

Feb. 19, 1929.

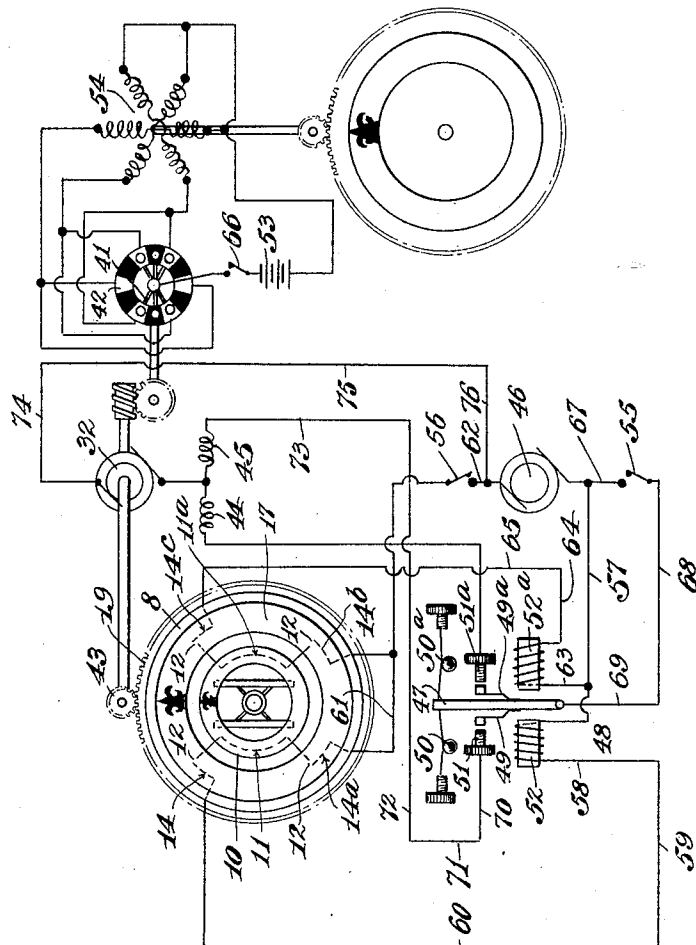
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E. L. HOLMES

MASTER COMPASS

Original Filed Jan. 23, 1925 3 Sheets-Sheet 1

Fig. 1.



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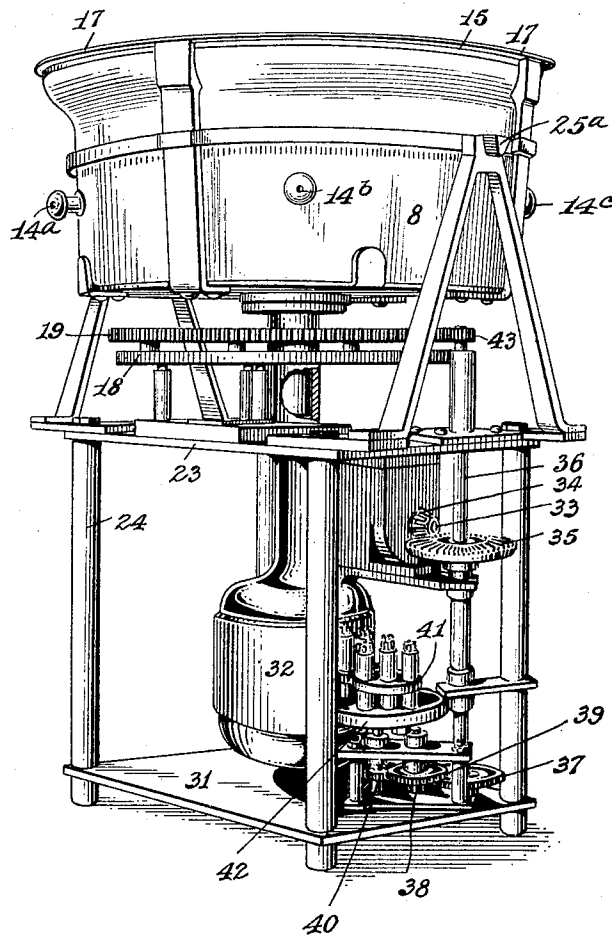
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Fig. 2



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Fig. 3.

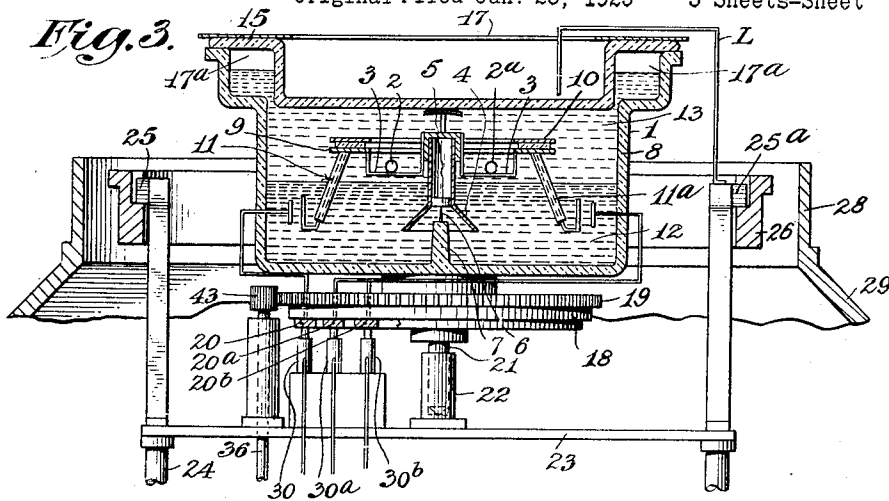
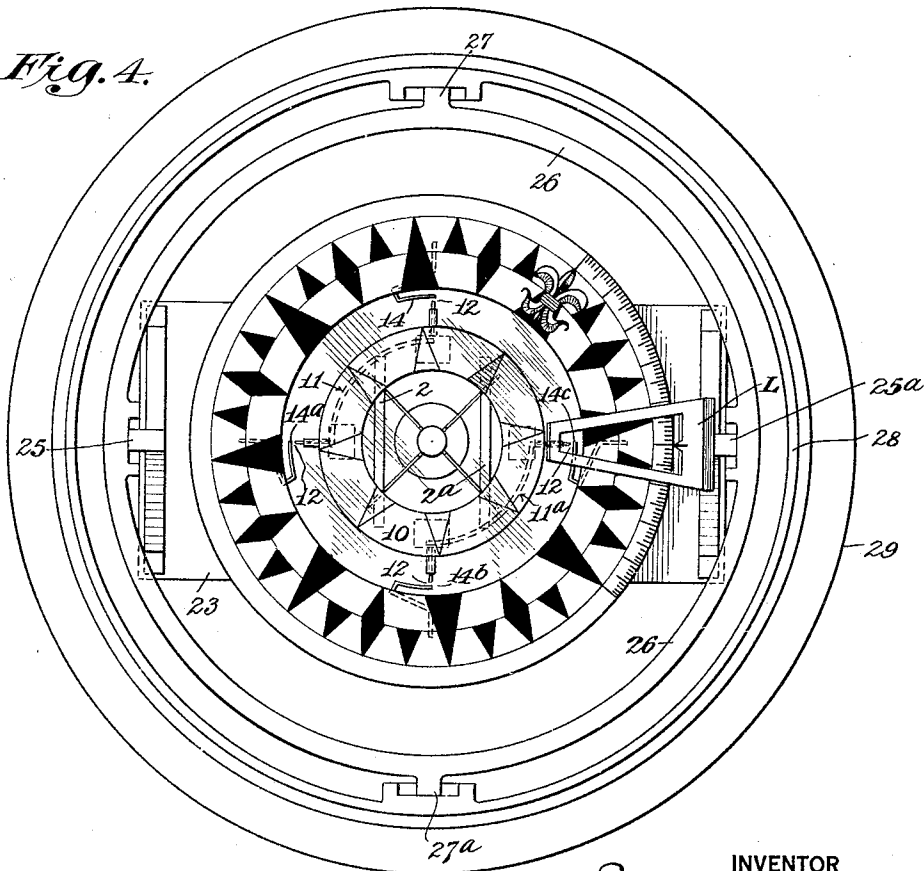


Fig. 4.



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MASTER COMPASS.

Original application filed January 23, 1925, Serial No. 4,151. Divided and this application filed June 22, 1926. Serial No. 117,687.

My present application is a division of my application Serial No. 4,151, filed in the United States Patent Office on January 23, 1925.

5 The following is a description of a master-compass embodying my invention in the form at present preferred by me; but it will be understood that various modifications and changes may be made without departing from the spirit of my invention and without exceeding the scope of my claims.

10 My invention will best be understood by reference to the accompanying drawings, in which I have illustrated the preferred form of devices for carrying out my invention, and in which Fig. 1 shows schematically the several units comprising the master-compass and a repeater-compass illustrative of mechanisms which may be actuated and controlled by the said master-compass—together with a wiring diagram of an electrical system which may be employed in connection therewith; Fig. 2 is a perspective view showing the master-compass and associated mechanical and electrical devices; Fig. 3 shows in vertical section the various elements of the magnetic-compass and some of the elements of the master-compass and supporting means for said compasses; and Fig. 4 is a top plan view of the magnetic-compass and some of the master-compass elements and the supporting means. Like reference characters indicate like parts throughout the drawings.

15 Referring to the drawings (Fig. 3), 1 indicates a liquid type magnetic-compass comprising magnetic needles 2 and 2^a, mounted upon arms 3, carried by conical hub 4 (preferably of glass), containing jewel 5, forming a bearing for pivot 6, supported on post 7 integral with follow-up compass bowl 8, formed of insulating material, such as glass. Arms 3 also carry annulus 9, preferably of mica, upon which are supported magnetic-compass card 10 (of material such as etched or engraved brass which is insoluble in oil), and compass card conductors 11 and 11^a, both ends of which conductors project downwardly into electrolyte 12 contained in the lower portion of follow-up bowl 8. Floating upon this electrolyte is a body of liquid 13, which serves to insulate and protect the metallic compass structure, in a manner to be hereinafter described. Integrally mounted in the periphery of follow-up bowl 8 and project-

ing into said bowl are bowl conductors 14, 14^a, 14^b and 14^c. Follow-up bowl 8 carries cover 15, preferably of glass, between which and said bowl is expansion chamber 17^a. Follow-up bowl 8 is supported on base 18 (Fig. 3), carrying follow-up bowl gear 19 and distributor rings 20, 20^a and 20^b, electrically insulated from said base and electrically connected to follow-up bowl conductors 14, 14^a, 14^b and 14^c. Attached to base 18 is shaft 21, operatively rotating in socket 22 on upper platform 23 of frame 24, suspended by gimbals 25 and 25^a to gimbal-ring 26, supported by gimbals 27 and 27^a on binnacle-ring 28, mounted on binnacle-stand 29. Also mounted on frame 24 is lubber's line bracket L, which has a lubber's line for the magnetic-compass card and also a lubber's line for the master-compass card. Mounted on upper platform 23 and electrically insulated therefrom are three brushes 30, 30^a and 30^b, which operatively contact electrically with distributor rings 20, 20^a and 20^b, respectively. Attached to the under side of upper platform 23 is follow-up motor 32, the armature shaft of which carries a worm (not shown) which drives a worm gear (not shown), mounted on shaft 33, which latter shaft also carries bevel pinion 34, meshing with and driving bevel gear 35, mounted on vertical shaft 36. Vertical shaft 36 carries at its upper end pinion 43, meshing with and driving follow-up bowl gear 19—whereby follow-up motor 32 rotates said follow-up bowl. Follow-up motor 32 has differential field windings 44 and 45 (Fig. 1), and receives current from generator 46 or other suitable source of electrical energy. The lower end of shaft 36 carries spur gear 37, meshing with and driving intermediate gear 38, integral with gear 39, mounted on a shaft having its bearing in lower platform 31 of frame 24, which gear 39 in turn meshes with and drives transmitter shaft gear 40—whereby follow-up motor 32 also rotates transmitter multiple brush 41, in electrical contact with transmitter distributor block 42.

The supply of current from source 46 to follow-up motor 32 is controlled by the movements of armature 47 of relay 48, which armature carries springs 49 and 49^a. Attached to said armature are adjustable suspended control weights 50 and 50^a, the purpose of which will be hereinafter explained. The

relay has adjustable contact members 51 and 51^a, coacting with contact members on the relay armature. The opposing adjustable electromagnet coils 52 and 52^a of said relay are continually energized by alternating current flowing through the two circuits associated with the follow-up bowl, included in which circuits is electrolyte 12. Relay armature 47 responds to a differential between the resistances of the two follow-up bowl circuits, in a manner to be hereinafter described. Current from the source 53 is conveyed through rotary transmitter 41—42 to the field coils of reversible step-by-step motor 54, causing said motor to rotate intermittently in either direction, in a well-known manner.

While the apparatus will be described as operating one repeater-compass only, it will be understood by those skilled in the art that it may be employed to control any number of such repeater-compasses, as well as other devices such as automatic steering mechanism, course-recorders and path-and-distance indicators.

The mode of operation of the apparatus is as follows: Binnacle-stand 29 is attached in the usual manner to a mobile object, such as a ship. Initially, follow-up bowl 8 and magnetic needles 2 and 2^a may not be in proper operative relationship; and in order to bring these elements into such relationship, switch 55 is manually closed and relay armature 47 is manipulated to close one or other of the circuits which include follow-up motor 32. The rotation of said follow-up motor in the proper direction turns follow-up bowl 8, and thus brings bowl conductors 14 and 14^a approximately opposite the downwardly-projecting portions of compass card conductor 11; and bowl conductors 14^b and 14^c approximately opposite the downwardly-projecting portions of compass card conductor 11^a. This operation also brings master-compass card 17 into approximate alignment with magnetic-compass card 10. Switch 56 is then manually closed, and the master-compass will thereafter automatically control the devices which may be electrically connected to it. With bowl conductors and compass card conductors in alignment, substantially the same amount of current flows through the circuit which includes lines 57, coil 52, line 58, lines 59 and 60, compass bowl conductor 14, electrolyte 12, compass card conductor 11, electrolyte 12, bowl conductor 14^a, line 61, switch 56 and line 62 as flows through the circuit which includes lines 57 and 63, coil 52^a, lines 64 and 65, bowl conductor 14^c, electrolyte 12, compass card conductor 11^a, electrolyte 12, bowl conductor 14^b, line 61, switch 56 and line 62. The energization of relay coils 52 and 52^a is therefore practically equal, and relay armature 47 remains in a neutral position in which it closes no secondary circuit. After follow-up bowl 8 has been brought into prop-

er operative relationship with compass needles 2 and 2^a, and before transmitter switch 66 is closed, the ship is brought to its set path, which is indicated both by magnetic-compass card 10 and by master-compass card 17—the displacement between magnetic-compass card and master-compass card resulting from turning the ship to its set path being corrected by the action of follow-up motor 32, which operates to restore the synchronism of the two compass cards whenever there is a disturbance thereof.

With the ship on its set path (which, for purpose of illustration, will be assumed to be 50° east of north), the repeater-compass shown in Fig. 1 is brought into synchronism with the master-compass in the following manner: With transmitter switch 66 open, no current flows through step-by-step motor 54; and the repeater-compass shaft, together with its attached compass card, is freely rotatable. The repeater-compass shaft is now manually rotated until point 50 on the repeater-compass card registers with the repeater-compass lubber's line. When the ship is exactly on its course, as indicated by the fact that figure 50 on master-compass card registers with master-compass lubber's line, transmitter switch 66 is closed. This results in the energization of some of the field magnets of step-by-step motor 54, whereby the repeater-compass becomes electromagnetically locked to the master-compass, and hence will subsequently follow all variations of the magnetic-compass, because the magnetic-compass controls the master-compass, which operates relay 48, the relay controls follow-up motor 32 driving transmitter 41—42, which in turn controls the direction and extent of rotation of step-by-step motor 54, driving the repeater-compass shaft. It will be apparent that the apparatus is universally adjustable to operate with reference to any desired path to which the repeater-compass shaft may be initially set.

Assuming now that the ship veers 1° to the right: Compass needles 2 and 2^a together with magnetic-compass card 10, will remain stationary in space, while the remainder of the compass structure, including follow-up bowl 8, will be displaced with reference to said compass needles, the movement of the bowl being in a clockwise direction. As soon as this displacement reaches one-sixth of one degree, the device operates for the reasons and in the manner following: Because of the form of bowl conductors 14, 14^a, 14^b and 14^c, and of the compass card conductors 11 and 11^a, respectively, and because of their relative positions, this displacement by one-sixth of one degree of follow-up bowl 8 does not materially change the length of the electrolytic paths between bowl conductors 14 and 14^a and the coacting downwardly-projecting ends of compass card conductor 11. There-

fore the resistance of the circuit which includes relay coil 52 remains substantially unchanged. However, this clockwise movement of follow-up bowl 8 does increase the length of the electrolytic paths between bowl conductors 14^b and 14^c and the coacting downwardly-projecting ends of compass card conductor 11^a, resulting in an increase in the resistance of the circuit which includes relay coil 52^a; and this increase in resistance reduces the energization of relay coil 52^a, permitting relay coil 52 to attract relay armature 47 and bring the same into contact with contact member 51. This closes the following circuit: From one terminal of source 46, line 67, switch 55, lines 68 and 69, relay armature 47, relay contact member 51, lines 70, 71, 72 and 73, motor field winding 45, armature of motor 32, lines 74, 75 and 76, to opposite terminal of source 46. Thereupon, follow-up motor 32 rotates in a direction to return follow-up bowl 8 to a position wherein the resistances of the two electrolytic circuits which include relay coils 52 and 52^a reach such values as to substantially equalize the energization of such coils and thus bring relay armature 47 to its neutral position—thereby opening the circuit which includes the follow-up motor and stopping said motor. While follow-up motor 32 was rotating follow-up bowl 8 in a counter-clockwise direction to re-establish the initial relationship between compass needles 2 and 2^a, and the follow-up bowl and its elements, said motor was also rotating transmitter 41—42, actuating the step-by-step motor 54, turning the repeater-compass shaft and thereby rotating the repeater-compass in a counter-clockwise direction one-sixth of one degree with reference to its lubber's line. With each successive deviation of the ship by one-sixth of one degree, there is a recurrence of this cycle of operation, until the total deviation of the assumed 1° has occurred.

I am aware that it has heretofore been proposed to utilize movements relative to the needle of a magnetic compass to actuate various external devices. For example, many attempts have been made to cause such movements to close metallic contacts in electric circuits. However, the force exerted by the earth's magnetic field upon a compass needle is inadequate to afford sufficient pressure to close such contacts without seriously interfering with the action of the needle.

It has also been attempted to utilize as a portion of electric circuits controlled by movements relative to the needle of the magnetic compass, an electrolyte in which the magnetic needle is immersed—direct current being conveyed through two circuits which include the electrolyte. I have found that such an arrangement is inoperative, for the reason that any compass change unbalances the resistances of the electrolytic portions of

the circuits, greatly disturbing the constant-polarity magnetic field which is associated with every circuit carrying direct current, and thereby producing a deflection of the compass needle. Moreover, if indestructible conductors, such as carbon, be employed in an electrolyte, direct current decomposes the electrolyte, resulting in the evolution of gases, which, in the form of bubbles, adhere to the conductors, the compass bowl, and the compass card. These bubbles produce changes in resistance in the electrolytic circuits, and also result in friction and capillary attraction between the moving parts. If direct current be employed, this evolution and deposition of gases occurs with all combinations of electrolytes and conductors except where pure metallic conductors are used in combination with an electrolyte containing a salt of the metal comprising one of the conductors. Under these conditions, gas bubbles do not collect, but a plating action occurs which results in the disintegration of the conductors which constitute the anodes, and in the building up of the conductors which constitute the cathodes.

It has also been attempted to cause a master-compass to follow a magnetic-compass by utilizing the differential in resistances between two electrolytic circuits carrying direct current to act upon magnetic brakes. Such systems are predicated upon the fallacious assumption that the resistance of an electrolytic circuit, like that of a metallic circuit, is directly proportional to the length of the path. This is not the fact, and such a master-compass cannot faithfully reproduce movements relative to the compass needle.

In attempts to utilize movements relative to the magnetic-compass needle, it has been proposed to convey electric current to the conductors through the pivotal bearing of the compass card. Such devices are impracticable for the reason that the compass card bearing must, under this condition, necessarily be metallic and of very minute area; and therefore any slight jarring which tends to separate the bearing elements causes arcing, with consequent fusion—thus quickly destroying the bearing. In my apparatus, the current is conducted directly through the electrolyte and conductors which are separate from the compass pivot, thereby obviating the defects above referred to.

I overcome the objections inherent in systems wherein the compass needle or compass card is caused to close metallic contacts in electric circuits by allowing my compass card to move freely in a liquid and without other physical external contact than the necessary pivotal bearing contact. The responsiveness of the directional element of my compass to the earth's magnetic field is therefore not interfered with.

Instead of employing direct current, with

its constant-polarity field, a variation in the strength of which causes a deflection of the compass needle, I utilize alternating current, the field of which is, of course, of alternating polarity. The inertia of my compass card is such that, with alternating current of say 60 cycles per second, and with proper current value, changes in the resistances of the two electrolytic circuits do not cause a deflection of the card. Other advantages of employing alternating current lie in the fact that it produces no plating action, and that its decomposing effect upon an electrolyte is much less than that of direct current. In fact, I have found that by employing an electrolyte composed of equal parts of distilled water and chemically-pure methyl alcohol, acidulated with chemically-pure hydrochloric acid to a point where the minimum resistance of the electrolytic circuit is from 1,000 to 2,000 ohms, in combination with alternating current of a frequency of 60 cycles per second, and with a current density in platinum conductors of about .75 of an ampere per square inch, there occurs no release of gases as a result of decomposition of the electrolyte. Such an electrolyte does not freeze at ordinary temperatures, which is an important practical consideration. Further, under these conditions, a very small movement relative to the magnetic-compass needles produces a marked differential between the resistances of the two electrolytic circuits.

Referring to Fig. 3: In order to protect the metallic portions of the compass card (which portions ordinarily consists of iron, copper and brass) from electrolysis, I so mount the compass card as to bring it above the level of the electrolyte, and immerse it in a body of liquid of high dielectric strength, such as mineral oil, floating upon said electrolyte and not miscible therewith—thus effectually insulating such metallic portions from current flowing through the electrolyte. By so mounting the compass card, the only metallic portions associated therewith which are in contact with the electrolyte are the platinum-iridium pivot upon which the card is supported, and the downwardly-projecting ends of the two platinum conductors 11 and 11^a. Under the conditions I have above described, neither platinum-iridium nor platinum is subject to electrolysis, when entirely immersed in the electrolyte. I have found, however, that at the juncture of the electrolyte and the insulating liquid, gas bubbles form upon the platinum conductors, which evidences decomposition at this point of either the electrolyte or the insulating liquid, or perhaps of both. In order to prevent this action, I preferably insulate the platinum conductors by fusing vitreous material thereon for some distance above and below the point where they are to contact with the juncture of the electrolyte and the insulating liquid.

I utilize the differential between resistances of the two electrolytic circuits to actuate a sensitive relay which, in turn, controls a follow-up motor driving both the follow-up bowl and a transmitter which governs the repeater-compass. I am thus enabled to operate my apparatus with a current as low as 35 milliamperes flowing through each of the electrolytic circuits—the relay responding to a differential as small as 3 milliamperes. With a movement of the ship, and, therefore, of the compass bowl, as slight as one-sixth of one degree, this relay closes the circuit which includes the follow-up motor; and the motor thereupon turns the follow-up bowl and the repeater-compass shaft one-sixth of one degree in the opposite direction—the rate of this movement being greatly in excess of the rate of movement of the ship. When the follow-up bowl has been returned to its original position, the follow-up motor stops—the equilibrium of the electrolytic circuits having been restored. As the ship continues to deviate from its set path, this step-by-step counter-rotation of the follow-up bowl and of the repeater-compass shaft recurs at each one-sixth of one degree—the relay each time opening the follow-up motor circuit upon a restoration of the equilibrium in the electrolytic circuits. Therefore, in my system, instead of attempting to utilize a progressively-increasing electrolytic resistance caused by a continuing deviation of the ship (which resistance, as I have explained, is not directly proportional to the changes in the length of the electrolytic path), I repeatedly utilize small, definite and uniform resistance changes to produce step-by-step movements throughout the time in which the deviation occurs. Thus, the fact that the electrolytic resistance is not directly proportional to the changes in the length of the electrolytic path becomes of no consequence in the operation of my apparatus, because such operation is by current increments and decrements which are always correlated to the same differential in resistances.

In order to insure that the operative differential will effect a continuous contact between the relay armature contact members and their coacting contact members, I overcome the vibratory effect upon such contact of the alternating current passing through the relay coils by opposing gravitational force to the force of magnetic attraction of the armature. I accomplish this result by suspending weights attached to threads supported between both sides of the upper end of the armature and stationary points. I have found that by this means, and by carrying the armature contact members on springs of suitable tension, a differential of 3 milliamperes will produce a continuous contact—all vibration between the armature contact members and their coacting contact members being elimi-

nated. Under these conditions, the vibration due to the alternating current is restricted to the armature itself, and does not affect the continuity of contact.

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

10 1. In combination, a directional element, a container for said element, an electrolyte in said container, conducting means carried by said directional element and in contact with the electrolyte, a source of alternating current, conducting means carried by the container and in contact with the electrolyte, an electric circuit including said electrolyte, conducting means and source, and electro-responsive means operative on variation in the electrolytic resistance of said circuit produced by relative movement between the conducting means.

20 2. In combination, a magnetic compass rose, a container for said rose, an electrolyte in said container, partially-insulated conducting means carried by said rose and in contact with the electrolyte, conducting means carried by the container and in contact with the electrolyte, a source of alternating current, conducting means carried by the container and in contact with the electrolyte, an electric circuit including said electrolyte, conducting means and source, and electro-responsive means operative on variation in the electrolytic resistance of said circuit produced by relative movement between the conducting means.

35 3. In combination, a directional element, a container for said element, an electrolyte in said container from which said directional element is electrically insulated, a support for said directional element, conducting means carried by said support and in contact with the electrolyte, a source of alternating current, conducting means carried by the container and in contact with the electrolyte,

an electric circuit including said electrolyte, conducting means and source, and electro-responsive means operative on variation in the electrolytic resistance of said circuit produced by relative movement between the conducting means. 45

4. Means for initiating the reproduction in repeating apparatus of displacement movements between a directional element and a mobile object carrying the same, said means including a container for the directional element, an electrolyte in said container, conducting means carried by said directional element and in contact with the electrolyte, a source of alternating current, conducting means carried by the container and in contact with the electrolyte, an electric circuit including said electrolyte, conducting means and source, and electro-responsive means operative on variation in the electrolytic resistance of said circuit produced by movement of the mobile object relative to the directional element. 50 55 60 65

5. Means for initiating the reproduction in repeating apparatus of displacement movements between a directional element and a mobile object carrying the same, said means including a container for the directional element, an electrolyte in the container from which the directional element is electrically insulated, a support for the directional element, conducting means carried by the support and in contact with the electrolyte, a source of alternating current, conducting means carried by the container and in contact with the electrolyte, electric circuits including the electrolyte, the conducting means and the source, and also including the windings of a differential relay operative on variation in the electrolytic resistance of the circuit produced by movement of the mobile object relative to the directional element. 70 75 80

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