

July 2, 1957

W. M. KOHRING
RESISTANCE COATINGS

2,798,140

Filed April 6, 1953

Fig. 1

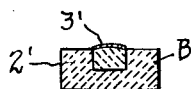
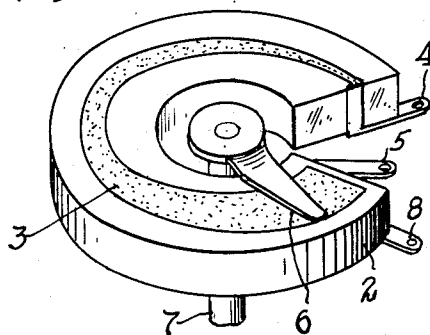


Fig. 2



Fig. 3

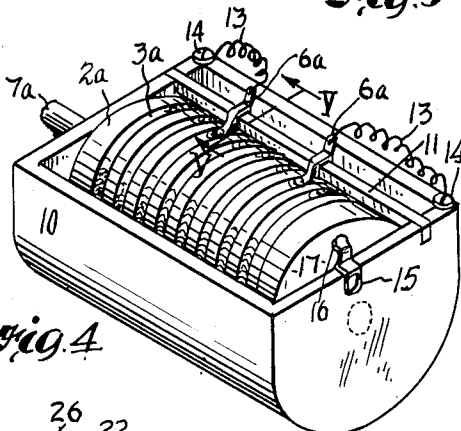


Fig. 4

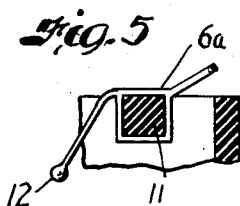


Fig. 5

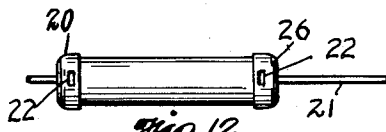


Fig. 6

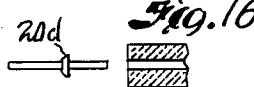


Fig. 7

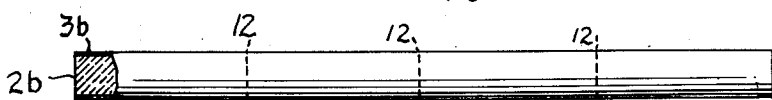


Fig. 8

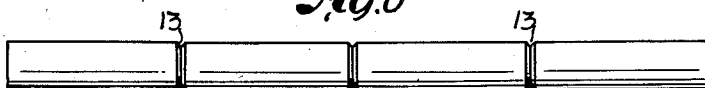


Fig. 9



Fig. 10

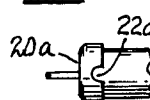


Fig. 11

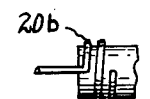


Fig. 12

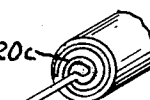


Fig. 13

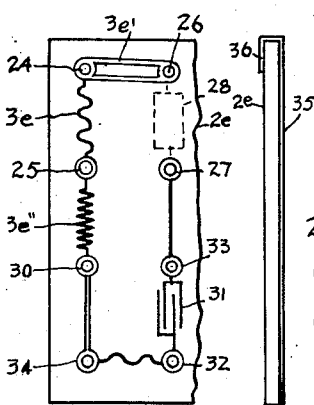


Fig. 14

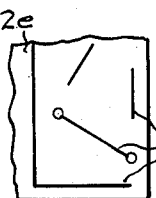


Fig. 15



Fig. 16

Fig. 17

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2,798,140

RESISTANCE COATINGS

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Application April 6, 1953, Serial No. 347,114

6 Claims. (Cl. 201—56)

This invention relates to electronic circuits, and involves preparation of such by selective application of metal coating on insulation supports of various desired form. By the present improvements, these devices can be made with particularly convenient large scale operation, and economical usage of metal and with savings in general costs. Other objects and advantages will appear from the following description.

To the accomplishment of the foregoing and related ends, said invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawing setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the various ways in which the principle of the invention may be employed.

In said annexed drawing:

Fig. 1 is a perspective view showing an embodiment of the invention;

Fig. 2 is a fragmentary sectional view of modified detail of structure;

Fig. 3 is a fragmentary larger scale detail section of a further modification;

Fig. 4 is a perspective view of another embodiment of the invention;

Fig. 5 is a fragmentary enlarged section on the line V, Fig. 4;

Figs. 6-11 inclusive show stages in preparing resistances of cylindrical form;

Fig. 12 is a side elevational view illustrating such finished devices;

Figs. 13 and 14 are fragmentary elevational views showing modified terminals;

Fig. 15 is a fragmentary perspective, and Fig. 16 a fragmentary section showing other modified terminals;

Figs. 17 and 18 are broken plan views illustrating printed circuit construction in accordance with the invention; and

Fig. 19 is an edge view thereof with the masking pattern plate in assembly.

In general, the invention involves selectively applying a thin metal surfacing to a portion of the surface only of an insulation support, and providing suitable terminals. In particular, the portions of the insulation support which are not to be metalized are covered by masking, and then the metalizing is performed by vacuum deposition. Masking which may be used may be tape, wax, water glass compositions including finely divided mineral filler, pattern plates of metal, synthetic resin, etc. The vacuum depositing is on the order of the known technique, the metal being vaporized by heated elements or filaments in a chamber under high vacuum, such as those commercially available as produced by Distillation Products Company, and the generally well known technique, as for instance "Vacuum Technique" by Saul Dushman (Pub. by John Wiley & Sons, Inc., N. Y., 1949), pp. 757-764. Metals which may be thus applied are

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for instance nickel, iron, chromium, cobalt, iridium, platinum, silver, gold, aluminum, zinc, copper, alloys of two or more such, commercial alloys such as "Invar," "Constantan," etc. The insulation support may be of ceramic material such as porcelain, steatite, glass, rubber, thermo-setting or thermo-plastic synthetic resin, fluor compound resins, such as polytetrafluoroethylene, polychlorotrifluoroethylene and the like ("Teflon," "Kel-F"), as preferred in any particular instance. Metals of desired thermal coefficient can be applied individually, or simultaneously, and by selection relative also to resistance characteristic, the end result may be controlled to a range desired. Such metals as nickel, iron, chromium, etc., being of high resistance character for instance, and such metals as copper and silver being of low resistance character, and particularly useful in alloying combinations. Metals of low thermal coefficient are nickel, iron, chromium, platinum, iridium, tantalum, tungsten; while aluminum, manganese and zinc are in relatively high range of thermal coefficient; and silver and copper in intermediate range.

The shape and character of the insulation body is contingent upon the final form of structure which is desired. Referring to Fig. 1, an insulation body 2, as of ceramic, is of general disc form, open at the center and a sector of the periphery at one point. Such ceramic blank is masked except for the particular limited surface which is to be resistance metalized, the masking for instance being a close-fitting sheet metal pattern plate with cut-out corresponding to the area to receive the metal-coating, or it may be a pressure-applied adhesive tissue pattern with cut-out, or it may be a water glass composition or a high-melting wax applied on the insulation body except the area which is to receive the metalizing. Thus, in Fig. 1, such surface for metalizing may be of the partial circular form 3 on the face of the insulation body 2. The insulation body thus masked except for the limited surface to be metalized, is then subjected to vacuum deposition of for instance a nickel-iron alloy containing about 36 percent nickel. The metal deposits on the exposed area, in this instance the incomplete-circular strip 3. This may be of uniform width throughout its extent, or in some cases it is preferred to have it in tapered form, wider at one extremity than the other. The metal adheres tightly to the insulation body, and the masking is removed, and terminals 4, 8 are applied, one connecting to the end of the metalized area, and the other to a central movable contactor 6 which is secured to the rotatable shaft 7 in form as known. Or a terminal 5 may give a potentiometer connection.

In some instances instead of applying the metal to a limited surface of the entire support, a separate resistance insert may be prepared, and as illustrated in Fig. 2 this may involve an insulation body 2' which may be of general near-circular form corresponding to the path of contact desired in a structure of the type of Fig. 1, and such body, masked except for its one exposed working surface is then subjected to the vacuum deposition and metal coat 3' is applied. Then on removing the masking, the body 2' is mounted with synthetic resin base B and is finished with terminals and contactors as in the form of Fig. 1. In some cases instead of the cross-sectional form of insulation body 2' as in Fig. 2, a desirable form is that of 2'', Fig. 3, in which, considering the structure to be of overall near-circular type, inner and outer grooves 10 facilitate application of masking other than liquid wax, for instance adhesive tape or a contractile rubber.

In similar procedure, a rheostat or potentiometer, depending upon which terminals are connected up, may be made in a form as illustrated in Figs. 4 and 5. Here, the

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insulation body 2a is a cylinder such as of ceramic, steatite, glass composition, synthetic resin, fluor compound resins, etc., with a shaft 7a for rotation, and is mounted in a support or frame 10 such as of synthetic resin insulation. The periphery of the cylinder carries a helical strip or pathway of vapor-deposited metal of resistance character, and moving contact is made with such pathway of resistance by slider-contacts 6a. Thereby the amount of the resistance path, and consequently the amount of resistance can be varied as desired, by appropriate rotation of the cylindrical body. While the resistance path may be a plain helical strip of the deposited metal on the periphery of the insulation cylinder, and the slider-contacts travel on a threaded rod having the same pitch as that of the resistance helix, and with a gear on the outer end of the rod and a coacting gear on the shaft 7a, it is preferable to form the resistance path as a groove. Thus, the cylindrical body is grooved as at 3a, and in the groove is the coating of deposited resistance metal. The sliders coact with this by riding freely on a fixed rectangular-section bar 11 mounted in the frame 10. Thereby, as readily seen, the sliders 6a, which as seen by the enlarged detail at Fig. 5 have a spring finger which terminates in a rounded end 12 fitting the groove. When the cylinder is turned in either direction, the easy-riding slider travels the groove and has its position adjusted thereby. From the sliders 6a flexible conductor cords 13 lead to terminal screws 14 to which outside connections may be made. Another terminal 15 with a spring finger 16 makes completion of the desired circuit by riding resiliently on the metal-coated end 17 of the cylinder. The metal is deposited on the selectively desired areas of the cylinder after first applying masking to cover the portions where the metal is not desired, such as the periphery between grooving, and the inactive end of the cylinder. Masking which may be employed for this may be applied as a water glass and filler composition, or a high-melting wax, or the masking may be a pattern templet with appropriate cut-out through which the metal is to deposit on the cylinder, and such templet may be formed of suitably distortionless sheet regenerated cellulose or plastic, and it is further advantageous to coat the inside surface with adhesive which adheres by application of pressure, and the templet after use can be stripped off. The vacuum depositing of the metal is as afore-described. This device by making outside circuit connections to the terminal 15 and one of the terminals 14 functions as a rheostat, or by using the terminal 15 and both terminals 14 it functions as a potentiometer.

Where a resistance of rod-like form is desired, a solid rod of insulation, 2b, Fig. 6 may be subjected to the vacuum-deposition metalizing to make a coat 3b. The end surfaces may be masked or not, as desired. Depending upon the length of the insulation rod, it may after metalizing, be severed, as indicated at the dotted line 12, to form separate units, or it may be employed as a whole without severing, to form one unit. To facilitate and simplify severing of metalized rods into multiple unit products, I prefer to start with rods which are circumferentially scored as at 13, Fig. 7, and such scoring may be at distances desired for respective lengths. This form of rod after being metalized is easily snapped into its segments without requirement of special severing means. While the forms just noticed are solid bodies, hollow units are preferable in some instances, and as shown at Fig. 8, a tube of insulation 2c may have its ends masked, and be subjected to vacuum deposition, thereby metalizing the exterior surface of the tube as coat 3c. Again, such metalized tube may be employed as a whole as a unit, or it may be severed into a plurality of units. Again, severing in such case is preferably facilitated by circumferential scoring 13, Fig. 9. Where an especially protected construction is preferred, the insulation tube may be masked on the outside, and then subjected to

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vacuum deposition metalizing, thereby depositing the metal 3d on the interior surface or bore of the tube, as illustrated in Fig. 10. Again, this may be finished up as a whole unit, or it may be severed to a plurality of smaller ones. And, again, the provision of circumferential scoring 13, Fig. 11, greatly facilitates and simplifies the sub-dividing of the tube into desired unit lengths. The units thus produced are equipped with end terminals, and as shown in Fig. 12 these may be metal caps 20 with riveted-on terminal wires 21, the caps being engaged over the ends and contacting the peripheral metal resistance coating. Preferably, these caps are provided with a small cut-out 22, in which application of solder may assure both retention and complete adequacy of contact. Instead of a cut-out 22 as foregoing, the caps may have simply a cut 22a, Fig. 13, this affording a more resilient grip on the end of the cylindrical body and its peripheral resistance coating, and again a small amount of solder may be applied in the cut to make sure of retention and completeness of contact. As shown in Fig. 14, the terminal 20b may be in the form of a short helix which engages over the end and exerts resilient holding, and a small amount of solder may be also applied. Instead of a helix-form terminal, a flat spiral, 20c may be employed, as in Fig. 15, and here the end of the insulation body may have been metal coated in the vapor deposition, or it may receive a coating of colloidal silver or the like, and soldering may complete the union. Or, as in Fig. 16, the terminal 20d may be of a form to insert into an end opening or bore in the insulation body, and again the latter may have deposited metal on the end or it may receive an application of colloidal silver, and be cemented or soldered into secure union.

In some simple cases, the shape of the insulation body is such as to render it more easily to apply the vacuum deposited metal over the surface, and then grind off portions where it is not to function. Thereby time may be saved over the operations of masking and then finally removing the masking. Ordinarily, however, where a pattern templet can be applied, this is particularly satisfactory.

By the present invention, circuit parts, or an entire circuit may be provided, as desired in any case, by the vacuum depositing of the metal. In Fig. 18 there is illustrated thus printed electronic circuit means in accordance with the present invention. On a plate of insulation 2e, of material as preferred, ceramic, synthetic resin insulation, or other, a masking pattern templet is applied in close contact with the surface of an insulation plate, this pattern templet having cut-outs in accordance with the form of the circuit elements to be deposited on the insulation plate. Thus, illustratively, there may be a resistance 3e in the form of a sinuous path of deposited metal between points 24, 25, or for particularly low resistance the deposited metal may be in the form of parallel lines 3e', as between points 24 and 26. Such latter may have openings to receive mounting prongs from transistors, small tubes, or other elements at the back of the plate. As required by the exigencies of any particular circuit, there may also be interposed as between points 26 and 27 units 28 with their terminals connecting at 26 and 27 respectively, such units being conventional capacitors, resistors, etc., and their wire terminals may be passed through the openings at 26, 27 and be soldered in circuit. Again by the present method a resistance between points 25 and 30 may be laid down in zig-zag form 3e'', or the resistance may be of varied form as indicated in the showing. Also, printed circuit elements such as capacitors may be formed on the insulation plate, as a plurality of spaced-apart line deposits 31, connecting between points 32 and 33. In such manner, as readily seen, printed circuit combinations of capacitance and resistance may be applied all at once for a complete circuit outfit with such elements as required in any particular case, and the other elements such as transistors or small

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tubes may be assembled by the mounting holes. The masking is particularly conveniently accomplished by a pattern templet with cut-outs appropriate to the particular detail circuit which is to be printed. And, a templet thus may be a thin sheet 35 of resilient metal, steel, brass, etc. And by providing this with a rebent flange 36, the templet may be easily and quickly clamped onto the plate and be held by such flange in resiliency, in adequate close contact with the insulation body plate 2e. Another satisfactory masking templet is of suitable distortionless sheet organic material, regenerated cellulose, synthetic resin plastic and the like, with the cut-outs appropriate for the particular circuit to be printed, and such sheet by application of an adhesive coating sensitive to pressure, may be adhered to the insulation body plate which is to be printed, and after subjecting to the vacuum deposition operation, the templet may be easily stripped off.

Where merely connecting line paths between points are wanted in completing any desired circuit, as illustrated at lines 23, Fig. 17, the appropriate pattern templet therefor is applied to the insulation plate, and the metal vapor-deposited is of particularly conductive order, such as silver, copper, etc., or alloys. The technique being as described.

As an example: A ceramic blank of flat cut-circular form is provided with masking except for a resistance path desired on the fact. The masked blank is inserted in a chamber equipped with connections for high vacuum, and with filament heating means and feed-metal of about 36 percent nickel, the remainder iron. With air pressure reduced to a small fraction of an inch, and vaporization of the nickel alloy, the vapors deposit, condensing on the blank. And on removal from the chamber, and clearing off the masking, and applying terminals, soldering as necessary to the deposited metal strip for circuit-completion, the device is thus quickly and simply manufactured. Depending upon which terminals are put into the outside circuit, the device functions as a rheostat or as a potentiometer.

As another example: A cylindrical ceramic blank with helical grooving is masked between grooves, and also on the inactive end, and is placed in the vacuum chamber and subjected to metal vaporization and deposition as foregoing. And on removal, and clearing off the masking, the cylinder is mounted in an insulation framing equipped with slider-contacts to ride in the grooves as they freely slide along on a guide bar and an end contact. Depending upon the particular outside connections made, the device functions as a rheostat, or as a potentiometer.

As another example: Cylindrical blanks, with spaced circumferential scorings are placed in the vacuum chamber and subjected to vapor deposition of metal as foregoing. On removal, these cylindrical blanks are snapped into unit pieces, and are equipped with terminals at their ends, for unit resistors.

As another example: An insulation plate of ceramic having holes spaced in accordance with the particular circuiting which is to be provided, is assembled with a masking pattern templet which has cut-outs for allowing vaporized metal to deposit on the insulation surface at the points required and in form as desired. A masking is applied to the back and edges of the plate, to prevent metal deposit there. And this assembly is put into the vacuum chamber and the metal is vaporized and deposited as foregoing. On removal, the pattern templet is taken off and other masking is removed, and the metal is found deposited in the precise lines determined by the templet. Transistors, tubes and other pre-formed accessories as required by the particular circuit which is in view, are then assembled with the plate.

As another example: An insulation plate having holes spaced in accordance with a particular circuiting which is desired, is assembled with a pattern templet which has cut-outs for allowing vaporized metal to deposit in generally line-form on the insulation surface to make out

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conducting paths. Masking is applied to the back and edges of the plate to prevent metal deposit there. This assembly is put into the vacuum chamber and silver is vaporized and deposited as foregoing. On removal, the pattern templet is taken off and other masking is removed, and the silver lines are found printed for the circuiting on the face of the insulation plate. Then, this surface is covered with masking, and likewise the edges of the plate, and a pattern templet with cut-outs for circuit elements, resistances, capacitance, etc., as desired, is applied to the other face of the plate. And the assembly is put into the vacuum chamber and a metal having resistivity of the extent desired for the particular work in view, for instance a nickel alloy, is vaporized and deposited through the pattern templet. On removal, the templet is taken off, and also the masking. The plate presents conductive circuiting lines printed on one face and circuit elements, resistances, etc., printed on the other. Transistors or tubes and completing connections as required are added to finish the desired assembly.

Resistance surfaces thus prepared are unique in that the deposited metal is characteristic and recognizable, and has a uniformity, and a fineness which is sui generis, and having an exceptionally fine finish and smoothness of surface, which is notably advantageous for sliding contactors. It is particularly noticed that this is in contrast to any metal deposit formed by electro-plating or by heating of colloidal metal compositions, as such electro-deposited or decomposed colloidal compositions have over-formed crystalline texture. And, the present kind of metal deposit is also very different in nature from deposited or flashed carbon which is of crystalline and abrasive character. The metal molecules in changing state from vapor to solid at the interface of the non-metallic body attach thereto with particular tenacity and durability. The thickness of deposit can be as desired, from a few hundred thousandths of an inch to several times that thickness. A small amount of supply metal provides an adequate dense tough coat on a very large number of blanks.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims or the equivalent of such be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In a device of the character described, a cylindrical insulation body, a helical groove on its periphery, vacuum-deposited metal coating in the groove, a shaft for rotating the cylindrical body, a first contactor in electrical contact with said metal coating, a second contactor traveling in the groove relative to said first contactor, and an insulation bar on which said contactor freely slides.

2. In a device of the character described, a cylindrical insulation body, a helical path of vacuum-deposited metal coating on its periphery, a shaft for rotating said body, a first contactor in electrical contact with such metal path, and a second contactor mounted for movement on the metal path relative to said first contactor upon rotation of the body, thereby to vary the length of that portion of the path between the two contactors.

3. In making a device of the character described, providing a cylindrical insulation body with a helical groove, masking the surfaces except for the groove, depositing a resistance metal coat in the helical groove, and removing the masking.

4. In making a device of the character described, masking a cylindrical insulation body except for a helical path, vapor-depositing a resistance metal at the exposed helical path, removing the masking, and mounting a contactor for relative movement on said path.

5. In making a device of the character described, masking a cylindrical insulation body except for a helical path on its periphery and one end thereof from which such path extends, vapor-depositing resistance metal at the exposed helical path and end, removing the masking, mounting a contactor for relative movement on said path, and

mounting a second contactor in engagement with such end.

6. In a device of the character described, a cylindrical insulation body, a helical path of vacuum-deposited metal coating on its periphery, a similar coating of metal on one end of the body connected electrically to such metal path, a shaft for rotating said body, a first contactor traveling on the metal path, and a second contactor engaged with the metal-coated end of the body.

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