Aug. 18, 1931. L. L. JONES 1,819,246

VARIABLE RESISTANCE UNIT

Filed March 28, 1929

Fig. 1.

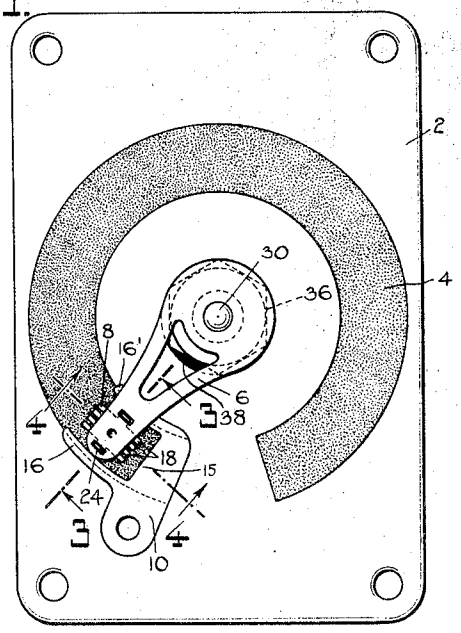


Fig. 2.

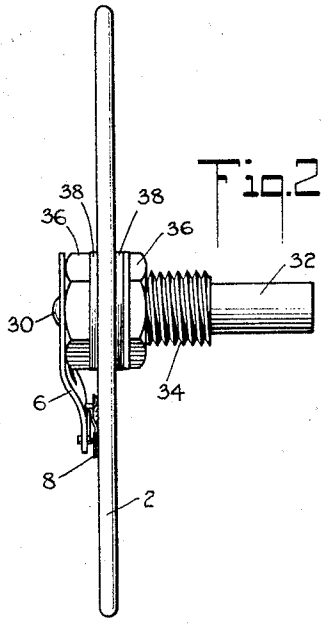


Fig. 3.

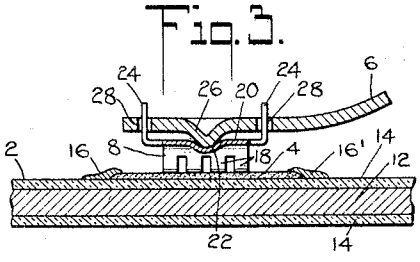


Fig. 4.

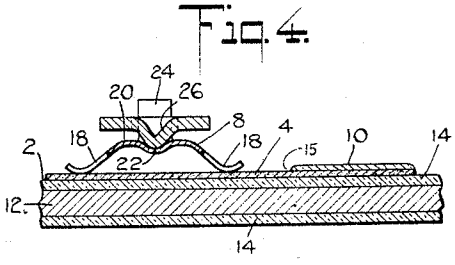


Fig. 5.

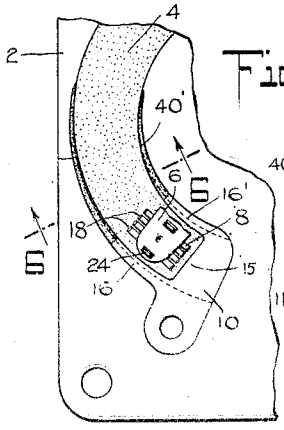


Fig. 7.

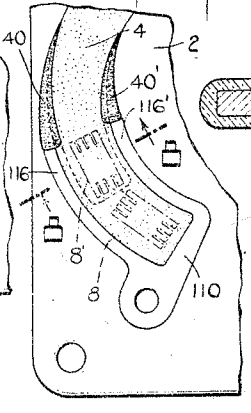


Fig. 6.

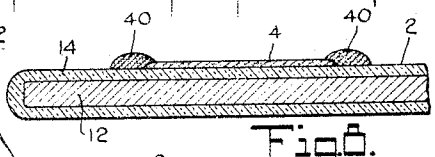
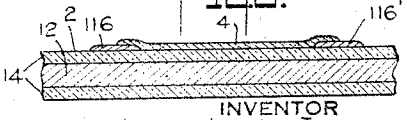


Fig. 8.



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UNITED STATES PATENT OFFICE

LESTER L. JONES, OF ORADELL, NEW JERSEY

VARIABLE RESISTANCE UNIT

Application filed March 28, 1929. Serial No. 350,731.

This invention relates to variable resistance units, and more particularly to variable high resistance units employing a resistance film.

In my copending application Serial No. 193,357 filed May 21, 1927. I have disclosed a variable high resistance in which the resistance elemen. consists of a high resistance film coated on an insulation base, while the contactor consists of a substantially flat sliding silver contact which is oscillatably supported at the end of a resilient contact arm. The general object of the present invention is to improve the construction and operation of such a variable resistance.

Because of the high maximum resistance which the unit is intended to have the film employed is exceedingly thin and possesses a very high specific resistivity. In consequence, when the sliding contact leaves the metallic terminal or short circuit point of the resistance element the resistance value changes abruptly from zero to an initial resistance value which is quite high. It is very difficult to obtain a gradual increase in resistance from zero to a moderate value, say 100 ohms, over so great a segment of rotation of the contactor arm that the range of resistance below that value may be usefully employed.

The primary object of the present invention is to overcome this difficulty, and to secure a gradual increase in resistance beginning with zero. To this end I provide a relatively low resistance path near the zero end of the resistance film which extends along and contacts with the film at an edge, and preferably at the two opposite edges thereof. In this manner an enclosure of low resistance material surrounds the contact area near the low resistance end of the film and is connected with the fixed terminal thereof. The low resistance coating is located outside of the path of the sliding contact, so that the current path is through the high resistance film, but may extend in many directions in relatively short radial paths from the sliding contact to the low resistance material, and thereby permits of a reduced initial resistance value when the sliding contact first leaves the fixed terminal of the resistor.

It is essential to the practice of the foregoing invention that constant points or areas of the sliding contact be in contact with the resistance film. In the resistor described in my copending application already referred to, this result is approximated by making the sliding contact slightly arcuate upwardly, and arranging the resilient contact arm so that its pressure on the center portion of the sliding contact tends to flatten the latter against the resistance film, and so mounting the contact on the arm that it is capable of oscillating thereon to seat itself as accurately as possible on the surface of the film. With a perfectly plane insulation surface as a foundation for the resistance film very satisfactory results are obtained with this arrangement. However, it is difficult to obtain a perfect insulation surface, and particularly with enamel for the insulation, the coating may not always be plane, in which case the area and the location of the points of contact by the sliding contact with the film may vary. This contact, if employed with the present invention, may lead to irregularities in the low initial resistance because of variations in the number of the short radial paths from the sliding contact to the low resistance margins of the film. To overcome this difficulty, and to provide a sliding contact having a definite constant contact area and location of contact, is a further object of my invention.

Other objects of the present invention are to permit a gradual rise in resistance to take place over any desired portion of the movement of the contact arm; to provide means for fixing a sliding contact to the contact arm permitting oscillating movement of the sliding contact on the arm; and to provide, when desired, an initial resistance as low as, say, a half ohm.

To the accomplishment of the foregoing and such other objects as will hereinafter appear, my invention consists in the elements of the resistance unit and their relation one to the other, as hereinafter are more particularly described in the specification

and sought to be defined in the claims. The specification is accompanied by drawings in which:

Fig. 1 is a rear elevation of a resistance unit embodying my invention;

Fig. 2 is a side elevation;

Fig. 3 is a section taken in the plane of the line 3—3 in Fig. 1;

Fig. 4 is a section taken in the plane of the line 4—4 in Fig. 1;

Fig. 5 is a fragmentary elevation showing a modification arranged for a more gradual rise in resistance;

Fig. 6 is a section taken in the plane of the line 6—6 in Fig. 5;

Fig. 7 is a modification arranged for an extremely low initial resistance; and

Fig. 8 is a section on the line 8—8 in Fig. 7.

Referring to the drawings, the resistance unit comprises a base 2 coated with a resistance film 4 and provided with a contact arm 6 which carries a sliding contact 8.

The base may be composed of any suitable insulation, such as glass or pyrex, but preferably takes the form of a sheet metal stamping 12, coated with a baked enamel coating 14 to place it in finished condition. This process of manufacture is an exceedingly simple one because all of the necessary perforations in the base may be stamped out at the same time that the base is stamped to configuration, and the subsequent enamel coating is applied to the peripheries of the various perforations as well as to the surface of the base.

In the form here illustrated the contact arm 6 is arranged for rotative movement, and the resistance film 4 is, consequently, arcuate in shape. It comprises almost an entire circumference of a circle, and may best be applied by rotating the base in a lathe and bringing a brush or other application means carrying resistance paint into contact with the rotating base at the proper radial distance from the center of rotation. If rapid rotation is employed so that a full circumference of resistance film is obtained, the film may subsequently be scraped away at one point in order to obtain the final discontinuous resistance strip indicated in the drawings.

The resistance paint per se is not described in detail here, as it may be of the type disclosed in my copending application already referred to, or any desired modification thereof, characterized by having a high resistance of permanently constant value, and by not being worn away by the friction of the sliding contact thereon.

At the low resistance end of the film a metallic coating is painted or otherwise applied in contact with the film, in order to provide the zero resistance or short circuit terminal 10. The metallic coating preferably is silver, because of the high conductivity and non-oxidizing properties of this metal. It may be applied by painting the surface with colloidal silver suspended in oil. By subsequent baking the oil may be driven off and the silver fused into a solid body.

The transverse edge 15 of the metallic terminal should be so located that all of the fingers of the sliding contact 8 leave the terminal simultaneously. This I find is exceedingly desirable because otherwise the initial resistance above zero will be that provided by only a single longitudinal resistance path instead of being that provided by a plurality of resistance paths distributed all along the trailing edge of the sliding contact. It therefore is essential that the edge 15 be made not radially, as might first be supposed, but rather parallel to a radial line at a distance therefrom equal to half of the length of the sliding contact. More broadly, the edge 15 is made parallel to the trailing edge of the contact 8 when the latter edge is located just above the edge of the terminal.

The silver coating may overlap the resistance film 4, as is best shown in Figs. 3 and 4, or vice versa, as in Figs. 7 and 8. Assuming the former condition to exist, and the terminal to be without the marginal extensions 16 and 16′, when the sliding contact 8 leaves the terminal 10 the initial resistance jumps suddenly, rather than graduallly, to an appreciably high initial value, say one or several hundred ohms. To overcome this difficulty and to permit of a gradual rise in resistance, I extend the metallic coating 10 marginally along an edge of, and in contact with, the resistance film, as is indicated by the extension 16, or along both sides of the film, forming the extensions 16 and 16′ shown in Figs. 1, 3, and 5. The low resistance coating is in electrical contact with the resistance film, but lies outside of the path of the sliding contact 8, which slides only on the high resistance film. An appreciable resistance is therefore introduced, but the magnitude of this resistance is not near so great as it would be in the absence of the low resistance marginal paths 16 and 16′, for current flows radially in a plurality of directions from the contact 8 to the nearest portions of the low resistance materials.

The regularity and predeterminable uniformity of the resulting operation is entirely dependent upon the sliding contact making contact with the resistance film over a constant total area and at constant points on the sliding contact. This result must be attained in spite of the possible existence of slight irregularities in the surface of the enamel coating and the resistance film. To this end I provide a contact 8 which is slit to form a plurality of individually flexible contact fingers 18. This expedient alone would not suffice were the sliding contact rigidly fastened to the contact arm, for the reason that in the event of a change in the surface

of the film, the contact fingers 18 would each be biased and contact along only one or the other of their edges. In other words, while the subdivision of the sliding contact would alone improve the performance and make it possible for each of the fingers to remain in contact with the resistance film at some point, nevertheless the area and point of contact of each of the fingers with the resistance film would be varied upon changes in the inclination of the film surface relative to the surface of the sliding contact. I, therefore, additionally provide means for mounting the sliding contact 8 on the resilient arm 6 so that it may oscillate in order to seat itself freely in most general agreement with the surface of the film. The combination of a freely oscillatable sliding contact with the individually flexible contact fingers provides as near an approach to perfect contact as is necessary in practice.

The entire resistor is a small unit, say two inches in diameter, and consequently the sliding contact is very tiny. Its fingers 18 are therefore incapable of supplying the necessary resilience for overall contact, and for this reason I make the relatively large arm 6 resilient, and keep it in a somewhat flexed position in normal operation.

The sliding contact 8 is preferably made of a soft highly conductive non-oxidizing material. It should be soft enough so that if wear between the contact and film takes place the wear is taken by the contact rather than by the film. It should be non-oxidizing so that it will not acquire a non-conductive coating which is apt to seriously vary the resistance value of the unit. The most suitable commercially practicable metal is silver.

The mode of mounting the contact 8 on the arm 6 is best illustrated in Figs. 1, 3, and 4, referring to which it will be seen that the sliding contact 8 comprises a raised or bridged central portion 20, and depending leading and following contact portion, the latter being longitudinally slit to form a plurality of individually flexible contact fingers 18. The raised portion 20 is provided with a rounded depression 22, and upstanding marginal lugs 24, which respectively cooperate with a rounded protuberance 26 on the contact arm 6, and a pair of transverse apertures 28 therein. The resilient contact arm 6 bears down upon the bridged or raised portion of the sliding contact 8 with sufficient force to slightly flex the contact fingers 18, and so to keep them in intimate contact with the resistance film. The spherical seat provided for the hemispherical protuberance 26 by the depression 22, together with the fact that the apertures 28 are made appreciably larger than the lugs 24, permits the sliding contact 18 to oscillate, relative to the contact arm 6, with a plurality of degrees of freedom, and sufficiently to permit of the desired maximum contact between the sliding contact and the resistance film.

While I am particularly anxious to provide a very constant and highly efficient sliding contact in the present resistor, in order to make constant the effect of the marginal low resistance paths, it nevertheless will be appreciated that the resulting contactor may be employed with great value in any resistance unit, whether or not the unit is designed for a gradual initial resistance increase.

For the sake of descriptive completeness it may be remarked, with reference to Figs. 1 and 2, that the contact arm 6 is riveted at the point 30 to the rotatable shaft 32, while the latter is rotatably but not axially movable within a threaded bushing 34, which is fixed to the base 2 by nuts 36, preferably bearing against insulation washers 38.

It sometimes is desired to have the resistance value rise gradually from zero to some moderate value, say 100 ohms, over a very considerable portion of the resistance unit, say one-third of the total permissible rotation of the contact arm. A slight modification providing for this is illustrated in Figs. 5 and 6, reference to which shows that the resistance film 4 is provided not only with a metallic terminal 10 which extends marginally along either side of the resistance film, as at 16 and 16′, but also with additional marginal low resistance extensions, preferably in the form of a heavy layer of relatively low resistance paint, indicated at 40 and 40′ in Figs. 5, 6, and 7. This resistance material need not be capable of taking wear for it is applied outside of the path of the sliding contact 8, although, of course, it overlaps and is in contact with the resistance film itself. The superimposed coating may be applied in any desirable proportion, and may be suitably tapered if a gradual increase in the rate of change of resistance is desired.

A resistance unit as so far described, may be made to have a total resistance of, say, 50,000 ohms, and yet be so tapered that half of the rotation of the contact arm is employed for an initial variation amounting to only about 1,000 ohms, while the initial resistance may be of the order of magnitude of 10 ohms. For some purposes it is necessary to provide in addition to the foregoing an exceedingly low initial resistance, and, if possible, to employ, say, the first eighth of the rotation of the contact arm for building up as little as 1 ohm of resistance. To fulfill this requirement I propose to employ, in combination with a resistor such as I have so far described, an invention of Emil Reisman, described in a copending application Serial No. 350,478, filed concurrently herewith.

An arrangement embodying this idea is illustrated in Figs. 7 and 8, and referring to these figures it will be noted that the silver

terminal 110 and the marginal extensions 116 and 116′ thereof have been painted upon the base before applying the resistance film thereto. In other words, the contact between the resistance film and the metallic terminal is obtained by painting the resistance film over the metallic terminal, instead of vice versa. In this manner the initial resistance is provided by merely the thickness of the resistance film, the current flowing transversely from the sliding contact 8 to the metallic terminal 110 through the resistance film. This provides the desired low initial resistance. The metal terminal 110 may be applied under the film, as is here shown, and yet the marginal extensions 116 and 116′ brought into contact with the film by being painted over the film, but I have shown both under the film in order that the entire metallic coating may be applied at one time. As the sliding contact 8 is moved to the position 8′ the rise in resistance takes place much as in the case of the modifications illustrated in Figs. 1 and 5.

It will be apparent that while I have shown and described my invention in the preferred forms, many changes and modifications may be made in the structures disclosed without departing from the spirit of the invention, defined in the following claims.

I claim:

1. A variable resistance comprising a contact arm, and a sliding contact made of a soft highly conductive sheet of non-oxidizing material longitudinally slit to form a plurality of collateral individually flexible contacting fingers, said entire sliding contact being freely oscillatably mounted on said contact arm.

2. A variable resistance comprising a contact arm, and a sliding contact carried thereby, said contact being made of a sheet of soft highly conductive non-oxidizing material having a raised portion and depending leading and following contact portions, the latter being longitudinally slit to form a plurality of collateral individually flexible contacting fingers, the raised portion of said sliding contact being oscillatably mounted on said contact arm.

3. A variable resistance comprising a contact arm, and a sliding contact carried thereby, said contact being made of a sheet of silver having a raised portion and depending leading and following contact portions, the latter being longitudinally slit to form a plurality of collateral individually flexible contacting fingers, the raised portion of said sliding contact being oscillatably mounted on said contact arm.

4. A variable resistance comprising a contact arm, and a sliding contact carried thereby, said contact being made of a sheet of soft highly conductive non-oxidizing material having a raised portion and depending leading and following contact portions, the latter being longitudinally slit to form a plurality of collateral individually flexible contacting fingers, the raised portion of said sliding contact being centrally recessed and carrying a pair of marginal upstanding lugs, and said arm having a protuberance and a pair of apertures for respectively cooperating with said recess and lugs, in order to mount the sliding contact freely oscillatably on the arm.

5. A variable high resistance comprising a base, a resistance film painted thereon, a contact arm, and a sliding contact carried thereby, said contact being made of a sheet of soft highly conductive non-oxidizing material slit to form a plurality of collateral individually flexible contacting fingers, said entire sliding contact being freely oscillatably mounted on said contact arm.

6. A variable high resistance comprising an enameled metallic base, a resistance film painted thereon, a resilient rotatable contact arm, and a sliding contact carried thereby, said contact being made of a sheet of silver and having a raised portion and depending leading and following contact portions, the latter being longitudinally slit to form a plurality of collateral individually flexible contacting fingers, the raised portion of said sliding contact being oscillatably mounted on said rotatable contact arm.

7. A variable high resistance comprising a base coated with a high resistance film, a short circuiting terminal therefor, contact means cooperating with the film, and means for securing a gradual rise in resistance from the short circuiting terminal comprising a relatively low resistance path near the low resistance end which extends along and contacts with the film at an edge thereof.

8. A variable high resistance comprising a base coated with a high resistance film, a short circuiting terminal therefor, contact means cooperating with the film, and means for securing a gradual rise in resistance from the short circuiting terminal comprising relatively low resistance paths from the short circuiting terminal which extend along and contact with the resistance film at the opposite edges thereof.

9. A variable high resistance comprising a base coated with a high resistance film, a metallic short circuiting terminal therefor, contact means cooperating with the film, and means for securing a gradual rise in resistance from the short circuiting terminal comprising a metallic coating forming a path from the short circuiting terminal which extends along and contacts with the resistance film at an edge thereof.

10. A variable high resistance comprising a base coated with a high resistance film, contact means cooperating therewith, and means for securing a gradual rise in

resistance from the short circuit point comprising a metallic coating at the short circuit point which extends transversely of the resistance film and longitudinally along and in contact with the resistance film at opposite edges thereof outside of the path of the contact means, the edge of the transverse portion being made parallel to the trailing edge of the contact means when the latter is located just above the edge.

11. A variable high resistance comprising a base coated with a high resistance film, contact means cooperating therewith, and means for securing a gradual rise in resistance from the short circuit point comprising a metallic coating at the short circuit point which extends transversely beneath the resistance film and longitudinally along and in contact with the resistance film at opposite edges thereof, outside of the path of the contact means.

12. A variable high resistance comprising a base coated with a high resistance film, contact means cooperating therewith, and additional resistance paint extending along and contacting with the edge of the resistance film outside of the path of the contact means in order to vary the effective resistance of a portion of the film.

13. A variable high resistance comprising a base coated with a high resistance film, contact means cooperating therewith, and means for securing a gradual rise in resistance from the short circuit point comprising additional resistance paint extending along and contacting with the edge of the resistance film near the low resistance end thereof outside of the path of the contact means.

14. A variable high resistance comprising a base coated with a high resistance film, contact means cooperating therewith, and means for securing a gradual rise in resistance from the short circuit point comprising a metallic coating at the short circuit point which extends along and contacts with the resistance film at opposite edges thereof, and a relatively low resistance paint extending further along the edges of the resistance film from the termination of the extensions of the metallic coating and contacting with the metallic coating and the resistance film.

15. A variable high resistance comprising a base, a resistance film coated thereon, a contact arm and sliding contact for cooperation with the film, said sliding contact being made of a soft highly conductive non-oxidizing material, slit to form a plurality of independently flexible contact fingers, and oscillatably mounted on the contact arm, and means to insure a gradual rise of resistance comprising a low resistance coating extending along opposite edges of the resistance film outside of the path of the sliding contact.

16. A variable high resistance comprising a base, a resistance film coated thereon, a contact arm and sliding contact for cooperation with the film, said sliding contact being made of silver, slit to form a plurality of independently flexible contact fingers, and oscillatably mounted on the contact arm, and means to insure a gradual rise of resistance from zero comprising a metallic coating extending from the short circuit point along opposite edges of the resistance film, outside of the path of the sliding contact.

17. A variable high resistance comprising a base, a resistance film coated thereon, a contact arm and sliding contact for cooperation with the film, said sliding contact being made of a soft highly conductive non-oxidizing material, slit to form a plurality of independently flexible contact fingers, and oscillatably mounted on the contact arm, and means to insure a gradual rise of resistance comprising additional resistance material extending along opposite edges of the high resistance film outside of the path of the sliding contact.

18. A variable high resistance comprising a base, a resistance film coated thereon, a contact arm and sliding contact for cooperation with the film, said sliding contact being made of a soft highly conductive non-oxidizing material, slit to form a plurality of independently flexible contact fingers, and oscillatably mounted on the contact arm, and means to insure a gradual rise of resistance from zero comprising a metallic coating extending from the short circuit point along opposite edges of the high resistance film, and additional resistance material extending further along opposite edges of the high resistance film, said metallic and resistance coatings being in contact with the high resistance film outside of the path of the sliding contact.

19. A variable high resistance comprising an enameled metallic base, an arcuate resistance film coated thereon, a rotatable resilient contact arm and sliding contact for cooperation with the film, said sliding contact being made of a sheet of silver and having a raised central portion and depending leading and following contact portions, the latter being longitudinally slit to form a plurality of collateral independently flexible contact fingers, the raised portion of said sliding contact being freely oscillatably mounted on the rotatable contact arm, and means to insure a gradual rise of resistance from zero comprising a metallic coating extending from the short circuit point along opposite edges of the high resistance film in contact therewith outside of the path of the sliding contact.

20. A variable resistance comprising a contact arm, and a bridged sliding contact carried thereby made of a sheet of soft highly conductive non-oxidizing material slit in its direction of movement to form a plurality of collateral individually flexible contacting

fingers at the leading and following edges thereof.

21. A variable high resistance comprising a base coated with a high resistance film, contact means movable thereon, a coated metallic conductive short circuiting terminal for the resistance film, and an extension of the terminal arranged in contact with the resistance film and out of the path of the contact means to provide a path from the contact to the movable terminal thru the film transversely of the direction of movement of the contact, in order to secure a gradual rise in resistance near the terminal.

22. A variable high resistance comprising a base coated with a high resistance film, metallic contact means movable thereon, a coated conductive short circuiting terminal for the resistance film, and an extension of the terminal arranged in contact with the resistance film and out of the path of the contact means to provide a plurality of paths from the movable contact to the terminal thru the film both longitudinally and transversely of the direction of movement of the contact, in order to secure a gradual rise in resistance near the terminal.

23. The method of applying a resistance film to a flat insulation base in order to make an annular resistance element for a variable high resistance which includes rotating the base about an axis normal to the surface which is to carry the film, bringing application means carrying resistance paint into contact with the rotating base at the desired radial distance from the center of rotation in order to form a resistance, and finally removing a segment of its circumference in order to open-circuit the resistance ring.

24. The method of applying a resistance film to a flat insulation base in order to make an annular resistance element for a variable high resistance, which includes relatively rotating the base and application means carrying the resistance paint about an axis normal to the surface which is to carry the film, and bringing the application means into contact with the base at the desired radial distance from the center of rotation in order to form a resistance ring, and finally removing a segment of the circumference of the ring in order to open-circuit the same.

Signed at New York, in the county of New York and State of New York, this 27th day of March, A. D. 1929.

LESTER L. JONES.