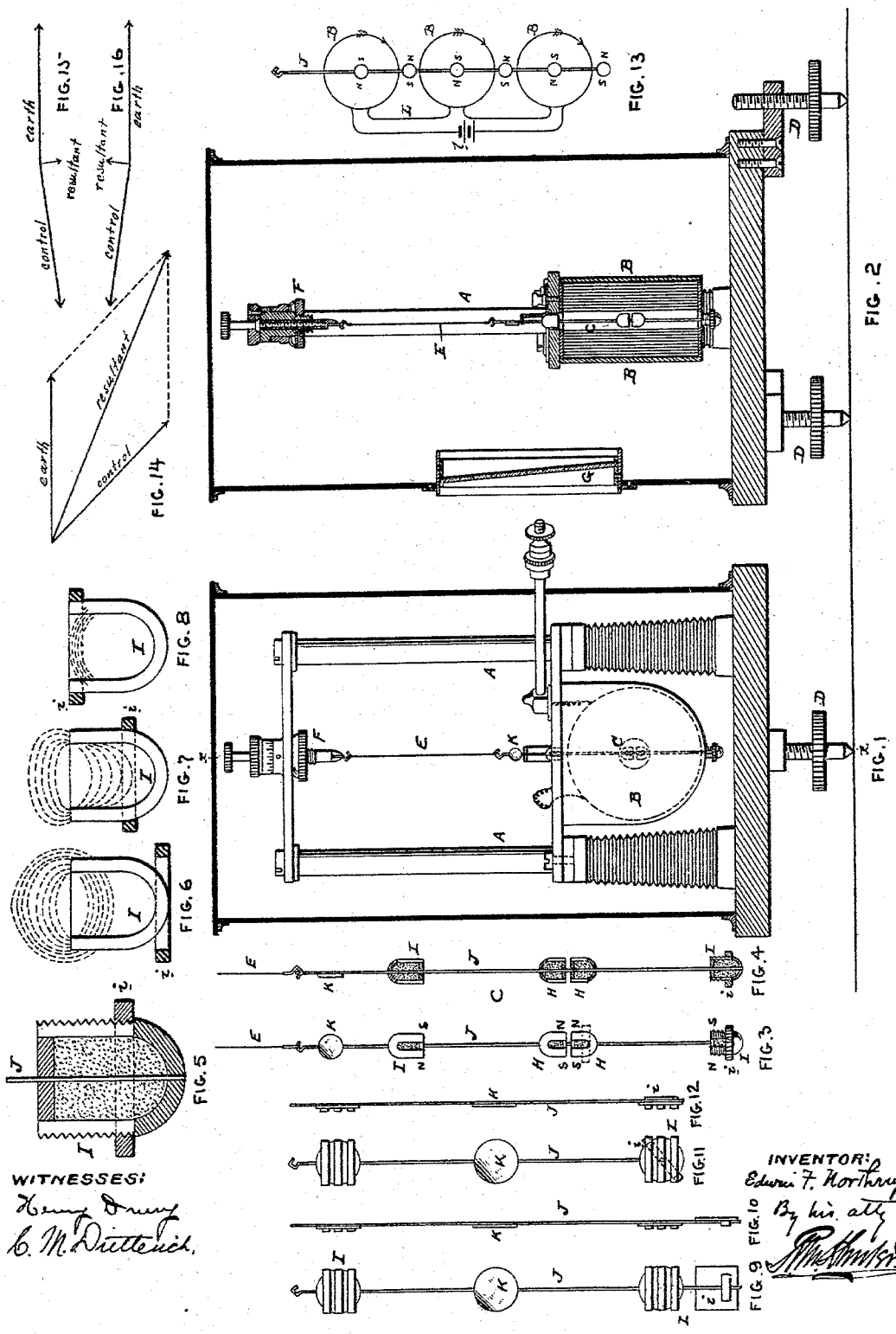
(No Model.)

E. F. NORTHRUP.

GALVANOMETER.

No. 494,964. Patented Apr. 4, 1893.



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UNITED STATES PATENT OFFICE.

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GALVANOMETER.

SPECIFICATION forming part of Letters Patent No. 494,964, dated April 4, 1893.

Application filed November 5, 1892. Serial No. 451,124. (No model.)

To all whom it may concern:

Be it known that I, EDWIN F. NORTHRUP, of Ardmore, county of Montgomery, and State of Pennsylvania, have invented an Improvement in Galvanometers, of which the following is a specification.

My invention has reference to galvanometers, and consists of certain improvements which are fully set forth in the following specification and shown in the accompanying drawings which form a part thereof.

My invention has reference more particularly to the construction of the moving parts or systems of galvanometers, and to the methods employed in regulating their sensibility.

Heretofore the usual method of varying the sensibility of the moving systems in sensitive reflecting galvanometers has been to produce artificially, by means of an adjustable external magnet, a magnetic field so disposed with relation to the earth's field that the resultant would be either strengthened or made less in intensity. This method, however, has great objections which will be more fully pointed out when referring to the accompanying drawings.

My improvement contemplates dispensing with all external adjustable magnets, and in lieu thereof, providing means to adjust the magnetic field of the moving magnet system of the galvanometer. This is accomplished by short circuiting more or less, the magnetic lines of force emanating from the poles of the magnets in the moving system, leaving the system entirely independent of any external field other than that of the earth. By this means the greatest sensibility is produced, and in actual practice I have found that the "drift," so objectionable in former types of galvanometers, is almst entirely eliminated, and my improved system can be made so "astatic" as to require as much as a minute or more for the complete period of vibration, and when the needle or mirror is allowed to come to rest, it returns to the same position or substantially the same position that it had.

My improvement will be better understood by reference to the accompanying drawings, in which:

Figure 1 is an elevation of my improved galvanometer with the inclosing case broken away to show the interior. Fig. 2 is a cross sectional elevation of same on line x—x. Fig. 3 is an elevation of the moving system. Fig. 4 is a sectional elevation of same. Fig. 5 is an enlarged view of one of the magnets shown in Figs. 3 and 4, and is provided with means for varying its magnetic field. Figs. 6, 7 and 8 are diagrammatic views illustrating the change of magnetic field in the magnets of the moving system. Fig. 9 is a front elevation of a modification of the moving system embodying my invention. Fig. 10 is a side elevation of Fig. 9. Fig. 11 is a front elevation of another modification of the moving system embodying my invention. Fig. 12 is a side elevation of same. Fig. 13 is a diagram and elevation illustrating the circuits of a light system embodying my invention; and Figs. 14, 15 and 16 are diagrams illustrating the magnetic forces which come into play on adjusting the former types of galvanometers.

Before proceeding with the description of my invention, I will briefly refer to the difficulties which arise with the galvanometer using external movable magnets for adjustment.

As already stated, the method of varying the sensibility of such galvonometers has been by producing artificially a magnetic field which assists or opposes the action of the earth's field upon the system. Diagrammatic Figs. 14, 15 and 16 will make this clear.

In Fig. 14 the earth's field is assisted by the field of the external movable or "control" magnet, and the direction and length of the lines indicate the intensity and direction of the respective magnetisms. As these lines both point in the same general direction, it is clear that the resultant field operating upon the system will be greater than either one and will intersect the angle of them. If the two lines are of equal length, then the resultant will bisect the angle made by them. If the controlling field is in the same direction as the earth field, the resulting field will obviously be their sum, and, likewise, if these two fields are directly opposed to each other, the resulting field will be their difference.

The resultant when the fields are not parallel, may be readily found by the use of the parallelogram of forces.

In Fig. 15 we have the earth's magnetism and the magnetism of the control magnet almost opposed to each other in such a manner as to produce but a small resultant nearly at right angles to their directions. If now the direction of one of these fields slightly changes its position so that the angle increases from slightly less than one hundred and eighty degrees to slightly greater than one hundred and eighty degrees, it is evident that the resultant will immediately shift through an angle nearly equal to one hundred and eighty degrees. This shifted position is indicated in Fig. 16. Thus it is seen that the resultant field shifts through a much greater angle than the changing field has shifted through.

It is well known that the earth's field undergoes certain periodical changes in direction, and these include a regular daily change by which at a certain time of day the magnetic meridian begins to move in a certain direction, either east or west; and after a certain time this difference from its original position reaches a maximum and the meridian then begins to recede toward, and finally passes through its original position until it reaches a maximum on the other side; it will then come slowly back to its original position and remain practically thus for a greater or less time, until the same cycle is again gone through on the following day. Superposed upon this is a periodical yearly change, and again superposed upon this latter change is another of still longer duration. It is only however the daily changes of the magnetic meridian which we need consider in the use of sensitive reflecting galvanometers. This daily change is different in amount in different localities, and in some places has been known to be as great as six to seven degrees, though as a rule it is much less approximating more nearly a degree or less. For this reason it has heretofore been impossible to carry on exceedingly accurate work involving galvanometers of the sensitive type having moving magnetic systems except at certain periods in the day. This necessity is obviously very inconvenient, especially as these galvanometers are the most desirable on account of their being the most sensitive and accurate now known. In consequence of this daily change of the magnetic meridian, it is found in practice, that the moving system of the galvanometer (the magnets and pointer or reflector) is not at rest, but is continually moving slowly from one side to the other with the periodic shifting of the magnetic meridian. This phenomenon which is so troublesome is known as the "drift" of the galvanometer needle. This drift is found in all galvanometers of the moving magnet type heretofore constructed, but is practically eliminated by my improved construction, thereby permitting the most delicate observations to be made at all times without reference to these changes of the earth's field to which I have above referred.

I will now proceed to describe my improved galvanometer, and then point out the method of its work.

A is a frame of any suitable construction and supports the moving system and coils of wire. The frame A is supported upon a base provided with adjusting screws D, by which it may be leveled.

B, B are the two coils, and in practice are made separable to expose the moving system C when desired. The moving system is very clearly illustrated in Figs. 3 to 5. By examining these figures it will be seen that a wire or support J of any diamagnetic material has threaded upon it four small bell-shaped magnets I, H. The two central magnets H, H are turned toward each other and have their south poles in the same direction. The two outer magnets I, I have their poles turned toward the central magnets but have their south poles oppositely disposed with reference to the south poles of the central magnets. Preferably these outer magnets are somewhat longer than the central magnets so that when all the magnets are uniformly magnetized, the central ones will be of less strength than the outside ones as is well known by those familiar with the art. The result is that the two outside magnets will "control" the system, and the north poles of the two outside magnets will overbalance the action of the south poles inside, thus causing the former to point to the north. It is evident that if one of the outside magnets, or both of them if desired, be gradually weakened, the central magnets will become relatively stronger, and if this adjustment is carried on to a further degree, the central magnets may acquire a predominating influence, and become stronger than the outside magnets so as thus to turn the system entirely around. It will thus be seen that the magnetic fields of the inner and outer magnets of the moving system may be relatively adjusted so as to require as small an amount of force to turn this system upon its axis as is desired. The couple of the coils B acting upon the magnetic system will not be sensibly reduced, since the coils act particularly upon the interior magnets H, and do not at best have very much effect upon the exterior magnets.

To vary the magnetic field of the outside magnets, I construct one or both of them as indicated in Fig. 5. The outer surface of the magnet is screw threaded and a soft iron ring *i* is secured upon the magnet so that it may be adjusted farther from or nearer toward the poles. In place of making the ring *i* adjustable by means of screw threads, it may be adjusted by friction as indicated in Figs. 7 and 8.

In Fig. 3 the adjustable ring *i* is shown in solid lines as placed about the bottom magnet only. Such a ring *i* is indicated in dotted

lines on the lowermost central magnet H, as it may be used upon these magnets also if desired. It is evident that this adjustable feature may be placed upon any or all of the several magnets, as the principle of the invention comprehends broadly the adjustment of the magnetic field of the moving system by means attached to the system itself without the necessity of the use of any external magnets as in the old method. The adjusting feature will be clearly understood by examining Figs. 6, 7 and 8.

In Fig. 6 the ring *i* is shown close to the neutral part or yoke of the magnet I and does not affect the magnetic lines of force. As this ring is moved upward (see Fig. 7) the magnetic field is reduced, since part of the lines of force are drawn down by the short circuiting of the ring. As the ring *i* is moved close to the poles as shown in Fig. 8, all of the lines of force are practically short circuited, and the power of the magnet I has been reduced to a minimum and becomes as a lump of steel or iron having no magnetic poles.

It is evident that instead of the rings *i* being adjusted with respect to the poles of the magnets, these rings *i* may be set upon the poles to weaken the field and will be held there by the magnetism. One or more of such rings or disks may be used.

In place of using the bell shaped magnets above described, I may use the construction illustrated in Figs. 9 to 12. In these figures no central magnets are shown, though they may be employed if desired. The magnets are formed of thin flat wires or bars I, I, cemented upon a suitable support carried by the rod J.

In the case of Figs. 9 and 10 a screen or movable part *i* of magnetic material, such as soft iron, is moved upon the rod J so as to short circuit more or less of the magnetic lines of the small magnets I, three of which are shown at each end of the moving system.

In the construction shown in Figs. 11 and 12 the short-magnetic bar *i* is shown as pivoted. When it is turned vertically it has no effect on the small magnets I, but when turned to an inclined position as indicated in dotted lines or parallel to the small magnets, it modifies to a more or less extent the magnetic lines of force and produces the desired adjustment. The movable magnetic piece might be a small magnet if so desired in place of soft iron.

It is immaterial to my invention what the particular details of construction of the moving system may be so long as the magnetic lines of forces of the magnets of the moving system shall be regulated by means of a part carried by and forming a portion of the moving system.

In some styles of galvanometers the reflecting mirrors K are arranged outside of the coils B, B, as indicated in Figs. 1 and 2, but again in other cases the mirrors K are placed so as to come in the center of the coils, and in that case they could be in the position indicated in Figs. 9 to 12. The moving system C is supported by a thread E of the very lightest fiber or preferably of some nonfibrous material such as quartz so that there is no normal torsional effect upon the suspended magnets.

F is a suitable adjusting device for adjusting the moving system and may be of any suitable construction.

The galvanometer proper is preferably inclosed in a suitable case, and the mirror may be seen through a window G in the side of the case. The ray of light may be projected upon the mirror through this window and the reflected ray caused to also pass through the window upon the scale. By this means a telescope may be employed to read the angles through which the mirror is turned.

In Fig. 13 is shown a diagram in which there are three coils of wire B connected with the one source of energy *l* by a common circuit L. The rod J is provided with a series of magnets or sets of magnets indicated by the letters N and S and having their poles arranged alternately in opposite direction. This is for exceedingly delicate work. The method of adjustment and general construction may be that above described with reference to the other figures.

What I claim as new, and desire to secure by Letters Patent, is—

1. In a galvanometer, the combination of the energizing coils with a moving system having two or more magnets suspended upon a shaft having freedom of movement and provided with one or more movable or adjustable parts adapted to modify the magnetic lines of force of any or all of the magnets.

2. In a galvanometer, the combination of the energizing coils, with a moving system having two or more magnets suspended with freedom of movement and provided with one or more movable or adjustable parts adapted to modify the magnetic lines of force of any or all of the magnets, and a reflecting mirror or indicator carried by the moving system and movable with it.

3. In a galvanometer, the combination of the energizing coils, with a moving system consisting of two or more bell shaped magnets carried upon a common support having freedom of oscillation, and one or more movable pieces of magnetic material respectively carried upon or adjacent to one or more of the bell shaped magnets to modify or change its magnetic field.

4. In a galvanometer, the combination of the energizing coils, with a moving system consisting of two or more bell shaped magnets carried upon a common support having freedom of oscillation, one or more movable pieces of magnetic material respectively carried upon or adjacent to one or more of the bell shaped magnets to modify or change its magnetic field, a suspension thread adapted to sustain the support and its magnets, and

an indicator or mirror carried by and moving with the magnet supports.

5. In a galvanometer, the combination of the energizing coils with a moving system consisting of a vertical rod or support suspended with freedom of movement, two magnets arranged in the center of the coils upon said support and having their similar poles in the same direction, and two additional magnets arranged upon the support at the outside of the coil at top and bottom and having their poles reversed with respect to the poles of the central magnets, and means substantially as set out for modifying or adjusting the magnetic field of one or more of said magnets.

6. In a galvanometer, the combination of the energizing coils, with a moving system consisting of a vertical rod or support suspended with freedom of movement, two magnets arranged in the center of the coils upon said support and having their similar poles in the same direction, and two additional magnets of greater strength than the central magnets arranged upon the support at the outside of the coils at top and bottom and having their poles reversed with respect to the poles of the central magnets, and means substantially as set out for modifying or adjusting the magnetic field of one or more of said magnets.

7. In a galvanometer, the combination of the energizing coils with a moving system consisting of a vertical rod or support suspended with freedom of movement, two magnets arranged in the center of the coils upon said support and having their similar poles in the same direction, two additional magnets arranged upon the support at the outside of the coils at top and bottom and having their poles reversed with respect to the poles of the central magnets, means substantially as set out for modifying or adjusting the magnetic field of one or more of said magnets, a mirror or indicator to indicate the movement of the moving system, and means to simultaneously adjust the magnets of the moving system vertically.

8. In a galvanometer, the combination of the energizing coils with a moving system having two or more magnets suspended with freedom of movement and provided with one or more movable or adjustable parts adapted to modify the magnetic lines of force of any or all of the magnets, a mirror or indicator to indicate the movement of the moving system, and means to simultaneously adjust the magnets of the moving system vertically.

9. A moving system for galvanometers consisting of a support of diamagnetic material provided with two or more magnets secured and carried thereon, and means also carried with and suspended by the support to adjust the magnetic field of one or more of the magnets.

10. In a galvanometer, the combination of the energizing coils, with a moving system consisting of a suspended support of diamagnetic material provided with two or more magnets adapted to be affected by the field produced by the coil, and suitable means for modifying the magnetic field of one or more of the said magnets.

11. In a galvanometer, the combination of the energizing coils, with a moving system consisting of a suspended support of diamagnetic material provided with two or more magnets adapted to be affected by the field produced by the coil, and suitable means vertically movable relatively to the magnets for short circuiting more or less of the magnetic field of one or more of the said magnets.

12. In a galvanometer, the combination of the energizing coils, with a moving system suspended with freedom of movement and consisting of a support of diamagnetic material having two or more magnets arranged substantially as set out, one or more of said magnets being provided with a piece of magnetic material adapted to be adjusted to or from its poles by means of screw threads.

13. The herein described method of adjusting sensitive galvanometers to eliminate the "drift" produced under the action of the change of magnetic meridian, which consists in short circuiting more or less of the magnetic lines of force of one or more of the magnets of the moving system.

14. The herein described method of adjusting a sensitive galvanometer to eliminate the "drift" produced under the action of the change of magnetic meridian, which consists in varying the relative field strength of two or more magnets of the moving system.

In testimony of which invention I have hereunto set my hand.

EDWIN F. NORTHRUP.

Witnesses:
A. L. MILLER,
E. W. MILLER.