

Nov. 17, 1936.

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2,061,107

METHOD OF MAKING RESISTANCE ELEMENTS

Filed Nov. 2, 1934

2 Sheets-Sheet 1

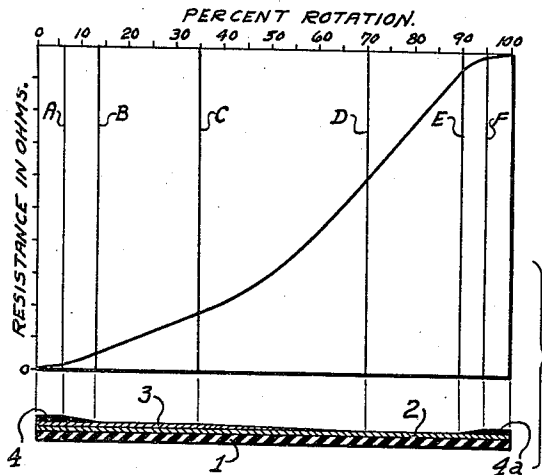


FIG. 1.

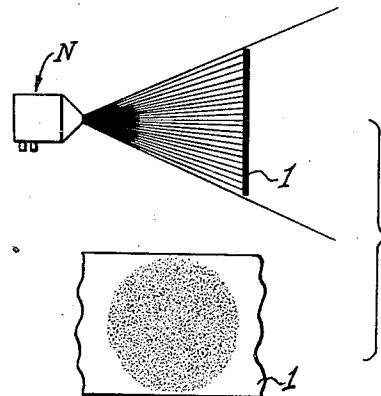


FIG. 2.

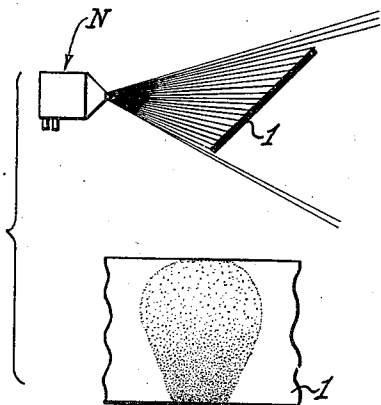


FIG. 3.

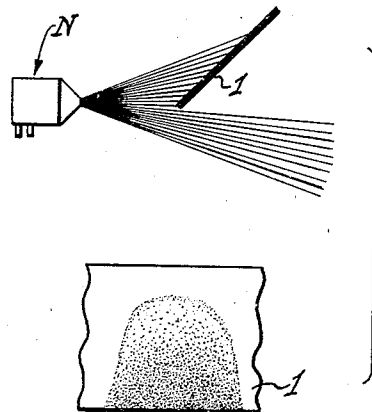


FIG. 4.

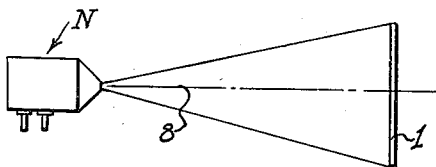


FIG. 6.

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2 Sheets-Sheet 2

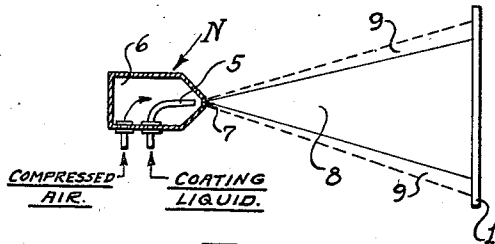


FIG. 5.

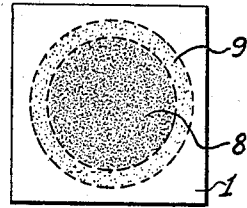


FIG. 5a.

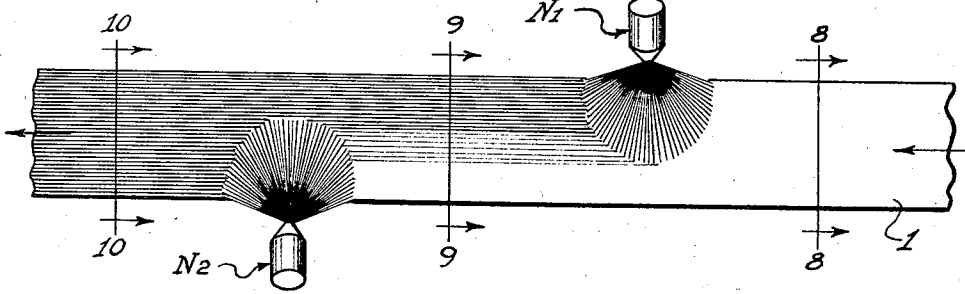


FIG. 7.



FIG. 10.



FIG. 9.



FIG. 8.

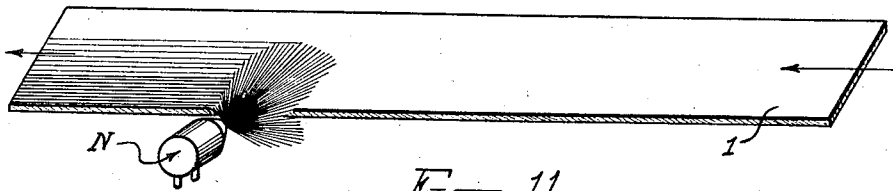


FIG. 11.

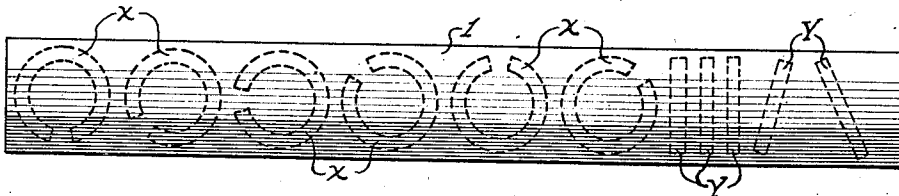


FIG. 12.

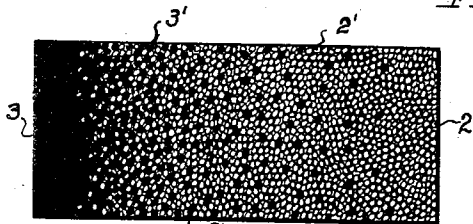


FIG. 13.

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2,061,107

METHOD OF MAKING RESISTANCE
ELEMENTSNewton C. Schellenger, Elkhart, Ind., assignor to
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Application November 2, 1934, Serial No. 751,192

4 Claims. (Cl. 91-68)

My invention relates to resistance elements and to the manufacture thereof, and more particularly to resistance elements of the planar carbonaceous type.

This application is a continuation in part of my co-pending application Serial No. 666,444, filed April 17, 1933, for "Resistance element".

In variable resistance devices, or volume controls, which for the sake of convenience will hereinafter be referred to as "rheostats", it is frequently desirable to have a resistance element, which is composed of a plurality of areas of conductive materials, each of a different specific resistivity than the others. The purpose for this is well known to be the demand in the radio art for rheostats in which the change of the effective resistance is not directly proportional to the degree of movement of the contactor over the contact surface of the resistance element. The rate of change of effective resistance, relative to the actual movement of the contactor, may be several thousand times greater in some portions of the resistance element than in others, to secure smooth control and evenness of reproduction in certain types of radio sets.

The demand for these composite resistance elements has heretofore been satisfied with elements made by disposing upon a suitable base, in abutting relation, various areas of conductive material; each of a different specific resistivity. So long as the contactor moves within the confines of any one of these areas, the increase or diminution of effective resistance, (depending on the direction of movement), is regular and smooth. However, when the contactor passes from an area having one specific resistivity, to an adjacent area of another specific resistivity, there is an abrupt change in resistance, which causes a sharp, angular departure in the resistance gradient of the element.

As indicated above, some of the contiguous areas of these resistance elements differ so widely relative to their respective specific resistivities, that an abrupt change of resistance follows when the contactor passes therebetween, which materially and adversely affects reproduction.

There have been efforts made to overcome this difficulty which have been only partially successful, and which have fallen far short of perfection. The most common practice has been to intersperse increments or particles of the abutting edges of adjacent areas in an effort to effect coalescence therebetween, to reconcile the difference in their specific resistances. However, this has not proved successful.

For the most part, resistance elements of this type were made by painting, or by electro-chemical deposition, and it is largely due to these methods of manufacture (which do not lend themselves to delicacy of control nor fineness of application) that the several coatings of composite elements have not been more gradually blended to secure less angular gradient curves.

In my prior Patent No. 1,771,236, I disclose a means of manufacturing a composite resistance element of the type hereinbefore discussed, where it is necessary to have the rate of resistance-increase constant through one range of movement of the contactor, and where, through another range, the rate of increase, although constant, is much more rapid than the first range. However, in such disclosure it is only possible to join the different sections abruptly, despite the desirability of having a gradual emergence thereof.

Therefore, it is an object of the present invention to provide a resistance element of the planar, carbonaceous, composite resistance type having its various sections of differing resistivities gradually merged to secure a regular, uniform resistance gradient.

It is another object of my invention to provide a novel method for making such an element whereby accuracy and evenness of coatings is assured and whereby a perfect gradual emergence between coatings is attained.

Other objects of my invention will become apparent upon consideration of the following specification when taken in conjunction with the following drawings, in which:

Fig. 1 is a diagrammatic vertical sectional view taken along the longitudinal axis of a resistance element made in accordance with my invention, in which the component parts of the element have been drawn in grossly exaggerated proportion; the element being projected upon a graph to illustrate the resistance-length curve thereof.

Fig. 2 is a diagrammatic composite view illustrating the pattern created upon a flat surface by a spray formed in accordance with my invention having its longitudinal axis perpendicular to the plane of the flat surface.

Fig. 3 is a diagrammatic composite view illustrating the pattern created upon a flat surface by my spray having its longitudinal axis directed at the center of, though obliquely disposed to, the plane of said flat surface.

Fig. 4 is a diagrammatic composite view illustrating the pattern created upon a flat surface by my spray which is partially intercepted by

the flat surface while disposed at a degree of inclination thereto.

Fig. 5 is a diagrammatic elevational view of my nozzle and spray, illustrated with the nozzle in section.

Fig. 5a is a plan view of a pattern created on a flat surface by the spray shown in Fig. 5.

Fig. 6 is a diagrammatic view of my nozzle and spray, showing the effect of the spray upon differently inclined surfaces.

Fig. 7 is a diagrammatic view of two sprays angularly disposed upon opposite sides of a moving strip.

Figs. 8, 9, and 10 are exaggerated sectional views taken along lines 8-8, 9-9 and 10-10, respectively, of Fig. 5.

Fig. 11 is a diagrammatic perspective view of an angularly inclined, moving strip passing before a horizontally disposed spray station, where it is receiving a transversely graduated coating in accordance with this invention.

Fig. 12 is a plan view of a blank prepared in accordance with my invention illustrating how a variety of resistance elements may be stamped therefrom, whereby each will have a different resistance gradient.

Fig. 13 represents a microscopic plan view of the contact surface of a composite resistance element made in accordance with my invention, illustrating the interspersion of particles of an overlying coating upon an underlying coating at their point of mergence.

Whereas, for purposes of illustration it has been necessary to show the conductive coatings of the resistance elements described herein as being of substantial thickness, it must be realized that such coatings are frequently only two to three thousandths of an inch in thickness, and but rarely exceed eight thousandths of an inch. Likewise, hereinafter where it has been necessary to refer to the mergence of adjacent coatings as "taper" or "tapering" of one such coating upon another, the "taper" refers not so much to an actual gradual diminution in thickness of the top coating, but rather to a lateral, progressively increased spacing between the particles of the top coating upon the bottom coating, whereby a gradual blending of the superficial areas of the adjacent coatings is effected.

Referring more specifically to the drawings in which like reference characters refer to like parts throughout:

In Fig. 1, 1 represents a suitable base or body portion which serves as a mounting for the conductive coatings 2, 3, 4 and 4a. The base may be either of conductive or insulatory material, and has applied to one of its surfaces, an overall coating 2, of any desired resistance value. Superimposed upon this coating are other coatings 3, 4 and 4a; each having a specific resistivity of the value necessary, when combined with the others, to create a resistance element having an overall resistance of any desired predetermined characteristics.

An arbitrary representation of a resistance gradient has been illustrated on the graph of Fig. 1 to show the effects of this invention when employed in the manufacture of a resistance element, as the one shown therein. The overall coating 2 is sprayed on in the manner shown in Fig. 2 whereby a coating of substantially uniform thickness is provided over the base 1. The coating 3 is sprayed over the coating 2 in a manner similar to that shown in Figs. 4 and 11 whereby a tapering effect is obtained. Then, to

each end of the element thus formed is sprayed low resistance paint 4, 4a, each, likewise, tapering to gradually merge with their respective underlying coatings, 3 and 2.

The effect of tapering these coatings is apparent in the graph: The low resistance paint 4 throughout its portions of uniform density produces a slow gradation of the curve. Its tapering out upon the coating 3 causes a diminution of its short-circuiting effect, and gives rise to a gradual increase of resistance. The line of demarcation between coatings 3 and 4 is imperceptible due to the gradual tapering-off of coating 4, nor is there any perceptible abrupt increase in the resistance gradient at this junction by virtue of the delicate gradation.

This gradual curve or "elbow" is represented on the graph between the projection lines A and B extending from the limits of the taper. Coating 3 gives a gradual increase of resistance at a definite rate, until the contactor traverses the taper thereof, which, as in the case of coating 4, causes the "elbow" shown between projection lines C and D on the graph. The overall coating 2, being of a greater specific resistance than coating 3, gives a greater increase in resistance for a given movement of the contactor, than does coating 2; and as suggested above, the difference in their resistance values is reconciled by the taper of coating 3. The low resistance paint 4a is applied so that a gradual short-circuiting may be achieved as represented upon the graph.

Resistance elements having the general characteristics of the one above described may be made by passing a strip or web 1 of suitable base material, such as heavy paper, past one or more nozzles N, according to the type of element desired, to receive a spray therefrom.

In my prior patent above referred to, I have disclosed various forms of conductive material which are suitable for this purpose. A mixture of different forms of carbon in a shellac solution may be employed, wherein the resistance characteristics of the mixture can be varied by changing the portions of conductive and non-conductive ingredients relative to each other.

The coatings may be applied uniformly over the entire web by positioning the nozzle centrally and perpendicularly thereover, as shown in Fig. 2, or they may be applied to taper in thickness across the web, as is shown in Fig. 3, by positioning the nozzle N to project a spray angularly thereover. As the spray diverges, the density of the coating decreases proportionally as the distance from the nozzle of the spray gun relative to the web is increased. In Fig. 4, the nozzle N and web 1 are positioned relative to each other to provide the web with a tapering coating which extends but partially across the surface thereof. This is likewise illustrated in Fig. 11.

The tapering effect of the spray may be augmented by employing a nozzle of certain construction, whereby the function of inclining the spray and web relative to each other to obtain a tapered coating is supplemented.

In Fig. 5, I have diagrammatically represented a nozzle in vertical section to illustrate the spray action referred to. The coating material is forced through the central jet 5 of the nozzle N. Compressed air is released through the passage 6, which is concentrically arranged about the jet 5, to atomize the coating material at the nozzle orifice 7. The nozzle imparts a swirling motion to the compressed air, whereby the outer portions of the stream being emitted from the jet 5 are

more completely atomized or aerated than the more central portions of the stream. Thus, the central portion 8 of the spray is of greater density than its outer portions 9.

5 Fig. 5a diagrammatically illustrates the pattern created by a spray when the nozzle is perpendicularly positioned over the web. Observe the comparatively uniform dense center 8' and the highly diffused peripheral portions 9' of the pattern.

10 To obtain the most uniform coating of maximum density, the web 1 should be perpendicularly positioned relative to the spray to intercept only the central portion 8 thereof, whereby the less dense and tapering portions 9 of the spray are not used. (See Fig. 6.) If the web is positioned as shown in dotted lines in this figure, the taper of the coating, as discussed in connection with Fig. 4, will be appreciably increased. That portion of the web intercepting the spray at its center, which is in closest proximity to the nozzle, will receive the densest coating. The web's inclination away from the nozzle combined with the less dense portions 9 of the spray cause a rapid diminution in the coating to effect a marked taper thereof.

Where it is deemed desirable to overlap coatings, two or more nozzles, as N₁—N₂ of Fig. 7, may be positioned to spray the web from its opposite sides to project sprays at an angle to the plane of the web. These nozzles are positioned in order that their sprays may play upon the moving web 1, so that their portions of less intensity, i. e., those portions playing upon the remoter portions of the web, fall in the same path on the web. Thus, the tapering portion of the coating thus formed applied by the spray of nozzle N₁, is overlapped by the tapering portion of the coating applied by the spray of nozzle N₂. In this manner a composite resistance element is formed, having a perfectly uniform contact surface, and smoothly graduated resistance characteristics. This may be better understood by referring to Figs. 8, 9 and 10 which represent sectional views of the web 1 shown in Fig. 7. These views have been greatly enlarged and exaggerated for purposes of illustration.

So far as I am aware, the only successful way of achieving these results is by depositing the conductive material upon the web by means of spraying, since no other method of deposition permits of such fine, controllable distribution and interspersation.

This will become more obvious from the inspection of Fig. 13. Here I have diagrammatically illustrated a microscopic view of a portion of my resistance element in order that I may more clearly point out the differences between composite elements made by spraying, as shown and described herein, and other well known methods of coating.

In Fig. 13, I have illustrated an overall coating, corresponding to the coating 2 of Fig. 1, by white particles 2', with a coating, corresponding to the coating 3 of Fig. 1, superimposed thereon, represented by the dark particles 3'. The view of Fig. 13 is taken at the point where the coating 3 tapers away to the coating 2.

By virtue of a spray being operated and controlled as has hereinbefore been discussed, the particles 3' of the dark coating are massed closely together to form a solid coating 3 over the coating 2, and gradually taper out upon coating 2. This solid coating 3 has a uniform rate of resistance increase throughout its length, and as was

mentioned in connection with Fig. 1, the coating 2, has a different, though uniform resistance increase throughout its length.

The densely massed particles 3' of the coating 3 were deposited by disposing that portion of the element upon which they rest closest to the spray gun. The portions of the element more remote from the spray gun received the particles in less compact relation. Thus, the density of the coating is inversely proportional as the distance from the spray gun. Hence, the particles 3' become scattered and more sparsely settled whereby more and more of the particles 2' appear at the surface.

For any unit area, the resistance is equal to the combined resistances of the particles; varying in the proportion that the dark particles 3' vary to the light particles 2'. Virtually, coalescence is effected between the coatings.

In all other methods of coating, there necessarily is a well defined line of demarcation between the coatings. Obviously there cannot be such an interspersation of particles when the coating material is applied with a brush or by electro-chemical deposition.

I have illustrated and described but a limited application of my invention. Nevertheless, I contemplate that any coating or combination of coatings, either conductive, insulatory or both, may be applied by my novel method to secure a resistance element having the desired characteristics.

Referring now to Fig. 12, the base 1, after having received a suitable coating or plurality of coatings, may have stamped therefrom arcuate or elongated pieces. These pieces constitute the resistance elements, and, of course, may be stamped out in any desired shape. By way of example, I have designated the arcuate elements with an X, and the elongated straight elements with a Y. It will be noticed that the elements X are illustrated in various positions; i. e., their end portions fall in different relative positions upon the web. In this manner resistance elements having different resistance gradients may be made from the same stock, whereby a greater range of demand may be satisfied. The strips Y may be cut transversely, longitudinally or obliquely from the web for the reasons recited above.

I have illustrated the web passing beneath or past stationary spray stations, but, of course, the web may be fixed, and the spray guns may be moved relative thereto to effect the same result. Likewise, any suitable manner of forming a spray which varies in intensity to provide a tapering coating, as by forming the spray nozzle orifice in any suitable way, is within the contemplation of this invention.

I claim as my invention:

1. The process of forming a resistance element having a plurality of resistance sections characterized by different specific resistivities which comprises, depositing on a base a conductive coating, and spraying on said base a conductive coating material superimposed over a portion of said first coating, said spray being controlled to taper, at a boundary of the second coating, the amount of coating material deposited on a unit area of surface.

2. The process of forming a resistance element having a plurality of adjacent sections of resistance characterized by different specific resistivities which comprises, depositing a coating composition on a base to form a conductive layer

thereon, and directing a spray of coating composition at an acute angle to a median plane of the base to deposit a second conductive layer overlying a portion of said first conductive layer, said second layer having a tapered edge.

3. The process of forming a resistance element having a plurality of adjacent sections of different specific resistivities with a smooth taper in resistivity between adjacent sections which comprises, depositing a layer of coating material on a base, and spraying on said base, over a portion of said layer, a coating material having a different specific resistivity than the first-named coating material, said spray being positioned with respect to said base to provide a smooth taper

in thickness of material at a lateral boundary of said second layer.

4. The process of forming resistance elements having sections of different specific resistivities, which comprises, depositing a conductive coating on a base to form a section having a predetermined specific resistivity, and directing at an acute angle to the plane of said coating a spray of conductive coating material to form a section overlying a portion of said first coating and having a different specific resistivity than said first section, the transverse juncture of said sections having a tapering specific resistivity.

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