

April 19, 1960

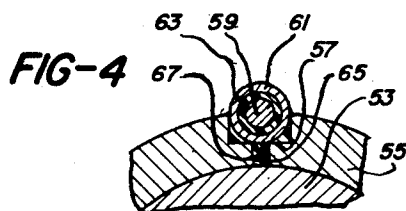
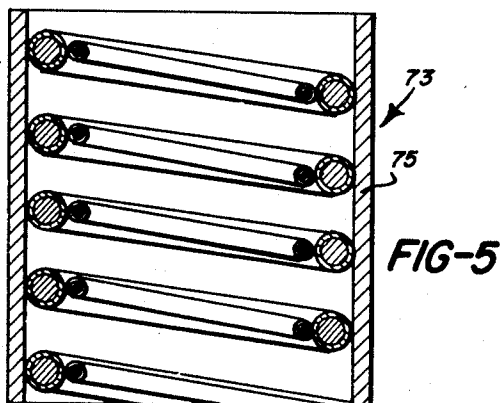
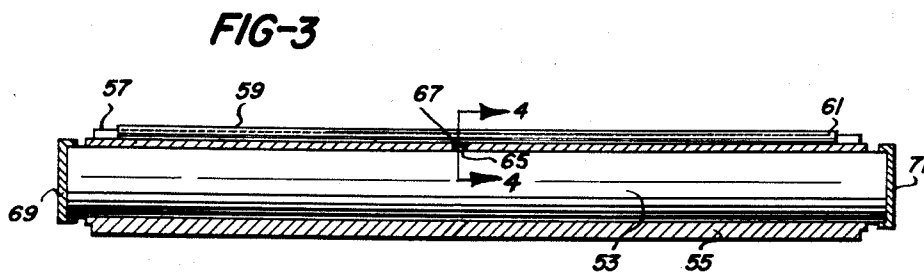
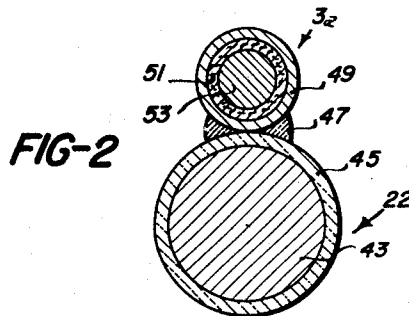
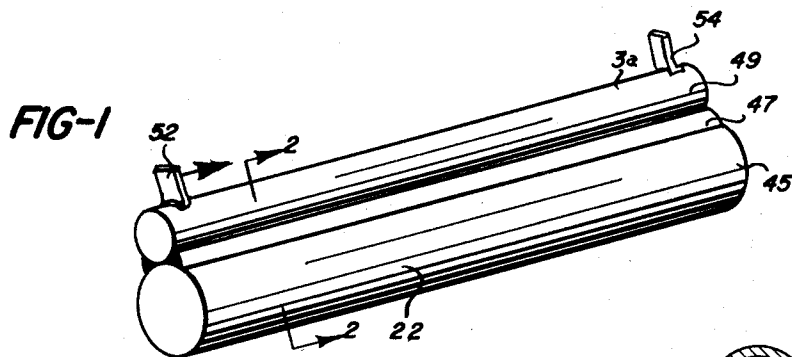
L. J. NOVAK ET AL

2,933,710

CONTINUOUSLY GAS PLATED WIRES FOR POTENTIOMETERS

Filed May 13, 1957

2 Sheets-Sheet 1



INVENTOR.
LEO J. NOVAK
JOHN R. WHITACRE
BY 

ATTORNEYS

April 19, 1960

L. J. NOVAK ET AL

2,933,710

CONTINUOUSLY GAS PLATED WIRES FOR POTENTIOMETERS

Filed May 13, 1957

2 Sheets-Sheet 2

FIG-6

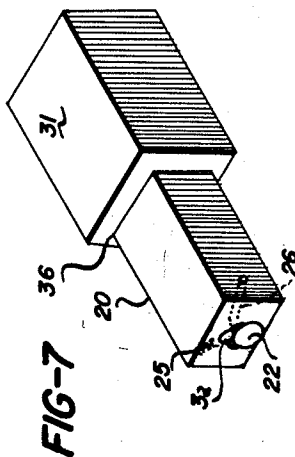
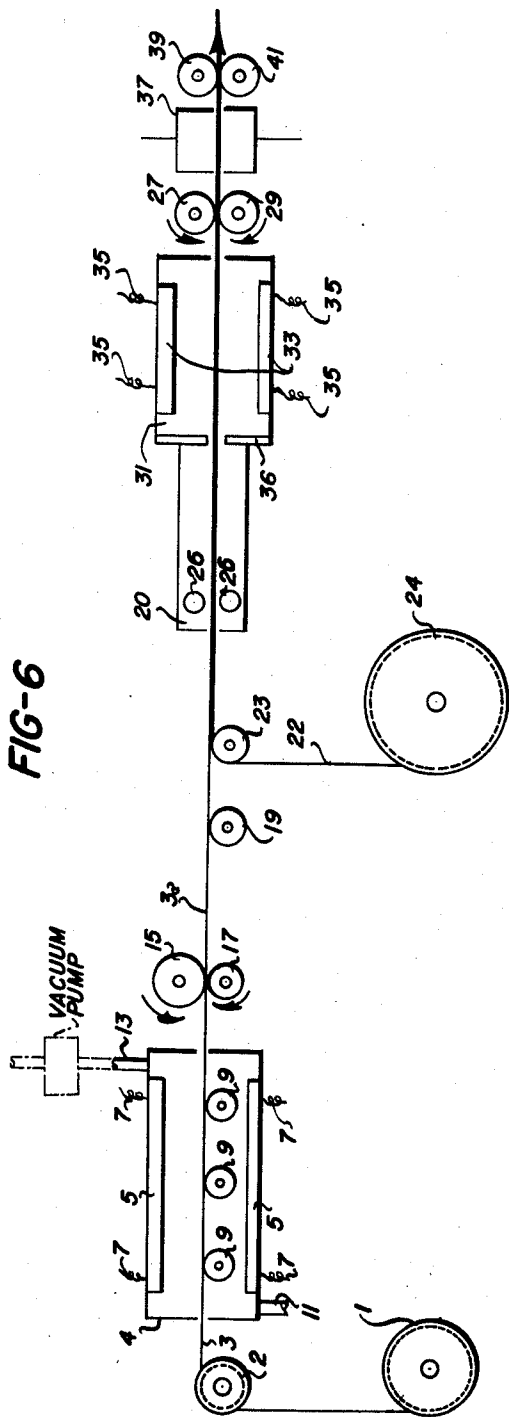


FIG-7

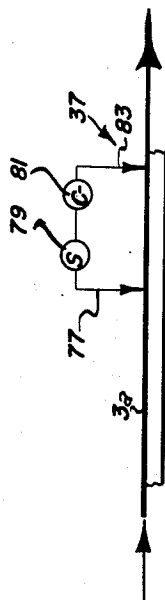


FIG-8

INVENTOR.
LEO J. NOVAK
JOHN R. WHITACRE
BY
Toulmin & Toulmin
ATTORNEYS

1

2,933,710

CONTINUOUSLY GAS PLATED WIRES FOR POTENTIOMETERS

Leo J. Novak and John R. Whitacre, Dayton, Ohio, assignors, by mesne assignments, to Union Carbide Corporation, New York, N.Y., a corporation of New York

Application May 13, 1957, Serial No. 658,675

8 Claims. (Cl. 338—308)

This invention relates to electrical resistance devices and to the manufacture thereof; more particularly the invention is directed to electrical resistance devices which in use are contacted by a moving element as in a potentiometer.

Various methods have been proposed for the production of electrical resistance devices and expedients have been devised to promote linearity in such devices in order that the resistance will vary uniformly in accordance with the movement of the potentiometer contactor. In general these procedures are laborious and expensive, and rely upon modifying a resistance element to attain the linearity rather than the production of an element with inherent characteristics of linearity.

It has now been found that relatively thin films of metal deposited from the gaseous state exhibit excellent linearity or high ohmic resistance when the film is supported in insulated relation and the electrical resistance thereof is measured over the film length. Accordingly a primary object of the present invention is to provide novel electrical resistance devices.

An important object of the invention is to provide a novel method of producing electrical resistance devices.

A particular object of the invention is to provide an electrical resistance device the physical structure of which may take various forms as, for example, a helical coil.

The invention will be more fully understood by reference to the following description and accompanying drawings wherein:

Figure 1 is a perspective view of an electrical resistance element in accordance with the invention;

Figure 2 is a sectional view taken substantially on line 2—2 of Figure 1;

Figure 3 is an elevational view and in section of a further modification of the structure of invention;

Figure 4 is a sectional view of the structure of Figure 3 somewhat enlarged and taken substantially on line 4—4 of Figure 3;

Figure 5 is a sectional view of yet another modification of the structure of invention;

Figure 6 is a schematic view illustrating apparatus for the formation of the structure of invention;

Figure 7 is a detail view in perspective of a portion of the apparatus of Figure 6; and

Figure 8 is a view illustrating a method of testing the electrical resistance of the product of the apparatus arrangement of Figure 6.

In the structure of invention the thickness of the metal deposit which forms the conductive component of the resistance element is an important factor. This thickness is maintained small as it has been found that such deposits exhibit good uniformity leading to uniformity of resistance per unit length. The deposit however must be sufficient to insure that the support for the deposit is completely coated. In general it has been found that a deposit should be at least .0005" thick and should not exceed about .005".

2

Further the core support for the metal deposit should be small in dimension as smaller cores require a lesser quantity of metal to attain the noted thicknesses and result in high resistances per unit length of the product.

5 Cores having diameters of up to about five times the deposit thickness are generally suitable. The lower limit of core thickness is determined by the physical requirements of the particular product, strength being an important factor as to handling the material in assembly and shipping operations.

10 Referring to the drawings and first particularly to Figure 6, the numeral 1 designates a reel of wire which is suitably an 18.5 mil nyl clad magnet wire. This insulated wire forms a core support for the conductive metal and is drawn over a guide 2 in the form of a strand 3 into the plating chamber 4. Plating chamber 4 is heated in any convenient manner as by suitably housed electrical heating elements designated at 5 and having suitable leads 7. If desired the wire alone in the chamber 20 may be heated by passing an electric current through a length thereof in known manner.

The wire in its passage through the plating chamber 4 is supported on rollers 9. The numeral 11 indicates an inlet for the plating gas which in the present instance 25 may be considered to be nickel carbonyl. The temperature within the chamber under such conditions is suitably maintained at about 475° F. and the wire is drawn through at a speed of about 4 feet per minute. The plating gas may flow into the chamber in relatively low volume, for example, about .03 cubic foot per minute. The outlet for the plating gas is designated by the numeral 13 and may be suitably connected to a vacuum pump to occasion the withdrawing of decomposed carbonyl from the chamber.

35 The wire in its passage through the plating chamber is plated with nickel which is occasioned by the thermal decomposition of the nickel carbonyl. At the exterior of the chamber there are positioned cooperating frictional rolls 15, 17 which rotate in the direction shown to draw the wire 3 through the chamber.

40 The numeral 3a designates the plated nyl clad wire which passes over a guide roll 19 to the die at 20. The die 20 (Figure 7) has a somewhat triangular shape which accommodates, at the apex of the triangle, the plating wire 3a.

45 The numeral 22 (Figures 6 and 7) designates a film protector element or base for the film support 3, the latter being so designated since it supports the nickel film. The base 22 is in the form of an insulated wire of approximately 70 mil diameter and is passed to the die 20 over a guide roll 23 from the reel 24. In practice of 70 mil Formvar coated wire has been found quite suitable for this purpose.

50 The strand or wire 22, as may be clearly noted from Figure 7, passes into contact with the coated wire 3a in the die. As shown at 25 the die 20 is apertured and nozzles indicated at 26 extend into the area adjacent the juncture of the coated wire 3a and the film protector wire 22. This provides for the injection of a suitable heat curable plastic material such as phenol-formaldehyde.

55 Rightwardly cooperable friction rolls 27, 29 engage the combined strand and draw it through the die 20 to a heater indicated at 31 having heating elements 33 provided with suitable leads 35. The heater 31 may be insulated from the die 20 in any convenient manner at 36.

The product emanating from the heater 31 comprises the firmly bonded metal coated wire 3 and the film protector element 22.

60 In the practice of the invention it is preferable to continuously test the wire as it is produced and for this purpose a test unit is indicated at 37, and reference

will be made to the test operation more particularly hereinafter.

Cooperable frictions rolls 39, 41 pass the formed resistant element to other operations such as cutting or storage as desired.

Referring now to Figures 1 and 2, the film protector 22 is shown to comprise (Figure 2) a central core 43 of metal such as copper coated with an insulating material 45 such as Formvar. The numeral 47 designates the bonding resin which is adhered between the Formvar and the nickel coating 49 on the element 3a.

As clearly shown in Figure 2 the nickel 49 is insulated by the nylon layer 51 from a magnet wire 53, and the nickel layer is joined by the bonding resin 47 to the film protector 22. As shown in Figure 1 a sliding contact 52 is movable over the nickel 49 towards and away from a fixed contact 54.

Referring now to Figure 3 the numeral 53 designates a longitudinally extending rod over which there is sleeved a body 55 of Formica. The Formica is slotted longitudinally at 57 and an element 59 corresponding to the element 3a of Figure 1 is received in the slot, the nickel coating being designated by the numeral 61 and extending slightly above the Formica insulation.

Centrally of the length of the rod 53 and the sleeve 55 the Formica is apertured through to the rod as at 65. Solder 67 connects the rod electrically to the nickel coating 61. This provides a resistance element having a zero center point. A resin bond 63 retains the metalized element 59 on the Formica sleeve 55, the resin preferably extending around a portion of slot 57. The ends of the rod 53 protrude from the Formica and are provided with cap contacts 69, 71.

In Figure 5 there is shown another version in which the resistance element, designated generally by the numeral 73, is wound helically around the interior of a cylinder 75, the conductive film being indicated at 74 and the support at 76.

The film support need only be insulated from the metal deposited from the gaseous state and need not be of a conductive core such as is indicated at 53 in Figure 2. The film support may, in fact, be a glass rod or other insulating material, such as ceramic.

Similarly, the film protector 22 need not be of a conductive core, such as indicated at 43, but likewise may be a glass rod, a ceramic rod, or a rod of other suitable insulating material. However, for a structure such as that shown in Figure 3 the core rod of the film protector must, of course, be electrically conductive.

Referring to Figure 8 there is indicated diagrammatically an arrangement for testing the product for electrical conductivity on a continuous basis. Thus the tester 37 (Figure 6) may comprise a lead 77 which contacts the element 3a. The other end of this lead connects to a source of constant voltage at 79, which voltage through the galvanometer 81 is connected to lead 83 which is in electrically conductive relation with the element 3a at a point spaced from the lead 77. Deviation of the galvanometer indicates a variation in electrical resistance as the element 3a passes beneath the fixed leads 77, 83 in the direction of the arrows.

In the practice of the invention other metals may be substituted for the nickel, such as chromium and iron, which may be deposited from chromium hexacarbonyl and iron pentacarbonyl. Similarly, other curable resins, such as ureaformaldehyde, may be employed, or bonding agents which set up at room temperature, may be utilized. The film protector 22 protects the element 3a, for example, from rough handling in the normal course of usage and may suitably be chosen to be flexible or to be substantially rigid for particular applications. Similarly, the film support is suitably a flexible material or a rigid material as dictated by the application to which the product is assigned.

In specific practice a plating chamber 4 having a vol-

ume of about 500 cc. had passed thereto nickel carbonyl at a rate of about .03 cu. ft. per min. The temperature within the plating chamber was about 400° F. and the insulated strand 1 having the wire core passed through the chamber at a rate of about 8 ft. per min. This strand had a diameter of about 18.5 mils. A twenty inch length of this wire plated as described exhibited a total resistance of 14,000 ohms. The wire when measured inch for inch for resistance along its length exhibited a maximum resistance variation of 4.1% and an average variation of 1.8%.

Such variation calculation is made in accordance with the formula

$$\frac{A}{T} \times 100 = D$$

where A is the actual resistance from one end of the deposited metal to a given point on the metal; T is the theoretical value of resistance over the same length predicated upon the total resistance divided by the wire length; D is the percent deviation for the measurement.

The average variation is the average of the variations found at each measurement over the length, the measurements being taken at one inch increments.

Thus values of resistance of 700 ohms per inch of length have been obtained at good linearity over the wire length.

By decreasing the speed of wire movement to about 4 feet per minute and increasing the deposition temperature to 475° F. with the same carbonyl flow of .03 cu. ft. per min. a slightly greater deposition was obtained on 18.5 mil wire, the resistance being an average of 570 ohms per inch; the maximum resistance deviation over the length in this instance was 3.2% while the average variation was about 1.8%.

In a further example the wire speed was increased to 36 feet per minute and the temperature to 500° F. but the wire diameter was decreased to 12.5 mils; in this instance the average resistance per inch was 2305 ohms while the maximum variation was 7.1% and the average variation 2.5%.

In general the average variation over a wire of 20 inch length ranges between 1.5 to 2.5%, the greater variations occurring when the films become quite thin. For high operational speeds the smaller diameter wires, that is 12.5 to 18.5 mils are preferred as they give the high resistance with adequate linearity.

Linearity is attainable at higher wire diameters; for example, a wire of 70 mils at about 500° F. plated at a speed of 12 feet per minute with .06 cu. ft. per minute of carbonyl flowing exhibited a maximum resistance variation of 2.5% and an average variation of 1.5%. However, the resistance in such cases is materially lower, in the above example 41 ohms per inch being obtained. Large core diameters require, as may be seen from the foregoing, relative large deposits of nickel metal to achieve linearity—and this reduces the resistance per inch attainable. Consequently it is preferred to maintain the wire diameter at or below 18.5 mils where resistance in hundreds of ohms per inch is desired. Such wires normally require an external support for applications such as potentiometer wires.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

We claim:

1. An electrically conductive unit of substantially linear ohmic characteristics comprising a longitudinally extending core support and a film of conductive metal thereon and electrically insulated therefrom, the film having a thickness in the range of .0005" to .005" and the support not exceeding about .025" in its largest cross-

5

sectional dimension, said film being exposed to the exterior of the said electrically conductive unit.

2. An electrically conductive unit of substantially linear ohmic characteristics comprising a core support, a film of conductive metal on and electrically insulated with respect to the core support, said support comprising an electrically insulated flexible wire and not exceeding about .025" in diameter, the metal film having a thickness of .0005" to .005" and extending around the circumference of the said core support, and a base mounting the metal-covered support in electrically insulated relation with the conductive metal film.

3. An electrically conductive unit of substantially linear ohmic characteristics comprising a core support, a film of conductive metal on and electrically insulated with respect to the core support, said support comprising an electrically insulated flexible wire and not exceeding about .025" in diameter, the metal film having a thickness of .0005" to .005" and extending around the circumference of the said core support, and a base mounting the metal-covered support in electrically insulated relation with the conductive metal film, said base comprising a flexible and electrically insulated wire.

4. A potentiometer unit comprising a longitudinally extending base and a core support on the base, said support having thereon a film of metal of a thickness of about .0005" to .005", the support having a diameter not exceeding about .025", said base being flexible and comprising electrical insulation material contacting said metal film, and means bonding said base and support together at said film.

5. A potentiometer unit comprising a longitudinally extending base and a core support on the base, said support having thereon a film of metal of a thickness of about .0005" to .005", the support having a diameter not exceeding about .025", said base being flexible and comprising electrical insulation material contacting said metal film, and a mass of resin on said base uniting said base and support together at said film.

6. In a potentiometer element, a longitudinally extending electrically conductive element, a sheath of insulating material surrounding said element, said insulation material having a longitudinal slot therein, a core support in the slot, said support not exceeding about .025" in

6

its largest cross-sectional dimension, and a film of metal having a thickness in the range of about .0005" to .005" surrounding said core support, said sheath of insulating material having an aperture therethrough, and means in said aperture electrically connecting said film of metal and said electrically conductive element.

7. In a potentiometer element, a longitudinally extending electrically conductive element, a sheath of insulating material surrounding said element, said insulation material having a longitudinal slot therein, a core support in the slot, said support not exceeding about .025" in its largest cross-sectional dimension, and a film of metal having a thickness in the range of about .0005" to .005" surrounding said core support, said sheath of insulating material having an aperture therethrough substantially midway of the length of the core support, and means in said aperture electrically connecting said film of metal and said conductive element.

8. In a potentiometer element, a cylinder and in the interior wall of the cylinder a potentiometer element comprising a base on said wall formed into a helix and extending lengthwise of the wall, and secured to the helix base and extending therewith a core support also in the form of a helix, said core support having a diameter not exceeding about .025", and a thin film of electrically conductive metal on the core support surrounding the support and electrically insulated with respect thereto, said film of metal having a thickness in the range of .0005" to .005".

References Cited in the file of this patent

UNITED STATES PATENTS

1,360,267	Chubb	Nov. 30, 1920
1,441,686	Jones	Jan. 9, 1923
2,061,107	Schellenger	Nov. 17, 1936
2,448,757	Alban	Sept. 7, 1948
2,472,930	Wilkes	June 14, 1949
2,529,914	Challenner	Nov. 14, 1950
2,689,803	Ackerman	Sept. 21, 1954
2,705,274	Buck	Mar. 29, 1955
2,785,651	Pawlyk	Mar. 19, 1957
2,785,997	Marvin	Mar. 19, 1957
2,817,141	Toulmin	Dec. 24, 1957