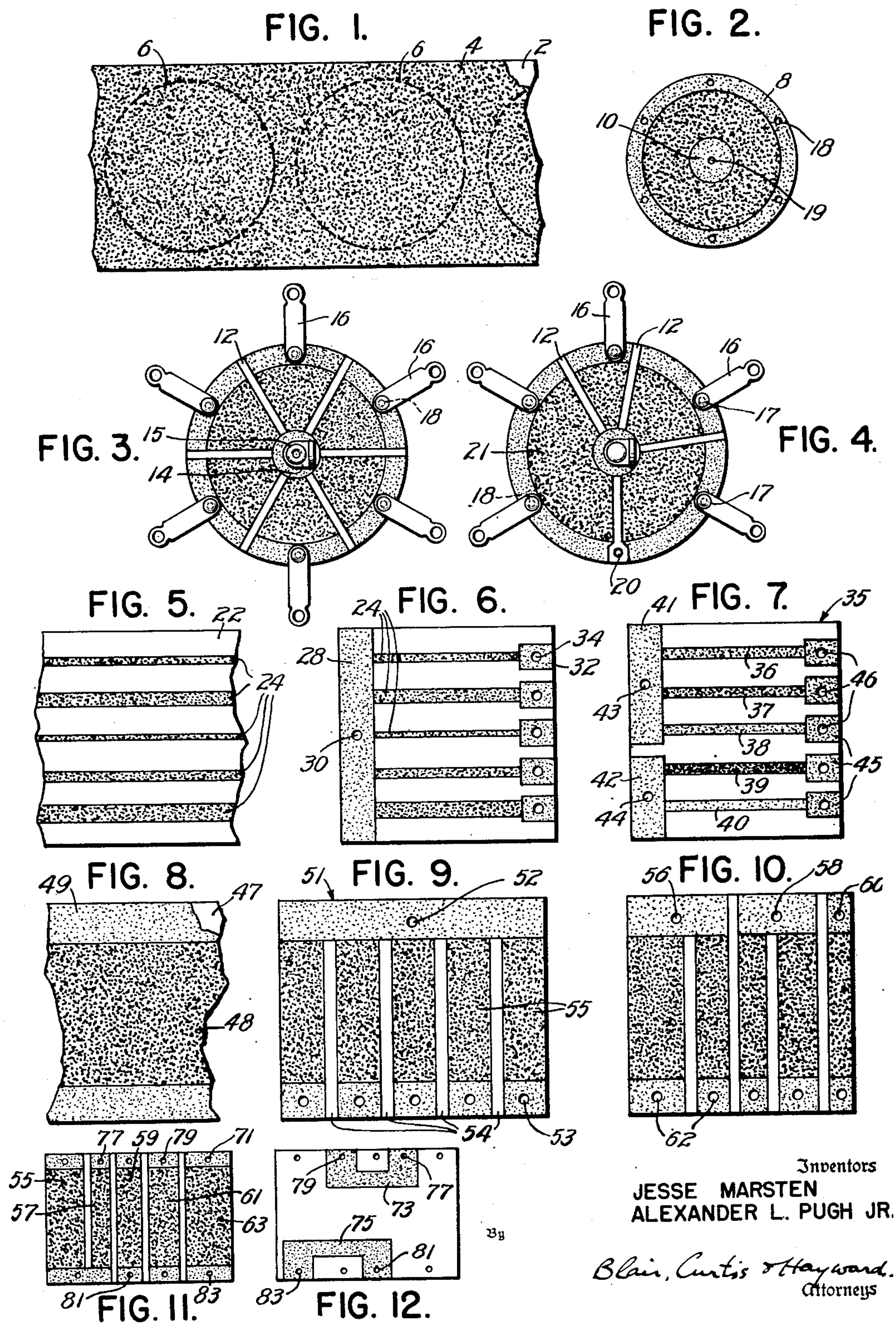
Feb. 24, 1953 J. MARSTEN ET AL 2,629,166

METHOD OF FORMING RESISTOR ASSEMBLIES

Filed Oct. 7, 1948 2 SHEETS—SHEET 1



Inventors
JESSE MARSTEN
ALEXANDER L. PUGH JR.

By Blair, Curtis & Hayward.
Attorneys

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FIG. 13.

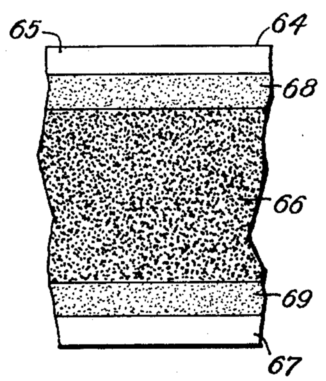


FIG. 14.

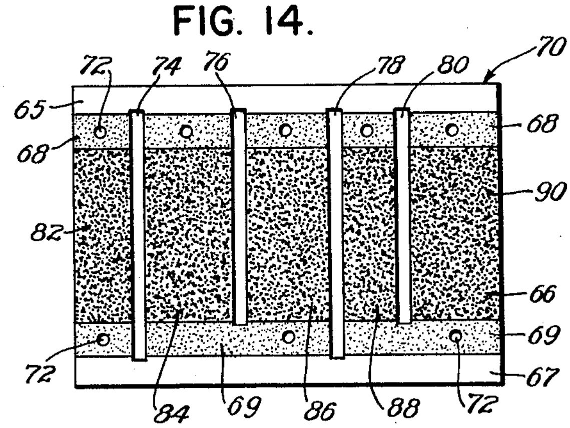


FIG. 15.

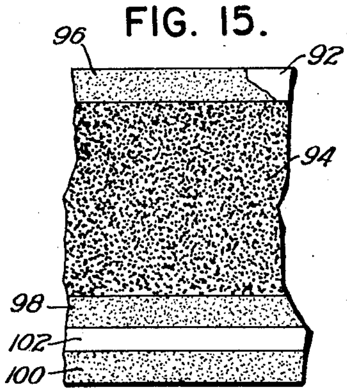


FIG. 16.

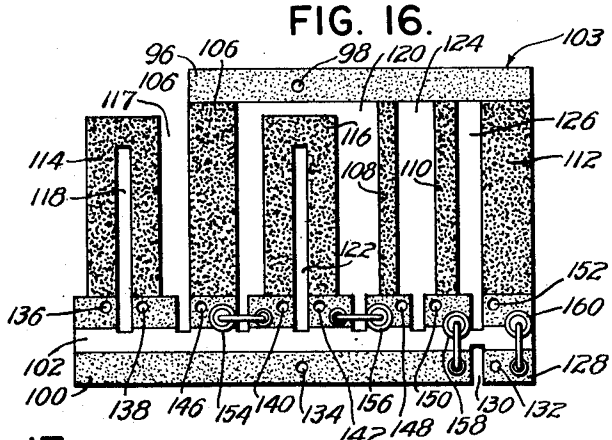
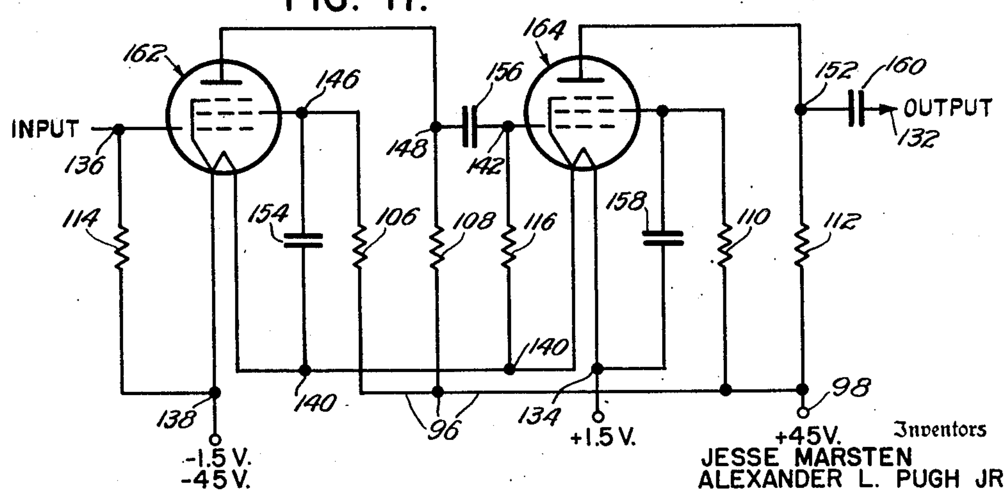


FIG. 17.



Inventors
JESSE MARSTEN
ALEXANDER L. PUGH JR

By

Blair, Curtis & Hayward.
Attorneys

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METHOD OF FORMING RESISTOR ASSEMBLIES

Jesse Marsten, Carroll Park, and Alexander L. Pugh, Jr., Bala-Cynwyd, Pa., assignors to International Resistance Company, Philadelphia, Pa., a corporation of Delaware

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4 Claims. (Cl. 29—155.5)

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This invention relates to electrical resistance units and resistance network assemblies; more particularly, this invention relates to the production of various kinds of resistance units and electrical circuits formed by reactance units connected in series and in parallel.

An object of this invention is to provide for the production of electrical resistance units and reactance circuit assemblies in a manner so as to meet the most rigorous standards of quality at minimum cost. A further object is to provide for the production of resistance units and reactance assemblies having extremely uniform electrical characteristics and yet of minimum size and of such structure as to stand up under severe conditions of use. A further object is to provide for the production of the above by processes which include steps, such as coating and stamping whereby maximum use may be made of large-scale mass production techniques. A still further object is to provide for carrying out the above in such a manner that relatively complicated electrical circuits may be manufactured without the use of connecting wires and electrical connecting techniques such as soldering. A further object is to provide an arrangement whereby resistance units or assemblies may be manufactured by simple process steps with each unit or assembly including two or more resistors having the same or different resistance values which are accurately determined. Further objects are to provide resistance units or assemblies and electrical circuits of the character referred to above and to provide processes for producing the same in an efficient and dependable manner. These and other objects will be in part obvious and in part pointed out below.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the drawings which show a number of embodiments of the invention:

Figure 1 is a top plan view of a strip of coated plastic sheet material from which resistor units or blanks are to be cut;

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Figure 2 is a top plan view of a resistor unit or blank after being cut from the strip of Figure 1;

Figures 3 and 4 are top plan views of completed resistor units or assemblies made from blanks such as that of Figure 2;

Figure 5 is similar to Figure 1 and shows another strip of coated plastic sheet material;

Figures 6 and 7 are similar to Figures 3 and 4 and show resistor assemblies produced from a sheet such as that of Figure 5;

Figures 8, 9 and 10 correspond respectively to Figures 5, 6 and 7 and show another embodiment of the invention;

Figure 11 is a top plan view on reduced scale of a resistor assembly similar to that of Figure 10;

Figure 12 is a bottom plan view of the resistor assembly of Figure 11;

Figures 13 and 15 are similar to Figure 8 and show strips for producing other embodiments of the invention;

Figures 14 and 16 show resistor assemblies produced respectively from the strips of Figures 13 and 15; and

Figure 17 is a schematic circuit diagram of the assembly of Figure 16.

Referring particularly to Figure 1 of the drawings, there is shown a thin sheet 2 of insulating material in the form of phenol-resin or "Bakelite" and having on its top surface a coating of resistance material 4 which is graphite or other carbon deposited with a varnish binder and then baked. In this embodiment the coating 4 is applied by a rubber roller but, under some circumstances, it is applied by spraying, by painting or by stamping. The strip 2 with its coating 4 has punched from it disks or blanks 6, indicated in broken lines, one of which is shown in Figure 2.

Each disk then is provided with conducting termination coatings, for example, silver coatings in the form of an outer annulus 8 and a central disk or annulus 10. These termination coatings are formed by spraying on a coating of varnish containing silver flakes and thereafter baking again. The disk of Figure 2 is then placed in an indexing machine which scrapes the coatings 4 and 6 from the disk along a plurality of spaced radial lines so as to expose the bare insulation material along radial strips 12. Thus, between the central annulus 10 and each sector of the outer annulus 8, there is a resistance unit or resistor 13 formed by a sector of the resistance coating 4. A central electrical terminal 14 is then attached by a rivet 15 to the center of the disk and each sector of the annulus 8 has an electrical terminal 16 attached by a rivet 17. For these rivets 15 and 17 each disk 6 has punched into it a central rivet hole 19 and appropriate outer rivet holes 18. These holes are punched simultaneously with the stamping of the disks from strip 2 and therefore the silver termination coatings will, to an extent, form beads down into the tops of the holes. In this way good electrical contact is insured between each electrical terminal and its rivet and the adjacent silver termination coating.

In the embodiment of Figure 3, the bare radial strips 12 are angularly equidistant from each other and they are of uniform width throughout. Therefore, the various resistors 13 have the same resistance values. The central terminal 14 is a common terminal for all the resistors, and it has a tab projecting upwardly to permit easy soldering. Each resistance section then has its own terminal 16 projecting radially outwardly so that the terminals are all spaced from each other a substantial distance and this has advantages during installation and use. Thus, a sturdy, high quality resistor is provided wherein the resistors occupy minimum space and are held rigidly in spaced relationship. In this embodiment the rivet 15 which holds terminal 14 in place is an eyelet which performs the additional function of attaching the disk to a mounting chassis (not shown).

In Figure 4 the various resistors have different resistance values; this result is obtained by so adjusting the indexing machine that there are different angular spacings between the various bare strips 12. Disks such as that of Figure 2 are used for producing the resistor assembly of Figures 3 and 4; in Figure 3 six resistors are provided while in Figure 4 there are only four resistors. In Figure 4, the largest resistor 21 has two connecting terminals, and as shown at the bottom of the figure, the resistance and termination coatings are scraped away from the lower hole 20 so that the disk may be mounted upon a metal bracket without the necessity for providing auxiliary insulation means. Also, the electrical terminals may be equally spaced from each other even though the resistance sections have different resistance values, but if desirable, the terminals may be so spaced that each is connected centrally of its termination coating sector or in any other convenient way.

As indicated above, coating 4 is formed by depositing a thin layer of varnish containing graphite or other carbon particles and then baking. The resistance value of the resistors thus formed is raised if there is less carbon in the varnish, and the resistance value is reduced if there is more carbon. Furthermore, within certain limits the resistance value depends upon the degree of baking; i. e., a certain minimum baking gives a relatively high resistance value, and the resistance value decreases as the baking continues. Thus, the resistance values may be controlled as desired during manufacture and extremely uniform products are produced; and after the baking operation has been completed the resistance value is constant. Throughout the drawings the relatively heavier shadings of the resistance coatings indicate correspondingly lower relative resistance values, and vice versa.

The production of resistors such as those of Figures 3 and 4 is carried on largely with automatic machinery; first the resistance coating is deposited and baked on sheet 2, and thereafter the disks are stamped out with the terminal or rivet holes and the termination coatings 8 and 10 are applied.

The coatings are then scraped off along strips 12 by an indexing machine which operation is also automatic. It has been indicated that the resistance value of the resistance coating may be varied by changing the amount of carbon in the coating and also by changing the time of baking, and the number of resistors and the specific resistance values of the various resistors may be changed by changing the adjustment of the indexing machine. Therefore, a production line may produce a wide variety of resistor assemblies having vastly different characteristics, and it is a relatively simple matter to change the characteristics of the resistor assemblies without modification of the procedure of manufacture. Thus, it is possible to produce a multiple number of resistors on one base suitably interconnected, and these are produced with a minimum number of operations. The resistance material and the conductive termination coatings may be applied simultaneously in one operation, and a single stamping operation may produce the multiple resistors and also cut the assembly from the main strip. In addition to the advantages in production of resistor assemblies in accordance with the present invention, there is the additional feature that a resistor assembly may be handled and assembled into an electrical circuit with much less work and expense than would be involved if the equivalent number of separate resistors were used.

In Figure 5 there is shown a strip 22 which is identical with strip 2 and which has five separate strips 24 of the resistance coating of the type of coating 4 which are applied simultaneously and continuously. After being coated and baked, strip 22 is cut into predetermined lengths to form resistor assemblies such as assembly 26 of Figure 6. At the left-hand side in Figure 6, sheet 22 is provided with a silver termination coating 28 of the same type as coating 8, and it is punched to provide a hole 30 for the attachment of an electrical terminal. At the righthand side of the figure, each of the resistance coating strips 24 is provided with a similar termination coating 32, and a hole 34 is provided for the attachment of an electrical terminal.

Thus the resistor assembly 26 is a base of insulating material which carries five resistors each connected at one end to a common terminal and connected respectively to separate terminals at the other ends. The widths and thicknesses of strips 24 may be the same with the result that the resistance values of the various resistors are the same and in this way the assembly of Figure 6 may be electrically similar to that of Figure 3. However, in Figure 6 the various strips 24 have different widths so that they have different resistant values and therefore the assembly corresponds more nearly to the assembly of Figure 4. Holes 30 and 34 may be punched simultaneously with the cutting of sheets into lengths.

As indicated above, the resistance value of a resistor of this type may be varied by changing the relative amount of carbon in the resistance coating. Therefore, as shown in Figure 7 an assembly **35**, similar to Figure 6, has five resistance strips of the same width but having different amounts of carbon in the coatings forming them. Thus, in Figure 7 the resistors **36**, **37**, **38**, **39** and **40** have different resistance values. For example, the center resistor **39** has a relatively small amount of carbon in it so that it has a high resistance value, whereas the next lower resistor **39** has a greater amount of carbon in it so that it has a relatively low resistance value. At the lefthand side of Figure 7, the assembly has a termination coating strip which is divided into two coatings **41** and **42**; the upper three resistors **36**, **37** and **38** are connected to one coating **41** and have a common terminal at an opening **43**, and the two lower resistors **39** and **40** are connected to coating **42** and have a common terminal at an opening **44**. At the right, each resistor has a termination coating **45** and a terminal hole **46**. Thus the resistor assembly **35** includes two electrically independent multiple resistor units or resistance networks.

In the embodiment of the invention of Figures 8, 9 and 10, a sheet or strip **47** of insulation material is first covered with a resistance coating **48** and baked, the same as in Figure 1, and then at the two sides of the strip there is applied high conductivity termination coatings **49** and **50** illustratively, silver or other low resistance material such as copper or graphite. The low resistance termination coatings may be applied simultaneously with the resistance coating **48**. Contact between the termination coatings and the resistance coating results automatically from the merging or fusing of the coatings together. After suitable baking as outlined above, the strip is cut into predetermined lengths and is simultaneously punched to form units **51** having terminal attaching holes **52** and **53** therethrough. Coatings **48** and **50** are then scraped off along five parallel strips **54** to expose sheet **47** and separate coatings **48** and **50** into spaced areas. This forms five resistors **55** of equal width and the same resistance values and with one common terminal at hole **52** and separate terminals at holes **53**. In Figure 10 the resistors have different widths and have different resistance values. In the embodiment of Figure 10, the resistors have different resistance values. Furthermore, the termination coating is divided to form two resistors at the left which have a common terminal at hole **56**, two adjacent resistors also have a common terminal at a hole **58**, and a righthand resistor having a terminal at a hole **60**. At the bottom there are five holes **62**, each for a terminal for one of the resistors.

In the embodiment of the invention of Figures 11 and 12, an arrangement similar to that of Figure 10 is shown wherein remote resistors are connected together by coatings on the back of the sheet. Five resistors **55**, **57**, **59**, **61** and **63** having different resistance values are formed on a sheet **71** in accordance with the technique of Figures 8 to 10 with resistors **55** and **57** having a common terminal at their lower ends. Upon the bottom or rear side of the insulation sheet there is at the top a U-shaped strip of silver flake coating **73** which extends from immediately behind the upper end of resistor **57** to immediately behind the upper end of resistor **61**. At the bottom of the sheet there is an inverted U-shaped coating **75** which extends from immediately beneath the lower end of resistor **59** to immediately beneath the lower end of resistor **63**. Thus by connecting an eyelet through each of holes **77** and **79** a connection is made between the upper ends of resistors **57** and **59**; and by connecting eyelets through each of two holes **81** and **83**, a similar connection is made between the lower ends of resistors **59** and **63**. Thus two electrical resistor networks are provided wherein the front side of the sheet of insulating material is the carrier for the resistors while the back side of the sheet is the carrier for additional electrical circuit connections.

The embodiments of Figures 13 to 17 are similar to those of Figures 8 to 12 and differ therefrom mainly in that the resistors are formed by punching out portions of the sheet material where the coatings are to be removed rather than scraping off the coatings to form the resistors. In Figure 13 a strip of sheet plastic **64** has a resistance coating **66** which is applied in the manner of Figure 8 except that the two border strips **65** and **67** of the sheet material are left bare. Silver termination strip coatings **68** and **69** are then applied overlaying the edges of the resistance coating **66**. Thus the coated sheet of Figure 13 is similar to that of Figure 8 except that there are the two uncoated border strips along the sides of the termination coatings.

The cutting and punching operation then is performed and this cuts the strip **64** into predetermined lengths or sheets **70** each of which is punched with an appropriate number of terminal holes **72**; this operation also punches out five transverse slots or openings **74**, **76**, **78** and **80**. Slot **74** extends completely across the width of coatings **66**, **68** and **69** and terminates at its ends in the uncoated border strips **65** and **67**. Thus slot **74** forms a resistor **82** which has terminal holes **72** at its ends. Slot **76** terminates at its upper end at border strip **65** and at its lower end at coating **69**, and slot **78** is identical with slot **74**. Thus, slot **76** forms with slot **74** a resistor **84**, and forms with slot **78** a resistor **86**. At their upper ends, resistors **84** and **86** have separate terminal holes while at their lower ends they have a common terminal hole. Slot **80** is identical with slot **76** and therefore forms two resistors **88** and **90** which have separate terminal holes at the top of the figure and a common terminal hole at the bottom. Resistors **84** and **86** are of the same width and have the same resistance value; whereas, resistor **88** is narrower than resistor **90** and has a higher resistance value.

The embodiment of Figures 15 to 17 is similar to that of Figure 14 and is a complete circuit of all of the resistors with the interconnections to form a two-stage vacuum tube resistance coupled amplifier. A strip **92** of sheet material has a resistance coating **94** at the upper margin of which is a strip of silver termination coating **96**. At the lower edge of coating **94** there is a cimilar strip of silver termination coating **98** and beneath this is a strip of similar coating **100** which is separated from strip **98** by an uncoated strip **102** of the sheet. Strip **92** is coated in this manner and properly baked as outlined above, and then in a single stamping operation it is cut into lengths **103** and punched to form openings as shown in Figure 16.

Along the top of Figure 16, each length **103** has an uninterrupted strip of termination coating **96** which has a terminal hole **98**, and connected to coating **96** is the upper end of each of four resistors **106**, **108**, **110** and **112**. Positioned at the left hand side of the unit is an inverted U-shaped resistor 114, and positioned between resistors 106 and 108 is a similar resistor 116. Resistor 114 is formed by a slot 117 and an elongated narrow slot 118. Slot 118 extends between the legs of the resistor and terminates at its lower end in the uncoated strip 102 and at its upper end a substantial distance below coating 96. Slot 117 terminates at the end of the U in the uncoated strip 102 and extends along the side of the resistor 114. Resistor 116 is formed by a somewhat similar set of slots; i. e., an inverted U-shaped slot 120 and a central slot 122. Resistor 108 is formed by the righthand side of slot 120 and (at the right) by a slot 124 which terminates at its lower end in a reduced portion at the uncoated strip 102, and extends up to coating 96. Resistor 110 is formed by slot 124 and a similar slot 126 which also forms resistor 112.

The righthand end portion of coating 100 is formed into a separate termination coating 128 by a slot 130 extending from the bottom edge of the sheet upwardly to the uncoated strip 102. This righthand coating 128 has a terminal hole 132, and the main portion of coating 100 has a hole 134. Resistor 114 has a pair of holes 136 and 138; and, resistor 116 has a pair of holes 140 and 142. Resistors 106, 108, 110 and 112 have their upper ends connected to hole 98 and they have at their lower ends, respectively, holes 146, 148, 150 and 152. As indicated above, the assembly of Figure 16 is for a two-stage vacuum tube resistance coupled amplifier. For this purpose, there are four capacitors connected as follows: a capacitor 154 connected between the lower end of resistor 106 and the lefthand end of resistor 116; capacitor 156 connected between the righthand end of resistor 116 and the lower end of resistor 108; capacitor 158 connected between the lower end of resistor 110 and coating 100; and, a capacitor 160 connected between the lower end of resistor 112 and the righthand coating 128.

In Figure 17 the schematic diagram of the amplifier circuit includes two vacuum tubes 162 and 164 connected to the various elements of the circuit of the assembly of Figure 16. In completing the amplifier from the assembly of Figure 16 it is only necessary to connect the sockets for tubes 162 and 164 to the appropriate terminal holes as indicated in Figure 17. Thus an amplifier of extremely rugged construction is provided which is compact and light in weight and which is mass-produced at a cost far below the cost of a comparable amplifier of the prior construction. The thin flat sheet of plastic material has sufficient rigidity to withstand considerable abuse and it fits snugly along the side of a small case for batteries or the like. No auxiliary supporting plate need be provided for the resistors and this saves weight and space. Furthermore, the elimination of connecting wires and solder joints gives a construction of superior quality and performance.

As indicated above, the production facilities such as those which are used in producing the resistor assemblies of Figures 3 and 4 are also adaptable to the production of resistors such as those shown in the other figures. It has been indicated that the resistance value of resistors is decreased by increasing the amount of carbon in the resistance coating and within certain limits the resistance is decreased by increasing the time of baking. Thus, the coating and baking equipment is adjusted to produce any specific form of resistance coated plastic sheets of uniform quality. Furthermore, strips of resistance coatings of different widths may be applied to a sheet as in Figure 5, or different coatings may be applied simultaneously to a sheet as in Figure 7. The termination coatings may be deposited by stamping or by other processes depending upon the particular demands of production. Under some circumstances a number of standardized resistance coated sheets may be produced and then these sheets may be fabricated into such widely varying forms as the embodiments of Figures 3, 4, 9 to 12, 14 and 16. Under such circumstances the same dies may be used with sheets having different resistance coatings so as to produce resistor assemblies having different resistance values.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

We claim:

1. In the art of continuously forming assemblies of separate fixed resistors some of which are electrically connected, the steps of applying resistance material to a surface of a dielectric sheet to form a continuous resistance coating, and applying termination coatings to spaced portions of said sheet to form a continuous electrical contact with said resistance coating, and removing portions of said resistance material and the termination coating according to a predetermined pattern to form a plurality of terminals and separate areas of resistance material connected therewith and dimensioned to achieve the resistance value desired for each resistor in each assembly, thereby to form a plurality of separate resistors from the resistance coating which may be connected in a desired circuit.

2. The art defined by claim 1 in which the sheet is a disc with the termination coatings applied at the center and adjacent the peripheral edge thereof while the coatings are removed along substantially radial lines.

3. The art defined by claim 1 wherein the coatings are removed by punching the sheet.

4. In the art of continuously forming assemblies of separate fixed resistors some of which are electrically connected, the steps of continuously applying resistance material on a dielectric strip to form a continuous resistance coating, applying spaced longitudinal strips of termination coatings to form continuous electrical contact with said resistance coating therebetween, and removing portions of said resistance material and termination coatings along lines between said termination coatings according to a predetermined pattern to form a plurality of terminals and separate transverse resistance strips connected therewith, each strip being of a width to achieve the resistance value desired for each resistor in each assembly thereby to form a plurality of separate resistors which may be connected in a desired circuit.

JESSE MARSTEN.
ALEXANDER L. PUGH, JR.

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