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POTENTIOMETER RESISTANCE DEVICE EMPLOYING CONDUCTIVE PLASTIC AND A PARALLEL RESISTANCE

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FIG. 1.

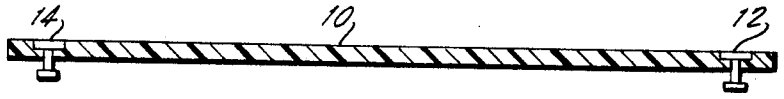


FIG. 2.

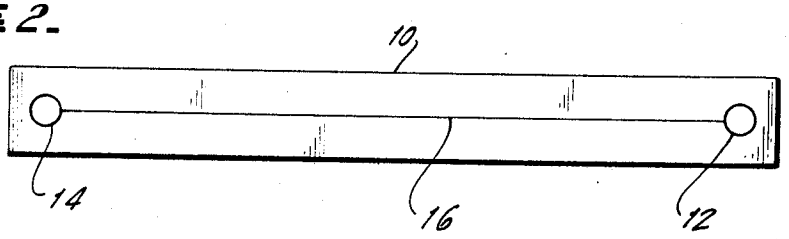


FIG. 3.

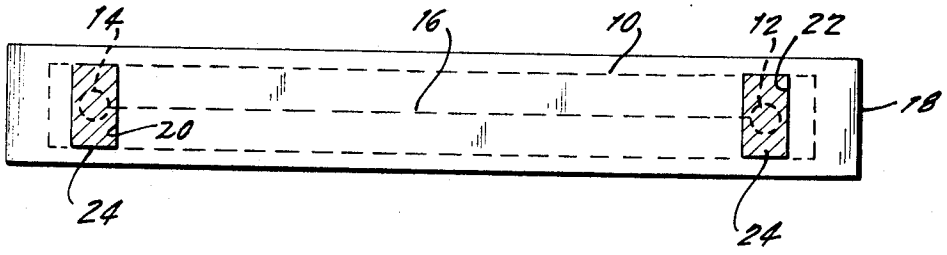


FIG. 4.

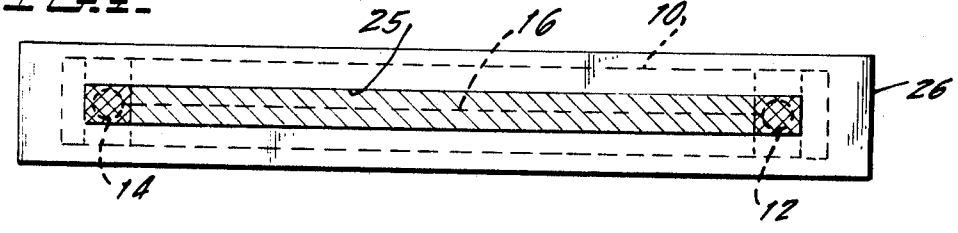
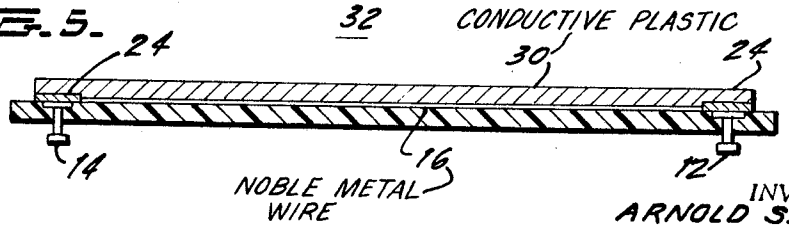


FIG. 5.



INVENTOR.
ARNOLD S. LOUIS

BY E. J. Berry

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POTENTIOMETER RESISTANCE DEVICE EMPLOYING CONDUCTIVE PLASTIC AND A PARALLEL RESISTANCE

Arnold S. Louis, Hastings-on-Hudson, N.Y., assignor to Markite Corporation, New York, N.Y., a corporation of New York

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10 Claims. (Cl. 338—9)

ABSTRACT OF THE DISCLOSURE

A potentiometer resistance device includes a conductive plastic track and a conductive element such as a noble wire in electrical parallel therewith. The resistance of the conductive element or wire is preselectively chosen relative to the resistance of the conductive track such that the equivalent resistance of the parallel arrangement will be influenced by only a fractional portion of the resistance characteristics of the conductive plastic. In this manner, the physical characteristics of the conductive track are taken advantage of while at the same time, the electrical characteristics of the conductive element are predominant.

This invention relates to precision potentiometers, and more particularly relates to improvements in the resistance elements of such potentiometers whereby desirable physical characteristics of certain materials may be taken advantage of while at the same time the effects of undesirable characteristics thereof may be minimized.

Broadly speaking, potentiometers may be described as including a resistive element upon which a contact, commonly designated a wiper, may travel to produce a voltage output proportional to the position of the wiper along the resistive element.

In early potentiometer development, the resistance element generally comprised wire strands or wire windings which, although they provided relatively small contact surface for the wiper and additionally were fragile and hence subject to poor wear over long periods of use, were still used because of their excellent resistance stability, especially when exposed to changes in humidity and temperature. To make the resistive element more rugged and to increase contact area, designers have turned to conductive plastic materials (conductive filler within a resinous insulation) which are generally characterized by excellent wear over extended periods of use while at the same time providing larger contact surface for the wiper. The utilization of conductive plastic has solved the problems of ruggedness and contact area but has one serious drawback, which up to now has been one of the main reasons for delaying complete acceptance of these materials for potentiometer resistance elements.

Specifically, it is a fact that most conductive plastics have a relatively poor resistance stability when exposed to high temperatures and high humidity environments (negative temperature coefficient of —100 p.p.m./° C. to —400 p.p.m./° C).

In accordance with the instant invention there is provided a resistance element for potentiometers which makes possible the utilization of conductive plastic to achieve the ruggedness and large contact area desired while at the same time minimize the affect that the relatively poor resistance stability thereof will have on the resistance device.

Specifically, and in accordance with the basic concept of the instant invention, a mathematical relationship of electrical resistances in parallel has been taken advantage of to the extent that two different resistive elements, a conductive plastic and a conductive element, preferably a

noble wire, may be combined in electrical parallel such that although the composite structure which results has the prevailing physical characteristics of rugged conductive plastic, the equivalent resistance of the composite structure is affected by changes in temperature and humidity only to a small fraction of the extent that the conductive plastic track alone would be affected by changes in temperature and humidity if it were not in parallel with the conductive element. As will be apparent from the example set out below, such fraction is proportional to the relative magnitudes of the conductivities of the conductive track and the resistance of the element.

For example, consider a conductive plastic track having a resistance of 10,000 ohms. If a conductive element such as a length of wire having a resistance of 1000 ohms is placed in electrical parallel with the conductive plastic track, by the well known law of electrical resistances in parallel, the resultant combination would have an equivalent resistance of approximately 900 ohms (909). Thus, it may be appreciated that the effect of the larger resistance of the conductive plastic track is to diminish the resistance of the wire by only 10%, the ratio of the resistance of the wire to the resistance of the plastic track. That is to say, the resistance of the conductive plastic track has relatively little effect on the overall resistance of the composite structure (only a 10% influence). Thus, and in accordance with the instant invention, this fact is taken advantage of so that if a predetermined change in humidity were to affect the resistance of the conductive plastic track, by say 2%, and assuming that the conductive wire is not affected at all by such humidity change (for all practical purposes this is true), then the equivalent resistance for the parallel arrangement of the conductive plastic track and the conductive wire would change by only .2%. This is necessarily so because all characteristics of the conductive track, including resistance stability, only affect the equivalent resistance of the parallel arrangement in accordance with the ratio of the magnitudes of the respective resistance.

Having set forth the basic concept of the instant invention, it should be apparent that its practice may be carried out in many different ways, the only prerequisite being an electrical parallel arrangement of the material (conductive plastic) which has the physical characteristics desired for the end product and a conductive element whose resistance is significantly smaller than the resistance of the chosen material.

In one preferred embodiment of the instant invention the conductive element takes the form of a length of wire which is placed along and in intimate electrical contact with the conductive plastic track. The composite resistance element is located on an insulative base in such a manner that the conductive wire is located between the conductive plastic track and the insulative base so as not to interfere with the potentiometer wiper which travels along the opposite surface of the track.

As will be set out in greater detail, one preferred method of manufacturing such composite resistance device is to first place the conductive wire between two terminals provided on the insulative base; spray a silver paint at the joints of the wire and the terminals to assure good electrical contact therebetween; and finally, with the use of a suitable mask, spray the conductive plastic over the wire whereby, after curing, the composite structure may be abraded or polished to achieve the proper uniformity of resistance versus length.

In accordance with another aspect of the instant invention, it has been discovered that if the wire chosen is relatively non-oxidizing, i.e., noble metals, the intimacy of electrical contact between the wire and the conductive plastic is assured such that the degree of electrical contact

therebetween is constant with respect to time and gives a linear output for the composite device. When a non-noble wire is used, apparently the wire oxidizes and makes poor contact with the conductive plastic to produce a non-linear output.

Accordingly, it is an object of the instant invention to provide a potentiometer resistance device which advantageously combines the characteristics of two distinct constituents thereof.

Another object of the instant invention is to provide such a potentiometer resistance device which has the desirable physical characteristics of conductive plastic while at the same time the relatively poor resistance stability thereof is compensated for by the inclusion of a conductive element having relatively good resistance stability in electrical parallel therewith.

Still another object of the instant invention is to provide such a potentiometer resistance device whereby the equivalent resistance of the parallel arrangement of a conductive plastic track and a conductive wire will be affected by changes in humidity and temperature only to a fraction of the extent that the resistance of the conductive plastic track alone would be affected if it were not in parallel with the conductive wire.

Still another object of the instant invention is to provide such a potentiometer resistance device comprising a conductive plastic track in electrical parallel with a conductive wire whereby the equivalent resistance of such parallel arrangement is affected by characteristics of the conductive plastic track in accordance with a ratio defined by the resistance of the conductive wire/the resistance of the conductive plastic track.

Yet another object of the instant invention is to provide a potentiometer resistance device comprising a parallel arrangement of a plastic conductive track and a conductive wire whereby the composite structure has the physical characteristics of the plastic conductive track while at the same time the thermal characteristics of the conductive wire.

Another object of the instant invention is to provide such a potentiometer resistance device in which such conductive wire is primarily of a noble metal whereby the degree of electrical contact between the wire and the plastic conductive track is constant over extended periods of use.

Other objects and a fuller understanding of the instant invention may be had by referring to the following description and drawings, in which:

FIGURES 1–5 illustrate steps in the manufacture of one type of composite potentiometer resistance device which may be constructed in accordance with the principles of the instant invention.

Turning to the figures, there will be described with respect thereto a sequence of events which may be utilized in producing one type of potentiometer resistance device in accordance with the principles of the instant invention. However, it is to be understood that the method set forth is for the purpose of example only and that, as noted previously, there is a multitude of methods which could be utilized to produce a virtually limitless number of resistance devices in accordance with the basic concept outlined above. Thus in its broadest aspect the invention resides in being able to take advantage of desirable physical characteristics of a particular material, in this case the ruggedness of a conductive plastic and the large contact surface provided thereby, while at the same time minimize its undesirable thermal characteristics by combining it in electrical parallel with a conductive element, such as a wire, which has a significantly lower resistance such that the undesirable thermal characteristics of the chosen material will have relatively little effect on the resistance of the composite structure. Thus it may be appreciated that in the practical application of the invention to manufacture potentiometer resistance devices, such devices might be comprised of various materials and take different

shapes dependent upon the characteristics desired for the finished product.

Thus in FIGURE 1 there is shown an insulative substrate **10** which is to form the base of a potentiometer resistance device constructed in accordance with the instant invention. The base **10** is provided with metal terminals **12** and **14** at opposite ends thereof by means of which a potential may be impressed across the resistance device which is to be built upon the base **10**.

In FIGURE 2, a conductive wire **16** is soldered to the metal terminals **12** and **14**. As disclosed previously, the wire is ultimately useful in the composite resistance device which is to be formed because of its resistance stability with changes in humidity and temperature. For reasons to be set forth in greater detail, it may be noted that preferably the wire **16** is of noble metal (either entirely of noble metal or an alloy thereof).

As shown in FIGURE 3, the next step in the method is to overlie the base **10** with a mask **18** apertured at **20** and **22** such that a silver paint **24**, or other conductive media, may be sprayed upon the soldered joint connections of the terminals **12** and **14** and the conductive element or wire **16** to enlarge the common contact area therebetween and thereby permit the easy flow of current.

Finally, after the silver paint **24** has dried, a second mask **26** having an elongated aperture **28** is placed over the base **10** (see FIGURE 4) such that a conductive plastic material, such as a paint comprised of acetylene black dispersed in a phenolic varnish, for example 20% acetylene black and 80% phenolic varnish, may be sprayed so as to coat the wire **16** and the silver paint and also to form the track **30**, shown in cross-section in FIGURE 5, upon which the wiper (not shown) of the potentiometer may ultimately travel.

Finally, the conductive plastic is baked and then, if desired, abraded and polished to calibrate it to desired tolerances.

It will be appreciated that the conductive wire **16** is necessarily in electrical parallel with the conductive track **30** whereby, as noted previously, the equivalent resistance of the composite device **32**, in FIGURE 5, will be given by the equation

$$1/R_{eq}=1/R_{30}+1/R_{16}$$

where:

R_{eq}=the equivalent resistance of the composite device **32**;
R_{16}=the resistance of the conductive wire **16**; and
R_{30}=the resistance of the conductive track **30**;

solving for R_{eq},

$$\frac{R_{eq}=R/_{16}\cdot R_{30}}{R/_{16}+R_{30}}$$

whereby it may be appreciated that the larger the resistance R_{30} relative to R_{16}, the less affect the resistance R_{30} has upon the equivalent resistance, and consequently the less the relatively poor thermal resistance stability of the conductive track will have upon the equivalent resistance.

Thus it may be seen that for the numerical example given previously, it was possible for a 2% change in resistance stability of the conductive track to be translated into only a .2% change in the overall resistance. To make the practice of the instant invention significant, the resistance of the conductive track **30** should be at least three times as great as the resistance of the wire **16**.

As noted earlier, it has been found that it is particularly advantageous to use a noble wire or an alloy thereof for the conductive wire **16** as opposed to a non-noble metal. Apparently the non-nobel metal oxidizes to vary the degree of contact between the wire and the conductive track thereby giving the variable electrical output. With a noble wire, one that does not oxidize, the electrical contact between the conductive track and wire is uniform over extended use, and the output is thereby maintained constant.

Thus there has been described a potentiometer resistance device which has the desirable physical characteristics of a conductive plastic material, while at the same time the undesirable affects of the relatively poor resistance stability thereof has been minimized. It is to be appreciated that by varying the magnitudes of resistance of the conductive plastic material relative to the conductive element utilized therewith, then for all practical purposes, the relatively poor resistance stability of the conductive plastic may be ignored.

Although there has been described a preferred embodiment of this novel invention, many variations and modifications will now be apparent to those skilled in the art. Therefore, this invention is to be limited, not by the specific disclosure herein, but only by the appending claims.

I claim:

1. A potentiometer resistance device comprising:
a conductive plastic track having a first predetermined resistance; and
a conductive element in electrical parallel with said conductive plastic track, said conductive element having a second predetermined resistance which is less than said first predetermined resistance of said conductive plastic track;
said second predetermined resistance being selectively chosen relative to said first predetermined resistance to achieve a predetermined ratio therebetween;
whereby the equivalent resistance of the parallel arrangement of said conductive plastic track and said conductive element will be influenced by only a fractional portion of the resistance characteristics of said conductive plastic track, said fractional portion being proportional to the relative magnitudes of the resisttance of said track and element.

2. The potentiometer resistance device of claim 1, wherein said conductive plastic track has a poor resistance stability when exposed to high humidity environments relative to the resistance stability of said conductive element whereby, for all practical purposes, changes in said equivalent resistance due to changes in humidity may be attributed to said conductive plastic track only.

3. The potentiometer resistance device of claim 2, wherein the resistance of said track is significantly greater than the resistance of said conductive element whereby the affect of said poor resistance stability of said conductive plastic track will be materially reduced.

4. The potentiometer resistance device of claim 3, wherein the resistance of said conductive plastic track is at least three times as great as the resistance of said conductive element.

5. A potentiometer resistance device comprising:
a conductive plastic track having a predetermined resistance; and
a conductive element in electrical parallel with said conductive plastic track, said conductive element having a resistance which is less than the resistance of said conductive plastic track;
whereby the equivalent resistance of the parallel arrangement of said conductive plastic track and said conductive element will be influenced by only a fractional portion of the resistance characteristics of said conductive plastic track, said fractional portion being proportional to the relative magnitudes of the resistance of said track and element;
wherein said conductive plastic track has a poor resistance stability when exposed to high humidity environments relative to the resistance stability of said conductive element whereby, for all practical purposes, changes in said equivalenet resistance due to changes in humidity may be attributed to said conductive plastic track only;
wherein said conductive element is a metallic wire.

6. The potentiometer resistance device of claim 5, wherein said wire is of non-oxidizing material.

7. The potentiometer resistance device of claim 6, wherein said wire is primarily of noble metal.

8. The potentiometer resistance device of claim 6, wherein said wire is in juxtaposition with said conductive plastic track and in contact along its length therewith.

9. The potentiometer resistance device of claim 8, wherein the entire length of said wire is in intimate contact with said conductive plastic track.

10. The potentiometer resistance device of claim 9, wherein said conductive plastic track and said wire are positioned on an insulative base with said wire sandwiched between said base and said track.

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LARAMIE E. ASKIN, *Primary Examiner.*

E. GOLDBERG, *Assistant Examiner.*