

Dec. 29, 1936.

T. R. HARRISON

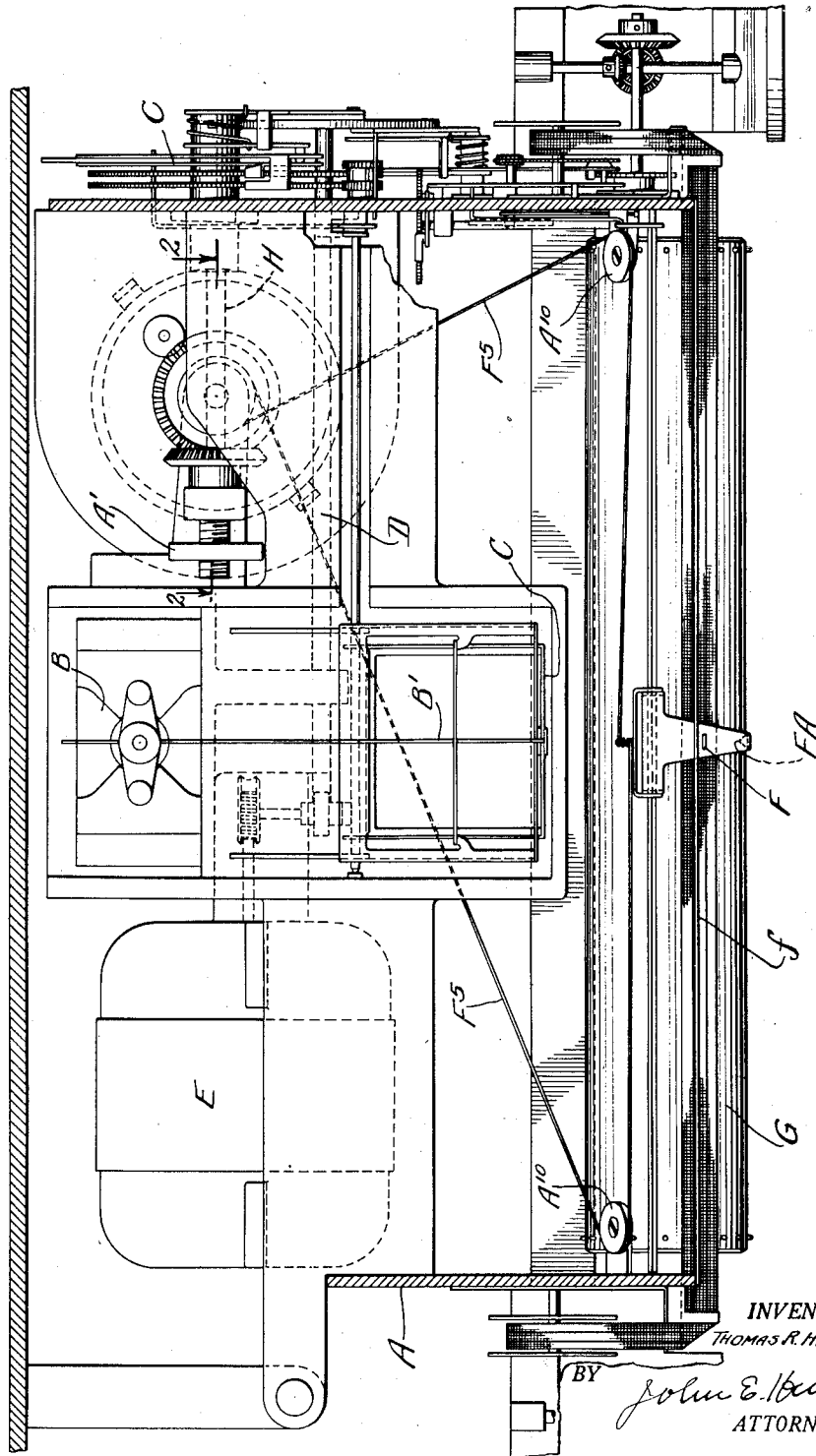
2,065,805

POTENTIOMETER

Filed Feb. 25, 1930

3 Sheets-Sheet 1

Fig. 1.



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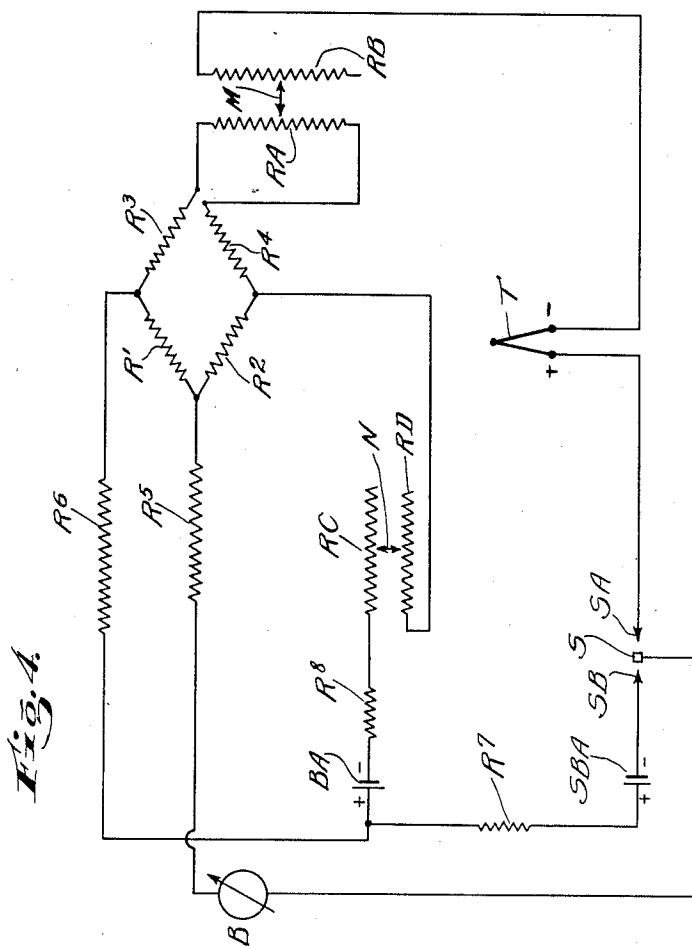
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2,065,805

POTENTIOMETER

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The Brown Instrument Company, Philadelphia,
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Application February 25, 1930, Serial No. 431,173

21 Claims. (Cl. 201—56)

My present invention relates to potentiometers of the type in which a difference in potential, such as the voltage of a thermo-couple, is measured, by means including a slide wire resistance and a contact movable along the slide wire resistance.

Potentiometers of the general character described above are now and long have been in extensive use under conditions in which the tendency to corrosion of the slide wire resistance or resistances is relatively great, and in which the voltages measured are relatively minute, so that even a very thin non-conducting film due to corrosion, furnace dust deposit, or the like, interferes seriously with the accuracy of the potentiometer. In the use of potentiometers in measuring furnace temperatures for which potentiometers are largely used, it has been found necessary in some instances to clean the slide wire resistances daily, to insure the desired accuracy and reliability of measurement.

A primary object of the present invention is to provide simple and effective means for eliminating the difficulties heretofore experienced from corrosion of, and dirt deposits on a potentiometer slide wire resistance. This object is obtained in accordance with the present invention, by keeping the slide wire resistance submerged in oil. Preferably the oil is held in a glass container permitting visual inspection at all times of the slide wire resistance or resistances and the movable contact or contacts therein.

Other objects of the present invention are to provide simple and effective means for disposing the slide wire resistance and the movable contact associated therewith so as to readily effect the relative adjustment of the slide wire and contact, and to permit of the use of a relatively long slide wire resistance along which said contact is moved. The form of the means which I have devised for the last mentioned purposes is such as to facilitate the attainment of the first mentioned object of the invention.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, and the advantages possessed by it reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:—

Fig. 1 is a plan view of a potentiometer;

Fig. 2 is a partial section on the line 2—2 of Fig. 1;

Fig. 3 is an elevation of the portion of the apparatus shown in Fig. 2 and associated contact controlling parts; and

Fig. 4 is a diagram of a potentiometer circuit in connection with which the apparatus shown in Figs. 1, 2 and 3 may be used.

In the accompanying drawings I have illustrated the present invention in connection with the potentiometer instrument A forming the subject matter of my prior application, Serial No. 322,269, filed November 27, 1928, which has matured into Patent No. 1,898,124, of which this application is a continuation in part, though those skilled in the art will understand that the invention disclosed and claimed herein may be embodied in other forms of apparatus.

As illustrated in Fig. 1, the instrument A is a recording instrument comprising a galvanometer B and mechanical relay provisions collectively indicated by C, which are controlled by the deflection from its neutral position of the galvanometer pointer B', and through which a power shaft D driven by a motor E or analogous source of power, periodically gives rotative movements varying in magnitude and direction with the deflections of the pointer B', to a shaft H through which corresponding adjustments are imparted to potentiometer resistance adjusting means and to exhibiting means. The latter as shown, comprise an indicator index F movable along an instrument scale f, and a recorder marking element FA, by which a record of the values of the quantity or quantities measured may be formed on a travelling record strip advanced at a definite time rate by a record strip feed roll G which may be driven by the motor E or by some other suitable driving means.

In respect to the general features noted above the recording potentiometer instrument shown in Fig. 1 does not differ in principle from instruments now and heretofore in use. The mechanical relay provisions C through which the shaft H is selectively actuated at intervals, shown in part in Fig. 1, may advantageously, though not necessarily, be of the character disclosed in my said prior application, Serial No. 322,269, wherein novel features of construction and arrangement embodied in said relay mechanism are claimed. Further reference to such relay mechanism herein is unnecessary, however, because that mechanism forms no part of the invention claimed herein, and an understanding of its details and characteristic features is not essential to a full understanding of the invention which is claimed herein.

As shown, the shaft H is horizontally disposed

and is journaled in the frame work A' of the instrument A. The shaft H carries a bevel gear H' in mesh with a bevel gear I having a hub portion I' also journaled in the instrument frame work A'. As shown, the gear member I comprises an upper barrel-like portion I² which serves as a winding drum or windlass for giving movement to a cable F⁵ looped about said drum. Portions of the cable F⁵ run over idler pulleys A¹⁰ mounted on the instrument frame work adjacent the ends of the path of movement of the indicating and marking elements F and FA to which the cable is connected so that the rotation of the gear I gives the parts F and FA their movements along the scale f and record-strip feed roll G.

The rotation of the shaft H effects potentiometer resistance adjustments through the gear I and a vertically disposed shaft J which has its upper end connected to and which is rotated by the gear I. For a purpose hereinafter explained, the gear I and shaft J are splined together so that the shaft J may be vertically adjusted, and when so adjusted will still be rotated when the gear I is rotated. The splined connection, as shown, comprises a pin J' extending through the upper end of the shaft J and having its ends received in axial slots I³ formed in the hub portion I' of the gear I.

The shaft J extends into a resistor housing. The latter comprises a body part L and a casing part LA detachably connected to the body part L. The latter is shown as cup-shaped with a head or flange enlargement L' at its upper end. As shown, screws A⁵ entering the head portion L' serve to secure the resistor housing to the instrument frame work A'. The housing body portion L is advantageously formed of some relatively strong insulating material such as bakelite. The shaft J which is disposed axially of the member L, extends through the bottom of the latter and as shown is journaled in an elongated tube or bearing sleeve K extending through the bottom of the member L and secured to the latter.

As shown, there are four slide wire resistances RA, RB, RC and RD mounted on, and surrounding the portion of the resistor housing member L, below the head portion L' of the latter.

In the preferred form illustrated, the major portion of the member L below the head portion L' is of cylindrical outline and is formed with two external side by side helical grooves. The main potentiometer slide wire resistance RA is received in one of said grooves and a second slide wire resistance RB is received in the other of said grooves. Advantageously each of the resistances RA and RB consists of a wire wound into a helix with closely spaced turns.

The operative relations of the resistances RA and RB to the circuits in which they are used may be varied by adjusting a bridging contact M spirally about the axis of the member L so that the contact moves lengthwise of the resistances RA and RB which are connected by the contact M. As shown, the contact M is carried by a sort of threaded nut or collar M'. The latter is formed by severing a ring of bakelite or other suitable insulating material at one side of the ring, and securing the contact M to the severed portions so as to hold the latter apart and thus convert the severed ring into one turn of a helix of such pitch that its inner edge engages the periphery of the body portion of the member L between the grooves receiving the conductors RA and RB. The latter serve as the walls of a screw threaded groove in which the inner portion of the contact

member M moves. In consequence, when the contact carrier M' is rotated about the axis of the member L the bridging contact M moves spirally about the axis of the shaft J in contact with and along the length of the resistances RA and RB.

The contact carrier M' is rotated and permitted its necessary movement parallel to the axis of the member L by means of a yoke member J² secured to the lower end of the shaft J. Uprising arm portions J³ of the member J² extend parallel to the shaft J, and pass through openings formed for the purpose in the contact carrier M'.

A flange-like portion L² of the member L below the resistances RA and RB, is formed with circumferential grooves receiving slide wire resistances RC and RD. The latter may also be formed of resistance conductor helices. The portions of the resistances RC and RD in circuit may be varied by adjustment of a bridging contact N angularly about the axis of the member L. As shown, the contact N is carried by a member O in the form of a gear wheel journaled on a tubular portion L³ of the member L which surrounds the sleeve Q. Attached to the gear wheel member O and at the upper side of the latter is another gear wheel OA.

The gear wheel OA may be manually adjusted to thereby angularly adjust the contact N, by means of a vertically disposed shaft P journaled in the member L and axially adjustable with respect thereto. The shaft P as shown is provided at its upper end with an operating knob P', and at its lower end the shaft carries a spur gear P². A spring P³ normally holds the shaft P in an elevated position in which the gear P² is above the plane of the gear wheel OA. When the shaft P is depressed, however, the gear P² is brought into mesh with the gear OA, and with these gears in mesh the rotation of the shaft P will produce a corresponding rotation of the gear OA and thereby of the gear O and the contact N carried by the latter. With the instrument circuit shown in Fig. 4, the above described manual adjustment of the resistances RC and RD may be effected to compensate for variations in the voltage of the potentiometer energizing battery BA.

To permit of the automatic adjustment at suitable timed intervals of the portions of the resistances RC and RD in circuit, means are provided for periodically connecting the gear O to the shaft J. This connection, with the construction shown, requires the axial depression of the shaft J to thereby bring a clutch finger or detent J⁴ carried by one of the yoke arms J³ into engagement with the teeth of the gear O. The means shown for depressing the shaft J for this purpose comprise a lever Q pivoted on a stationary fulcrum pin A²⁰ and serving, when turned in the clockwise direction as seen in Fig. 3, to engage a collar J⁵ on the shaft J. A spring J⁶ acting between the resistor housing and the collar J⁵ normally maintains the shaft J in its elevated position in which the detent J⁴ is above the plane of the gear O as shown in Fig. 2. The lever Q is oscillated at regular timed intervals through connections shown as comprising a cam q mounted on some suitable slow moving shaft q', a cam q² carried by the shaft q', a lever QA pivoted on the shaft or pin A²⁰ and engaging the cam q², and a spring Q' connecting the levers Q and QA. The spring Q' normally holds a projection QA' of the lever QA in engagement with the lever Q.

Except at intervals determined by the speed of rotation of the shaft q', the lever Q exerts no

downward thrust on the collar J⁵ carried by the shaft J. When the rotation of the shaft q' permits the transversely projecting end of the lever Q to be moved toward the shaft q' along the face of one or the other of the shoulders q'¹⁰ of the cam q, the spring Q', then under tension, moves the lever Q in the clockwise direction as seen in Fig. 3, thereby depressing the shaft J and connecting the latter through the detent J⁴ to the gear wheel O carrying the contact N. For this purpose the spring Q' must exert a force, when under tension, sufficient to effect the compression of the spring J⁶. Shortly after the lever Q moves into the position shown in Fig. 3, in which the shaft J⁵ is depressed, the continued rotation of the shaft q' permits the transverse end portion of the lever QA to move along the face of a shoulder qa¹⁰ on the cam qa toward the shaft q'. When this occurs the spring Q' holds the projection QA' against the lever Q, and no longer tends to compress the spring J⁶, and the latter then raises the shaft J and thereby disconnects it from the gear O. As the cams q and qa continue to rotate, the transverse end portions of the levers Q and QA are spread apart by the cams and the spring Q' is again put under tension preparatory to a repetition of the above described longitudinal adjustments of the shaft J. As shown, the cams Q and Q' are arranged to depress the shaft J twice during each rotation of the shaft q'.

The manual depression of the shaft P and the automatic depression of the shaft J each serves to separate a switch contact S from a switch contact SA with which it is normally in engagement, and to move the contact S into engagement with the contact SB from which it is normally separated. This result is obtained by providing the contact S with an insulated extension S' which is engaged and depressed by the collar P⁴ carried by the shaft P when the latter is depressed, and is engaged and depressed by a collar J⁷ on the shaft J, when the latter is depressed. The purpose of thus adjusting the switch contact S is to connect a standard battery SBA shown in Fig. 4, to the terminals of the galvanometer, and thereby make it possible to automatically vary the portions of the resistances RC and RD in circuit as required to properly recalibrate the apparatus.

To prevent over-travel in either direction of the gear I, and consequent over-travel of the cable P⁵, and of the shaft J, the instrument is provided with means for limiting the range of rotative movement in either direction of the shaft H. The provisions shown for this purpose comprise a threaded extension H² of the shaft H, and a sliding nut h on said extension. Said nut is held against rotation by the engagement of the flat side of the nut with a bearing surface A²¹ formed on the instrument frame work. The threaded portion h of the shaft H carries limit pins H¹⁰ and H¹¹ on opposite sides of the nut. When the nut h is moved by the rotation of the shaft H into a position at either end of the range of rotative movement desirably permitted the shaft H, one or the other of the limit pins H¹⁰ or H¹¹ engages the corresponding end of a stop pin h' carried by the nut h and projecting through the latter.

The casing section or part LA of the resistor housing is cup-shaped, and when in place surrounds the portion of the housing part L below its head portion L'. The casing section LA forms a receptacle for oil in which the slide wire resist-

ances RA, RB, RC and RD and the bridging contacts M and N are immersed. Advantageously, the casing section LA is made of glass and is formed with an external thread LA', adapted to be screwed into a depending internally threaded flange L³ carried at the underside of the head portion L' of the member L to detachably connect the casing part LA to the body part L of the resistor housing.

As those skilled in the art will readily understand, the potentiometer instrument illustrated, and in particular the potentiometer resistance adjusting mechanism shown in Figs. 2 and 3, may be employed in connection with various potentiometer circuit arrangements. One potentiometer circuit arrangement of suitable and desirable form is shown diagrammatically by way of example in Fig. 4. In the circuit arrangement diagrammatically shown in Fig. 4, T represents a thermo-couple or analogous device creating a variable potential measured by the instrument A. In Fig. 4 the negative terminal of the thermo-couple T has one end connected to one end of the slide wire resistance RB. The positive terminal of the thermo-couple is connected to one terminal of the galvanometer B through the contacts SA and S, in the normal position of the latter. The second terminal of the galvanometer B is connected to the main potentiometer slide wire resistance RA through a bridge comprising ratio arms including resistances R' and R², and third and fourth arms including resistances R³ and R⁴, respectively, the latter being connected to the opposite ends of the slide wire resistance RA. R⁵ represents a resistance which may be an ordinary galvanometer resistance through which the said second terminal of the galvanometer is directly connected to the junction point of the ratio arms including the resistances R' and R².

The potentiometer is shown as energized by a battery BA having its positive terminal connected through a resistance R⁶ to the junction point of the bridge arms including the resistances R' and R³. The negative terminal of the battery BA is connected through a resistance R⁸ to one terminal of the slide wire resistance RC. The latter as previously explained, is connected by the bridging contact N to the slide wire resistance RD, one terminal of which is connected to the junction point of the bridge arms including the resistances R² and R⁴. The resistances RC and RD are so arranged that movement of the bridging contact N in one direction diminishes, and its movement in the opposite direction increases the amount of each of the resistances RC and RD included in the potentiometer energizing circuit.

The movement of the bridging contact M along the slide wire resistances RA and RB varies the relative portions of the resistance RA in the bridge arms including the resistances R³ and R⁴, respectively, and also varies the amount of resistance RB in circuit. As shown, when the portion of the resistance RA in the bridge arm including the resistance R³ is increased, the portion of the resistance RB in circuit is increased. The purpose of varying the amount of resistance RB in circuit in the manner described, is to maintain the galvanometer sensitiveness or deflection range approximately constant, by keeping the total amount of resistance in the galvanometer circuit approximately the same with different positions of the bridging contact M. For this purpose, the resistances should be so relatively

proportioned that the total bridge resistance between the resistance R^5 and the contact M is diminished when the contact M is moved downward as seen in Fig. 4, by an amount approximately equal to the increase due to such contact movement of the amount of resistance RB in circuit.

For recalibration purposes, a standard battery SBA has its positive terminal connected to the positive terminal of the battery BA and has its negative terminal connected to the switch contact SB. When the contact S is moved out of engagement with the contact SA and into engagement with the contact SB the measuring apparatus may be calibrated by manual or automatic adjustment of the bridging contact N as required to obtain zero deflection of the galvanometer B. When this occurs, the voltage drop through the fixed resistances R' and R^6 , balances the voltage of the standard cell SBA. The resistance R^7 between the positive terminals of the battery SB and SBA should be large enough to keep the current drain on the battery SBA very small, even though the strength of the current from the battery BA is quite different from its intended value at the time of recalibration. The various resistances $R'-R^7$, inclusive, are advantageously mounted within the cavity formed in the cup-shaped housing part L beneath the removable cover plate L^5 , and advantageously may have their terminals connected to terminal members L^6 . The latter are advantageously attached to the housing part L by imbedding them therein, if the latter is made of moulded bakelite or analogous insulating material as I consider ordinarily preferable. The resistance R^8 which serves to compensate for the effect of temperature changes on the voltage of the battery BA is advantageously located alongside the latter so as to be exposed to the same temperature.

The resistance housing and adjusting provisions illustrated in Figs. 2 and 3 are simple, compact and effective. The disposition made of the varying resistances protects them against injurious contact while permitting adjustments, and changes in connections to be easily made. An important practical advantage is obtained by having the various slide wire resistances submerged in oil. The oil prevents the deposit of dust on the resistances and prevents corrosion of the latter. Dirt collecting on the slide wire resistances or bridging contacts is washed off when the contacts are adjusted and settle to the bottom of the container formed by the casing section LA.

The protection against corrosion is especially important because potentiometer instruments of the general character shown in Fig. 1 are frequently used in proximity to furnaces or other sources of corrosive fumes. Corrosion of potentiometer slide wire resistances ordinarily involves increased contact resistance and thus impairs the operativeness or accuracy of the measurements obtained. In some installations of instruments including slide wire potentiometer resistances exposed to corrosive action, it has been found necessary to subject the slide wire resistances to daily cleaning operations. Since the slide wire resistances are protected against corrosion by the oil, the material used in such resistances need not be one selected with a view to its capacity to resist corrosion, but may well be a material such as a manganin having a low temperature coefficient and high resistance. The formation of the casing

section LA of glass permits of visual inspection of the slide wires and contacts at any time.

While the formation of the slide wire resistances as helices, and the coiling of the helices about the support L obviously contributes to compactness, it will be apparent that the general advantages of submerging the slide wire resistances in oil, are not restricted to any particular form or shape of the slide wire resistance.

The resistances R', R^2 , etc. mounted in the housing part L may or may not be submerged in oil held in the cavity formed in the housing part L and receiving said resistances. With the described arrangement the journalling of the shaft J in the elongated sleeve K passing through and rigidly secured in the bottom wall of the housing part L prevents the passage of oil along the shaft J out of the cavity in the member L, when the casing section part LA is removed.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention as set forth in the appended claims and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention what I claim as new and desire to secure by Letters Patent is:—

1. In a potentiometer instrument, a supporting structure, an axially and rotatably adjustable shaft mounted in said structure, resistances mounted on said structure and curved about said shaft, two movable contacts one associated with each of said resistances and connections between said shaft and contacts permitting axial adjustment of said shaft without a corresponding axial adjustment of either contact and through which said contacts may be moved along the corresponding resistance angularly with said shaft when the latter is rotated, the connections between one of said contacts and said shaft being operable when said shaft is in one, but not in the second of two axial positions of said shaft, and the connections between said shaft and the other of said contacts being operable when said shaft is in said second axial position.

2. A potentiometer instrument comprising a chambered body, a potentiometer resistance wound about said body, a shaft journaled in said body, contact means actuated thereby for adjusting the amounts of said resistance in circuit, a casing containing insulating and temperature equalizing oil into which said body extends and other instrument resistance elements mounted in said body in proximity to the first mentioned resistance and thereby subjected to substantially the same temperature conditions.

3. In an instrument, a molded supporting body of electrical insulating material, having a cylindrical portion, an electrical resistor helically arranged and supported on the exterior of said cylindrical portion, an electrical contact arranged to engage the resistor, means extending axially of and journaled in the cylindrical portion of the body for relatively adjusting the contact and resistor, electrical conductors embedded in the material of the body and arranged for connection with the resistor and with the instrument leads, a hollow transparent body detachably mounted on the supporting body and cooperating therewith to form a closed chamber about the

resistor, said electrical conductors extending exteriorly of the chamber for connection with the instrument leads, said means being available exteriorly of the chamber for operation, insulating liquid in the chamber immersing the resistor.

4. In an instrument, a cylindrical support, an electrical resistance element helically arranged on the support, the successive convolutions of the helix being evenly spaced, a helical member arranged to move in the track formed by adjacent convolutions of the element, an electrical contact carried by said member in engagement with the element, an arm engaging said member and movable over the helix to turn the member about the axis of the helix, said arm and member being constructed to permit movement of the member relative to the arm in a direction parallel to the axis of the helix, and means for moving the arm.

5. In an instrument, a cylindrical support, an electrical resistance element helically arranged on the support, the successive convolutions of the helix being evenly spaced, a helical member arranged to move in the track formed by adjacent convolutions of the element, an electrical contact carried by said member in engagement with the element, an arm engaging said member and movable over the helix to turn the member about the axis of the helix, said arm and member being constructed to permit movement of the member relative to the arm in a direction parallel to the axis of the helix, means for moving the arm, a hollow body detachably mounted on the support and cooperating therewith to form a chamber enclosing the element, said means being available exteriorly of the chamber for operation.

6. In an instrument, a molded hollow support, a slide wire resistance arranged on the exterior of said support, resistors carried within said support, electrical conductors embedded in said support and arranged for connection with the resistance and the resistors, means for adjusting the effective value of the slide wire resistance, and supporting means for an insulating and temperature equalizing body of oil into which said support extends.

7. In an instrument, a molded hollow support, a slide wire resistance arranged on the exterior of said support, resistors carried within said support, electrical conductors embedded in said support and arranged for connection with the resistance and the resistors, means for adjusting the effective value of the slide wire resistance, a hollow body detachably mounted on the support and cooperating therewith to form a closed chamber enclosing the resistance, said means being available for operation exteriorly of the chamber.

8. In an instrument, a first electrical resistor, a second electrical resistor, automatic means for adjusting the effective value of the first resistor, means whereby the effective value of the second resistor may be adjusted, intermittently operating means for associating the second mentioned means with the automatic means for operation thereby and for disassociating the two last mentioned means to maintain the adjustment value of the second resistor effected by said operation, said automatic means remaining in operative association with the first resistor throughout the operation of the intermittently operating means.

9. In an instrument, a first electrical resistor, a second electrical resistor, automatic means for adjusting the effective value of the first resistor, means whereby the effective value of the second resistor may be adjusted, intermittently operating

means including a single thrust member for associating the second mentioned means with the automatic means for operation thereby and for disassociating the two last mentioned means to maintain the adjustment value of the second resistor effected by said operation, a switch electrically associated with at least one of said resistors, and arranged for operation by said member.

10. In an instrument, a first electrical resistor, a second electrical resistor, automatic means for adjusting the effective value of the first resistor, means whereby the effective value of the second resistor may be adjusted, intermittently operating means for associating the second mentioned means with the automatic means for operation thereby and for disassociating the two last mentioned means to maintain the adjustment value of the second resistor effected by said operation, a switch electrically associated with at least one of said resistors, and arranged for operation by said intermittently operating means, said automatic means and first resistor remaining in operative association throughout the operation of the intermittently operating means.

11. In an instrument, a first electrical resistor, a second electrical resistor, automatic means for adjusting the effective value of the first resistor, means operable by the automatic means for adjusting the effective value of the second resistor and for maintaining each adjustment thereof during a following adjustment of the first resistor, and auxiliary means independent of the automatic means for adjusting the second resistor.

12. In an instrument, a first electrical resistor, a second electrical resistor, automatic means for adjusting the effective value of the first resistor, means operable by the automatic means for adjusting the effective value of the second resistor and for maintaining each adjustment thereof during a following adjustment of the first resistor, auxiliary means independent of the automatic means for adjusting the second resistor, said automatic means being in operative association with the first resistor during operation thereof for adjusting the second resistor.

13. In an instrument, a first resistor, a second resistor, automatic means for adjusting the effective value of the first resistor, means whereby the effective value of the second resistor may be adjusted, intermittently operating means for associating the second mentioned means with the automatic means for operation thereby and for disassociating the two last mentioned means to maintain the adjustment value of the second resistor effected by said operation, auxiliary means for adjusting the effective value of the second resistor, a switch electrically associated with at least one of said resistors, and arranged for operation by either the intermittently operating means or by the auxiliary means.

14. In an instrument, a first resistor adapted to form the slide wire of a potentiometer circuit, a second resistor adapted to form a calibrating resistance in the potentiometer circuit, a standard cell normally in open circuit, a galvanometer normally connected into the potentiometer circuit to respond to off-balance conditions thereof, normally inoperative means for adjusting the resistance of said second resistor, and a common actuating element operable at will for rendering said means operative and for simultaneously connecting said galvanometer and standard cell in a closed circuit including said second resistor.

15. A system comprising a galvanometer, a measuring circuit, a rotatable structure element, actuating means therefor controlled by said galvanometer, a variable impedance for controlling the current in said circuit having a rotatable operating element, means for intermittently giving one of said elements movements relative to the other to effect engagement of said elements, and switch means actuated by said movement to change the circuit connections whereby said current is standardized for subsequent measurements.

16. In an instrument, a resistor normally included in and forming the slide wire of a potentiometer measuring circuit, a calibrating impedance in said circuit, a switch adjustable between a normal position in which it is adapted to connect a control galvanometer into said circuit and a second position in which it is adapted to operatively disconnect said galvanometer from said circuit and connect it in circuit with a standard cell, means operative when said switch is in its normal position to adjust said resistor as required for galvanometer balance without adjustment of said impedance, a common means for adjusting said switch and for rendering the first mentioned means operable to adjust said impedance when said switch is in its second position, and other means for adjusting said switch into said second position.

17. In an instrument, a resistor normally included in and forming the slide wire of a potentiometer measuring circuit, a calibrating impedance in said circuit, a switch adjustable between a normal position in which it is adapted to connect a control galvanometer into said circuit and a second position in which it is adapted to operatively disconnect said galvanometer from said circuit and connect it in circuit with said standard cell, means operative when said switch is in its normal position to adjust said resistor as required for galvanometer balance without adjustment of said impedance, a common actuating means for adjusting said switch and for rendering the first mentioned means operable to adjust said impedance when said switch is in its second position and other means for adjusting said switch into said second position and for operating said impedance to permit adjustment of said impedance by means independent of the first mentioned means.

18. In a potentiometer instrument, a supporting structure, an axially and rotatably adjustable shaft mounted in said structure, resistances mounted on said structure and curved about said shaft, a contact associated with each of said resistances, and an operating connection between

said shaft and one of said contacts operative independently of the axial adjustment of said shaft, and an operating connection between said shaft and the other contact, which is operative or inoperative according to the axial adjustment of said shaft, whereby the rotation of said shaft rotates said one contact only or rotates both contacts.

19. In a potentiometer instrument, the combination with a resistance supporting structure, a potentiometer resistance wound about said structure, a compensating resistance also wound about said structure, adjustable contacts movable along said resistances, and means for so moving said contacts comprising a common operating shaft journaled in said structure and operatively connected to one of said contacts and comprising means operable to connect said shaft to, and to disconnect it from the other of said contacts, whereby when disconnected from the latter said one contact may be angularly adjusted when the shaft is rotated without disturbing the angular relation of the other contact and its resistance.

20. In an instrument, a supporting body having a cylindrical surface, helical electrical resistance convolutions surrounding said body and extending outwardly from said body, adjacent convolutions of the helix being evenly spaced, an electrical contact member in electrical engagement with and extending between adjacent convolutions and in guiding relation with said convolutions whereby the latter prevent movement of said contact transversely of said convolutions, and means for moving said contact relative to said surface angularly about said axis while permitting the contact freedom for adjustment longitudinally of said axis by said convolutions in consequence of said guiding relation.

21. A system comprising a galvanometer, a measuring circuit, an element rotatable to adjust said circuit, means controlled by said galvanometer for rotating said element, a variable impedance for controlling the current in said circuit including a second rotatable element, means for intermittently moving one of said elements into and out of engagement with the other element whereby when said elements are engaged rotative movement of said one element will impart rotative movement to the other element and thereby vary said impedance, and circuit changing switch means comprising relatively movable parts, one of which does and another of which does not share in the said movements given said element whereby said circuit connections are changed in one way and in a reverse way as said elements engage and disengage.

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