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2,798,137

POTENTIOMETER AND CONTACT THEREFOR

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Fig. 1.

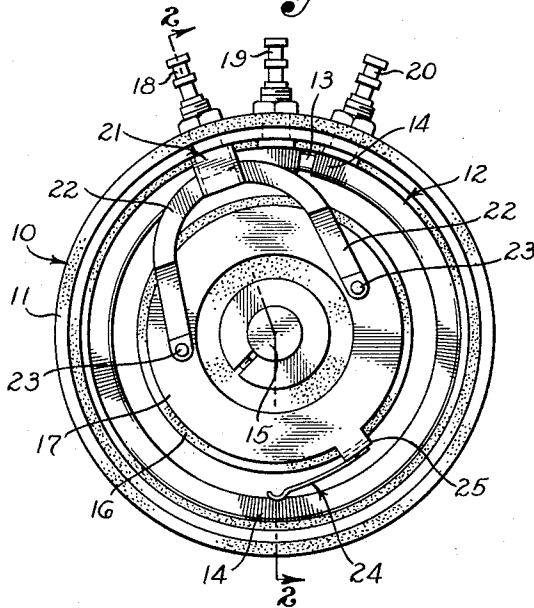


Fig. 2.

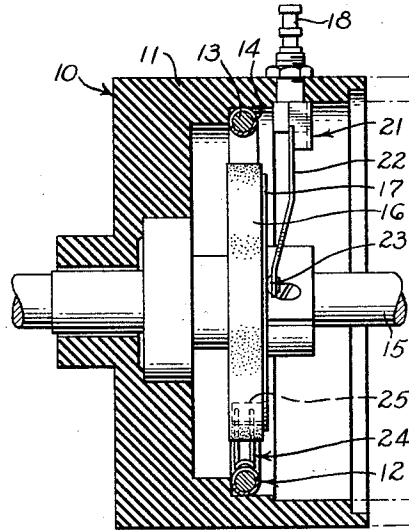


Fig. 3.

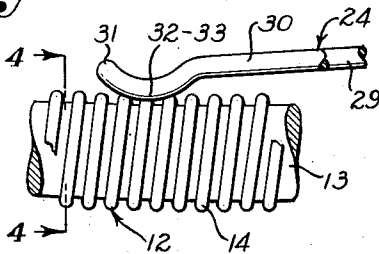


Fig. 4.

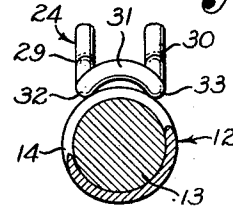


Fig. 5.

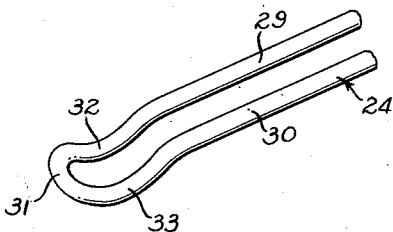
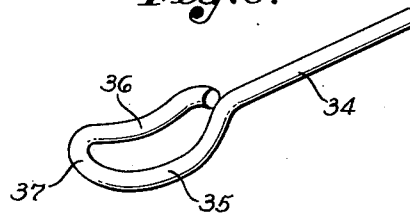


Fig. 6.



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POTENTIOMETER AND CONTACT THEREFOR

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This invention relates to potentiometers and to contacts therefor, the term "potentiometer" being herein used to include variable resistors as well as voltage-dividing potentiometers. The invention is particularly concerned with contacts for use in connection with a resistance element which is convex in shape.

The serviceability and life of a potentiometer depend in a large measure upon the construction of the movable contact. In the past, contacts of various sizes and shapes have been used without a complete study or analytical understanding of factors which must be considered in the design of a fully satisfactory precision-type potentiometer.

Two important problems which arise are the "noise" voltages created by the contact as it passes over the potentiometer windings and the wear of the contact and of the windings. Noise has been found to result from poor contact or from a transiently high resistance or open circuit as the contact moves across the windings. It is often amplified by other circuit elements and can sometimes lead to harmful results, such as upsetting electrical computer circuits which are coupled with high gain amplifiers.

As a moving potentiometer contact approaches an individual turn of a wire-wound resistance element, the contact has a certain amount of kinetic energy which may be computed by the formula $E = \frac{1}{2} mv^2$ where E is the kinetic energy, m is the mass of the contact, and v is its linear velocity in a forward direction transverse to the turns of the winding. In order for the contact to establish and maintain contact with the turns, it is designed to bear against the windings with a biasing force which may, under static conditions, be expressed simply by the constant F . When the contact strikes a turn of the resistance wire, it is displaced minutely in a direction opposite to the biasing force and a certain fraction K of the kinetic energy of the contact must be absorbed by the spring or resilient means which holds the contact against the winding. This absorbed energy results in a deflection of the contact away from the winding, and the deflection due to a single contact impulse has been found by analysis to be represented by the formula

$$x = \frac{Kmv^2}{2F}$$

where x equals the deflection and the remaining symbols are as have been defined. It has been found that these minute deflections are a major cause of noise in wire-wound potentiometers.

The deflection x represents an actual movement of the contact away from the winding. Generally, a completely closed contact represents a resistance of 1 ohm or less, while an air space in excess of 1 mil represents an infinite resistance at ordinary voltages. The deflection x is, however, customarily of the order of .1 mil or less. The exact amount of resistance which is introduced by the deflection x is difficult to define due to limited present-day knowledge regarding the electrical phenomena associated with contact openings of this order of magnitude.

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It is a well-known fact, however, that such deflections do greatly increase the resistance and result in a variation in contact voltage.

Referring to the formula for computing the deflection x , it may be seen that the amount of the deflection may be reduced by increasing the force F with which the contact bears against the winding. This results, however, in increased wear of both the contact and the windings, with a resulting shorter life for the potentiometer, not to mention increased operating torque. Decreasing the linear velocity of the contact is another possibility, but this is usually determined by the user of the potentiometer and is beyond the control of the manufacturer.

The factor K , which may also be considered a measure of roughness, or a "roughness factor," could be made quite small by lapping the contact and resistance element together, as with a polishing compound. Still, there is a practical limit to how "smooth" a resistance element can be made. Moreover, the smoothing operation, by thinning the windings, would shorten the potentiometer life, and also seriously and adversely affect linearity and precision of the resistance value.

This leaves the possibility of reducing the mass of the potentiometer contact in order to reduce the deflection. The problem is one of providing a contact which is light in mass, but which will nevertheless provide optimum contact when used in connection with a potentiometer resistance element which is convex in shape. Prior workers in this art have not recognized the critical relationship between contact mass and noise, nor the possibility of solving the very pressing noise problem by proper contact design.

It is an object of the invention to provide a contact, for use in a resistance means, which develops a minimum amount of noise voltage and has a maximum useful life. With my invention, reductions in noise voltage of 90% are common and reductions from several volts to less than a millivolt have sometimes been achieved. Wear measurements indicate that the amount, in volume, of my contact which is worn off is only 5–20% of the amount worn off standard contacts under similar conditions.

In essence, my invention contemplates a contact, for use in a resistance means, which is light in mass, which is preferably formed of wire or other suitable material, and which is shaped to provide at least two stable points of contact with the winding on opposite sides of a plane passing through the resistance element, the contact-making elements being stabilized and restrained from any tendency to separate from each other in consequence of their contact with oppositely-curved or sloping surfaces of the convex resistance element.

It is a further object of my invention to provide a contact which, because of outstanding low wear characteristics, may be used with all types of resistance wire, including those made of soft copper-nickel and magnesium alloys. This obviates the necessity for stocking several types of contact materials for use with different types of resistance wire, as is customary at the present time.

Another object is to provide a contact of small overall dimensions which may be used in applications where space is limited. A further object is to provide a contact on which, effectively, any desired contact face radius can conveniently be obtained, as demanded by varying diameters of resistance wire and spacing of turns.

It is an object of my invention to provide a contact which, because of its smaller mass, will provide better performance under conditions of vibration and shock than contacts which are presently in use. My contact will also remain noise-free at considerably higher operating speeds than conventional contacts, due to its higher resonant frequency.

It is an object of my invention to provide a potentiometer and contact therefor having two contact surfaces instead of one, so that noise voltages are reduced, particularly where the potentiometer is exposed to contamination from dirt, oxides, etc. Another object is to provide a contact having a smoother motion and less wear by being operated along its own grain direction instead of against the grain, as is commonly the case at the present time.

It is an object of the invention to provide potentiometers and contacts therefor having one or more of the features or advantages discussed above.

While I have shown in the accompanying drawings and detailed description preferred embodiments of my invention, it should be understood that the same are susceptible of modification and change without departing from the spirit of my invention.

In the accompanying drawing:

Fig. 1 is an elevational view, with the cover removed, of a potentiometer equipped with one embodiment of contact means of the invention;

Fig. 2 is a longitudinal sectional view taken along the line 2—2 of Fig. 1;

Fig. 3 is an enlarged elevational view of the contact means of Fig. 1;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 3;

Fig. 5 is a perspective view of the contact means of Figs. 1, 2, 3 and 4; and

Fig. 6 is a perspective view of an alternative embodiment of the contact means of the invention.

The invention may be used with straight, single-turn or multi-turn potentiometers. A single-turn embodiment which has been selected to illustrate my invention comprises a potentiometer 10 having an outer housing 11. Mounted within the housing 11 is a circular resistance element 12, which comprises a core 13 which is formed from a circular turn of wire, around which is wound a large number of turns of relatively fine-gauge resistance wire, comprising a resistance winding 14. The turns are space-wound or otherwise electrically insulated from each other.

Extending through the axis of housing 11 and rotatably mounted therein is a shaft 15. A rotor 16 is attached to shaft 15 and adapted to be rotated thereby. Rotor 16 is composed of electrically non-conducting material. Mounted on one side of rotor 16 is a circular slip ring 17 which is electrically conductive.

Extending from the outside of housing 11 are three electrical terminals 18, 19 and 20. Terminals 19 and 20 are respectively connected to the opposite ends of resistance winding 14. A brush 21 is attached to the opposite end of terminal 18 within the housing 11. Brush 21 has a pair of arms 22 which are formed of resilient material. Arms 22 are provided at their outer ends with a pair of contact points 23 and are bent slightly to bring contact points 23 into resilient contact with the outer surface of slip ring 17. The contact points 23 of brush 21 travel along a path adjacent the inner circumference of slip ring 17 when shaft 15 is rotated with respect to housing 11.

Means for establishing an electrical contact between slip ring 17 and resistance winding 14 is provided by a contact 24, which is mounted on the outside of rotor 16 on a base 25, which is attached and electrically connected to slip ring 17. Base 25 is a contact base and is bent at a right angle adjacent the edge of rotor 16 to extend along the outside thereof.

Attached to the bent portion of base 25, as by welding or soldering, are the base or rear portions of the contact 24. This contact is shown as comprising a loop of wire, typically a wire which is bent back upon itself to form a pair of substantially parallel contact elements or arms 29 and 30 joined by a bridge 31 adjacent the ends thereof. While various bridge means can be used to

connect the arms, a section of the wire, arched as shown in Fig. 4, is preferred. Arms 29 and 30 are provided adjacent their joined ends with a pair of arcuate portions 32 and 33 which are held in resilient engagement with side portions of the resistance element by use of any suitable biasing means, such as the arms 29 and 30, or either of them. The points of engagement occur on the surfaces of arcuate portions 32 and 33.

In use, connections to external circuit elements are customarily made at terminals 18, 19 and 20 of the potentiometer 10. The resistance between terminals 19 and 20 is the total resistance of winding 14. The amount of resistance between terminal 18 and terminal 19 or between terminal 18 and terminal 20 is determined by the position of contact 24, which is in turn dependent upon the rotation of shaft 15.

Referring to Fig. 3 of the drawings, it should be noted that while resistance element 12 is circular, any small portion thereof which is engaged by contact 24 can be considered as substantially cylindrical in shape. Referring to Fig. 4, it may be seen that resistance element 12 has a convex exterior or exposed surface with side portions which are oppositely sloped on opposite sides of a longitudinal plane passing through resistance element 12. The arcuate portions 32 and 33 of arms 29 and 30 thus engage oppositely-sloping portions of resistance element 12, which portions tend to force arms 29 and 30 apart from each other. Bridge 21 prevents such separation by joining arms 29 and 30 together at the opposite ends of arcuate portions 32 and 33 to hold arms 29 and 30 in fixed spaced relationship to each other. Without such bridge means joining arms 29 and 30, the movement of contact 24 along resistance element 12 would force arms 29 and 30 apart, resulting in poor electrical contact and increased noise voltage.

Another embodiment of my invention is shown in Fig. 6 of the drawings. In such embodiment, the contact comprises a single arm 34, formed from a piece of wire which is bent back upon itself in the shape of a loop. The loop is provided with a pair of arcuate portions 35 and 36, which are joined by a bridge 37. In this embodiment of my invention, bridge 37 serves the same purpose of preventing the portions of the contact which engage oppositely-sloping side portions of resistance element 12 from being separated from each other.

If desired, the arm or arms of the contact and the biasing means may be separate, although it is desirable that the arm or arms be somewhat resilient to aid in biasing the contact into engagement with resistance winding 12.

In operation, my contacts provide less noise voltage and less wear. One reason for the superior performance of my contacts is that they have greater agility in following the contours of successive winding turns of the resistance element, i. e., in mounting and dismounting the asperities which this discontinuous structure represents, while previous contacts have tended to dig into the asperities, producing longitudinal score marks and a condition of sustained roughness. Another benefit of my contacts is that the sliding motion is smoother along the grain of the contact rather than across the grain, resulting in less noise voltage and less wear due to such smoother movement.

Extensive and accurately-made tests, comparing potentiometers employing contacts of the invention with potentiometers equipped with conventional present-day contacts show that the invention is capable of reducing wear manyfold and to such an extent that wear is practically negligible even after 1,000,000 revolutions of the rotor; also that noise is very markedly reduced, sometimes as much as 90% or more, both initially and after such number of revolutions.

Various changes and modifications can be made without departing from the spirit of the invention as defined in the appended claims.

I claim as my invention:

1. A resistance means having a resistance element formed with oppositely-sloping portions on opposite sides of a longitudinal plane of such resistance element, a contact means, and means for guiding said contact means for movement relative to said resistance element in a direction parallel to said longitudinal plane, said contact means including a spring contact extending substantially in said direction parallel to said longitudinal plane and biased toward said resistance element, said contact having side-by-side spaced contact arms extending substantially in said direction and lying on opposite sides of said plane, said contact arms respectively engaging said oppositely-sloping portions of said resistance element in opposed contact areas as the sole electrical connection between said spring contact and said resistance element during said relative movement, said contact including a bridge means integral with said contact arms and interconnecting same against spreading under the bias of said spring contact when such contact arms engage said oppositely-sloping portions, said bridge means being on one side of a transverse plane traversing said resistance element and passing through said contact areas.

2. A combination as defined in claim 1 in which said means for guiding said contact means for relative movement in said direction includes a contact base, said contact arms comprising a mounting portion on the opposite side of said transverse plane, said mounting portion being secured to said contact base.

3. A resistance means having a resistance element formed with a longitudinal convex contact zone, said contact zone having oppositely-sloping side portions on opposite sides of a longitudinal plane passing through the center of said resistance element, a contact means relatively movable in a longitudinal direction with respect to said contact zone, means for biasing at least a portion of said contact means toward said contact zone of said resistance element, said contact means including a contact having spaced contact elements extending side by side along said resistance element in said longitudinal direction and respectively adjacent said oppositely-sloping side portions thereof, said contact elements having at least one mounting portion adjacent one end thereof and having opposed contact surfaces adjacent the other end thereof, said contact surfaces respectively engaging the oppositely-sloping side portions of said contact zone in opposed contact areas spaced from each other in a plane transverse to said resistance element, the engagement of said opposed contact surfaces with said opposed contact areas being the sole electrical connection between said contact means and said resistance element during such relative movement, the pressure exerted by said biasing means tending to move said contact elements farther apart, and bridge means extending between said other ends of said contact elements to maintain same in substantially fixed spaced relationship to each other irrespective of the pressure exerted by said biasing means, said bridge means being disposed near the contact surfaces of said contact elements.

4. A combination as defined in claim 3 in which said bridge means is disposed entirely on one side of said plane transverse to said resistance element.

5. A combination as defined in claim 3 in which at least one of said contact elements has a resilient portion integral therewith, said resilient portion holding the contact surface of such contact element in continuous engagement with said resistance element during relative movement thereof.

6. A resistance means comprising: a resistance element comprising a substantially cylindrical core and a plurality of turns of resistance wire wound helically on said core, said turns compositely providing a convex surface having oppositely-sloping portions on opposite sides of a

longitudinal plane passing through the center of said core; a contact relatively movable longitudinally of said resistance element and transversely with respect to said turns, said contact providing two contact arms extending side by side substantially parallel to but on opposite sides of said plane and being spaced from each other laterally of the direction of relative movement, said contact arms providing contact portions respectively engaging said oppositely-sloping portions of said resistance element in opposed contact areas, such engagement being the sole electrical connection between said contact and said resistance element during such relative movement, said contact including bridge means interconnecting said contact arms and maintaining same in substantially fixed spaced relationship to each other irrespective of contact pressure between said contact portions and said oppositely-sloping portions, said bridge means extending between said contact arms near said contact portions thereof; and means for mounting said resistance element and said contact for such relative movement with said contact portions of said arms pressing against said opposed contact areas to produce said contact pressure, said last-named mounting means including a contact base carrying said contact, and means for guiding said contact base to move said contact in said longitudinal plane with said contact arms on said opposite sides thereof.

7. In a resistance means having a longitudinal convex resistance element formed with oppositely-sloping portions on opposite sides of a longitudinal plane of said resistance element and a contact base relatively movable parallel to such plane, a contact means relatively movable along said resistance element and secured to said contact base, said contact means including: a single integral length of wire bent back upon itself comprising two contact elements joined by a bridge section of said wire, said contact elements lying on opposite sides of said plane and respectively engaging said oppositely-sloping portions of said resistance element during relative movement therealong, said bridge section maintaining said contact elements in substantially fixed spaced relationship to each other, said bridge section extending between said contact elements near said resistance element.

8. In a resistance means having a longitudinal convex resistance element formed with oppositely-sloping portions on opposite sides of a longitudinal plane of said resistance element and a contact base relatively movable parallel to such a plane, a contact means relatively movable along said resistance element and secured to said contact base, said contact means including: a pair of parallel lengths of a piece of wire joined by an integral bridge extending between the ends thereof, each of said parallel lengths including a contact element, said contact elements lying on opposite sides of said plane and respectively engaging said oppositely-sloping portions of said resistance element during relative movement therealong, said bridge section being adjacent the points of engagement of said contact elements with said resistance element, and maintaining said contact elements in substantially fixed spaced relationship to each other, said bridge section extending between said contact elements near said resistance element.

9. A contact means as defined in claim 8, in which said parallel lengths of wire are provided adjacent the ends thereof with arcuate portions adapted to engage said resistance element, said bridge section comprising an arch extending between the ends of said arcuate portions.

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