

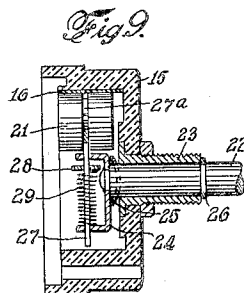
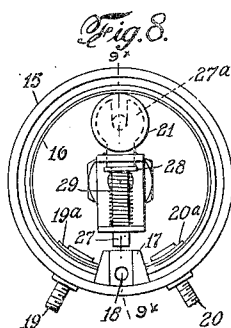
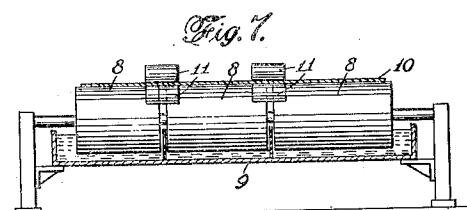
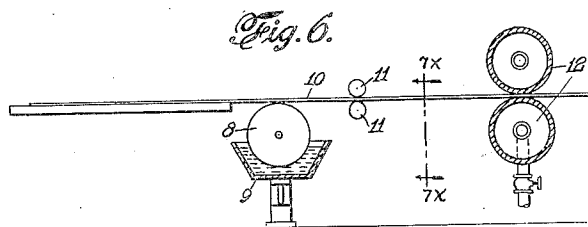
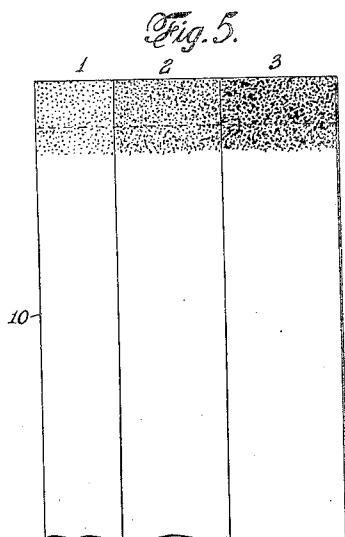
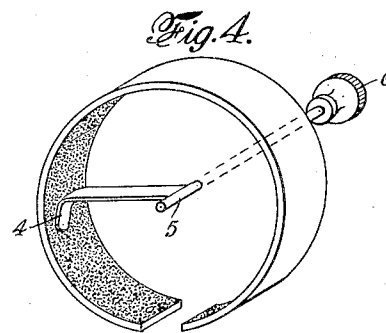
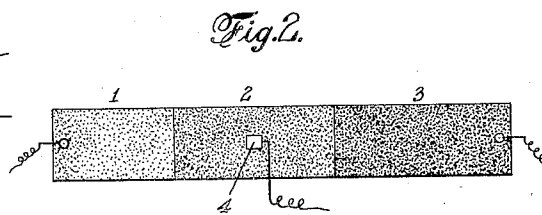
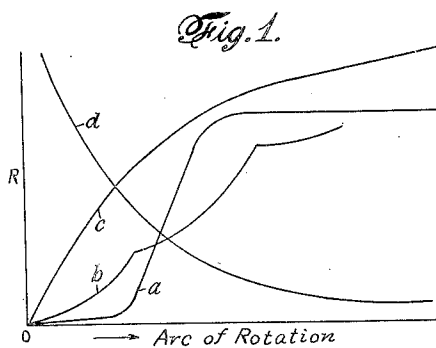
Nov. 10, 1936.

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2,060,114

METHOD OF MAKING VARIABLE RESISTANCE UNITS

Filed April 26, 1934



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2,060,114

METHOD OF MAKING VARIABLE
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Application April 26, 1934, Serial No. 722,474

4 Claims. (Cl. 201-76)

My present invention has for its object to provide a new type of resistance unit for use in connection with electric circuits which is so constructed that the voltage or flow of current may be regulated in a plurality of successive steps and at the same time graduated or regulated within each step, the successive steps becoming cumulative in their action.

A further object of my invention is to provide a current regulator comprising a strip member having successive areas of different resistivities forming a terminal of a circuit in association with a contact adapted to be the other terminal of such circuit, said two members being so mounted that relative linear movement may be had whereby the contact may traverse all the various sections or areas of the strip.

My invention also embraces the method of constructing resistance units with electrically connected areas of different resistive values and a simple apparatus for coating either sheets or continuous ribbons of suitable material with parallel longitudinal bands of carbonaceous material from which the unit strips may be formed by severing the sheets or ribbons transversely into desired widths.

To these and other ends my invention consists in further improvements all as will be more fully described, the novel features being more fully pointed out in the appended claims.

In the drawing:

Fig. 1 is a diagram illustrating several different resistance curves showing the capabilities of resistance units made in accordance with my invention.

Fig. 2 is a plan view of a strip member of a resistance unit made in accordance with my invention.

Fig. 3 is a cross section thereof greatly enlarged.

Fig. 4 is a diagrammatic perspective view illustrating one form of associating the contact strip with a cooperating circuit terminal.

Fig. 5 is a plan view of a portion of a sheet or ribbon of the coated material.

Fig. 6 is a diagrammatic view of the principal elements of a coating machine for applying the coated areas to sheets such as shown in Fig. 5.

Fig. 7 is a transverse view thereof, taken on the line 1x-1x of Fig. 6 illustrating the sectional coating rolls, ink tray and smearing idlers.

Fig. 8 is a front view showing one form of a commercial assembly; and

Fig. 9 is a vertical sectional view taken on the line 2x-2x of Fig. 8.

The several reference characters appearing on the several figures indicate similar parts.

In my experiments in various branches of the electrical industry, I have demonstrated that there are certain types of apparatus which require voltage regulation that operate better if, instead of using a step by step rheostat, or the usual type of continuously regulated voltage divider, the current is graduated intermediately in progressive steps. Especially is this so in the operation and control of certain types of thermionic tubes or vacuum tubes employed in the transmission and reception of radio signals.

In Fig. 1, I have shown four different forms of curves indicative of the manner in which the voltage in a given circuit may be controlled to meet any desired requirement by means of a regulator or unit embodying my invention. Observing curves *a*, *b*, *c*, it will be noticed that for a given distance through which the movable contact member first travels the resistance increases gradually, that when this reaches a desired number of ohms the resistance greatly increases upon additional slight movement of the contact and rapidly increases as the contact is further advanced until another stage is reached whereupon there is still a further sudden increase of the resistance which likewise may be gradually increased. Curve *d* is indicative of an action different from that just mentioned in which, starting with a high resistance, we have upon movement of the contact member a lowering of the resistance. There is no reasonable limit to the number of control steps which may be provided but in the great majority of cases three or four such steps will meet practically all commercial requirements. In the last step the maximum resistance, provided as indicated by curves *a*, *b*, and *c*, will remain practically constant or rise very slowly upon further movement of the contact, or, as shown by curve *d* will have reached the lowest point.

As shown in Fig. 2 the above objects are accomplished by providing a contact strip having successively disposed areas of conductive material indicated by 1, 2 and 3, each of a different resistive value. The length of each of said areas is not arbitrarily fixed, as shown, but is predetermined according to the conditions to be met in the particular circuit in which the resistance element is employed. Cooperating with the latter is a longitudinally movable contact 4. The contact may, however, be stationary and provisions made to adjust the resistance, if desired. In practice the resistance strip may be conveniently bent into circular form, as shown in Fig. 4, and

the cooperating contact mounted to rotate therein. In practice the resistance element comprises a lining for the inner periphery of the wall of a suitable container, the wiper or brush 4 being carried upon a central shaft 5 supported in a suitable bearing which may be rotated by the knob 6.

Reliability in an instrument of this kind is of primary importance and I have devised a method of making the strip to provide one having a long life and one that will not vary materially with thermal conditions. To this end I provide a base 7 of a phenol condensation product which in the process of curing I treat so that the resinous substances are not completely hardened. Briefly stated this is accomplished by only semicuring the sheet initially, i. e. polymerization is arrested before it is completely effected. In the next step I coat the areas, indicated by 1, 2 and 3 in Fig. 2, with resistance materials containing carbon, or similar conductive substances, in different proportions.

In carrying out my invention I prefer to make the several resistances in fluid form and apply them in any approved manner. To this end I may make a primary solution of carbonaceous material, organic resin and an organic solvent. The exact proportions are not essential but as an example of a solution which I have satisfactorily used in practice I employ 21% of carbon, 26% resin and 53% of solvent. The resin used is one which has an affinity for that in the sheet to which the solution is applied viz. a phenol-formaldehyde product and the solvent is a selected one such as acetone or ethyl acetate which will dissolve the resin and also have a tendency to soften the semicured surface of the sheet. The character of the carbonaceous material used and the quantity employed, it will be understood, is varied in the several solutions used to coat different areas of the sheet in accordance with the requirements of the different resistances which it is desired to obtain in each of said areas. After the solution, or solutions are applied to the sheet the curing of the latter is completed by the application of heat.

In Fig. 6 I have shown diagrammatically the elements of a coating machine comprising a coating roller 8 composed of the desired number of sections rotating in different compartments of a pan 9 and serving to transfer the several graded solutions of resistance substances to the under side of a sheet or ribbon 10 to coat it with parallel longitudinal strips as shown in Fig. 5. Immediately following the coating rolls 8 there are small rolls 11 which overlap the contiguous edges of the band coatings. The lower rolls of each of these pairs of rolls serve to blend or smear the different coatings together so that in the finished strips there will be no break in the conductivity from one end of the strip to the other. The coated sheet finally passes between a pair of calender rolls 12 heated to approximately 350° Fahrenheit for completing the curing of the coated phenol composition sheet and making a perfect union between it and the coating or coatings on its surface. In this way I find I am able to provide a resistance surface which is bonded to the support or backing and will wear practically indefinitely.

The method of manufacture described has certain other advantages in that the finished surface is hard, does not rub off and possesses long life. In some instances I recommend that the coated surface be calendered, in addition to the calendering action of the rolls 12, to burnish it,

as I find that in so doing all sound, in highly amplified circuits, due to the adjustment of the contact, can be eliminated.

In Figs. 2 and 3 the various areas referred to are shown separated by faint lines and the different areas are indicated by various degrees of shading, or stippling. These are merely means I have employed to convey an idea of the manner in which the invention is carried out as in the finished product these lines of demarcation are not visible to the naked eye.

As an example of a satisfactory commercial instrument I have shown in Figs. 8 and 9 a casing 15, preferably of moulded insulating material, having a cylindrical inner wall against which the resistance strip, indicated by 16, rests. Across this surface a small rib 17 extends, the opposite edges of which form abutments for the ends of the strip. This facilitates the assembly and prevents the strip from shifting. Also the added material at this point of the casing provides space for an aperture 18 by means of which the casing may be mounted by a suitable bolt to a panel. For electrically connecting the conducting portions of the strip with a circuit I provide the terminals 19 and 20 in the form of bolts projecting through the wall 15 and beneath the heads of the bolts small contact plates 19a, 20a rest upon the ends of the coated areas of the strip 16.

The contact member in this instance, corresponding with the wiper 4 of Fig. 4, is a roller 21 moved by oscillating the shaft 22. The latter is journaled in a sleeve 23 secured to the base of the casing 15 and at its inner end carries a yoke 24. A spring washer 25 lies between the yoke and the inner end of the sleeve to prevent the movement of the shaft in one direction and hold the collar 26 on the shaft in contact with the outer end of the sleeve. The extremities of the yoke 24 extend outwardly and are slotted to form a guide for the flat stem 27 of the roller carrying member. The roller 21 is slotted to receive the forked outer end 27a of the stem 27. It will be observed that in constructing this member I carry the enlargement of the end of the stem carrying the roller through the contiguous guide portion of the yoke so as to form shoulders against which rests a washer 28, pressed outwardly by a coil spring 29. In this way the contact roller 21 is held against the conducting surface of the contact strip with a uniform pressure in all positions of adjustment notwithstanding slight irregularities which may occur.

In the description herein I have referred to a resistance strip having two or more coatings but it will be understood that my invention also comprehends a single coating of the nature described which will have many uses in the electrical art where a continuously progressive resistance, acting the same as the present wire wound resistors or voltage dividers, may be used. It will also be appreciated that the different areas indicated, for instance in Fig. 2, may be made in the form of bars of material of different resistance values united end to end to provide a continuous electrical path without a backing or support and may be made either flat or curved.

I claim as my invention:

1. The method of making resistor elements comprising applying to the surface of an incompletely polymerized sheet of phenol condensation product a solution containing carbonaceous material a phenol-formaldehyde resin and a solvent for said resin and sheet and subsequently com-

pleting the polymerization of said sheet with the coating on the surface thereof.

2. The method of making resistances consisting of the steps of semicuring a non-moisture absorbing base composed of a sheet of phenol condensation product, coating it on the surface with adjacent strips of conductive material possessing phenol-formaldehyde having an affinity for the substances of which the base is composed and completing the curing of the latter leaving the conductive material on the surface of the base.

3. The method of making resistances comprising applying thin coatings on a sheet of semicured phenol condensation product as adjacent bands of conductive material of different resist-

ance values, uniting the adjacent edges of said bands, heating the coated strip to complete the curing thereof and cutting the sheet transversely of said bands to form a plurality of strips.

4. The method of making resistances comprising coating one surface of a sheet of partially cured phenol condensation product with adjacent bands of conductive material of different resistance values containing phenol-formaldehyde substances having an affinity for the materials composing said sheet and completing the curing thereof to effect a bond between the sheet and the coatings thereon.

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