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MANUFACTURE OF ELECTRIC RESISTANCE ELEMENTS

Filed July 22, 1936

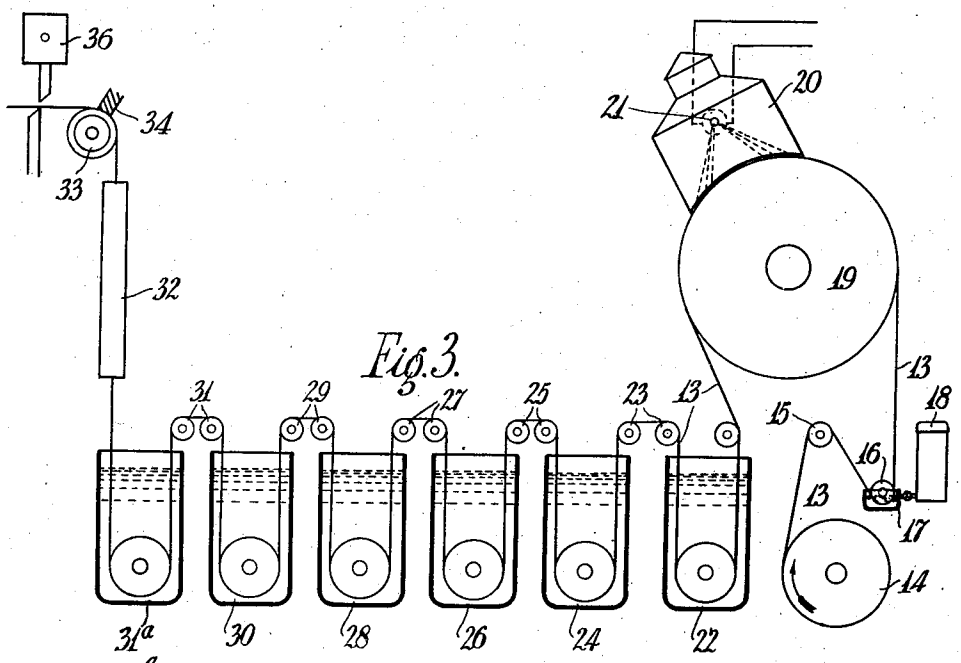


Fig. 3.

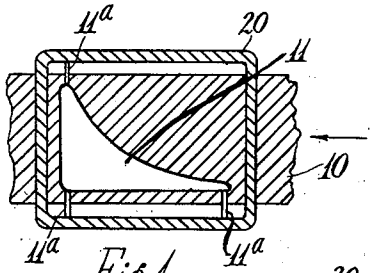


Fig. 1.

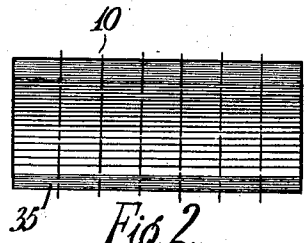


Fig. 2.

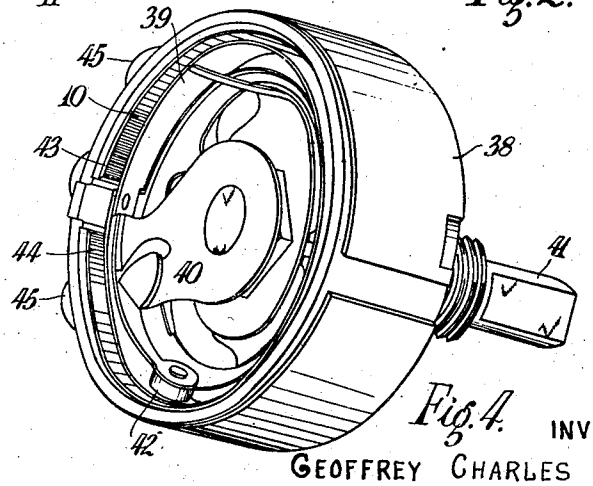


Fig. 4.

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MANUFACTURE OF ELECTRIC RESISTANCE ELEMENTS

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9 Claims. (Cl. 201—76)

This invention relates to the manufacture of electric resistance elements and variable resistances and has for its object to provide an improved resistance and an improved method of manufacture therefor such that the ohmic value of the resistance and its grading (in the case of a variable resistance) can be very accurately controlled.

The primary feature of the present invention resides in the use of a conductive film or surface which is produced from a photo-sensitive compound, for example, silver bromide, silver chloride, silver iodide, or the like in which is incorporated a suitable conductor in finely divided form or in the form of a suspension or dispersion, e. g. carbon of colloidal or substantially colloidal dimensions. Upon development the activated silver salt or equivalent photo-sensitive compound is reduced to the metallic state so that the conductivity of the film depends on the amount of carbon or equivalent conductor incorporated therein and the amount of reduced metal compound.

A further feature of the present invention resides in the manner of graduating the resistance element for use in a variable resistance by control of the size and shape of the area subjected to activation, while a further feature of the invention concerns the provision of a process for producing resistance elements according to the invention in a continuous manner.

In one convenient way of carrying the invention into effect we utilise a suitable base or support which may be Celluloid, cellulose acetate, paper or the like and to this we apply a coating which will adhere to the base. This coating consists of a photo-sensitive compound in which is incorporated a suitable conductor as described above. The photo-sensitive material carried by the base or support is then subjected to the action of actinic light, use being made of a suitable stencil plate or mask if it is desired to graduate the resistance. The exposed element is then subjected to development, fixing, etc. similarly to an ordinary photographic plate whereupon a resistance element having values determined by the composition of the photo-sensitive compound and the degree of exposure to light is produced. Such elements are of particular use in connection with the manufacture of variable resistances or potentiometers.

In order that the invention may be more readily understood reference will now be made to the accompanying drawing wherein,

Fig. 1 is a plan view of a suitably apertured mask for producing a graded type resistance element;

Fig. 2 is a view of a resistance element produced with the aid of the mask shown in Fig. 1;

Fig. 3 represents a schematic layout of apparatus for carrying out the method of the invention in a continuous manner;

Fig. 4 is a perspective view of a variable resistance or potentiometer incorporating the element shown in Fig. 2.

A suitable base or support 10 (Fig. 2) consisting of Celluloid, cellulose acetate, paper or the like is provided with a coating of photo-sensitive compound which will adhere to the said base. As an example, in the case of a Celluloid base we have found the use of a lacquer consisting of nitro-cellulose containing the photo-sensitive compound (silver bromide) and the conductor (carbon) to be satisfactory. A suitable photo-sensitive lacquer for application to a Celluloid or like base can be made as follows:—

	Grams
Pyroxylin (high viscosity)	1.5
Silver nitrate	11
Ammonium bromide	6.25
Carbon ("light soot")	.75
	Cubic centimeters
Ethyl alcohol	21
Ammoniacal ethyl alcohol	4
Methyl alcohol	4
Ether	12
Acetone	6
Diacetone alcohol	0.5
Triacetin	1

In preparing such a lacquer we may prepare a mixture of all of the ingredients except the ammonium bromide, silver nitrate and carbon. The ammonium bromide and silver nitrate are added in powder form in small quantities at a time to the mixture and finally the carbon is added, the whole mixture being continuously stirred with stainless steel or glass stirrers during the addition of these three components. The addition of the first two components under stirring may occupy about one hour and of the third about half an hour. In this and the subsequent stages of the manufacture due precautions must obviously be taken to prevent any undesired influence due to light. The small solubility of silver nitrate and ammonium bromide in alcohol permit these two components to react together completely to form silver bromide, which, in the presence of the dispersed nitro cellulose, is produced as a colloidal solution. The size of the silver bromide particles can be varied

in known photographic manner by the presence of ammonia and by the time and temperature of the stirring operation. Triacetin is employed as a plasticiser. Small quantities of resin and ester gum may be added to the mixture.

When the base or carrier has been prepared by the application of the photo-sensitive material such as described above it is then subjected to the action of actinic light, e. g. from a mercury discharge tube or arc lamp, a suitable stencilled plate or mask such as shown at 11 in Fig. 1 or an optical wedge being used where necessary to control the light falling on the coated base or carrier 10. The exposed element is then subjected to development, fixing, etc. similarly to an ordinary photographic plate; washing should be effected in pure alcohol. The exposed element is preferably passed through a bath of ammonium bromide in alcohol to prevent fogging before it is developed. The developer used may consist of pyrogallic acid in ammoniacal alcohol while fixing may be effected by a bath of ammonium thiocyanate in ammoniacal alcohol. In this manner the resistance element shown in Fig. 2 is produced, the ohmic resistance of which is determined by the composition of the photo-sensitive lacquer and the degree and extent of activation of the photosensitive compound while the graduation thereof is controlled by the configuration of the mask 11 shown in Fig. 1.

While it is possible to manufacture elements by treatment one at a time, e. g. with an optical wedge, we prefer to provide for a continuous process in order to speed up the output. Referring now to Fig. 3 which illustrates in a schematic manner such a continuous process use is made of a band 13 of Celluloid, paper or the like which is fed from a supply drum 14 over a jockey pulley 15 to a drum 16 forming part of a constant-level emulsion bath 17 which is fed with suitable emulsion, for instance, that previously described, from a supply tank 18. The band 13 is thereby coated with emulsion to the desired extent and is subsequently fed on to the outer surface of an exposure drum 19. In the movement of the band 13 around the axis of this drum 19 it passes into a lamp chamber 20 where it is subjected to the action of actinic light from a suitable source 21 such as a mercury discharge tube or arc lamp so as to activate the photo-sensitive component or components of the emulsion. The band 13 is then passed by way of suitable rollers to a bath 22 containing an anti-fog solution such as ammonium bromide in alcohol and from this bath the band 13 is passed by way of further guide rollers 23 to a washing tank 24 preferably containing pure alcohol. From this tank the band 13 is directed over guide rollers 25 to a developing tank 26 containing a suitable developer such as pyrogallic acid in ammoniacal alcohol and then over rollers 27 to a further washing tank 28. From this tank it passes over further rollers 29 to a tank 30 where fixing is effected preferably by means of a bath of ammonium thiocyanate in ammoniacal alcohol from whence it is directed over rollers 31 through a further washing bath 31a and a drying tunnel or chamber 32 to a roller 33. All of the rollers, as well as the drum 19, may be driven from a suitable drive source (not shown).

The band 13 after passing over the roller 33 is delivered to an automatically operated guillotine 36 where it is cut transversely into sections each constituting a resistance element of specified value determined by the composition of the photo-sensitive lacquer and the duration and extent of exposure to light.

If the resistance desired is to be of the graded type such as a logarithmic or other element for use in a variable resistance, a mask 11 having supports 11a to the lamp chamber 20 as shown in Fig. 1 is interposed between the light source 21 of the lamp chamber 20 and the strip 13. In this case the exposure varies transversely of the band in accordance with the configuration of the mask so that at the upper edge in Fig. 1 the photo-sensitive lacquer is subject to maximum exposure during the travel of the band while near the lower edge it is subject to minimum exposure, the extreme lower edge however being completely exposed. The resulting conductivity is shown by the graduated shading in Fig. 2, the dotted lines indicating how the band is subsequently cut into strips 10 by guillotine 33. The lower conductive section 35 forms a low-resistance contact element for contact making purposes during the subsequent mounting of the element, the other contact being of course made to the top of the strip. Either before or after severing into strips the band 13 is preferably polished, e. g. with soft filter paper or like pad as indicated at 34.

Instead of controlling the conductivity by varying the exposure we may control it by suitable choice of wavelength. For example, by using a prism (preferably quartz) in conjunction with a source of substantially white light we may project a spectrum on to the band.

In place of a separate mask we may use a supporting band of varying opacity and illuminate through the band.

While we have referred to the use of a support coated with photo-sensitive lacquer it is clear that the latter need not form a permanent fixture on the support. It may be removed from the support after treatment or, if sufficiently strong, processed without the aid of a support.

Fig. 4 shows a variable resistance or potentiometer employing such a resistance element and comprising a hollow cylindrical body 38 around the inner circumferential surface of which is disposed the resistance element constituted by a strip 10 (Fig. 2) produced either individually or continuously as previously described. A flexible metal band 39 held against rotary movement but mounted so as to allow movement thereof in a radial direction serves to make contact with any part of the resistance element 10 by means of a rotatable pressure arm 40 connected to a control spindle 41. The pressure arm 40 carries a button 42 which engages and presses the flexible band 39 against the resistance element 10. Rotation of the pressure arm 40 causes the button 42 to move around the band 39 to press that part of it lying beneath the button 42 against the resistance element so that any portion of such element between the two ends 43, 44 may be connected to the flexible band 39. These ends 43, 44 of the strip 10 are each connected to external contact making means such as soldering contacts 45 in known manner.

We claim:

1. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of forming a sensitized photographic layer having a conductor in finely divided form incorporated therein, the photosensitive ingredient in said photographic layer being of a type which forms a permanently conductive material upon suitable photographic exposure and development,

exposing said layer to actinic radiations adapted to affect said photosensitive ingredient and controlling the exposure to produce a predetermined gradation of photographic effect across said layer, and developing and fixing said layer to produce said resistance element having a graduated resistance value across said layer.

2. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of forming a sensitized photographic layer having a conductor in finely divided form incorporated therein, the photosensitive ingredient in said photographic layer being of a type which forms a permanently conductive material upon suitable photographic exposure and development, exposing said layer to actinic radiations adapted to affect said photosensitive ingredient and interposing a mask of desired graded light transmitting characteristics and shape in the path of said radiations to produce a predetermined gradation of photographic effect across said layer, and developing and fixing said layer to produce said resistance element having a graduated resistance value across said layer.

3. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of forming a sensitized photographic layer having finely divided carbon and a photographically sensitive silver compound incorporated therein, exposing said layer to radiations adapted to photographically affect said silver compound and controlling the exposure to produce a predetermined gradation of photographic effect across said layer, developing said layer to reduce said silver compound to silver in a graded density corresponding to said exposure and fixing said developed layer.

4. The method of making an electric resistance element which includes the steps of forming a sensitized photographic lacquer comprising nitro-cellulose, a photographically sensitive silver compound and finely divided carbon, applying said lacquer as a layer onto a base of cellulosic material, exposing said layer to radiations adapted to photographically affect said silver compound and controlling the exposure to produce a predetermined gradation of photographic effect across said layer, developing said layer to reduce said silver compound to silver in a graded density corresponding to said exposure and fixing said developed layer.

5. A continuous process for manufacturing electric resistance elements which includes the steps of feeding a band of sheet material having a layer of photographically sensitive compound thereon under a beam of radiations adapted to photographically affect said sensitive compound while controlling the amount of radiations to effect a gradation across said layer of the total radiation reaching the various lateral parts thereof, subsequently passing said band through developing, washing, fixing and drying means, and finally cutting said band transversely into a plurality of strips of graded linear resistance.

6. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of dissolving pyroxylin, silver nitrate and ammonium bromide in a common solvent together with an insoluble conductor in finely divided form suspended in said solvent, depositing the mixture in a thin layer on a sheet base, exposing said layer to actinic radiations adapted to affect the silver salt in said layer and limiting the exposure to different extents at different points across said layer to produce a predetermined gradation of photographic effect across said layer, and developing and fixing said layer to produce said resistance element having a graduated resistance value across the said layer.

7. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of dissolving pyroxylin, silver nitrate and ammonium bromide in a common solvent together with an insoluble conductor in finely divided form suspended in said solvent, depositing the mixture in a thin layer on a sheet base, exposing said layer to actinic radiations adapted to affect the silver salt in said layer and limiting the exposure to different extents at different points across said layer to produce a predetermined gradation of photographic effect across said layer, and developing said layer in pyrogallic acid in ammoniacal alcohol and fixing said layer to produce said resistance element having a graduated resistance value across said layer.

8. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of forming a sensitized photographic layer of pyroxylin, silver bromide and a uniformly distributed conductor in finely divided form, exposing said layer to actinic radiations adapted to affect said silver bromide and limiting the exposure to different extents across the said layer to produce a predetermined gradations of photographic effect across said layer, and developing and fixing said layer to produce said resistance element having a graduated resistance value across said layer.

9. The method of making an electric resistance element for use with a movable contact in adjustable resistance devices which includes the steps of forming a sensitized photographic layer of pyroxylin, silver bromide and a uniformly distributed conductor in finely divided form, exposing said layer to actinic radiations adapted to affect said silver bromide and limiting the exposure to different extends across said layer to produce a predetermined gradation of photographic effect across said layer, and developing said layer in pyrogallic acid in ammoniacal alcohol and fixing said layer to produce said resistance element having a graduated resistance value across said layer.

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