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J. F. STEVENS.

ELECTRIC GROUND DETECTOR FOR CONSTANT CURRENT ARC LIGHT CIRCUITS.

(Application filed Sept. 25, 1899.)

(No Model.)

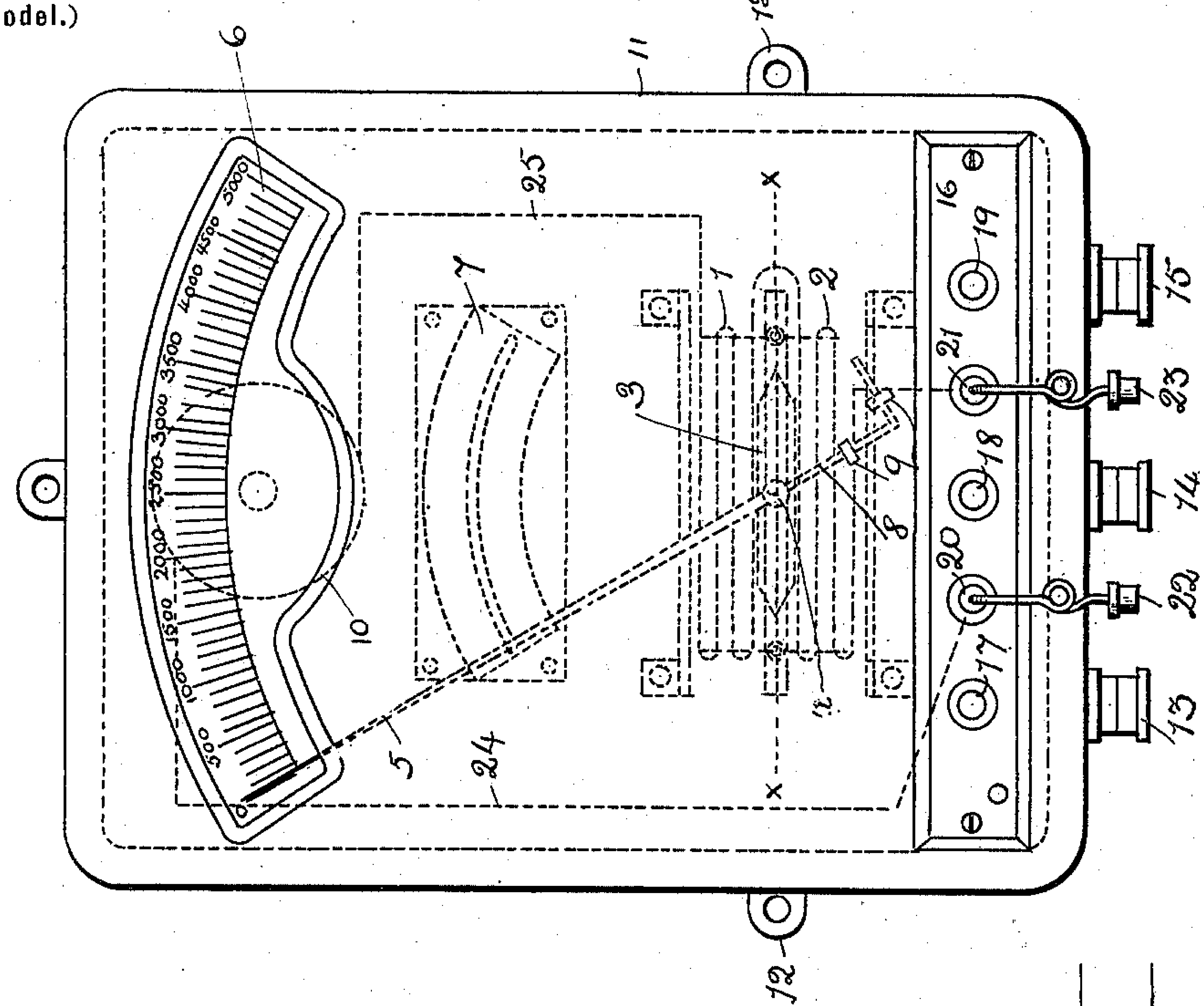

Fig 1

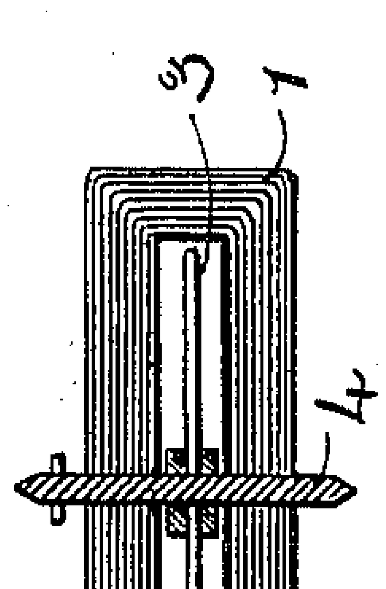

Fig 2

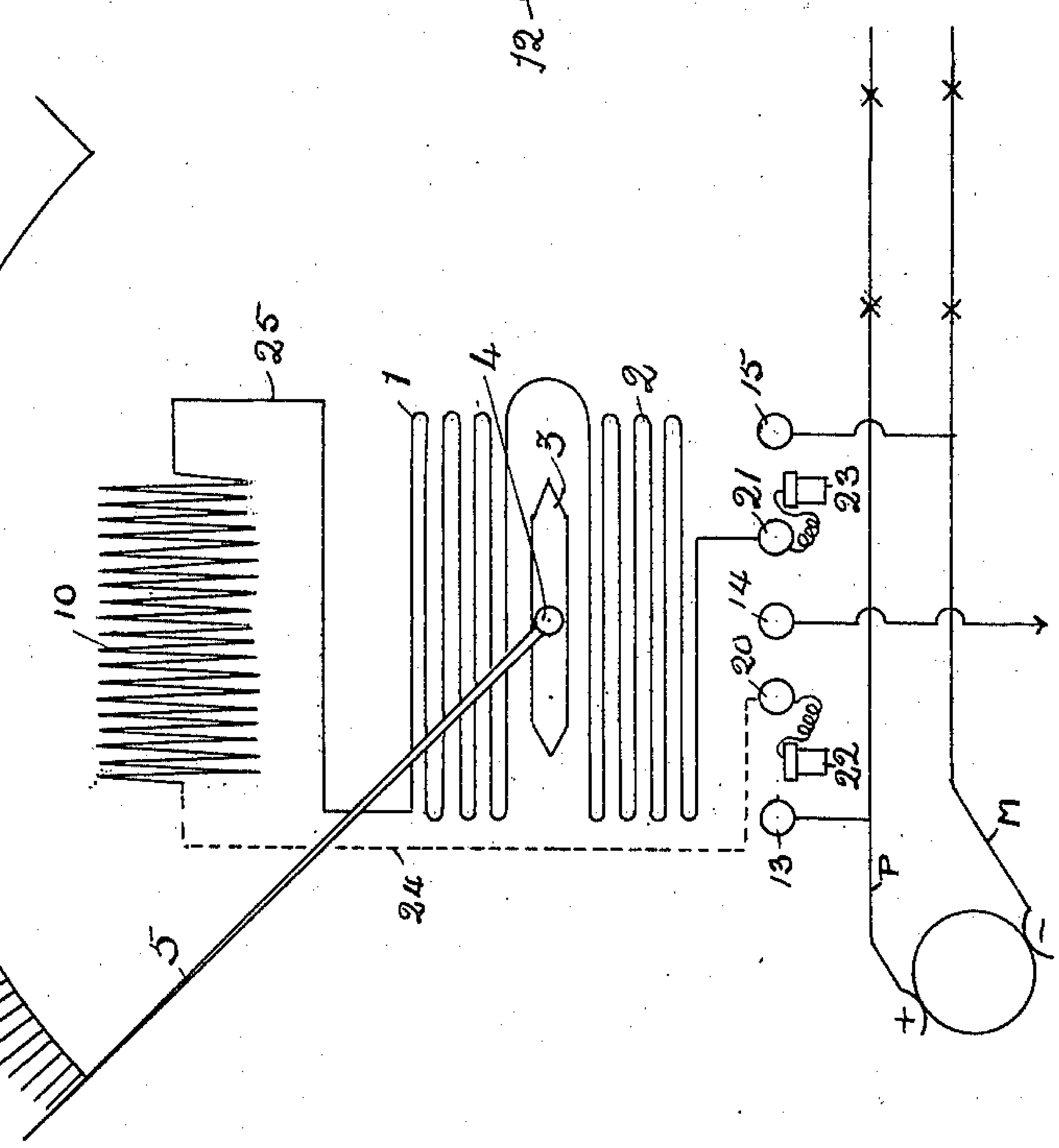

Fig 3

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ELECTRIC GROUND-DETECTOR FOR CONSTANT-CURRENT ARC-LIGHT CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 639,459, dated December 19, 1899.

Application filed September 25, 1899. Serial No. 731,569. (No model.)

To all whom it may concern:

Be it known that I, JOHN FRANKLIN STEVENS, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented a new and useful Electric Ground-Detector for Constant-Current Arc-Light Circuits, of which the following is a specification.

My invention relates to electric ground-detectors for constant-current arc-light circuits; and my object is to provide an improved method whereby such indications may be observed and whereby the extent of the ground, together with its location on the line, may be readily determined by means of one self-contained indicating instrument located at or near the source of power. I attain this object by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a plan view of my device. Fig. 2 is a cross-section on line *x x* of Fig. 1 of the fixed coil and pivoted magnetic vane. Fig. 3 is a diagrammatic view of the paths of the current.

Similar numerals refer to similar parts throughout the several views.

Upon the spools of non-conducting material are wound the coils 1 and 2, said coils being so wound and connected as to form a single solenoid or fixed coil. In cross-section this solenoid is elliptical—that is, about eight times as wide as it is high, as shown in Fig. 2, while its length from pole to pole is about equal to its largest dimension. I do not mean to confine myself to these ratios absolutely, but have found that with the relative proportions given the strength of field due to a given number of ampere-turns of the energizing-wire is greater than with any other ratio I have tried, this by reason of the field being concentrated and the magnetic circuit through the air short. Within this solenoid is a magnetized steel vane 3, mounted on an axis 4, which passes through suitable holes in the sides of the solenoid, carrying jeweled bearings properly supported from the frame of the solenoid. This steel vane is made from highly-tempered steel magnetized in a strong magnetic field while hot and tempered glass-hard in mercury while still under the influence of the field. The action of the solenoid on this vane when the instrument is in circuit is such that its original magnetization is reinforced and there is no tendency for it to weaken and so change the calibration of the instrument. To this axis 4 is rigidly attached a pointer 5, which is free to move with said axis and vane and to sweep the scale 6, which is marked off in divisions of a volt or multiples thereof. This pointer carries with it an aluminium blade moving in a dash-box 7, whereby the oscillations of the pointer are damped. Attached also to the same axis is a bent counterpoise 8, with weights 9 threaded thereon, whose position on the counterpoise may be varied at will, forming an adjustable gravity control for the system.

In series with the solenoid formed by 1 and 2 is a non-inductively-wound resistance 10 on the insulated spool.

All of the above-described mechanism is mounted in an iron containing-case 11, provided with lugs 12 at the back, by means of which it can be secured to the wall or switchboard. This case, in addition to forming a cover and support for the mechanism of the instrument, also acts as a magnetic shield, preventing the instrument from being affected by external fields. In the bottom and outside of the case are mounted three rubber-covered binding-posts 13, 14, and 15, set in insulated bushings. These binding-posts serve to receive the leads from the circuit and the ground connections. Set in the front plate of the instrument-case is a switchboard or block 16, of hard rubber, in which are mounted the receptacles 17, 18, and 19, connected inside the case by means of insulated wires with the aforementioned binding-posts 13, 14, and 15, respectively. In this switchboard 16 is also mounted the two plug-receptacles 20 and 21, to which are attached the flexible conductors and plugs 22 and 23. All of these plug connectors and receptacles are sunk below the surface of the rubber block to obviate any danger to the user by a possible touching of two terminals at the same time.

The operation of the instrument is as follows: Assume that the binding-post 13 is connected to P, the plus side of the line, and the binding-post 15 to M, the minus side of the line, while the binding-post 14 is connected to ground. Then, since 13 is connected with

17, 14 connected with 18, and 15 connected with 16, if we place the plug 22 in 17 and 23 in 16, current will flow from the line through 13 to 17, thence to 20, then, by the wire 24, to resistance 10, thence, through wire 25, to coils 1 2 of solenoid to 21, to 19, to binding-post 15, and then back to the minus side of the line. Now the solenoid 1 2 being energized by the current flow will endeavor to draw the vane 3 into a position at right angles to that shown—that is, the lines of force in the vane and solenoid will endeavor to place themselves in parallel by the well-known actions of solenoids on magnetized vanes. The angular movement of the vane will be proportional to the impressed electromotive force of the circuit, and the pointer will indicate directly, assuming the instrument to have been properly calibrated, the total electromotive force at the terminals of the generating-dynamo. In the same way if the plug 22 is put in 17 and 23 in 18 the plus side of the line will be connected to ground through the instrument, and if there is any ground on the plus side of the line the instrument will measure the drop between the point where 13 is connected to the line and the point which is grounded, indicating by the movement of the pointer across the scale the extent of the drop in volts to which the ground corresponds. By placing the plug 22 in 18 and 23 in 19 the same indication may be had for the minus side of the line.

The method of reading and operating the instrument is as follows: The instrument is first set up and secured to the wall or switchboard, the pointer standing at zero on the scale. The plus side of the line is connected to 13, the minus side to 15, and the binding-post 14 to ground, line connections being made between the dynamo and first lamp. Now put plug 22 in 17 and 23 in 18. If there is no deflection of the pointer, there is no current flowing through the instrument and no ground. This may be checked by putting 22 in 17 and 23 in 19, and if there was no deflection with the first set of connections there should be none with the second. Suppose, however, that when 22 is placed in 17 and 23 in 18 there is a deflection. Note the deflection in volts, calling it V. Then place 22 in 18 and 23 in 19 and note the second deflection. Call it V_1. Now place 22 in 17 and 23 in 19 and note the deflection. (This will be the voltage across the terminals of the dynamo.) Call this V_2. Now in so much as V was the drop between the dynamo and the ground-point on the plus side and V_1 the drop from the grounded point back to the minus side of the dynamo, while V_2 measured the total electromotive force of the dynamo, the sum of $V + V_1$ will equal V_2 if there is a dead-ground, and the location of the ground may be found by dividing V, the drop from the plus terminal of the dynamo to the grounded point by V_3, which is assumed as the drop through one lamp, so that this quotient is the number of lamps out from the plus side of the dynamo, just beyond which the ground is located. This operation, expressed mathematically, is that when $V + V_1 = V_2$ there is a dead-ground on the line and if we call N the number of the lamp beyond which the ground is to be found, counting out from the plus terminal of the dynamo, $N = \frac{V}{V_3}$.

To insert numerical values in the above, let us assume a line with ten arc-lamps in series each having a drop of fifty volts, (V_3.) Suppose we test the plus side and get a deflection of one hundred volts (V) and on the minus side a deflection of four hundred volts, (V_1,) while V_2 equals five hundred from the conditions stated. Then $100 + 400 = 500$, and we know there is a dead-ground, so we divide $V = 100$ by $V_3 = 50$ and we get 2 as a result, which means that the ground is between the second and third lamp out from the plus side of the dynamo. Now suppose $V + V_1$ is less than V_2. Then we know that there is not a dead-ground, but merely a ground through a resistance, which resistance is great or small, as the sum of $V + V_1$ is much less than or nearly equal to V_2. This is because the instrument in this case has in series with it when connected to the ground on either side the resistance of the ground, which operates to change the calibration of the instrument by the ratio of the sum of the resistance of the ground and the resistance of the instrument to the resistance of the instrument alone. At the same time the reading across the terminals of the dynamo is not affected, since no extra resistance is interposed in this circuit. Then we have for N the following relation and value:

$$N = \frac{VV_2}{V_3(V+V_1)}.$$

As will be noted, this becomes the general equation of a ground, whether dead or partial, for when the ground is dead $V + V_1 = V_2$, and this factor cancels, leaving the original $\frac{V}{V_3}$, $\frac{V_2}{V+V_1}$ being the resistance factor, which modifies the true value of V in the original calibration of the instrument.

To assume a numerical example of the above, consider the same plant that was used in the illustration of a dead-ground condition and assume a partial ground through ten thousand ohms between the second and third lamp, and, further, assume the resistance of the instrument to be ten thousand ohms. Now when V is measured the total resistance in the instrument-circuit will be twenty thousand ohms and the values of the readings will be halved, or five hundred volts will read only two hundred and fifty, so the drop to the point of ground being normally one hundred will only register fifty and from the ground back to the minus side of the dynamo only two hundred in place of four hundred, while, since there is no extra resistance in circuit when the instrument is across the terminals of the dynamo, V_2 reads five hundred, as before. Now taking the equation

$$N = \frac{VV_2}{V_3(V + V_1)}$$

and substituting the readings $V = 50, V_1 = 200, V_2 = 500$, and $V_3 = 50$ we have

$$N = \frac{50 \times 500}{50 \times (50 + 200)} = \frac{25,000}{12,500} = 2.$$

Having demonstrated a partial ground and its location, its resistance in ohms may be determined by the following equation, where R_1 is the resistance of the ground in ohms and R is the resistance of the instrument in ohms:

$$R_1 = R\frac{(V_2 - V - V_1)}{(V + V_1)}.$$

Inserting the values used above, we have

$$R = 10,000\frac{(500-50-200)}{(50+200)} = \frac{10,000\,(250)}{250} = 10,000.$$

So, as claimed above, by the use of the instrument described a station-manager can, by taking three readings on the instrument by the use of the two plugs and three receptacles provided, determine from the station the presence of a ground, its character and location on the line, and by knowing the resistance of the instrument can determine its ohmic value.

What I claim is—

1. In an instrument for the detection of grounds on constant-current arc-light circuits, a fixed coil, a permanent magnet rotatable and pivoted therein, a pointer secured to the axis of the magnet, a resistance in series with the fixed coil, a switchboard containing three sockets, each electrically connected with a separate binding-post, two movable plugs adapted to fit the sockets, one plug electrically connected with one end of the fixed coil and the other electrically connected through the resistance with the other end of the fixed coil, as adjustable means for changing the connection between the instrument and the line and ground, substantially as and for the purpose specified.

2. In an instrument for the detection of grounds on constant-current arc-light circuits, a fixed coil having elliptical cross-section, a permanent magnet rotatable and pivoted therein, a pointer secured to the axis of the magnet, a resistance in series with the fixed coil, a switchboard containing three sockets, each electrically connected with a separate binding-post, two movable plugs adapted to fit the sockets, one plug electrically connected with one end of the fixed coil and the other electrically connected through the resistance with the other end of the fixed coil, as adjustable means for changing the connection between the instrument and the line and ground, substantially as and for the purpose specified.

3. In an instrument for the detection of grounds on constant-current arc-light circuits, a fixed coil having, in cross-section dimensions, a width of about eight times its height, a permanent magnet rotatable and pivoted therein, a pointer secured to the axis of the magnet, a resistance in series with the fixed coil, a switchboard containing three sockets, each electrically connected with a separate binding-post, two movable plugs adapted to fit the sockets, one plug electrically connected with one end of the fixed coil and the other electrically connected through the resistance with the other end of the fixed coil, as adjustable means for changing the connection between the instrument and the line and ground, substantially as and for the purpose specified.

4. In an instrument for the detection of grounds on constant-current arc-light circuits, a fixed coil having, in cross-section dimensions, a width of about eight times its height and a length from pole to pole equal to its greatest dimensions a permanent magnet rotatable and pivoted therein, a pointer secured to the axis of the magnet, a resistance in series with the fixed coil, a switchboard containing three sockets, each electrically connected with a separate binding-post, two movable plugs adapted to fit the sockets, one plug electrically connected with one end of the fixed coil and the other electrically connected through the resistance with the other end of the fixed coil, as adjustable means for changing the connection between the instrument and the line and ground, substantially as and for the purpose specified.

5. In a ground-detector, a fixed coil, a permanent magnet, a non-inductively-wound resistance in series with the fixed coil, a switchboard containing three sockets, each electrically connected with a separate binding-post, two movable plugs, adapted to fit the sockets, one electrically connected with one end of the fixed coil and the other electrically connected through the resistance with the other end of the fixed coil, said plugs adapted to fit said sockets as adjustable means for varying the method of connection between the instrument and the line and ground, substantially as and for the purpose specified.

6. In a ground-detector, a fixed coil, a permanent magnet pivoted therein and carrying a pointer secured to its axis, said pointer adapted to sweep a scale suitably located with respect thereto, a bent counterpoise also secured to said axis with weights threaded thereon as adjustable gravity control for said pivoted magnet, a switchboard containing three sockets each electrically connected with a separate external binding-post, two movable plugs one connected with one end of the fixed coil, and the other connected through the resistance with the other end of the fixed coil, said plugs adapted to fit said sockets as adjustable means for connecting the instrument with the line and ground, all contained in an iron casing forming a magnetic shield from external fields, substantially as and for the purpose specified.

7. In a ground-detector, a fixed coil, a permanent magnet pivoted therein and carrying a pointer secured to its axis, said pointer adapted to sweep a scale suitably located with respect thereto, a bent counterpoise also secured to said axis with weights threaded thereon as adjustable gravity control for said pivoted magnet, a switchboard containing three sockets each electrically connected with a separate external binding-post, two movable plugs, one connected with one end of the fixed coil, and the other connected through the resistance with the other end of the fixed coil, said plugs adapted to fit said sockets as adjustable means for connecting the instrument with the line and ground, and an iron casing adapted to contain all of said mechanism, and to support said external binding-post, as a support and cover and also a magnetic shield to prevent the instrument from being affected by external fields, substantially as and for the purpose specified.

JOHN FRANKLIN STEVENS.

Witnesses:

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MAE HOFFMANN.