Similar reference numerals, however, designate similar parts in both.

In one of the optical tubes 93 a number of lenses are mounted so as to focus light from a suitable source into and through the passage 86′ and upon the string and suitable magnifying lenses are provided in the other optical tube for projecting an enlarged image of the illuminated part of the string 62 upon a suitable screen or photographic film, as usual in prior types of such instruments. The details of the arrangement of the optical lenses are not per se a part of this invention and consequently are not illustrated or described, in order that the invention will not be confused.

The small space between the tapered ends of the pole pieces through which the string 62 passes should be as small as possible so that the magnetic flux shall be as great as possible and so that there will be little danger of air currents disturbing the deflections of the string. At the same time this space must be large enough so that dust particles which might obtain access to the space will not interfere with the motion of the spring or the uniformity of the magnetic flux between the poles. The guiding fingers 34 which are carried by the wedge 16 are provided with slots 99 extending over the vertical space between the pole pieces so that the string will be unrestricted between its anchorage ends.

In the use of this instrument a number of the wedges 16 may be provided and a separate string 62 mounted in each wedge. These strings may be of different sizes and characteristics so that when one desires to change the string it is merely necessary to remove the wedge 16 which is within the instrument and substitute the wedge with the new string to be utilized. These strings may be mounted in the wedges at the factory and adjusted properly under a microscope in a special instrument of hardened and ground steel so that when mounted in this manner the wedges with mounted string can be inserted into any of the instruments of this type with assurance that the string will be properly positioned in the air gap between the poles. By the provision of the guides 34 there will be practically no danger of one's injuring the string while inserting the wedge into an instrument since it is necessary properly to position the wedge before the fingers 34 will enter the guiding grooves in the plate 30 located upon the upper and lower faces of the abutting pole pieces. Even with this interchangeable feature of the strings, the string and air gap are completely enclosed so as to be substantially air tight and dust proof and yet the strings may be interchanged within a few moments. By manipulating the button 84 the tension of the string may be varied within limits. When the strings are mounted upon the wedge 16 the screw 49 in one end of the wedge is adjusted so that the spring 48 will tension the string only to the safe maximum. Thus with this setting if the screw 74 in the cap 75 is adjusted upwardly too far by an inexperienced person, there will be no danger of breakage of the string.

With the particular method of anchoring the string to the wedge the alignment and lateral adjustment of the string into proper position may be quickly and easily accomplished and the construction involved is exceptionally simple, durable and relatively inexpensive.

When a source of light is placed at one end of the instrument so that the light radiates therefrom, it will enter one of the optical tubes and will be concentrated by the lenses therein upon the string and the shadow of this string will be magnified by the lens system in the other optical tube. This magnification may be observed through the eye piece, or the shadow or image of the illuminated section of the string may be projected upon a suitable film for the purpose of making a record of the variations of the string by variations of the current which may be passing at any time through the string. With the particular mountings described for the optical tubes they may be adjusted laterally to a limited extent so as to be brought into alignment with one another and for proper focussing purposes and by adjustment of the sleeves 91 may be shifted toward and from the string to any desired extent within the limits of the construction.

While the illustrated embodiment of the invention has been described in considerable detail, it will be understood that the details referred to are described merely for the purpose of setting forth the nature of the invention and that various changes may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim:

1. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an electrio-conductive string member, a self-centering detachable carrier unit for said member upon which the latter may be stretched, and means for supporting the carrier unit with said member disposed in the space between the opposed pole pieces.

2. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an electro-conductive string member, and a carrier unit for the string member having thereon spaced means for anchoring the ends of the member, stretching it lengthwise of itself and adjusting it laterally of itself, said carrier unit being separably attachable and self-centering so as to be supported in a manner

to position said member in the space between the pole pieces and transversely of the path of the magnetic flux, whereby when a current is passed through the member it will be deflected laterally.

3. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an electro-conductive string member, a carrier unit for said member having an anchorage at one end for one end of the member, the other end of the carrier unit having a V-shaped channel extending in a direction lengthwise thereof, an anchorage element to which the other end of the string member may be secured, having a V-shaped edge nesting in and slidable along the said channel to tension said member, and a spring element for urging the anchorage element along the channel in a member-tensioning direction, and also holding it within the channel.

4. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an electro-conductive string member, a carrier unit for said member having an anchorage at one end for one end of the member, an anchorage element to which the other end of the string member is secured slidable along the unit in a direction lengthwise thereof, and a spring element connected between the carrier unit and the anchorage element for urging the latter along the unit in a direction to tension the string member.

5. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, an electro-conductive string member, and a carrier unit for said member, upon which it may be mounted and stretched, having a V-shaped portion intermediate of its ends, fitting into the V-shaped space so as to position the string member in the space between the ends of the pole pieces, whereby when a current to be detected is passed through the string member it will be deflected laterally of itself.

6. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, a V-shaped wedge fitting into the V-shaped space, means for confining the wedge within said V-shaped space, and means carried by the confining means and adjustable against the wedge to wedge it tightly into the V-shaped space.

7. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on opposite sides to provide between them V-shaped channels at opposite sides, and a concentrated flux gap between the channels, an electro-conductive string member in the concentrated flux gap between the pole pieces, V-shaped wedges interposed in the channels to form a substantially closed small air space through which the string member passes, and straps of non-magnetic material connecting the pole pieces, confining the wedges therein, one of the wedges having a transverse passage from its apex outwardly, through which the string member may be observed.

8. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, an electro-conductive string member, a carrier unit for said member, upon which it may be mounted and stretched, having a V-shaped portion intermediate of its ends, fitting into the V-shaped space so as to position the string member in the space between the ends of the pole pieces, whereby when a current to be detected is passed through the string member it will be deflected laterally of itself, the electromagnet having a guide groove extending transversely of the length of the V-shaped space, and a finger carried by the carrier unit and sliding in said groove as the unit is inserted into the V-shaped space, to guide the unit into position without danger of injuring the string member carried upon the unit.

9. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an electro-conductive string member, a self-centering carrier unit separably attached to the electromagnet adjacent the space between the pole pieces and detachable therefrom, and means provided upon the ends of the unit for receiving the ends of said string member and stretching it, said means being individually adjustable at each end for adjusting the string member into proper position between the pole pieces.

10. In a galvanometer, a split-sleeve clamp, a support carried by the clamp, an anchorage carried by the support, means for adjusting the anchorage on the support, and an electro-conductive string member disposed in a magnetic field and having one end secured to the anchorage.

11. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, an anchorage member, an element having a channel, an anchorage member slidably mounted in the channel, and an electro-conductive string member carried by the anchorage members so as to be positioned in the space between the opposed pole pieces.

12. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole

pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, an electro-conductive string member, a carrier unit for said member, upon which it may be mounted and stretched, having a V-shaped portion intermediate of its ends fitting into the V-shaped space so as to position the string member in the space between the ends of the pole pieces, whereby when a current to be detected is passed through the string member it will be deflected laterally of itself, the carrier unit having a guide, and means adapted to be engaged by the guide to guide the V-shaped portion of the carrier unit into the V-shaped space.

13. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, a V-shaped wedge fitting into the V-shaped space and having an extension on each side of the space between the pole pieces, a guide carried by each extension, a shell enclosing each extension, means adapted to be engaged by the guides to guide the wedge into position between the pole pieces, means for holding the shells in position about each extension, and an electro-conductive string member in the said space secured to the extensions.

14. In a galvanometer, an electromagnet having approaching opposed slightly spaced pole pieces, the approaching ends of the pole pieces being beveled off on corresponding sides to provide between them a V-shaped space converging toward the slight space between the ends thereof, a V-shaped wedge fitting into the V-shaped space and having an extension on each side of the space between the pole pieces, a shell enclosing each extension, means for holding the shells in position about each extension, and an electro-conductive string member in the said space secured to the extensions.

15. A carrier unit for the electro-conductive string member of a string galvanometer having an intermediate portion and two end portions, the end portions being provided with anchorages for the ends of the string member, and the intermediate portion having means for guiding the carrier unit into position in the galvanometer without danger of injuring the string member carried upon the carrier unit.

16. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, a carrier unit having two anchorage members, an electro-conductive string member the ends of which are carried by the anchorage members, means for guiding the carrier unit into position in the galvanometer so that the string member shall be positioned in the space between the pole pieces and without danger of injuring the string member, and means for detachably supporting the carrier unit with the string member so positioned.

17. In a galvanometer, an electromagnet having opposed slightly spaced pole pieces, a carrier unit having an extension on each side of the space between the pole pieces, a shell enclosing each extension, and an electro-conductive string member in the said space secured to the extensions.

18. In a string galvanometer, an electromagnet having opposed slightly spaced pole pieces, a carrier unit having two anchorage members, a single electro-conductive string member the ends of which are carried by the anchorage members so that the spring member is stretched lengthwise of itself between the anchorage members, means for detachably and interchangeably supporting the carrier unit with the anchorage members respectively above and below the space between the pole pieces and with the string member positioned in the space between the pole pieces transversely to the path of the magnetic flux between the pole pieces, means for producing a beam of light traversing the space between the pole pieces parallel to the said path, and means for receiving the shadow produced by the string member in the beam of light.

In testimony whereof I have hereunto set my hand.

CHARLES F. HINDLE.