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SLIDE WIRE RESISTANCE

Original Filed June 23, 1931 3 Sheets-Sheet 1

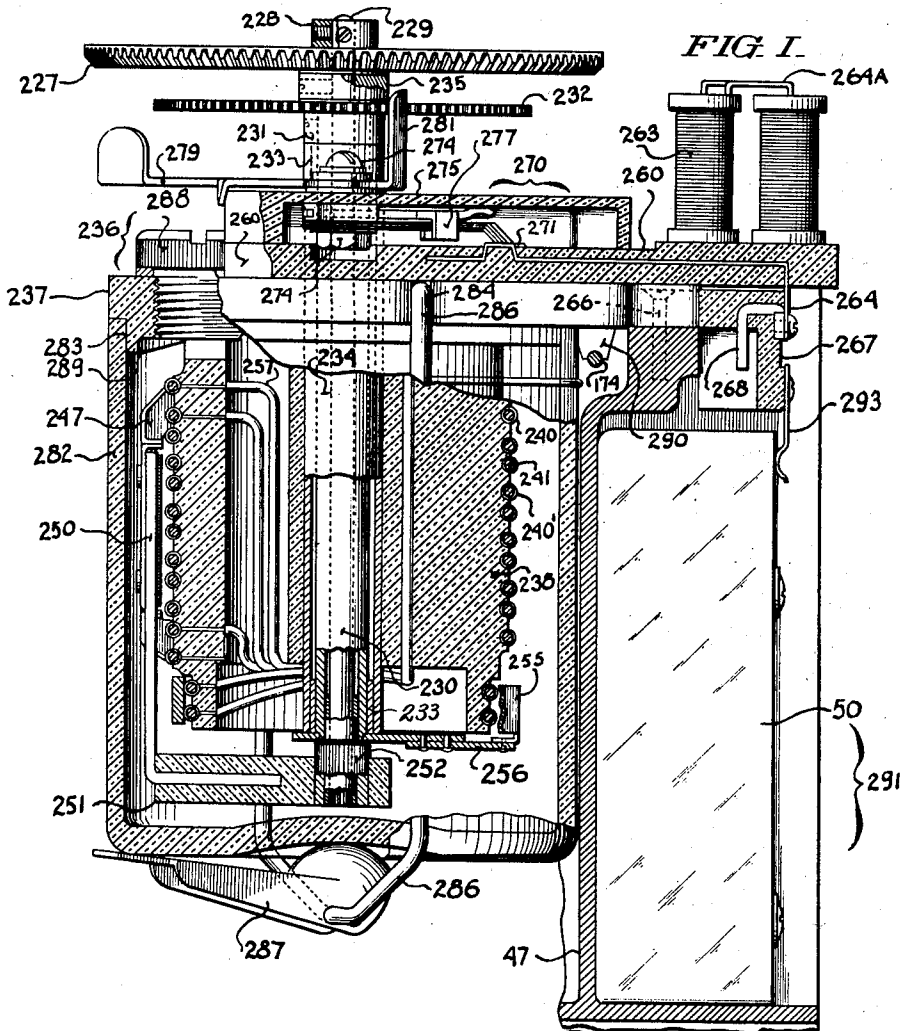


FIG. 2.

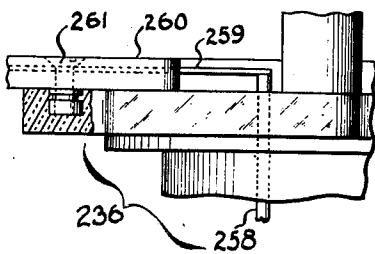
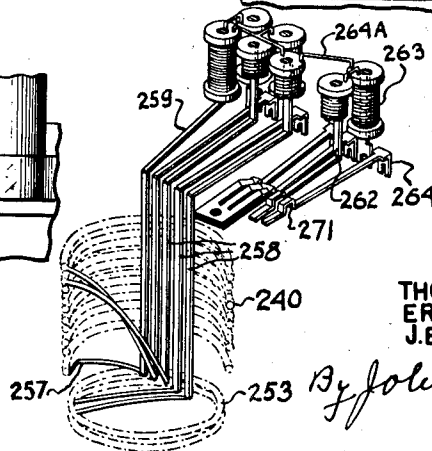


FIG. 3.



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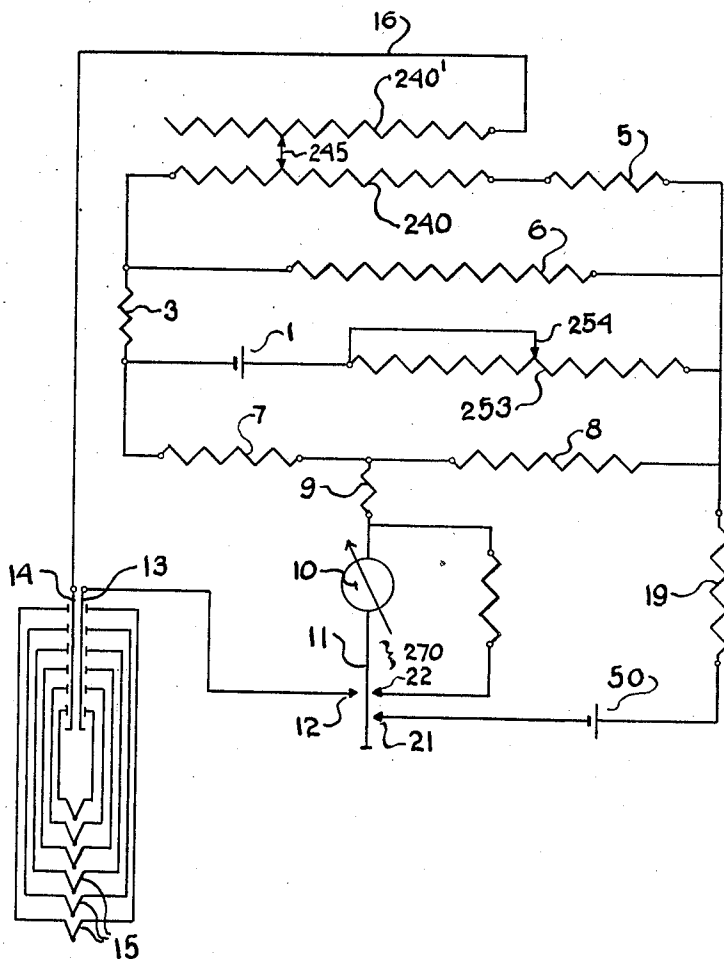
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FIG. 6.



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SLIDE WIRE RESISTANCE

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Original application June 23, 1931, Serial No. 546,290. Divided and this application April 26, 1934, Serial No. 722,466

11 Claims. (Cl. 201—56)

The general object of the present invention is the provision of an improved form of slide wire construction primarily devised for use in and as a part of a potentiometric measuring and recording instrument. More specific objects of the invention are to provide a form of slide wire construction affording a greater facility of manufacturing process, to provide an improved form of construction and operation of the slide wire per se, to provide a greater degree of convenience and efficiency of operation of the slide wire in conjunction with the related units of a potentiometer instrument, and to provide a slide wire assembly in the form of a separate slide wire assembly unit complete in itself for mounting in a frame in which other related parts, and in particular other related parts of a potentiometer instrument, may be mounted, so as to facilitate the manufacture, assembly and service of the slide wire assembly unit as well as of the related parts mounted in said frame. Other objects and advantages of the invention appear in the detailed description which follows:

In the accompanying drawings:

Fig. 1 is a cross sectional view of a slide wire unit and associated parts showing the assembled relation of the unit to the frame and standard cell of a potentiometer instrument;

Fig. 2 is a detail showing, partly in section, of a portion of the slide wire assembly;

Fig. 3 is a view in perspective showing electrical connections for the slide wire unit;

Fig. 4 is a top plan view, partly broken away and in section, of the slide wire unit;

Fig. 5 is a view in front elevation of the slide wire assembly unit; and

Fig. 6 is a diagrammatic view of the circuit of a potentiometer instrument in which the slide wire assembly unit may be used.

The slide wire assembly unit shown in Figs. 1 to 5 was primarily devised for use in and as a part of a self balancing potentiometer measuring and recording instrument, such as is fully disclosed in our prior application, Serial No. 546,290, filed June 23, 1931, of which this application is a division. One use of the instrument disclosed and claimed is illustrated diagrammatically in Fig. 6 of the drawings herein, which shows electric circuit arrangements of such a potentiometer instrument as is disclosed in our said prior application.

In Fig. 6, 1 designates a substantially constant source of electromotive force such as an ordinary dry cell connected in series with an adjustable resistor 253, the adjustment of which is adapted to vary the current flow in the circuit containing the cell 1, a ballast resistor 3, a slide wire 240, another ballast resistor 5, and a calibrating resistor 6 which completes the circuit and the value and manner of connection of which

may be varied in order to vary the measuring range of the potentiometer circuit. A shunt circuit containing resistors 7 and 8 is provided. The resistor 7 is included in the measuring circuit completed through resistor 9, galvanometer 10, the switch contacts 11 and 12 of a switch 270, conductors 13 and 14, across which are connected a source of potential, such as one or another of a series of thermocouples 15, the value of which is to be measured, conductor 16, resistor 240' and sliding contact 245 to the slide wire 240. By making the resistor 7 with a suitable temperature coefficient of electrical resistance, the variation in temperature of a thermocouple cold junction may be automatically compensated for, as is well known in the art. The resistor 8 is included in an auxiliary circuit extending from resistor 8 through resistor 19, standard cell 50, switch contacts 11 and 21 of switch 270, galvanometer 10, and resistor 9, thus completing the circuit. A resistor 22' may be shunted about the galvanometer 10 in order to properly damp its movement by arranging the switch 270 to bring contact 11 into engagement with the contact 22 at the same time that the contact 11 is brought into engagement with the contact 21.

In operation of the apparatus shown diagrammatically in Fig. 6, the source of electromotive force 1 supplies a steady current through slide wire resistor 240, thereby creating a definite potential drop across the resistor. The circuit including a thermocouple 15 applies an electromotive force on the slide wire 240 in a direction such as to oppose that created by the cell 1. By adjusting the sliding contact 245 along the resistor 240, a point on the resistor 240 is reached where the potential of the thermocouple applied to the resistor 240 is equal and opposite to the potential of the resistor 240 at that point. At such time the galvanometer 10, which is normally connected in circuit with the thermocouple 15 by the switch 270, will have a zero deflection. Variations in the value of the electromotive force of the thermocouple cause deflection of the galvanometer 10 in a direction depending upon whether the variation is an increase or a decrease from that value for which the potentiometer system is previously balanced. The contact 245 may be adjusted again to bring the galvanometer into a position which corresponds to a balanced condition of the measuring system. When the potentiometer circuit is unbalanced a current, due to the thermocouple, flows through the circuit including the resistor 240, and corresponding changes in the position of the contact 245 to balance the circuit, thereby varies the amount of electrical resistance due to resistor 240 which is included in the thermocouple and galvanometer circuit tending to change the constant of the galvanometer circuit. The resistor 240' is

connected in series in the thermocouple and galvanometer circuit in such a manner that additional resistance is added from resistor 240' when a like amount of resistance is eliminated from resistor 240 by movement of contact 245, thereby maintaining a constant electrical resistance in the thermocouple and galvanometer circuit so as to maintain an unvarying galvanometer constant throughout the measuring range of the potentiometer.

Inasmuch as the circuit energizing cell 1 tends to deteriorate slightly with age and use, it is necessary from time to time to adjust the resistor 253 in order to maintain a predetermined current flow through the slide wire resistor 240. For standardizing the current flowing in the slide wire resistor, switch 270 is adjusted to bring the contact 11 into engagement with contacts 21 and 22, thereby connecting the galvanometer in a circuit which includes the standard cell 50 as a source of electromotive force arranged to oppose the potential drop across the resistor 8 due to the current flowing in the resistor 8 from the cell 1. Variations from the standard in the current flowing through resistor 8 from the cell 1, cause a deflection of the galvanometer 10 from the position of zero deflection. The resistor 253 is then adjusted to bring the galvanometer to a position of zero deflection which corresponds to a balance between the potential drop across resistor 8 and the potential of standard cell 50 thereby standardizing the current.

Except for the galvanometer 10, the resistors 9 and 19 directly associated with the galvanometer, the standard cell 50, the thermocouples 15 and means for connecting the latter to the switch contact 12 and resistor 240', all of the parts illustrated diagrammatically in Fig. 6 may advantageously be included in the slide wire assembly unit shown in Figs. 1-5, which, as shown, includes a gear 227 which is rotated to make slide wire adjustments as hereinafter described. In the self-balancing potentiometer instrument of our said prior application, the gear 227 is intermittently rotated in one direction or the other by relay mechanism controlled by the galvanometer 10, but that mechanism is not illustrated herein, as the present invention is not directly concerned with the means for, or matter of, effecting the rotative movements of the gear wheel 227.

In the form of the slide wire unit shown in Figs. 1-5, the gear 227 has a collar 228 carrying set screws for rigidly securing the gear 227 onto a shaft 229. The shaft 229 is journaled in a hollow shaft 230 to which is secured by a set screw, or in any other suitable manner, the hub 231 of a serrated wheel 232. Hollow shaft 230 is journaled in collars or bushings 233 in a stationary tube 234. A collar 235 is secured to the shaft 229 by a set screw and is interposed between gear 227 and wheel 232 so as to maintain shaft 229 in place when gear 227 is removed. The tube 234 is secured as by molding, or in any other suitable manner, into the molded support 236. Molding 236 has a top portion 237 adapted to form a cap for the slide wire unit and a cylindrical body portion 238 depending from the top portion 237. The cylindrical portion 238 is hollow and the members 229, 230, and 234 extend axially there-through. The cylindrical portion 238 is formed, by molding, with a pair of helical grooves 239, which extend from top to bottom of the cylindrical portion, and which are adapted to receive the coiled electrical resistors 240 and 240'. The electrical resistors 240 and 240' are each wound

upon a corresponding body member of wire 241, the ends of which are clamped beneath plates 242 by pressure exerted, the screws 243 securing the plates 242 to the molding into which the screws are threaded. The coiled resistors 240 and 240' when tightly arranged in the helical grooves 239, and the ends thereof secured by clamps 242, are adequately supported by the cylindrical body 238 of the molding.

The resistors 240 and 240' are evenly spaced 10 throughout their length to provide a track 244 in which the slide wire contact 245 may ride. The contact 245 is a small cylindrical body of electrical conducting material of a size to span the track 244 formed between the resistors 240 and 240' and complete an electrical circuit therebetween, the resistors being bare along the points of contact. Roller contact 245 is arranged to ride in a slot 246 in a frame or plate 247, the roller contact being provided with reduced projections 20 or pins 248, which engage the inner faces of the plate 247 adjacent the slot 246 and prevent the roller contact 245 from passing through the slot 246. The slot 246 extends transversely with respect to the track 244, and the plate 247 is urged by spring 249 disposed about the axle for the plate and cooperating with a supporting frame 250 and the plate 247, so that the contact 245 is maintained in position between the slot 246 and the track 244 as the contact moves over the resistors. The track 244 provides a guide for moving the contact throughout the length of the resistors. The supporting frame 250 is molded into and supported by the arm 251 having a bushing 252 molded thereinto, in which the end of shaft 229 is secured by a force fit, or in any other suitable manner. Movement of the shaft 229 by gear 227 sweeps the supporting frame 250 over the surface of the helically arranged resistors 240 and 240', carrying the contact 245 along the track formed between the resistors as to thereby adjust the amount of electrical resistance in the measuring circuit of such a potentiometer as is illustrated in Fig. 6.

At the bottom of the cylindrical body of the molding 238 is formed a pair of grooves adapted to accommodate a resistor 253 of the same type and mounted in the same manner as each of the resistors 240 and 240'. The resistor 253 is formed in two parallel portions providing a track therebetween in which a contact 254, similar to contact 245, rides, being supported thereagainst by a plate 255, having a slot therein to accommodate the contact 254. Plate 255 is carried upon an arm 256 rigidly connected to the hollow shaft 230. Rotation of the serrated wheel 232 sweeps the plate 255 over the resistors 253, carrying the contact 254 along the track therebetween to adjust the electric resistance thereof. Adjustment of the contact 254 may be effected by the manual rotation of wheel 232 to thereby standardize the current flowing through the potentiometer circuit.

The electrical connections for the resistors 240 and 240' and 253 are made by conductors 257 passing through apertures formed in the wall of the cylindrical molding 238 and united to the resistors by soldering or in any other suitable manner. As shown diagrammatically in Fig. 3, the conductors 257 are joined to the lower extremities of conducting rods 258, which extend into the molded cylinder 238. The conducting rods 258 are molded into the material of the cap 237 of the molding 236 and project above the surface thereof, as shown in Fig. 2. A plurality of hori-

zontally arranged conducting rods 259 are embedded in the body of a molding 260 adapted to be secured to molding 236 by screws 261, or in any other suitable manner. When the molding 260 is secured upon molding 236 the conductors 259 make connection with the terminals of conductors 258, the two being united by screws or soldering, or in any other suitable manner.

As shown more clearly in Fig. 3, some of the rods 259 are upturned at their other extremities, as indicated at 262, to form supports and electrical connections for spools 263 of electrical resistance wires which may constitute such potentiometer circuit resistances as those designated 15 3, 5, 6, 7 and 8, shown diagrammatically in Fig. 6. Suitable electrical conductors 264A are provided for joining the resistance spools electrically. Other of the conducting rods 259 extend downwardly and are provided with connecting clips 264, as shown in Figs. 1 and 3. The molding 236 is provided with apertures 265 to accommodate bolts 266 passing therethrough into threaded engagement with a supporting frame 47 thereby mounting the slide wire unit upon said frame. In the use of the invention in our said prior application, the frame 47 is a potentiometer instrument frame member. Separately attached to the frame 47 is a molding 267 in which are embedded conductors 268, so arranged that when the molding 260 is secured in place upon the molding 236 and attached to the frame 47, the projections 264 of conducting rods 259 are juxtaposed to the conductors 268, as shown in Fig. 1 where the conductors 264 and 268 may be united electrically by means of screws or in any other manner. Conductors extending into connection with a thermocouple 15 may be connected to the conducting bars 268 to place said thermocouple, the slide wire, resistors 240 and 240', and the calibrating resistance 253 in the electrical measuring circuit.

The previously mentioned switch 270 may be and preferably is included in the slide wire assembly unit. In the form of the unit shown in Figs. 1-5, the switch operations to effect engagement of the switch contacts 11 and 12, and the engagement of the switch contacts 11 with the contacts 21 and 12, as shown in Fig. 6, result from movements of a pivoted switch blade 272 relative to contacts 271. The contacts 271 are formed as illustrated most clearly in Fig. 3 by bending up a portion of each of certain of conductors 259 so that the bent up portions are exposed at the surface of the molding 260. The switch blade 272 is of the spring brush type adapted to press against the contacts 271 and is carried by a shaft 273 having a flat thereon adapted to prevent rotation of parts mounted thereon relative thereto. The switch blade 272 fits over the shaft 273 and is secured by bolt and nut cap 275, being secured thereto by the bolt 274.

Cap 275 is arranged to cover the switch contacts 271 when it is secured in position upon the molding 260 by screws 276. A rider fits over the switch blade brushes and presses against the bottom surface of the top wall of the molding 275 to hold the brushes in wiping engagement with the contacts 271. Stops 278 are formed in the material of the cover 275 to limit the stroke of the switch, the stops cooperating with a handle 279 of the switch.

Inasmuch as in the use of the apparatus shown in Fig. 6, the calibrating resistor 240' should not be adjusted at any time other than when the switch is in such position as to connect the cali-

brating resistor and standard cell 50 in series with the galvanometer 10, it is desirable to lock the wheel 232 against movement when switch 270 is in the position placing the galvanometer 10 in the measuring circuit. A spring 280, arranged along the wall of the molded cap 275, thrusts the switch blade 272 to the left, as shown in Fig. 4, in which position the galvanometer is placed in the measuring circuit. The operating handle 279 of the switch is provided with a projection 281 arranged to engage with the serrated periphery of the wheel 232 when the switch is in the position illustrated in Fig. 4. When it is desired to standardize the current in the potentiometer circuit, the operating handle 279 is manipulated manually to move the switch blade in a clockwise direction, as viewed in Fig. 4, thereby placing the galvanometer in series with the calibrating resistor and standard cell, and at the same time moving the projection 281 out of engagement with the wheel 232 so that the adjustment of the calibrating resistor 253 may be effected manually. When the current has been calibrated, the switch handle 279 is released and the spring 280 moves the switch blade to that position placing the galvanometer in the measuring circuit and moving the projection 281 into locking engagement with the wheels 232.

Inasmuch as the resistance of the slide wire resistor, which is placed in circuit at the time that the potentiometer circuit is in balance, provides the measure of the electromotive force under measurement, it is highly desirable to protect the slide wire resistor, and for similar reasons to protect the calibrating resistor from mechanical injury and accumulation of foreign material which would tend to change the resistance thereof, or to cause deterioration thereof. It is also desirable, in order to attain great sensitivity, to provide a slide wire resistor of great length, and accordingly, by arranging the slide wire resistor as a helix upon a cylinder, as illustrated in Figs. 1 and 4, it becomes possible to employ a slide wire of great length arranged in such a compact manner as to afford opportunity for enclosing the slide wire resistor and immersing it in a bath of insulating oil to protect the same. The arrangement of the cylindrical molding 238 in a vertical position, when the slide wire unit is arranged in the frame of the instrument, allows the use of a cup-like vessel 282 arranged to fit a rim 283 formed in the material of the molded cap 237, from which the cylindrical molding 238 depends. Recesses 284 (see Figs. 1 and 4) are formed in the molded cap 237, to accommodate the turned ends 285 of a wire bail 286, which extends beneath the vessel 282. A snap acting clamp 287 is arranged on the bail 286 to engage the bottom of the vessel 282 and force the same into sealing engagement with the rim 283 on the top of the molding 237, as shown in Fig. 1. By manipulation of the clamp 287, the bail 286 may be freed so that it may be swung out of the way and the vessel 282 removed. The vessel 282 may and preferably does contain oil rising to a height sufficient to immerse the resistors on the cylindrical projection 238. A plug 288 is threaded into the cap 237 and may be removed to add oil to the vessel 282.

The molded cap 237 is provided with a projection 289 (see Figs. 1 and 5) arranged to form a guide for the upper end of the plate 247, so that when the contact 245 approaches either end of the track formed by the resistors 240 and might tend to ride up over the clamps 242, the projec-

tion 289 supports the plate 247 against such an outward thrust, thereby preventing the contact 245 from riding free of the track 240 at the ends thereof. The molding is provided with a lug 290 (see Fig. 1) which, in cooperation with frame 47, of the instrument, provides a bearing for the shaft 174, forming a part of the mechanism disclosed in our said prior application not immediately related, except as noted, to the apparatus disclosed and claimed herein.

That portion of the frame 47, on which the slide wire unit is mounted, is provided with a recess 291 into which the standard cell 50 fits. The projection 267 on the molding 236, carries a clip 293 arranged to press against the standard cell and hold it in place.

The slide wire unit described hereinabove and embodying the features of this invention, is formed largely from molded parts which may be constructed with a minimum of labor and material, and which, when formed, require no further fabricating operations thereon, and wherever possible other parts have been supported in said molded parts by embedding therein, and by employing such moldings the number of parts have been reduced to a minimum thereby simplifying the operation of the assembled parts of the unit, and by arranging the support for the resistors as a vertical cylinder the use of an immersed slide wire of a great length is made possible. Furthermore the electrical and mechanical parts which are operatively associated in the potentiometer circuit are assembled for convenience of operation in the unit, providing an exceedingly compact construction, reliable in operation, readily accessible for inspection and repair, and convenient for mounting in operative association with the other parts of the potentiometer instrument. Novel details of construction of the parts of the unit, and their manner of assembly, afford efficiency and accuracy, and convenience of operation of the unit. The slide wire unit may be assembled on an instrument frame in a position where its condition and operation may readily be observed, and where the switch 270 is conveniently available for operation from the front of the instrument, and where the standardizing resistor 240' may be conveniently manipulated from the front of the instrument. The slide wire unit, the resistors associated therewith, and the standard cell, are arranged as shown in a convenient, compact group readily accessible for making the electrical connections thereto, and conveniently arranged for servicing and the slide wire unit is demountable from its supporting frame as a unit, thereby facilitating replacement of parts.

While in accordance with the provisions of the statutes, we have illustrated and described the best form of embodiment of our invention now known to us, 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 our invention as set forth in the appended claims and that in some cases certain features of our invention may be used to advantage without a corresponding use of other features.

Having now described our invention, what we claim as new and desire to secure by Letters Patent is:

1. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire wound about said support and comprising side by side convolutions at opposite sides

of a circumferentially extending strip portion of said surface, a cylindrical contact member having transverse end surfaces and having its axis transverse to the first mentioned axis and having its periphery in engagement with the convolutions at the side of said strip, and a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces.

2. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire wound about said support and comprising side by side convolutions at opposite sides of a circumferentially extending strip portion of said surface, a cylindrical contact member having transverse end surfaces and having its axis transverse to the first mentioned axis and having its periphery in engagement with the convolutions at the side of said strip, and a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces, said member having axial extensions from said transverse end surfaces engaging the side of said guide adjacent said surface at the opposite sides of said slot.

3. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire wound about said support and comprising side by side convolutions at opposite sides of a circumferentially extending strip portion of said surface, a cylindrical contact member having transverse end surfaces and having its axis transverse to the first mentioned axis and having its periphery in engagement with the convolutions at the side of said strip, a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces, said member having axial extensions from said transverse end surfaces engaging the side of said guide adjacent said surface at the opposite sides of said slot, and means resiliently pressing said guide member toward the first mentioned axis.

4. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire wound about said support and comprising side by side helical convolutions at opposite sides of a circumferentially extending strip portion of said surface, forming a contact track, a cylindrical contact member having transverse end surfaces and having its axis transverse to the axis of said surface and having its periphery in engagement with the convolutions at the side of said track, an arm revoluble about the first mentioned axis, a guide hinge-connected to said arm to turn relatively to the latter about an axis parallel to the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces, said member having axial extensions from said transverse end surfaces engaging the side of said guide adjacent said surface at the opposite sides of said slot, and means acting between said arm and guide resili-

iently pressing the latter toward the first mentioned axis.

5. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire helically wound about said support and comprising side by side helical convolutions at opposite sides of a helically extending strip portion of said surface forming a contact track, a cylindrical contact member having transverse end surfaces and having its axis transverse to the axis of said surface and having its periphery askew to, and in engagement with the convolutions at the side of said track, and a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces.

6. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire helically wound about said support and comprising side by side helical convolutions at opposite sides of a helically extending strip portion of said surface forming a contact track, a cylindrical contact member having transverse end surfaces and having its axis transverse to the axis of said surface and having its periphery askew to, and in engagement with the convolutions at the side of said track, and a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces, said member having axial extensions from said transverse end surfaces engaging the side of said guide adjacent said surface at the opposite sides of said slot.

7. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire helically wound about said support and comprising side by side helical convolutions at opposite sides of a helically extending strip portion of said surface forming a contact track, a cylindrical contact member having transverse end surfaces and having its axis transverse to the axis of said surface and having its periphery askew to, and in engagement with the convolutions at the side of said track, a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel to the first mentioned axis and in guiding relation with said transverse end surfaces, said member having axial extensions from said transverse end surfaces engaging the side of said guide adjacent said surface at the opposite sides of said slot, and means resiliently pressing said guide toward the first mentioned axis.

8. In combination, a support having a surface extending cylindrically about an axis, electric resistance wire helically wound about said support and comprising side by side helical convolutions at opposite sides of a helically extending strip portion of said surface forming a contact track, a cylindrical contact member having transverse end surfaces and having its axis transverse to the axis of said surface and having its periphery in engagement with the convolutions at the side of said track, a guide overhanging said convolutions and revoluble about the first mentioned axis and formed with a slot into which said member extends and having opposite side edges parallel

to the first mentioned axis and in guiding relation with said transverse end surfaces, and means through which said guide presses said member against said track and the adjacent convolutions.

9. In combination, a cylindrical support, electric resistance wire wound helically on said support to provide side by side spaced apart convolutions, said resistance wire extending radially outward from the peripheral surface of said support, a member adapted to be rotated about the axis of said support and comprising a portion adjacent but spaced outwardly from said surface and formed with a guide parallel to said axis, and a bridging contact of conducting material and extending into the space between adjacent portions of side by side convolutions and being in wedging engagement with said portions and thereby held out of engagement with said surface, said member being adapted to resiliently press said contact inward toward said axis, whereby said wedging engagement is maintained and said contact is moved helically about said axis when said member is rotated about said axis.

10. In combination, a first electrical resistance adapted to form a slide wire for a potentiometer circuit, an auxiliary electrical resistance adapted to form the calibrating resistance for the potentiometer circuit, electrical contacts for each of said resistances, first means for relatively adjusting the first resistance and its contact, second means for relatively adjusting said auxiliary resistance and its contact, and a switch adapted to change the potentiometer circuit from a measuring circuit to a calibrating circuit, said switch including an arm adapted to engage second mentioned means and prevent operation of the latter when said switch is in position to energize the measuring circuit, and to disengage said second mentioned means and permit operation of the latter when said switch is in position to energize the calibrating circuit, each of said means comprising a shaft, one of said shafts being tubular and coaxial with and surrounding the other, and said arm being movable angularly about an axis laterally displaced from the common axis of said shafts into and out of engagement with said second mentioned means.

11. In combination, a first electrical resistance adapted to form a slide wire for a potentiometer circuit, an auxiliary electrical resistance adapted to form the calibrating resistance for the potentiometer circuit, electrical contacts for each of said resistances, first means for relatively adjusting the first resistance and its contact, second means for relatively adjusting said auxiliary resistance and its contact, and a switch device adapted for adjustment to change the potentiometer circuit from a measuring circuit to a calibrating circuit, and including locking means adapted to engage the second mentioned means and prevent operation of the latter when said switch device is adjusted to energize the measuring circuit, and to disengage said second mentioned means and permit operation of the latter when said switch device is adjusted to energize the calibrating circuit, each of said means comprising a shaft, one of said shafts being tubular and coaxial with and surrounding the other, and said locking means being movable angularly about an axis laterally displaced from the common axis of said shafts into and out of engagement with said second mentioned means.

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