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AUTOMATIC ELECTRICAL MEASURING APPARATUS.

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899,193. Patented Sept. 22, 1908.

Fig. 1.

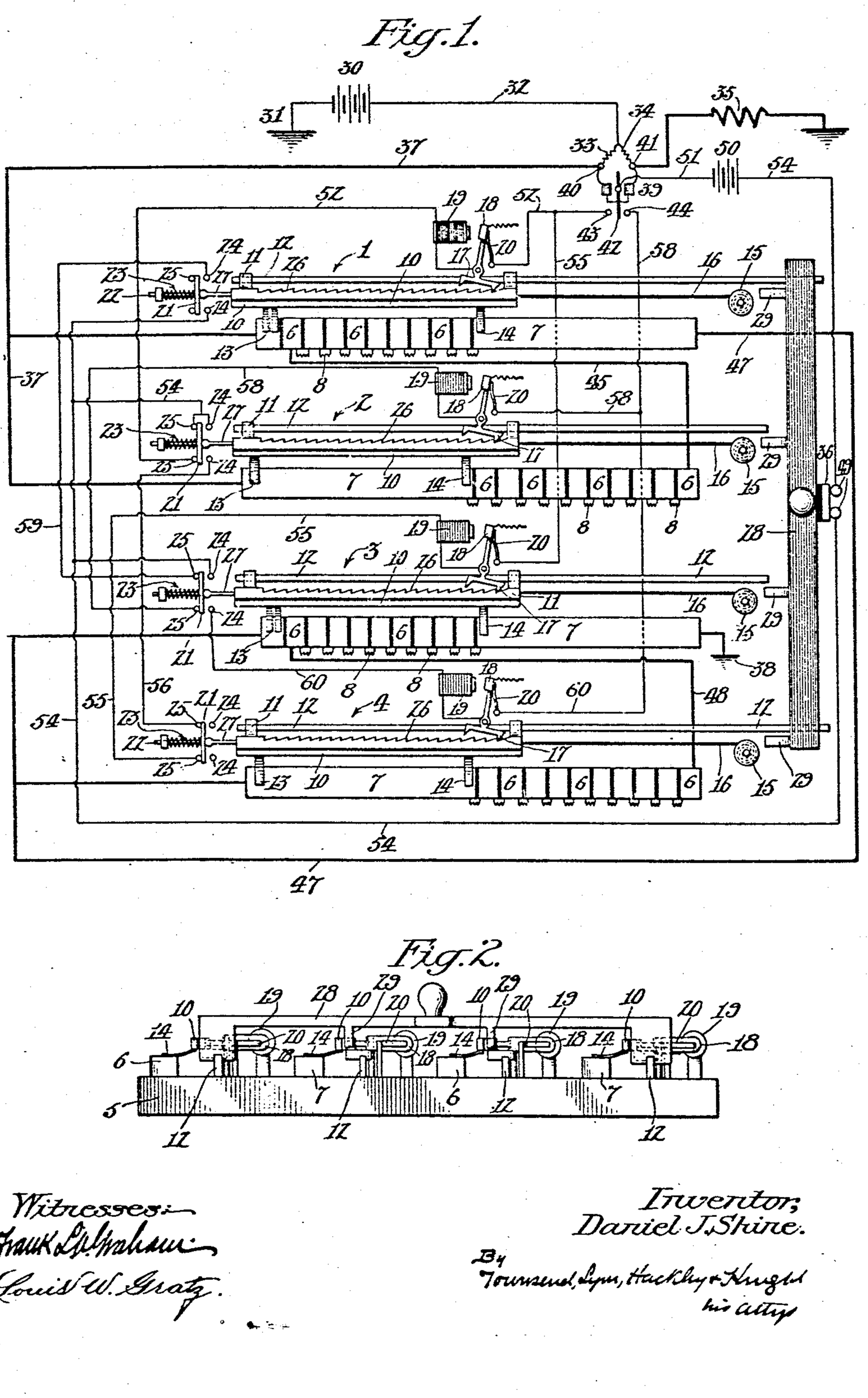

Fig. 2.

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AUTOMATIC ELECTRICAL MEASURING APPARATUS.

No. 899,193. Specification of Letters Patent. Patented Sept. 22, 1908.

Application filed March 4, 1907. Serial No. 360,584.

To all whom it may concern:

Be it known that I, DANIEL J. SHINE, a citizen of the United States, residing at Las Vegas, in the county of Lincoln and State of Nevada, have invented a new and useful Automatic Electrical Measuring Apparatus, of which the following is a specification.

The main object of the present invention is to provide means for automatic measurement of electrical resistance by the zero or balance method.

The invention comprises means for applying a variable resistance in connection with an electric circuit, whose existence is to be determined and automatically varying said variable resistance until it balances or bears a definite ratio to that of the resistances to be measured, this balance or definite relation being indicated by suitable means such as a galvanometer.

The invention further comprises means for automatically adjusting the variable resistances by alternate increments and decrements of successively smaller dimensions to continually approach the ultimate condition of balance.

In the accompanying drawings:—Figure 1 is a plan of the apparatus, showing the electrical connection diagrammatically. Fig. 2 is an end elevation.

The apparatus which may be mounted on any suitable support, indicated at 5, comprises a plurality of rheostatic or resistance devices 1, 2, 3, 4, each including a series of insulated contacts 6 arranged in fixed position in a continuous line and a continuous contact bar 7 arranged in line with the said separate contacts. Resistances 8 are connected to these contact means as hereinafter described.

For convenience in mechanical construction, particularly in connection with the resetting means, the location of the separate contacts and of the continuous contact bar is reversed in successive devices; for example, the separate contacts being at the left in devices 1 and 3 and at the right in devices 2 and 4, the devices 1 and 3 being the cutting-in or resistance increasing devices and the devices 2 and 4 being the cut-out or resistance decreasing devices. In such an arrangement the left hand end of the apparatus will be the initial end or that from which the operation starts. Sliding or movable contact means is provided for each resistance device, said means consisting, for example, of a conductor 10 carried by a carrier or carriage 11 sliding on a track or rail 12, said conductor having brushes or flexible contacts 13, 14 adapted to contact with the separate contacts and with contact bar as hereinafter set forth. The contact brushes are so spaced that for resistance devices 1 and 3, when the movable contact is in the initial position at the extreme left, the said brushes will bear respectively on the first of the separate fixed contacts 6 and on the bar 7. In resistance devices 2 and 4 the corresponding brushes will both bear on the contact bar 7 near the respective ends thereof. Suitable means are provided for drawing each carriage and the contact means carried thereby toward the right, said means consisting, for example, of a spring drum indicated at 15 connected to the carriage by flexible connection 16. Such movement is arrested by escapement means indicated at 17, which may be of any suitable character, and is operated by the armature 18 of a magnet 19, so that on each energization of the magnet the escapement will allow the carriage to move forward one step or tooth of the escapement rack 26. The magnet 19 for each escapement is in a local operating circuit, including a circuit breaker 20 operated by the armature of the magnet. The local connections are also controlled by switches or circuit closers 21 operated by the carrier 11 and consisting of a contact bar carried by a stem 22 and operated toward the carrier by a spring 23, said bar working between a pair of front contacts 24 and a pair of back contacts 25 and being pressed against the back contacts when the apparatus is in normal or starting position by a pin or projection 27 on the carrier engaging the same.

28 designates resetting means for the sliding contact carriers, consisting, for example, of a bar sliding on two of the rails 12, and having lugs 29 to engage the carriers. The resetting means carries a circuit closing contact 36 which, when the resetting bar is in normal position, (at the extreme right in Fig. 1) closes on fixed contacts 49 in the return connection of the local or operating circuits.

Resistances 8, say of one thousand ohms each, are connected between successive contacts 6 of the first device (with the exception of the first two contacts, which are not so connected) and between the last con-

tact and the bar 7. The contacts 6 of device 2 are connected together and to bar 7, in series, by resistance sections 8, say of one hundred ohms each. The connections are as follows,—assuming that the apparatus is used in making the measurements by the Wheatstone bridge method. The circuits comprise measuring or meter circuit, and local or operating circuits. The measuring or meter circuit is energized by a source of electromotive force or battery 30 grounded at 31, and having a connection 32 to the junction of the two standard resistances 33, 34 of a Wheatstone bridge connected respectively to terminals 40, 41. The other arms or branches of the bridge lead from said terminals and are formed respectively by the line, or resistance 35, to be tested or measured, which is grounded at the other end, and by a circuit 37 leading from resistance 33 through to the rheostatic devices 1 and 2, this circuit being continued by connections within the apparatus as hereinafter set forth and being grounded at 38 to complete the bridge. The bridge thus includes two parallel circuits, one circuit, including resistance arm 34, is provided with a terminal 41 for the line or resistance to be measured. The other circuit, including resistance arm 33, is provided with a terminal 40 for connection of the variable resistance which is to be adjusted to balance the line. A galvanometer 39 is connected across between the terminals 40, 41 of the bridge, and the needle 42 of said galvanometer controls the local or operating circuits by engaging contacts 43, 44 connected to said circuits. Said contacts may be mercury contacts or any suitable form of contacts. The wire 37 aforesaid is connected to the first contact of rheostatic device 1 and to the contact bar of rheostatic device 2. From the second contact 6 of device 1, a wire 45 leads to the last contact 6 of rheostatic device 2. From the contact bar 7 of device 1 a wire 47 leads to the first contact of device 3 and to the bar 7 of device 4. The contact bar 7 of device 3 is grounded as stated, and the second contact 6 of device 3 is connected by wire 48 with the last contact 6 of device 4.

The local or operating circuits are energized by a battery 50 connected by wire 51 or suitable means to make electrical connection without impeding freedom of movement to the galvanometer needle 42. From the contact 43 engaged by said needle on deflection thereof in one direction, a wire 52 leads to the circuit breaker 20 for the escapement magnet 19 of device 1 and thence to a back contact 25 of the circuit closer 21 operated by the rheostatic device 2. The other back contact 25 of said circuit closer is connected to a return wire 54 leading through circuit closer 36 to the other side of the battery, said circuit closer being normally closed by the resetting means. Thus the local operating circuit for rheostatic device 1 is controlled by the rheostatic device 2 and is only closed when said rheostatic device 2 is in normal position. Another wire 55 leads from the aforesaid contact 43 of the galvanometer through the circuit breaker 20 and escapement magnet 19 for rheostatic device 3 and thence to the back contact 25 of the circuit closer 21 for rheostatic device 4. The other back contact of said circuit closer is connected by wire 56 to the front contact 24 of circuit closer 21 of rheostatic device 2, the other front contact of said circuit closer being connected to the return circuit 54 aforesaid, so that the escapement magnet for rheostatic device 3 is controlled by the rheostatic devices 2 and 4 and is only closed when the rheostatic device 4 is in normal position and rheostatic device 2 has moved from normal position. From the other contact 44 of the galvanometer, a wire 58 leads through the circuit breaker 20 and escapement magnet 19 for rheostatic device 2, and thence to the back contact 25 for circuit closer 21 of rheostatic device 3, the other back contact 25 thereof being connected by wire 59 to the front contact 24 of rheostatic device 1, and the other front contact of rheostatic device 1 being connected to the return circuits 54 aforesaid, so that the operating circuit for rheostatic device 2 is controlled by rheostatic devices 1 and 3, and can only be closed when said rheostatic device 3 is in normal position and rheostatic device 1 is moved from normal position. Another wire 60 leads from the wire 58 through circuit breaker 20 and magnet 19 for the device 4 to the front contact 24 of the third circuit closer 21, the other front contact 24 of said circuit closer being connected to return wire 54, so that the operating circuit for the device 4 is closed except for the break at the galvanometer by starting in operation of the device 3.

The operation is as follows:—The line or circuit 35 to be tested being connected, as stated, to one terminal of the bridge at 41 and the parts being positioned as shown in Fig. 1, with all of the contact carriers at the extreme left and the resetting means at the extreme right, the meter circuit will be closed as follows: from battery 30 through wire 32, resistance branch 34 of the Wheatstone bridge and line or resistance 35 to ground and back to battery 30 thus completing one side of the bridge; and from the battery 30 through the resistance 33 of the bridge, terminal 40, wire 37, first contact 6 of the rheostatic device 1, thence through the sliding contact means 13, conductor 10, sliding contact 14, and contact bar 7 to wire 47, thence through the first contact, movable conductor, and contact bar 7 of the rheostatic device 3 to ground at 38, thus completing the other side of the Wheatstone bridge. The

only resistance included in this side of the bridge is the standard resistance 33 which is balanced by or is in definite ratio to the other standard resistance 34 on the other side of the bridge, whereas on the other side of the bridge there is not only the standard resistance 34, but the resistance of the line to be tested, so that there will be a difference of potential between the terminals 40 and 41 of the bridge, and current will flow through the galvanometer, deflecting the same to contact with contact at 43, whereupon current will flow in the local circuit or escapement magnet for operating the rheostatic device 1 to cut in resistance in the measuring side of the bridge. It will be noted that connections lead from this controlling contact to the operating magnets of both the device 1 and the device 3, but the local circuit for device 3 is opened at the front contact of device 2, so that the current will flow only to the operating magnet of the device 1 as follows: from contact 43 through wire 52, the circuit breaker 20 and escapement magnet 19 of device 1, circuit closer 21 of device 2 and return wire 54 to battery 50 and from the other side of the battery by wire 51 to the galvanometer needle. The magnet 19 is thereby energized and attracts its armature, this operation causing the circuit to be opened at 20 and allowing the armature to be retracted, this operation being repeated indefinitely as long as this local circuit remains closed at the galvanometer and the consequent vibration of the armature causing the escapement 17 to allow the carrier 11 to travel to the right under the action of its operating means 15, thereby causing the brush 13 on the carrier to move successively over the contacts. In order to avoid any open-circuiting, this brush is preferably divided so as to contact with the succeeding contact 6 before breaking with the preceding one. This initial step of the movable conductor, bringing brush 13 on the second contact, transfers the connection through the second device 2 and then back to the second contact 6 of device 1, this step therefore including in circuit all the resistance of device 2, the total of which is equal to one section of device 1, say one thousand ohms.

It will be noted that the conductor 10 for the rheostatic device 1 is a short-circuiting conductor, normally short-circuiting all of the resistances 8 in the device 1 and in the progressive movement of this movable conductor toward the right the resistances 8 are successively cut into circuit so that the resistance in this side of the bridge is continually increased by such movement. When by this means the resistance in this side of the bridge has been so increased as to be greater than the resistance on the other side of the bridge, including the resistance to be measured or to be greater than a definite ratio thereof, as determined by the ratio of resistances 33, 34, the difference of potential at the points 40, 41 of the bridge will be reversed and the galvanometer needle will deflect oppositely, to contact with contact 44. This contact is connected to the operating local circuits of contact devices 2 and 4. The local circuit for device 2 has been now closed by movement of the circuit closer at device 1, the carrier having moved away therefrom, allowing the spring thereof to move against the front contacts. The local circuit for device 4 is still open at the circuit closer of device 3 so that the current will proceed as follows: from the battery 50 through the galvanometer needle, contact 44, wire 58, circuit breaker 20 and electromagnet 19 for device 2, circuit closer 21 at device 3, front contacts and circuit closer 21 at device 1, to return circuit 54 and back to the battery. Magnet 19 in this local circuit is thereby energized to vibrate the escapement and allow the movable conductor to be moved forward step by step. In normal position this conductor is inoperative, but as it moves forward its forward sliding contact 14 comes successively onto the fixed contacts 6 of the rheostatic device 2 and thus progressively short-circuits an increasing number of resistance sections 8. The first rheostatic device 1 having first included in circuit all the resistance sections of device 2 and then successively increased the resistance by large amounts, say of one thousand ohms each, it is evident that when the galvanometer is reversed it indicates that the resistance thus cut in to the measuring circuit is greater than the resistance of the line to be tested or greater than the proper definite ratio thereof by something less than one thousand ohms, and the function of the second rheostatic device is to successively cut out or subtract from this resistance fractional portions of these one thousand ohms, say one hundred ohms at a time, until too much is thus cut out, whereupon the galvanometer will again reverse, to its first position, showing that the measuring resistance is too small by something less than one hundred ohms. The third rheostatic device is now brought into action, the operating circuit of the first rheostatic device being broken by the circuit closer 21 of the second device 2, and the third operating circuit being established by the front circuit closer contacts of devices 2 and the back circuit closer contact of device 4, so that the movable conductor of device 3 is operated to cut in, first all the resistances of device 4 and then successively cut in the resistances of device 3, in similar manner to that above set forth. When the resistance is thus increased above the proper amount to balance the line, the fourth operating circuit is brought into action by the galvanometer to cut out resistance, one ohm at a time, in

device 4, until balance is attained. The operation of each rheostatic device thus opens the operating circuit of the preceding devices and establishes a connection for the circuit of the succeeding device, this operation, in connection with the alternatively opposite deflector of the galvanometer, causing the sequential operation of the rheostatic devices.

The invention may be applied in other connections than the one shown as a means for automatic adjustment of a resistance to a determinate relation to another resistance, any suitable means, which is responsive to the position of the movable carrier with reference to the point of observation in the case, or elsewhere, being utilized to give suitable indication of the amount of resistance cut in to the measuring or meter circuit. Thus, any usual or suitable galvanometer may be used, for example, a differential galvanometer. Switches and connections, not being shown, as they form no part of my present invention, will or may be used in connection with the system to facilitate the operation; for example, a transposing or reversing switch may be used to facilitate the initial connection of the circuits in the proper direction with respect to the galvanometer.

What I claim is:—

1. A resistance measuring apparatus comprising a set of resistances of relatively large magnitude and a set of resistances of relatively small magnitude, an electric circuit including said sets of resistances in series, said circuit having a connection for the resistance to be measured, a current responsive means responsive to the relative resistance condition of said circuit and of the resistance to be measured, operating circuits controlled by the current responsive means, and means operated by said operating circuits to control each set of resistances and to vary the resistance first by relatively large amounts, until the current responsive device is operated, and to then vary the resistance inversely by smaller amounts.

2. In a resistance measuring apparatus, the combination of a plurality of rheostatic devices each provided with a set of resistances the resistances being of different magnitude in the different devices, connections including said rheostatic devices in series, electromagnetically operated movable contact means for each of the rheostatic devices, circuit connections for connecting the rheostatic devices in series with the resistance to be measured, an electromagnetically operated circuit closer responsive to the total amount of the variable resistance included in circuit, and circuits controlled by said circuit closer for operating the movable contact means to progressively increase by definite amounts the amount of resistance included when the said responsive means indicates deficiency of resistance and to progressively decrease, by smaller amounts, the amount of resistance included when the current responsive means indicates excess resistance relatively to the amount required to balance the resistance to be measured.

3. In combination with a Wheatstone bridge and the galvanometer thereof, a set of resistances and movable contact means therefor adapted to progressively insert resistances in an arm of the bridge, a set of resistances and movable contact means therefor adapted to progressively cut out resistances from said arm of the bridge, such cut out resistances being fractional parts of said inserted resistances, electromagnetically controlled operating means for said movable contact means, and controlling circuits for said operating means controlled by the galvanometer of the bridge.

4. The combination with a series of contacts, a movable conductor adapted to make contact successively with said fixed contact, a carrier for said movable conductor, electromagnetic means for controlling the movement of the carrier, a series of resistances connected to said contacts to be successively cut in or out of circuit by the movement of the conductor, a galvanometer connected to the circuit of said resistances to respond to the resistance condition therein, means controlled by said galvanometer to operate said carrier step by step, said means comprising a circuit controlled by the galvanometer, a magnet in said circuit and an escapement controlled by the magnet, rack means on the carrier controlled by said escapement, and means for drawing the carrier in one direction.

5. A variable resistance for the purpose set forth comprising a plurality of rheostatic devices, each having a movable contact means working thereover to progressively vary the resistance in the said devices, movable carriers for said contact means, operating circuits, and means controlled thereby to operate said movable contact means, and circuit closer means controlled by the said carriers to close a connection for the operating circuit for one of the rheostatic devices by operation of the carrier of the preceding rheostatic devices.

6. A variable resistance for the purpose set forth comprising a plurality of rheostatic devices, each having a movable contact means working thereover to progressively vary the resistance in the said devices, movable carriers for said contact means, operating circuits and means controlled thereby to operate said movable contact means, and circuit closer means controlled by the said carriers to open a connection for the operating circuit for one of the rheostatic devices by operation of the carrier of the succeeding rheostatic device.

7. A variable resistance for the purpose set forth comprising a plurality of rheostatic devices, each having a movable contact means working thereover to progressively vary the resistance in said devices, movable carriers for said contact means, operating circuits and electromagnetic means operated thereby to progressively operate the said movable carriers, a resetting device engaging with all the said carriers and provided with a switch controlling said operating circuits.

In testimony whereof, I have hereunto set my hand at Las Vegas Nevada this 23d day of February 1907.

DANIEL J. SHINE.

In presence of—
WALTER R. BRACKEN,
P. JAY MILLER.