Aug. 14, 1956 H. R. BROWN, JR 2,759,078

COMPENSATED MINIATURE POTENTIOMETER AND METHOD OF MAKING

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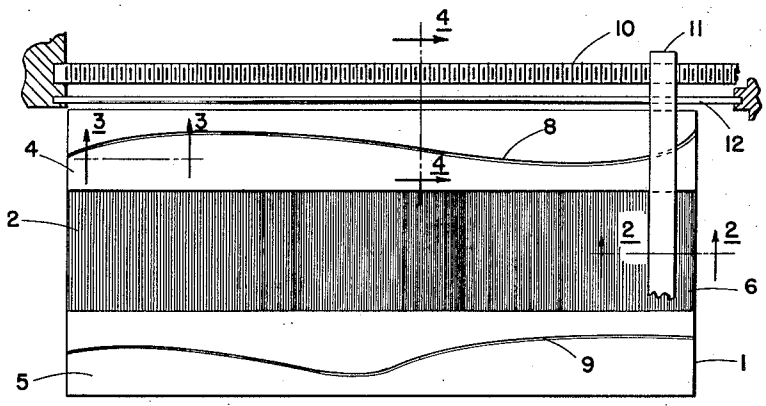

FIG. 1

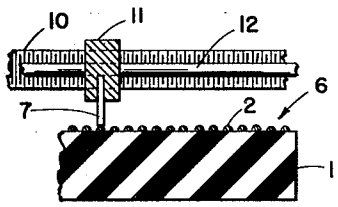

FIG. 2

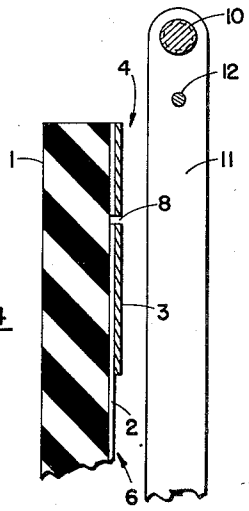

FIG. 4

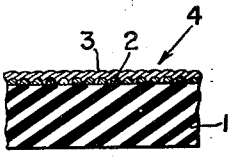

FIG. 3

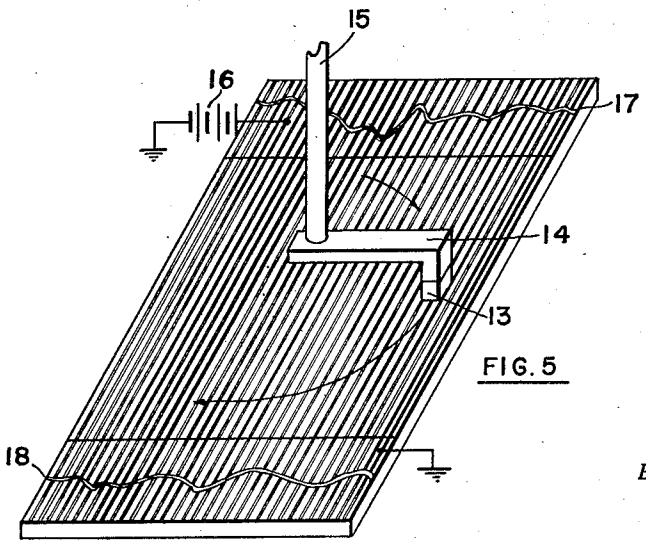

FIG. 5

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COMPENSATED MINIATURE POTENTIOMETER AND METHOD OF MAKING

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9 Claims. (Cl. 201—48)

This ivention relates to potentometers, and particularly to a resistance element for a miniature potentiometer.

Resistance elements for potentiometers have, in the past, been constructed either by winding many turns of resistance wire on a card or other structural form, or by applying to a strip of insulating material a film or layer of conducting material, the resistance of which is known. In order to make a potentiometer having nonlinear characteristics, i. e., a potentiometer in which the output resistance is not a linear function of the shaft rotation, it is necessary in the case of the first type of construction to vary the spacing of the wire wound upon the card, and in the case of the second type to vary the thickness or other characteristics of the resistance material. In the case of the wire-wound potentiometer, varying the spacing of the resistance wire results in serious limitations upon the resolution of the device; while in the case of the second mode of construction, variation in the thickness of the deposited film or layer of conducting material is difficult to achieve with any great accuracy.

This invention contemplates a potentiometer with a resistance element construction which combines the advantage of high resolution with ease of obtaining nonlinear characteristics of almost any predetermined kind.

It is therefore an object of this invention to provide a resistance element for a potentiometer which is easy to construct.

It is another object of this invention to provide a resistance element for a potentiometer which may be readily controlled as to linearity.

It is another object of this invention to provide an improved potentiometer.

It is another object of this invention to provide a resistance element for a potentiometer which is easy to mass produce.

It is another object of this invention to provide a potentiometer whose resistance is a predetermined function of the displacement of its wiper.

It is another object of this invention to provide a resistance element for a potentiometer having high resolution.

It is another object of this invention to provide a method of making a potentiometer resistance element which may be compensated to any desired function of resistance vs. displacement of the potentiometer wiper.

It is another object of this invention to provide an accurate method of producing a device which will yield a voltage proportional to the sine and cosine of any shaft rotation angle.

Other objects of invention will become apparent from the following description taken in connection with the accompanying drawings in which

Fig. 1 is a plan view of the invention;

Fig. 2 is a sectional view of the device shown in Fig. 1 taken at 2—2 in Fig. 1;

Fig. 3 is a sectional view of the device shown in Fig. 1 taken at 3—3 in Fig. 1;

Fig. 4 is a sectional view of the invention taken at 4—4 in Fig. 1;

And Fig. 5 is a perspective view of a modified form of the invention.

Referring to the drawings, a flat card or plate 1 of insulating material is covered with uniformly spaced conducting lines 2 laid in a transverse direction upon a card. These conducting lines are uniformly spaced at from 100th to 1,000th of an inch, on centers. A conducting film 3 is applied to zones 4 and 5 along the lateral edges of the card to cover the conducting lines and to provide a resistance to be obtained from the potentiometer. Central zone 6 is left uncovered by conducting film 3 to provide space for a wiper 7 which makes contact with conducting lines 2. Zones 4 and 5 are trimmed either by scribing lines or by simply cutting the card along lines 8 and 9. Wiper 7 is caused to traverse the card from end to end by rotation of lead screw 10. Wiper 7 is attached to lead nut 11 which is free to slide on stabilizing rod 12 when lead screw 10 is rotated.

In operation, connections are made to either end of the card and to wiper 7. Movement of the wiper along zone 6 produces a resistance which is the desired function of the displacement of wiper 7. It will be observed that conducting lines 2 do not contact each other directly, but make electrical contact through film 3 at either edge of the card. The resistance of the film between the conducting lines, of course, is a direct function of the cross-sectional area of the film therebetween. This cross-sectional area is determined, in part, by the position of trim lines 8 and 9. By trimming the potentiometer carefully any predetermined function of resistance vs. displacement may be obtained.

Lines 2 are laid on card 1 by applying a photosensitive coating to a thin film of metal such as fired silver paint or copper thermally evaporated in a vacuum which has previously been applied to card 1 which may be made of glass, ceramic, or a plastic. A photosensitive coating is then applied to the metal—which coating becomes less soluble when exposed to light. This coating is exposed to light through a photographic negative which incorporates accurately the equally spaced lines which are to be applied transversely of the card. The card and the photosensitive coating are then washed and the areas which have not been exposed to light are washed off, leaving these areas subject to chemical attack in an etching tank. The underlying metal in the areas exposed to light is therefore left, while the remaining area is etched away, leaving the lines as shown in Fig. 1. The photosensitive coating is then removed, and conducting film 3 is applied by evaporating a thin metal film upon zones 4 and 5 of the card. The card is then trimmed to attain the desired function of resistance vs. displacement, and is ready for use.

It is to be observed that wiper 7 does not contact the card in the areas covered by the conducting film so that repeated use of the device does not result in changes in the resistance characteristics of the device, nor in appreciable wear, the metal lines or conductors being capable of withstanding the slight abrasion of the wiper. Card 1 may be made up in great lengths and cut to the length desired for any given potentiometer, and each potentiometer may be trimmed individually to attain the characteristics desired.

The device shown in Fig. 5, which is a modified form of the invention, may be used to achieve sine and cosine functions to greater advantage. In Fig. 5, a short length of card, identical to card 1 of Fig. 1 is traversed by wiper 13 attached to arm 14 which in turn is rotated by shaft 15. Electrical connections are made to arm 14 and to both ends of the card. If it is desired to generate a voltage proportional to the sine or cosine of the

angle of rotation of shaft **15** a source of electromotive force such as a battery **16** is attached to a conducting line on one end of the card, and a conducting line on the opposite end of the card is connected to ground. If wiper **13** is caused to traverse a circular path upon the central portion of the card a voltage proportional to the sine or cosine of the angular displacement of shaft **15** is supplied to wiper **13** and may be picked off by any convenient means such as a slip ring from shaft **15**. Any slight discrepancies between the voltage picked up by wiper **13** and the true sine or cosine function of the angular displacement of shaft **15** may be compensated by trimming the card along lines such as lines **17** and **18** which are scribing through the conducting film laid down in the end areas of the card. The film on one of these end areas may be made somewhat thicker than the film on the other end area so that a relatively coarse trim may be achieved on one end, and a very precise trim may be achieved on the other end.

There is thus provided means for achieving a voltage or a resistance which is any predetermined function of either a linear or an angular displacement of a potentiometer wiper. Since the wiper traverses only the conducting lines and does not touch or affect the conducting film relied upon for electrical resistance, the device may be depended upon to furnish the identical function of resistance vs. displacement throughout its use. Since the conducting lines may be spaced very close together the resolution of the device is excellent.

Although the invention has been described and illustrated in detail, it is to be clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation, the spirit and scope of this invention being limited only by the terms of the appended claims.

I claim:

1. A resistance element for a potentiometer comprising an elongated sheet of insulating material, a plurality of spaced conducting lines placed transversely of said sheet, and a thin layer of resistance material having a higher resistivity compared to said conducting lines and positioned to cover a portion of each of said lines, said resistance material applied to at least one zone on said sheet leaving a zone on said sheet which is covered only by said spaced conducting lines.

2. A potentiometer adapted to be compensated accurately to a predetermined function of resistance versus displacement comprising a card of insulating material, a plurality of parallel conductors insulated from each other on one face of said card, a film of electrically conducting material covering a portion of said conductors along at least one end thereof on said card, said end being trimmed along a predetermined line to thereby vary the cross-section area of said film between adjacent conductors, and a wiper for making electrical contact with an uncovered central portion of said conductors along a predetermined path whereby the resistance between said wiper and one of said conductors is a predetermined function of the displacement of said wiper.

3. A device as recited in claim 2 in which said wiper is caused to describe a circular path on said card whereby the resistance between one of said conducting lines near the edge of said card and said wiper is a trigonometric function of the angular displacement of said wiper.

4. A potentiometer comprising a flat card of insulating material, a plurality of thin parallel conductors on one face of said card, a shaft disposed normally to said card and adjacent said conductors, an arm on the end of said shaft near said conductors and rotatable thereby, a wiper on the end of said arm for making contact with said conductors along a circular path in the central portion of said card, and a film of conducting material covering said conductors on the surface of the ends of said card the conducting film being of differing thickness on either end of said card and the widths of said conducting film

being adjusted predeterminately by selectively trimming the ends of said card whereby the resistance between one of said conducting lines not contacted by said wiper and said wiper is a predetermined function of the angular rotation of said shaft.

5. The method of making a potentiometer resistance element comprising applying a plurality of parallel conductors to an insulating plate, covering with a thin film of conductive material at least one end of said plate in a zone including a predetermined length of said conductors, and trimming said conductors in said zone to predeterminately modify the resistance characteristics of said potentiometer resistance element.

6. A method of making a potentiometer resistance element comprising providing a plurality of parallel conductors upon a suitable surface of insulating material, covering with a thin film of conducting material of different thicknesses each of the end portions of said conductors to interconnect them electrically, and trimming said end portions to thereby establish the unit linear resistance between said parallel conductors.

7. An improved potentiometer comprising a resistance element including a plurality of parallel insulated conductors and a conductive film having a predetermined resistivity covering a portion only of each of said conductors leaving a second portion of each of said conductors uncovered, the cross-section area of said film between adjacent conductors being adjusted to a predetermined value by selectively trimming said film and said covered portion of said conductors, and wiper means for making electrical contact with said conductors in said second portion thereof along a predetermined path whereby the resistance between said wiper and one of said conductors may be made to follow any predetermined function of the displacement of said wiper.

8. A potentiometer comprising a flat card of insulating material; a plurality of equispaced parallel conductors rigidly attached to one face of said card and extending to opposite edges of said card; a first layer of resistive material on said face covering a portion of said conductors along one of said edges; a second layer of resistive material on said face covering a portion of said conductors along the other of said edges, said first and second layers of resistive material having different thickness; and wiper means for making electrical contact with the uncovered center portions of said conductors whereby the electrical resistance between any two of said conductors is adjustable over a wide range of values by selective trimming of said two edges of said card to thereby vary the cross-section area of said layers of resistive material between said conductors.

9. A potentiometer comprising a card of insulating material; a plurality of parallel equispaced wires attached to one face of said card, said wires extending to at least one edge of said card; a layer of resistive material on said face covering a portion of said wires along said edge to a uniform depth; and a wiper for making electrical contact along a predetermined path with portions of said wires which are not coated with said resistive material whereby the electrical resistance between any two of said wires is adjustable by selectively trimming said edge of said card to thereby vary the cross-section area of said layer of resistive material between said wires.

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