Dec. 12, 1967 W. D. KIRKENDALL 3,358,259

POTENTIOMETERS

Filed Sept. 26, 1966 3 Sheets-Sheet 1

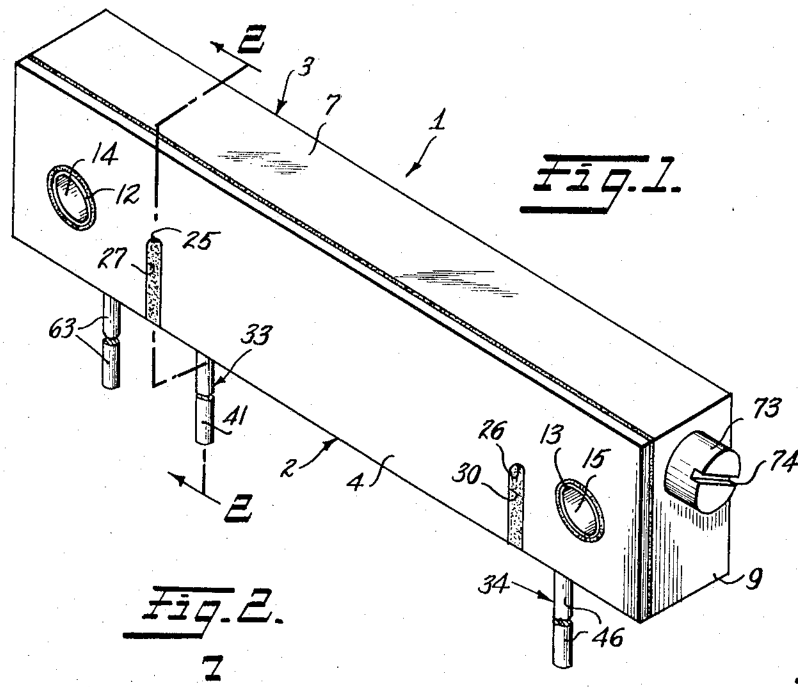
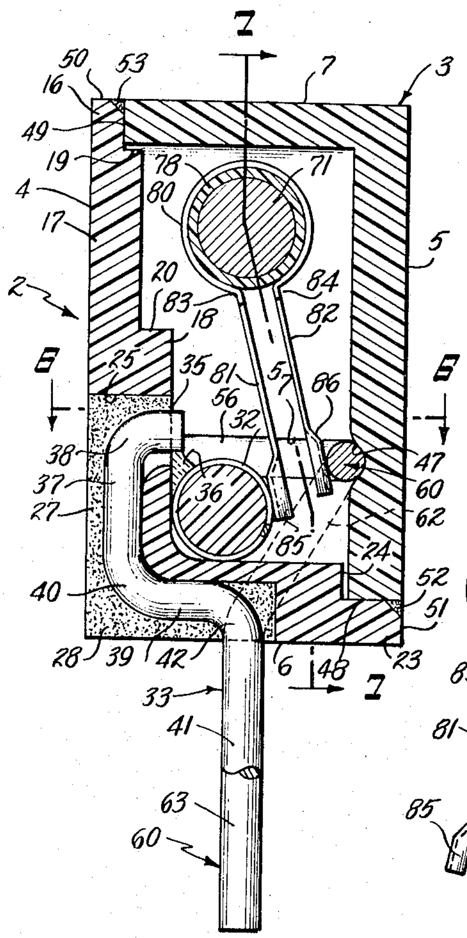


Fig.1.

Fig.2.



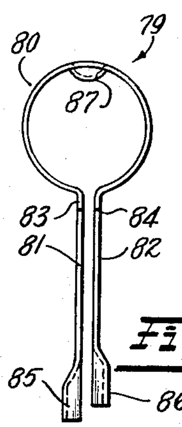
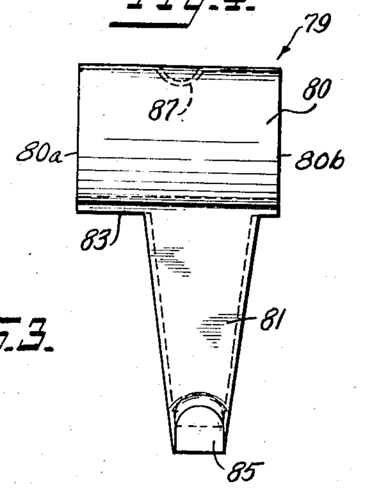


Fig.3.

Fig.4.



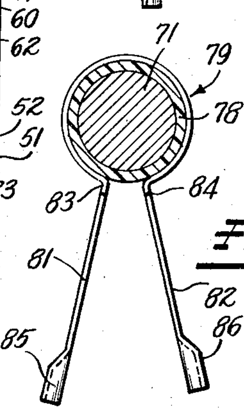


Fig.5.

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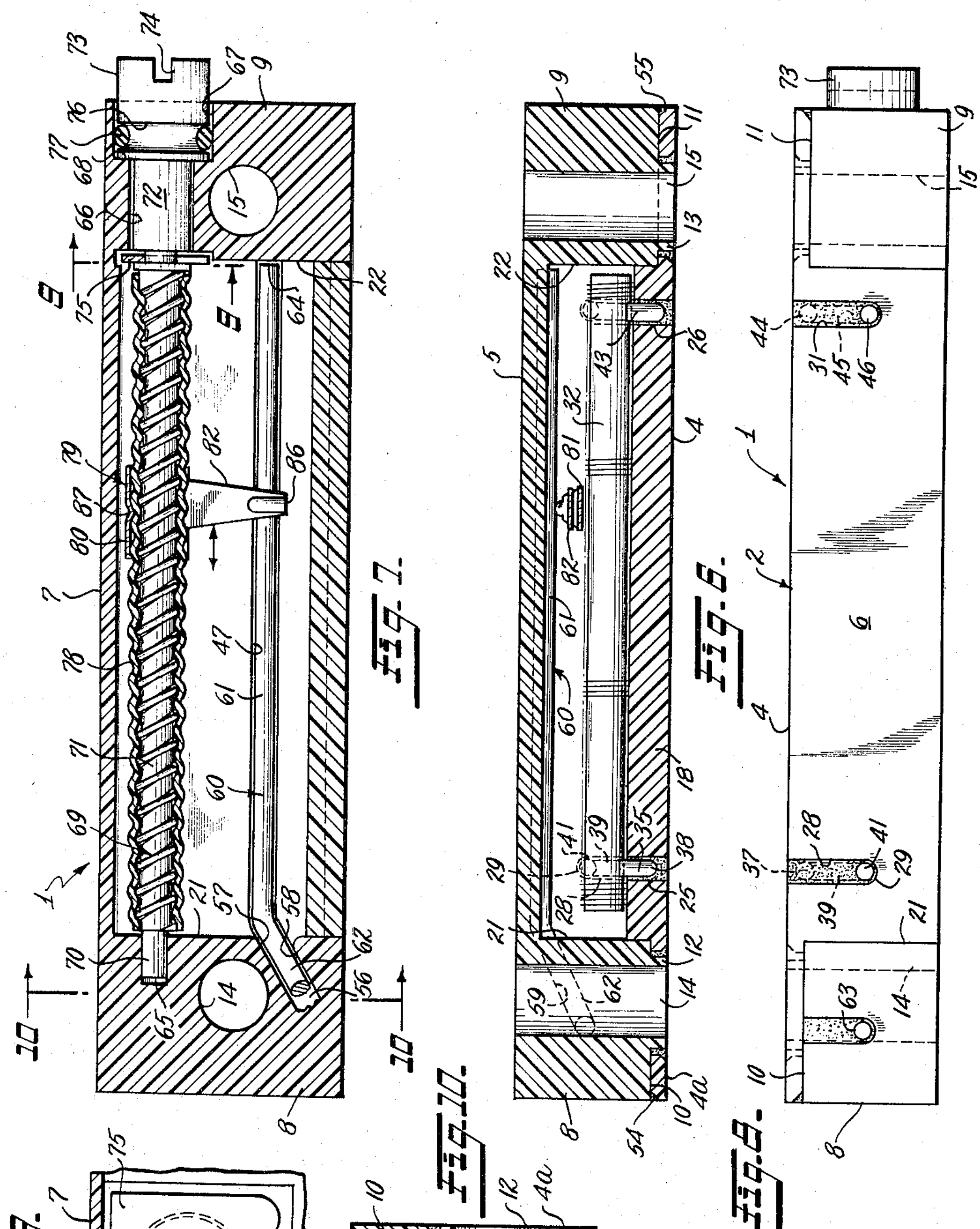

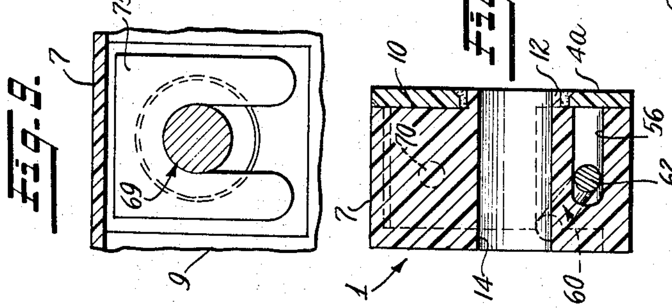

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POTENTIOMETERS

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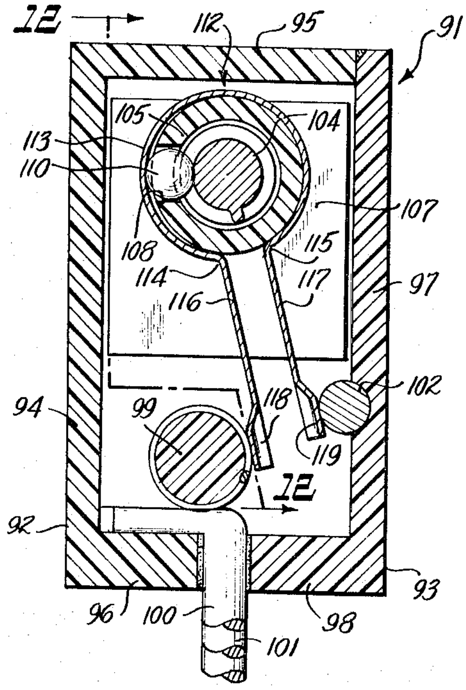

Fig. 11.

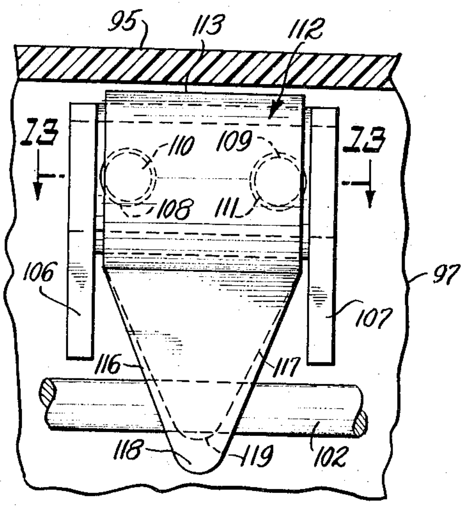

Fig. 12.

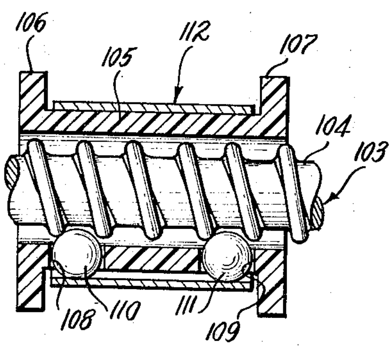

Fig. 13.

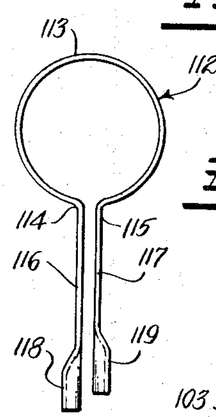

Fig. 14.

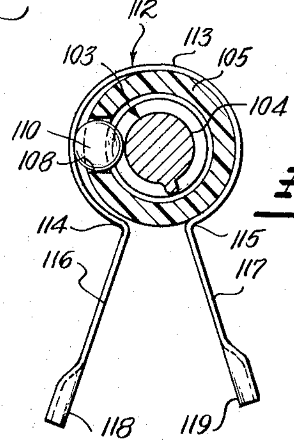

Fig. 15.

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POTENTIOMETERS

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Filed Sept. 26, 1966, Ser. No. 581,943
9 Claims. (Cl. 338—183)

This invention relates to potentiometers, and more particularly, to miniature potentiometers of the type including an elongated resistance element, a movable contact slidably engaging the resistance element, and a lead screw parallel to the resistance element and arranged to drive the movable contact rectilinearly along the resistance element.

Such potentiometers are commonly produced in very small sizes, typically employing a casing in the form of an elongated rectangle on the order of 1.25" x 0.3" x 0.2". Because of the small size of such devises, prior-art workers have found it difficult to devise a structure wherein the lead screw and movable contact structure operate to complete satisfaction. Since the lead screw in such a device may have a diameter of only 0.08", the problems involved in attempting to assure positive and dependable operation will be readily appreciated.

A general object of the invention is to devise an improved lead screw and movable contact structure for miniature potentiometers.

Another object is to provide such a mechanism employing a metal lead screw and a spring metal contact structure, with the contact structure being insulated electrically from the lead screw.

A further object is to provide a miniature potentiometer of the lead screw operated type employing a movable contact structure formed as an integral unit from spring sheet metal stock, the arrangement being such that good contact pressures and dependably operative engagement with the lead screw are attained by using the resiliency of the contact structure.

Stated broadly, potentiometers according to the invention comprise an elongated casing, an elongated resistance element and a return conductor disposed longitudinally in the casing and spaced apart transversely, a longitudinally extending lead screw in the casing and spaced transversely from the locations of the resistance element and return conductor, a tubular body of electrically insulating material surrounding the threaded body of the lead screw, and a movable contact unit comprising an integral structure of spring sheet metal including a tubular body portion extending as an incomplete cylinder and having edge portions which are adjacent to each other when the body portion is relaxed and undistorted, and two contact arms each extending outwardly from a different one of the edge portions of the tubular body portion and each having a contact at its free end. The inner diameter of the body portion of the contact structure is smaller, when the body portion is relaxed and undistorted, than the outer diameter of the tubular body of electrical insulating material surrounding the lead screw. The body portion of the contact structure embraces the tubular body of electrical insulating material and, because of the difference in diameters, is deformed resiliently, causing the edge portions to spread apart and the contact arms to diverge outwardly. The contact arms extend into the space between the resistance element and the return conductor, that space being limited so that, with one contact engaged with the resistance and the other with the return conductor, the arms are forced toward each other, good contact pressure thus being maintained resiliently. The body portion of the contact structure has an inwardly projecting deformation engaged in the lead screw threads, so that rectilinear movement of

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the contact structure occurs as a result of turning of the screw. Advantageously, the tubular body of electrical insulating material is a thin sleeve of thermoplastic synthetic resinous material heat shrunk into uniform continuous engagement with the lead screw, in which case the inwardly projecting deformation on the contact structure engages the outer surface of the synthetic resinous material. Alternatively, a rigid cylinder of insulating material freely surrounds the metal lead screw and has at least one radial aperture in which a spherical body of insulating material is disposed, the resilient body of the contact structure embracing the cylinder and forcing the ball into engagement with the lead screw threads.

In order that the manner in which the foregoing and other objects are attained in accordance with the invention can be understood in detail, particularly advantageous embodiments thereof will be described with reference to the accompanying drawings, which form part of this specification, and wherein:

FIG. 1 is a perspective view of a potentiometer constructed in accordance with one embodiment;

FIG. 2 is an enlarged transverse sectional view taken on line 2—2, FIG. 1;

FIG. 3 is an end elevational view of a contact unit employed in the potentiometer of FIG. 1, showing the same in its relaxed or undistorted condition;

FIG. 4 is a side elevational view of the unit of FIG. 3;

FIG. 5 is a view, partly in transverse cross-section and partly in end elevation, showing the unit of FIG. 3 operatively engaged with the lead screw of the potentiometer of FIG. 1;

FIG. 6 is a longitudinal sectional view taken on line 6—6, FIG. 2;

FIG. 7 is a longitudinal sectional view taken on line 7—7, FIG. 2;

FIG. 8 is a bottom plan view of the potentiometer of FIG. 1;

FIG. 9 is a fragmentary transverse sectional view taken on line 9—9, FIG. 7;

FIG. 10 is a transverse sectional view taken on line 10—10, FIG. 7;

FIG. 11 is a transverse sectional view, similar to FIG. 2, of a potentiometer constructed in accordance with another embodiment of the invention;

FIG. 12 is a fragmentary view, partly in longitudinal section and partly in side elevation, of a portion of the potentiometer of FIG. 11;

FIG. 13 is a fragmentary longitudinal view, with some parts shown in elevation, taken on line 13—13, FIG. 12;

FIG. 14 is an end elevational view of the contact structure of the potentiometer of FIG. 11, showing the same in its relaxed or undistorted condition; and

FIG. 15 is a view, partly in transverse cross-section and partly in end elevation, of the contact structure of FIG. 14 applied to a cylindrical carriage forming part of the potentiometer of FIG. 11.

Turning now to the drawings in detail, the casing 1 comprises half sections indicated generally at 2 and 3 respectively. Half sections 2 and 3 are each in the nature of an integral unit molded of suitable synthetic resin material, such for example as a conventional glass filled diallyl phthalate composition, having good electrical insulating properties. When assembled, casing 1 includes two spaced opposite sides 4 and 5, a third side 6, and a fourth side 7, all four sides having rectangular outer surfaces. As seen in FIGS. 1 and 2, sides 6 and 7 are narrower than are sides 3 and 4, so that the transverse cross-section of the casing is a rectangle which is elongated in the direction in which sides 6 and 7 are spaced apart.

Half section 2 comprises sides 4 and 6, while half section 3 comprises sides 5 and 7 plus two end portions 8 and 9. As will be clear from FIGS. 1, 2, 6 and 7, the end portions of side 4 extend across flat side faces 10 and 11, respectively, of casing portions 8 and 9 and are provided with circular openings which accommodate cylindrical projections 12 and 13 formed on end portions 8 and 9, respectively. Bores 14 and 15 are provided in end portions 8 and 9, respectively, and extend transversely of the casing, each bore 14, 15 having its axis centered relative to the corresponding projections 12, 13. The latter are of such length that, with the casing fully assembled, the ends of projections 12 and 13 lie in the plane of the outer surface of side 4. Bores 14 and 15 are provided to accommodate suitable mounting rods or bolts (not shown) when two or more of the potentiometers are to be mounted side-by-side with side 4 of one potentiometer in engagement with side 5 of the next potentiometer.

While the outer surface of side 4 is completely flat, the inner surface is of stepped configuration arising from the fact that the edge portion 16, FIG. 2, of side 4 most distant from side 6 is relatively thin, the intermediate portion 17 is thicker, and the portion 18 of side 4 adjacent side 6 is still thicker. The inner surfaces of portions 16 and 17 are joined by a shoulder 19, and the inner surfaces of portions 17 and 18 by a shoulder 20, shoulders 19 and 20 facing away from side 6. As best seen in FIG. 6, the end portions of side 4 which overlie faces 10 and 11 of casing end portions 8 and 9 are of the same thickness as portion 16 throughout their entire extent. Accordingly, thicker portions 17 and 18 extend longitudinally only for the distance between the respective inner faces 21 and 22 of casing end portions 8 and 9.

Side 6 extends longitudinally only between faces 21 and 22 of casing end portions 8 and 9. For most of its width, this side is of the same thickness as portion 18 of side 4. The edge portion 23, FIG. 2, of side 6 most distant from side 4 is of reduced thickness, the inner surfaces of the two portions being joined by a longitudinal shoulder 24.

At points generally adjacent casing end portions 8 and 9, respectively, when the casing is assembled, side 4 is provided with circular apertures 25 and 26. A straight groove 27, of generally U-shaped transverse cross-section, is provided in the outer surface of side 4, one end of the groove opening into aperture 25, the groove extending from that aperture to the junction between the outer surfaces of sides 4 and 6 and there joining a like straight groove 28 in side 6. Groove 28 extends just beyond the longitudinal center line of side 6, terminating in a semi-circular end 29, FIG. 8, the center of curvature of end 29 lying on the longitudinal center line of side 6. The central axes of aperture 25, groove 27 and groove 28 lie in a common plane transverse to casing 1. A straight groove 30 in the outer surface of side 4 communicates with the second aperture 26 and joins straight groove 31 in the outer surface of side 6, groove 31 terminating in semi-circular end 32, the combination of aperture 26, groove 30 and groove 31 being in all material respects identical to that just described for aperture 25, groove 27 and groove 28.

A conventionally formed wire wound resistance element 32, FIGS. 2 and 6, is fixedly secured to half section 2, as by being cemented thereto with epoxy cement. Element 32 is elongated and of a diameter which, as seen in FIG. 2, is markedly smaller than the space between the inner surface of portion 18 of side 4 and the inner surface of side 5. The resistance element extends longitudinally along the junction between walls 4 and 6 and, as seen in FIG. 6, is longer than the space between apertures 25 and 26 but shorter than the space between faces 21 and 22 of casing end portions 8, 9. Terminal leads for the resistance element are provided in the form of conductors 33 and 34 which are, for example, of round nickel wire plated with gold.

As best seen in FIG. 2, conductor 33 includes a straight end portion 34 which projects inwardly through aperture 25 and terminates adjacent the corresponding end portion of resistance element 32. End portion 35 is connected electrically, and secured mechanically, to the resistance element by solder at 36. The outer end of portion 35 joins a straight portion 37 of the conductor in a right angle bend 38. Straight portion 37 extends through groove 27 and joins a second straight portion 39 in a right angle bend 40, portion 39 extending through groove 28 and joining an elongated straight end portion 41 in a right angle bend 42 such that portion 41 projects away from side 6 and lies in a plane which is at right angles to that side and contains the longitudinal center line thereof. Straight portions 37 and 39 of conductor 33 lie in respective engagement with the bottoms of grooves 27 and 28. As seen in FIG. 8, conductor 33 is of a diameter slightly shorter than the width of the grooves and markedly smaller than the depth of the grooves. The conductor is fixed to the casing by epoxy cement, as seen in FIG. 2, the cement completely filling the grooves 27 and 28 and completely covering all otherwise exposed portions of the conductor save for the elongated end portion 41, so that the conductor is properly insulated electrically.

The diameter of conductor 33 is significantly smaller than that of aperture 25. The space between end portion 35 and straight portion 39 is such that, considering manufacturing tolerances, end portion 35 will always be disposed within aperture 25 when the conductor is properly oriented and straight portion 39 is in engagement with the bottom of groove 28.

Conductor 34 is in all respects identical to conductor 33 and includes an end portion 43 projecting through aperture 26 and soldered to the remaining end of resistance element 32. Straight portions 44 and 45 of conductor 34 lie in grooves 30 and 31, respectively. Straight end portion 46 projects away at right angles from side 6 and lies in the plane containing end portion 41 of conductor 33 and the longitudinal center line of side 6. Conductor 33 is secured to casing 1, and appropriately insulated, by epoxy cement which fills grooves 30 and 31.

Side 5 of the integral unit constituting half section 3 is a flat portion of uniform thickness save for the presence of a straight longitudinally extending groove 47 of slightly more than semi-circular transverse cross-section. Groove 47 is provided in the inner surface of side 5 and is of a diameter significantly smaller than that of resistance element 32. The longitudinal edge 48 of side 5 is a flat surface adapted for flush engagement with the inner surface of the edge portion 23 of side 6. Groove 47 extends parallel to edge 48 and is spaced therefrom by a distance sufficiently greater than the diameter of resistance element 32 that, when the casing is fully assembled, the center line of groove 47 is spaced significantly farther from the outer surface of side 6 than is the center line of resistance element 32.

Side 7 of half section 3 is also a flat portion of uniform thickness and terminates in a flat longitudinal edge surface 49 adapted for flush engagement with the inner surface of edge portion 16 of side 4.

Sides 4 and 6 are at right angles, as are sides 5 and 7, and edge surfaces 48 and 49, and the inner surfaces of edge portions 16 and 23, are all so located that, when the two half sections of the casing are properly fitted together, the respective flat longitudinal edge surfaces 50 and 51 of sides 4 and 6 lie in the same planes as the outer surfaces of sides 7 and 5, respectively. The longitudinal edges at 50 and 51 are chamfered, as indicated respectively at 52 and 53, FIG. 2, and the end edges are similarly chamfered, as indicated at 54 and 55, FIG. 6, so that the two half sections can be secured together by epoxy cement which fills the triangular grooves provided by the chamfers.

As will be understood from a comparison of FIGS. 6, 7 and 10, casing end portion **8** is provided with a slot **56** which extends transversely of the casing and opens both through surface **10** and through surface **21**, the mouth of the slot at surface **10** being closed by portion **4a** of side **4**. Slot **56** is defined by a flat wall **57**, facing side **6**, a flat wall **58**, facing side **7**, and an inner wall **59** which is of semi-circular transverse cross-section and slants from a point at the longitudinal center line of side **6** to a pivot adjacent the inner surface of side **5** at the end of groove **47**. Walls **57** and **58** are parallel to each other and to the transverse edges of casing end portion **8**.

Slot **56** and groove **47** accommodate a return conductor **60** which can be of round, gold plated nickel wire of the same diameter as lead conductors **33** and **34**. Conductor **60** includes a straight portion **61** disposed in and extending for the full length of groove **47**, a straight portion **62** extending in engagement with wall **59** of slot **56**, and a straight elongated end portion **63** projecting at right angles away from side **6**, so that conductor portions **41**, **46** and **63** all lie in a common plane at right angles to side **6** and including the longitudinal center line thereof. Slot **56** is completely filled with epoxy cement, so that return conductor **60** is fixed to the casing and only terminal portion **63** is exposed uninsulated. Tip **64** is disposed in groove **47** at face **22** of casing end portion **9**.

Casing end portion **8** is provided with a cylindrical recess **65** which opens through face **21** and is coaxially aligned with a through bore provided in end portion **9** and comprising a cylindrical inner portion **66** and a cylindrical outer portion **67**, the latter being of larger diameter than portion **66** so that a transverse annular shoulder **68** is provided. A metal lead screw, indicated generally at **69**, extends longitudinally of the casing and includes a plain cylindrical tip **70** rotatably engaged in recess **65**, a threaded body portion **71** extending between faces **21** and **22**, a smaller plain cylindrical portion **72** journaled in bore portion **66**, and a larger cylindrical head portion **73** disposed in and projecting outwardly from bore portion **67**, the head portion having a suitable slot **74** to receive an operating tool. At the inner end of portion **72**, the lead screw has a transverse annular groove accommodating a U-shaped retaining plate **75** which cooperates with casing end portion **9** to prevent longitudinal removal of the lead screw from the assembled casing, and presents a surface which faces toward the opposite end of the casing and, in effect, is a continuation of face **22**. Portions **72** and **73** are joined by a transverse annular shoulder which cooperates with shoulder **68** to limit longitudinal movement of the lead screw inwardly relative to the casing. Adjacent this shoulder, head portion **73** has a transverse annular groove **76** which accommodates an O-ring **77**, providing a fluid-tight seal between the lead screw and the casing.

Threaded portion **71** of the lead screw is completely covered by a thin, uniform sheath **78** of electrical insulating material. Advantageously, sheath **78** is in the form of a thin walled tube of synthetic resinous material shrunk onto the threaded body portion of the lead screw in such fashion as to lie in continuous, uniform contact therewith and thus assume precisely the surface configuration of the threaded portion of the lead screw so that the lead screw thus presents a non-conductive threaded surface. Typically, a tube or sleeve of heat shrinkable thermoplastic material having good anti-friction characteristics, e.g., polyethylene or polytetrafluoroethylene, is slipped over the body portion **71** of the lead screw and is then shrunk into tight uniform engagement therewith by application of heat.

Cooperating with the lead screw is a movable contact structure indicated generally at **79** and shown in detail in FIGS. 3–5. Structure **79** is formed as an integral unit from spring sheet metal such, for example, as beryllium-copper alloy, and includes a body portion **80** which is bent cylindrically, and a pair of elongated contact arms **81** and **82** projecting respectively from the longitudinal edge portions **83** and **84** of the body portion. Edge portions **83** and **84** are bent outwardly and the relaxed configuration of the structure is such, as seen in FIG. 3, that the edge portions are in side-by-side engagement with each other, with contact arms **81** and **82** also extending in mutual engagement. Arm **81** terminates in a contact tip **85** bent into shallow U-shaped transverse cross-section tip **85** being concave relative to arm **82**. Arm **82** similarly terminates in a contact tip **86** of shallow U-shaped transverse cross section, tip **86** being concave relative to arm **81**. Arm **81** is slightly longer than arm **82**. At a point midway in its length and diametrically across from edge portions **83**, **84**, the tubular body portion **80** is provided with an inwardly projecting hemispherical dimple **87**, FIGS. 3 and 4, of such size as to project into and be closely embraced by the valley of the continuous thread presented by the lead screw, when body portion **80** resiliently embraces the threaded portion of the lead screw.

As will be clear from a comparison of FIGS. 3 and 5, the inner diameter of body portion **80** is significantly smaller than the effective outer diameter of the threaded portion of the lead screw, when the contact structure is in the relaxed condition seen in FIG. 3. The movable contact structure is operatively installed on the lead screw, as the latter is inserted through casing end portion **9**, by spreading contact arms **81** and **82** apart and thus increasing the inner diameter of body portion **80** to such an extent that it can be slipped over the tip **70** of the lead screw and onto threaded portion **71**, the contact arms then being released to allow body portion **80** to contract resiliently and forcibly embrace the continuous ridge of the thread presented by sheath **75**. Since the effective diameter of the ridge is significantly larger than the normal or relaxed inner diameter of tubular body portion **80**, the edge portions **83** and **84** are now spaced apart, as seen in FIG. 5, and contact arms **81** and **82** therefore diverge outwardly to such an extent that contact tips **85** and **86** are spaced apart by a distance substantially greater than the space between resistance elemnt **32** and return conductor **60** in the assembled potentiometer.

Lead screw **69** and contact structure **79** are installed on casing half section **3** before the latter is secured to half section **2**. The contact structure, with arms **81** and **82** diverging as seen in FIG. 5, is rotated on the lead screw to bring contact tip **86** into engagement with return conductor **60**. Resistance element **32** and its lead conductors having been installed on half section **2**, the assembly of half section **3**, return conductor **60**, lead screw **69** and contact structure **79** is moved laterally (from right to left as viewed in FIG. 2) in such manner that contact tip **85** first comes into engagement with resistance element **32** and edges **48** and **49** then come into proper respective engagement with edge portions **23** and **16**, such movement causing the contact structure to be resiliently deformed in such manner that arms **81** and **82** become generally parallel and spaced apart, as seen in FIG. 2. Because of such deformation, and the fact that the contact structure is formed from spring stock, contact tips **85** and **86** are urged resiliently into good sliding engagement with resistance element **32** and conductor **60**, respectively.

Since the combination of arms **81** and **82** is disposed between resistance element **32** and conductor **60**, and since body portion **80** firmly embraces sheath **78**, the contact structure is held against rotation. When lead screw **79** is turned, engagement of dimple **87** in the valley of the continuous thread presented by sheath **78** causes the contact structure to be moved longitudinally along the lead screw, in a direction depending on the direction of rotation of the screw, with contact tips **85**, **86** therefore sliding along resistance element **32** and return conductor **60**, respectively.

Faces **21** and **22** of the casing end portions constitute stops to limit the extent of travel allowed the contact structure. When the lead screw has been turned to such an extent that body **80** engages one of faces **21**, **22** and turning of the screw in that direction is then continued, body **80** is resiliently deformed in such fashion as to allow dimple **87** to disengage from the valley of the screw thread once during each turn of the screw, so that the excessive turning of the screw is permitted without damage. Such deformation is essentially an increase in diameter of body portion **80**, with edge portions **83** and **84** spreading further apart and therefore moving slightly around the periphery of sheath **78** in directions away from side **6**. In this connection, the lengths of arms **81** and **82**, and particularly of contact tips **85** and **86**, are adequate to assure that the contact tips will remain properly engaged with the resistance element and return conductor.

From FIG. 6 it will be noted that the ends of resistance element **32** are respectively adjacent faces **21** and **22**, and that conductor **33** is spaced from face **21** by a greater distance than conductor **34** is spaced from face **22**. Referring again to FIG. 4, dimple **87** is equidistant from the ends **80*a*** and **80*b*** of body portion **80** of the contact structure **79**, but contact arms **81**, **82** are offset longitudinally of the body portion toward end **80*b***. The contact structure is installed on the lead screw with end **80*b*** directed toward head **73** and, therefore, toward face **22**. Accordingly, the longer distance between end **80*a*** and the contact arms accommodates the greater spacing between face **21** and conductor **33**, still allowing the contacts **85** and **86** to be at the location of conductor **33** when end **80*a*** engages face **21**.

In the embodiment shown in FIGS. 11–15, casing **91** comprises sections **92** and **93** secured rigidly together to define an elongated rectangular cavity. Section **92** provides side walls **94** and **95** and a wall portion **96**. Section **93** provides side wall **97** and a wall portion **98**, the latter cooperating with portion **96** to form a complete rectangular wall. Elongated resistance element **99** is carried by section **92** and connected at its ends respectively to longitudinally spaced conductors **100** and **101**. Return conductor **102** is secured in a groove in the inner face of wall **97**.

A metal lead screw **103**, journaled in the end portions of the casing, includes a threaded body portion **104** which extends longitudinally through substantially the entire cavity defined by the casing. A rigid cylindrical body **105** of suitable electrical insulating material surrounds the threaded body of the lead screw, the inner diameter of body **105** being slightly larger than the maximum diameter of the lead screw body. Body **105** has transverse annular outwardly projecting end flanges **106** and **107**. A radially directed cylindrical aperture **108** is provided adjacent end flange **106**, and an identical aperture **109** is provided adjacent end flange **107**, apertures **108** and **109** being longitudinally aligned and spaced apart by a distance such that, as seen in FIG. 13, both apertures can be simultaneously directed toward valley portions of the lead screw thread. The two apertures respectively accommodate rigid spherical bodies **110** and **111** of electrical insulating material, such as glass, bodies **110** and **111** being identical and of a diameter significantly greater than the thickness of the wall of cylindrical body **105**.

Contact structure **112** is formed as an integral unit from spring sheet metal and comprises a tubular body portion **113** which extends as an incomplete cylinder having edge portions **114** and **115**. Contact arms **116** and **117** extend outwardly from edge portions **114** and **115**, respectively, the arms terminating in contacts **118** and **119**, respectively. When contact structure **112** is in its relaxed, undistorted condition, as seen in FIG. 14, edge portions **114** and **115** are in engagement, and contact arms **116** and **117** extend in face-to-face engagement with each other. In this condition, the inner diameter of body portion **113** is significantly smaller than the outer diameter of body **105**. Accordingly, when body portion **113** of the contact structure is snapped onto body **105**, the difference in diameters causes body portion **113** to be resiliently distorted to a larger diameter, so that edge portions **114** and **115** are spread apart and arms **116** and **117** diverge outwardly, as seen in FIG. 15. As will be seen from a comparison of FIGS. 11 and 15, the space between resistance element **99** and return conductor **100** is substantially less than the normal space between contacts **118** and **119** when arms **116** and **117** are allowed to diverge freely as shown in FIG. 15. Accordingly, when the potentiometer assembly is completed by placing casing sections **92** and **93** together, arms **116** and **117** are resiliently deformed toward each other, assuring good pressure between contacts **118** and **119**, on the one hand, and the resistance element and return conductor, respectively, on the other hand.

Body portion **113** is of such length as to occupy most of the space between end flanges **106** and **107**, and engagement of body portion **113** with both bodies **110** and **111** is thus assured. The diameter of bodies **110** and **111** is sufficient to assure that body portion **113** bears directly on bodies **110** and **111** when the latter engage the lead screw, and the spherical bodies are thus resiliently urged into rolling contact with the thread of the lead screw. Accordingly, since engagement of the contacts with the resisance element and return conductor prevents contact structure **112** from turning, rotation of the lead screw will result in rectilinear movement of the contact structure. In this regard, the frictional engagement between body portion **113** and body **105**, and the fact that the inner surface of body **105** is spaced outwardly from the lead screw, assure that body **105** will not turn relative to the contact structure.

Though bodies **110** and **111** can have any angular orientation within the confines of all of the body portion **113**, it is desirable to have bodies **110** and **111** disposed in a radial plane which is at an angle to the radial plane extending midway between contact arms **116** and **117**, as illustrated in FIG. 11.

Both embodiments of the invention hereinbefore described have the advantages of ease of manufacture and assembly, and are further characterized by the fact that resilient deformation of the contact arms toward each other, by reason of engagement of the contacts with the resistance element and return conductor, assures not only adequate contact pressure but also a constant resilient biasing of element **87**, FIGS. 3 and 4, and elements **110**, **111**, FIGS. 11 and 13, inwardly into operative engagement with the threads of the lead screw means.

Attention is called to my copending application Ser. No. 581,942, filed concurrently herewith and directed to the casing and lead means aspects of the embodiment shown in FIGS. 1–10.

While preferred embodiments of the invention have been described to illustrate the invention, it will be understood that various changes and modifications can be made therein without departing from the scope of the invention as defined in the appended claims.

What is claimed is:

1. In a potentiometer, the combination of an elongated casing having transversely spaced side walls; an elongated resistance element and a return conductor disposed in said casing and extending longitudinally thereof, said resistance element and said return conductor being spaced apart in the direction of the spacing between said side walls; elongated lead screw means extending longitudinally within said casing parallel to said resistance element and said return conductor, said lead screw means being spaced transversely from the locations of said resistance element and said return conductor; and a movable contact unit comprising an integral unit of spring sheet metal including a tubular body portion extending cylindrically and having edge portions which are adjacent to each other when said body portion is in its relaxed, undistorted condition, and two contact arms each extending outwardly from a different one of said edge portions and each having a contact at its free end, the potentiometer further comprising a tubular body of electrical insulating material surrounding said lead screw means and having a maximum outer diameter significantly larger than the inner diameter of said tubular body portion of said contact unit when said body portion is in said relaxed, undistorted condition, said body portion embracing said tubular body of electrical insulating material and being resiliently deformed by reason of said difference in diameters, whereby asid edge portions are spaced apart and said contact arms tend to diverge outwardly, said contact arms extending into the space between said resistance element and said return conductor, with said contact of one arm slidably engaging said resistance element and said contact of the other arm slidably engaging said return conductor, the space between said resistance element and said return conductor being significantly smaller than the space which would exist between said contacts if said arms were allowed to diverge at the angle established by said difference in diameters, whereby said arms are resiliently deformed toward each other and said contacts are correspondingly urged respectively against said resistance element and said return conductor, said movable contact unit including means resiliently urged inwardly into operative engagement with the threads of said lead screw means by said tubular body portion to effect longitudinal movement of said movable contact unit when said lead screw means is turned.

2. A potentiometer according to claim **1**, wherein said lead screw means comprises a threaded metal lead screw body and a thin tubular layer of synthetic resinous material completely enclosing said threaded body and lying in continuous contact with the threaded surface thereof so as to present an outer surface conforming to the threads of said lead screw body, said thin tubular layer constituting said tubular body of electrical insulating material and being directly embraced by said body portion of said movable contact unit.

3. A potentiometer according to claim **2**, wherein said casing includes longitudinally spaced end portions in which said lead screw means is journaled, said tubular layer of synthetic resinous material extending substantially the entire distance between said end portions, said end portions presenting stop faces exposed for engagement by the respective ends of said tubular body portion of said movable contact unit, continued rotation of said lead screw body after such engagement being allowed by the resilience of said tubular body portion of said movable contact unit.

4. A potentiometer according to claim **2**, wherein said body portion of said movable contact unit has an inwardly projecting deformation directly engaging said outer surface of said tubular layer of synthetic resinous material, said deformation being located generally diametrically across said body portion from the space between said edge portions.

5. A potentiometer according to claim **3** and further comprising lead means comprising a first conductor connected to one end portion of said resistance element and extending laterally away from said casing generally at the location of said one resistance element end portion, a second conductor connected to the other end portion of

said resistance element and extending laterally away from said casing generally at the location of said other resistance element end portion, and a third conductor connected to one end of said return conductor and projecting laterally away from said casing at one of said casing end portions, said one resistance element end portion and said first conductor being located adjacent said stop face of the other of said casing end portions and said other resistance element end portion and said second conductor being located adjacent said stop face of said one casing end portion, the longitudinal space between said stop face of said one casing end portion and said second conductor being significantly greater than the longitudinal space between said stop face of said other casing end portion and said first conductor, said lead screw means having a head portion longitudinally exposed at the end of said casing defined by said other casing end portion, said tubular body portion of said movable contact unit being elongated and said contact arms being offset longitudinally from the midpoint thereof toward one end of said contact unit, said one end of said contact unit being directed toward said stop face of said other casing end portion, the other end of said contact unit being directed toward said stop face of said one casing end portion.

6. A potentiometer according to claim **1**, wherein said lead screw means includes a threaded metal lead screw body, said tubular body of electrical insulating material is a rigid cylinder of such inner diameter as to be freely movable longitudinally relative to said lead screw body and provided with at least one radial aperture, said movable contact unit including a spherical body of electrical insulating material disposed in said aperture and having a diameter greater than the thickness of the wall of said cylinder, said tubular body portion embracing said cylinder in the area of said aperture and therefore urging said spherical body into engagement with the threads of said lead screw, said spherical body being freely rotatable in said aperture.

7. A potentiometer according to claim **6**, wherein said rigid cylinder has transverse annular outwardly projecting end flanges and said tubular body portion embraces said cylinder between said end flanges.

8. A potentiometer according to claim **7**, wherein said aperture is adjacent one of said end flanges, said cylinder being provided with a second radial aperture adjacent the other of said flanges, said movable contact unit further comprising a second spherical body of electrical insulating material disposed in said second aperture, said tubular body portion embracing said cylinder in the areas of both of said apertures.

9. A potentiometer according to claim **6**, wherein said spherical body is centered on a line which extends radially relative to said lead screw body and which is at an angle to said contact arms.

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