

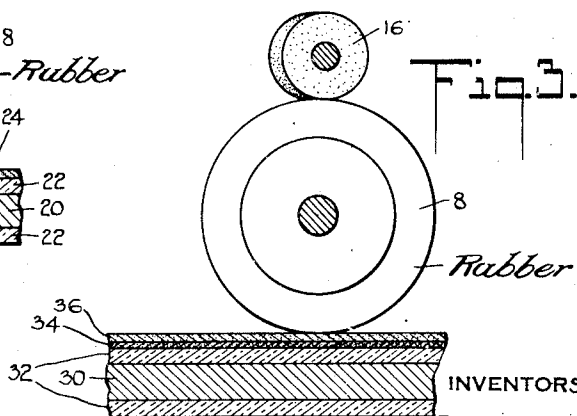
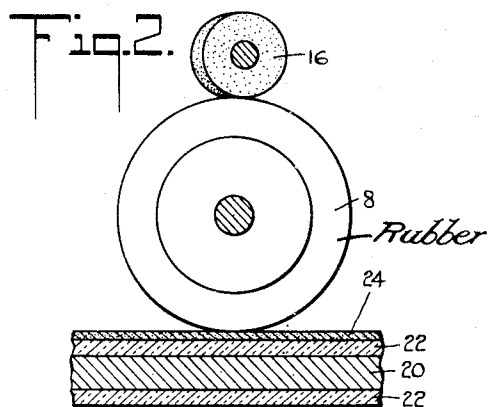
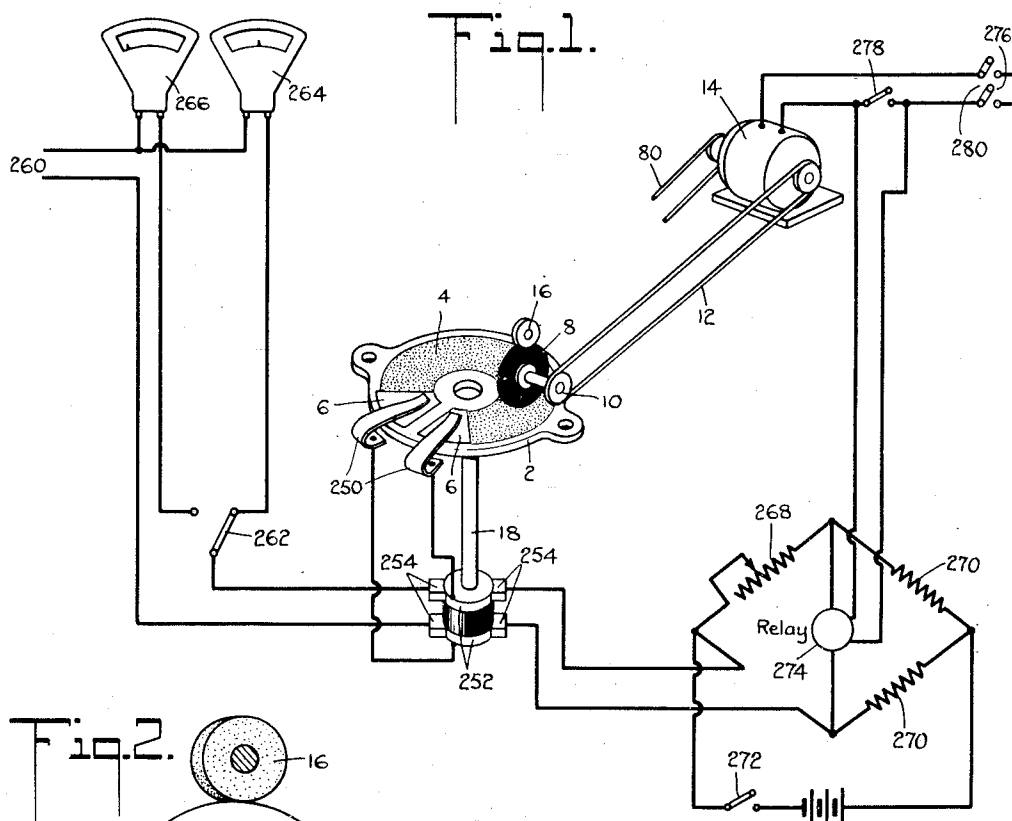
June 12, 1934.

J. A. FLANZER ET AL
MANUFACTURE OF RESISTORS

1,962,438

Filed July 14, 1930

4 Sheets-Sheet 1



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June 12, 1934.

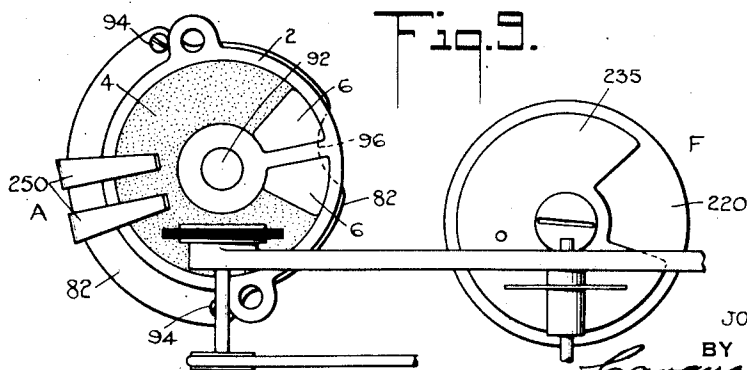
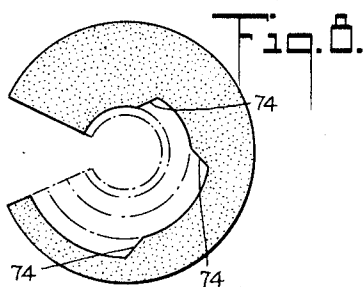
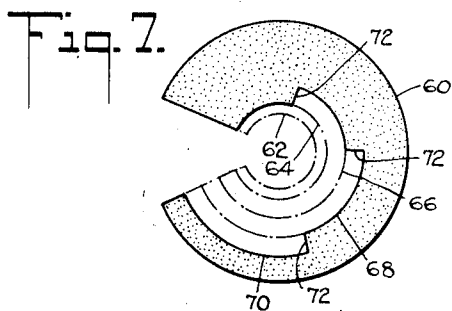
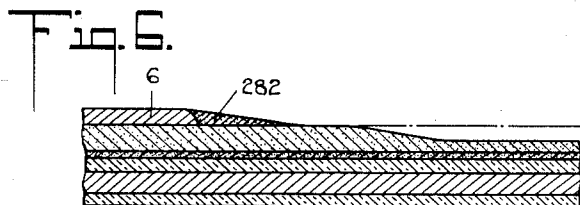
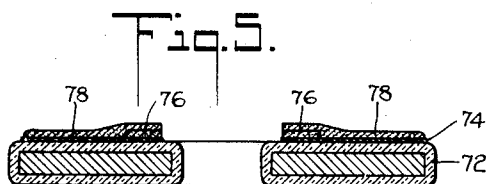
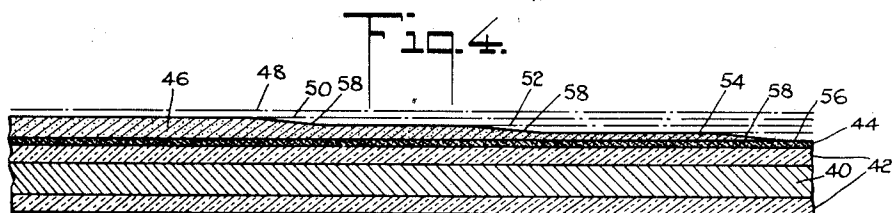
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1,962,438

MANUFACTURE OF RESISTORS

Filed July 14, 1930

4 Sheets-Sheet 2



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Filed July 14, 1930

4 Sheets-Sheet 3

Fig. 10.

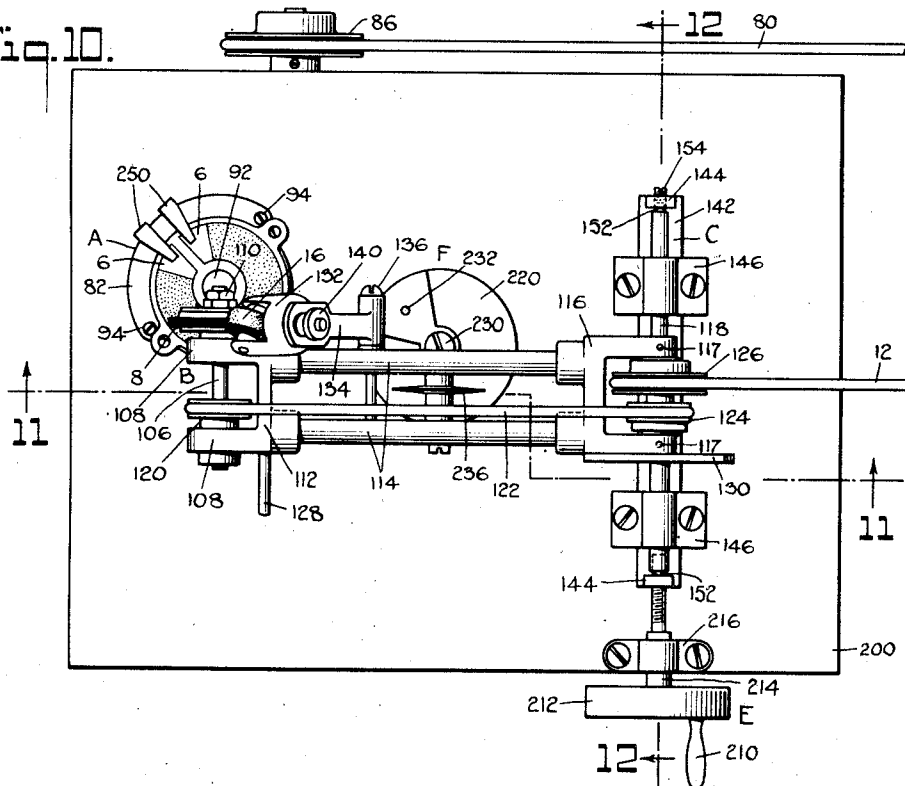
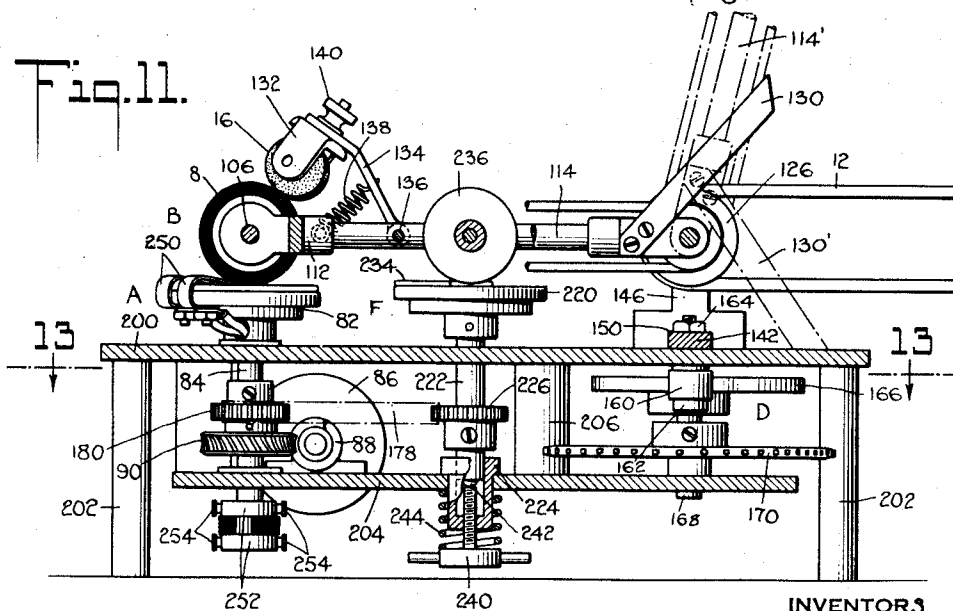


Fig. 11.



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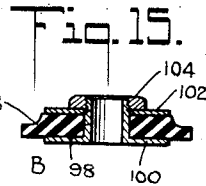
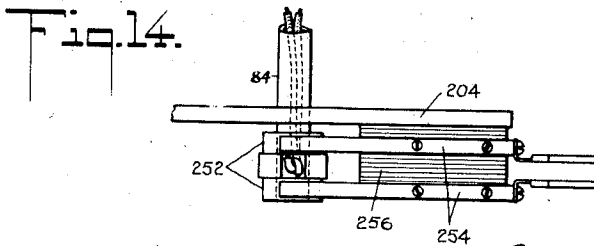
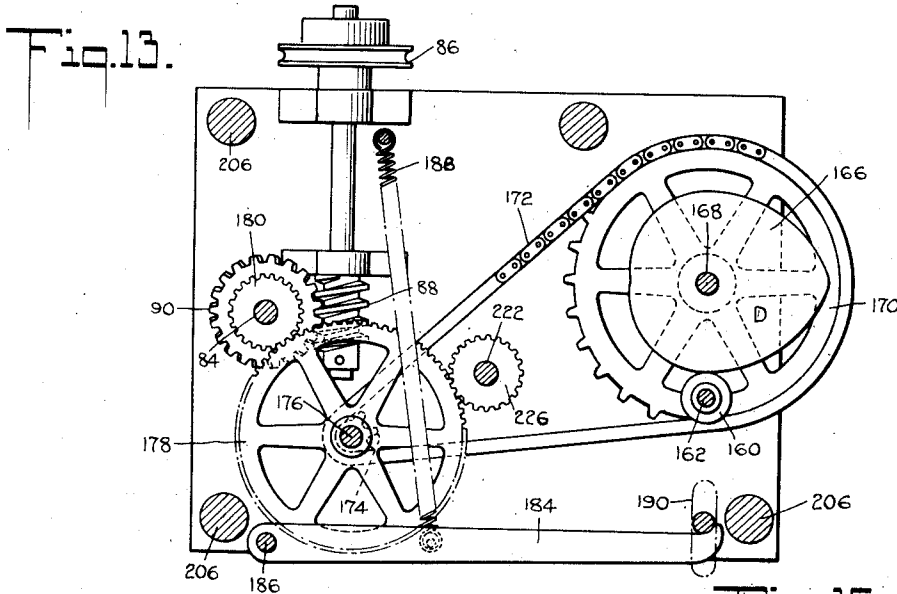
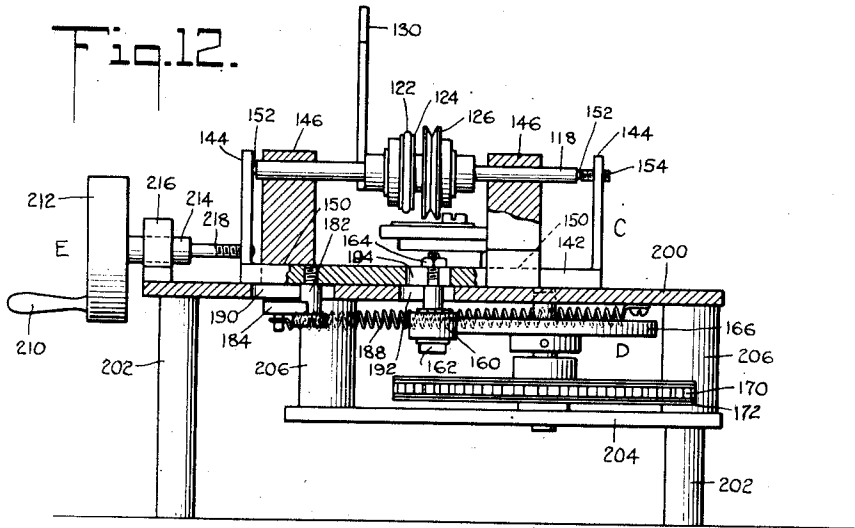
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J. A. FLANZER ET AL
MANUFACTURE OF RESISTORS

1,962,438

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

1,962,438

MANUFACTURE OF RESISTORS

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Application July 14, 1930, Serial No. 467,832

26 Claims. (Cl. 51-101)

This invention relates to the manufacture of resistors, and more particularly to a method and means for manufacturing variable resistors.

In copending applications of Lester L. Jones, Ser. No. 193,357, filed May 21, 1927, and Ser. No. 350,731, filed March 28, 1929, there are disclosed and claimed variable resistors and methods for making the same. These resistors may be generally described as comprising a resistance film obtained by painting an insulation base with an appropriate resistance paint.

In a copending application of Joseph A. Flanzer, Ser. No. 444,614, filed April 15, 1930, there is disclosed a method for improving the uniformity of the resistance values obtained in either fixed resistors or variable resistors of the above described type. The method there disclosed makes it possible to predetermine the resistance of a given order or batch of resistors within several per cent with a departure of, at most, say about 10%.

Although for ordinary requirements, particularly when dealing with variable resistors of the uniform or linear type, the method of the prior application yields sufficiently accurate results for all usual purposes, there sometimes arise situations in which a precision resistor having its resistance confined within exceedingly close limits is required. One general object of the present invention centers about the provision of such a precision resistor. The method which we employ to fulfil this object is founded upon the discovery that although the resistance film is exceedingly tough and durable, and shows no signs of wear even though a metallic slider be rubbed against the film for indefinite periods of time, it nevertheless may be removed rather readily if rubbed by a rubber eraser such as is ordinarily used to erase writing on paper. In accordance with the method of our invention, the base is coated with a resistance film having a resistance lower than that desired, and the resistance is thereafter raised to the desired value by erasing and thereby reducing the cross section area of the film.

The resistance paint adheres tenaciously to the base largely by reason of chemical reaction therebetween. The resulting paint is relatively hard and is difficult to erase. One of the objects of our invention is to speed up the erasing operation so that the resistance units may be manufactured in rapid succession. To this end we have found it desirable to first coat the base with a coat of relatively hard high resistance paint and to superimpose thereon an additional coat of

relatively soft low resistance paint. The latter may be erased relatively quickly until the desired total resistance is obtained. To the fulfillment of the same object we have further found it to be desirable to use an eraser which is loaded with a finely divided abrasive material.

When the eraser has been in operation for a while, it is found that it loses its efficiency, and the time necessary to raise the resistance of a resistor to the desired value rapidly increases until it may become a matter of hours instead of minutes. We find that this effect is due to the surface of the eraser becoming charged or filled up with the particles or carbonaceous or graphitic resistance material removed from the resistance film by the eraser. Accordingly, another object of our invention is to overcome this difficulty and to keep the erasing operation at its optimum speed. For this purpose we clean the eraser continuously during the erasing operation. The eraser is preferably in the form of a disc which is rapidly rotated under power, and a preferred form of cleaning means comprises simply a cleaning wheel the surface of which is roughened and which is pressed against the periphery of the eraser and rotated thereby, preferably about an axis which is inclined relative to the axis of the eraser, in order to obtain a transverse rubbing or cleaning component of motion.

As will subsequently be described in greater detail, the cross section area of the resistance film may be reduced in a number of ways, the respective merits of which depend upon the particular requirements which the finished resistor must fulfil. Accordingly, a further object of our invention resides in the provision of methods and of mechanism for the practice of these methods which will make it possible to treat the resistor in any one of a number of ways best suited to the requirements which the particular resistor must meet. Briefly stated, the cross section area of the resistance film may be reduced by thinning down the film, that is, erasing the entire surface of the film in order to reduce the thickness thereof, or by narrowing down the film, that is, erasing an edge of the film in order to reduce the width of the film, or, in special cases, by combinations of both thinning down and narrowing down. Another object of our invention is to provide a single erasing machine which may be selectively altered at will to accomplish either the thinning down or narrowing down process.

When erasing the resistor, particularly by the thinning down process, the resistor is supported on supporting means, and the rapidly rotated

eraser and the supporting means are relatively moved by automatic means in order to permit the eraser to cover the entire surface of the resistance film. As the cycle of operations is repeated, the eraser tends to travel over the same path, and the resistance paint may be worn away in fine lines instead of being kept perfectly smooth. It is another object of the present invention to guard against the formation of such lines of wear, and accordingly, the relative movement of the eraser and the resistance supporting means is kept in proper relation to prevent the eraser from taking the same path in successive cycles of the erasing operation.

As so far discussed, the objects of our invention have been outlined in connection with either fixed or uniformly variable resistors, particularly with a view to obtaining precision resistance values. Further objects of our invention center about the provision of variable resistors characterized by a non-uniform or non-linear resistance variation. Such resistors are in great demand for a variety of purposes but are difficult to provide when it is required that the resistances of the different portions of the film, as well as the total resistance, be accurately determinable. The type of resistor here considered is inherently characterized by remarkably smooth operation and resistance variation, and considerable effort has therefore been expended in an effort to produce such resistors with non-linear resistance variation. Excellent results have been obtained by changing the width of, or the number of coats of paint in the resistance film when painting the same, but these methods are not satisfactory when accurately defined specifications must be met.

Accordingly, one of the important objects of our invention resides in the provision of methods and of apparatus for the practice of the methods, which will make it possible to readily secure non-linear variable resistors. This is accomplished, generally, by employing either the thinning down or narrowing down processes in successive stages. The base is coated with a resistance film having a specific resistance lower than that desired for the low resistance portion of the unit, and the resistance is then raised by thinning or narrowing the film until the specific resistance is equal to that desired at the low resistance portion of the unit. The resistance film is thereafter further reduced, except at the low resistance portion thereof, until the desired resistance for the next higher resistance portion is obtained, and so on until the unit has the desired resistance values. The lower resistance portions of the unit may be protected by a stencil, or more preferably by a separately mounted stencil-like templet which serves to separate or lift the eraser from the resistance unit at the portions thereof which are not to be erased. In accordance with another object of the invention, means are provided to slightly vary the effective dimension of the templet while not varying the actual dimension thereof so as to make it possible to accurately define the unerased portion of the resistor.

The specific resistor subsequently described employs an annular resistance film coated on a flat base. The resistor is rotated on a resistor turntable, and for the thinning down process the rapidly rotating eraser is slowly reciprocated across the width of the film. If this reciprocation takes place at a uniform rate, it is evident that the inner periphery of the annular film is subjected to a longer erasing period than the outer pe-

riphery of the film because of the smaller circumference at the inside of the film. On the other hand, when dealing with the narrowing down process, a difficult problem arises because of the fact that it is desirable to keep the film as wide as possible for a given resistance value, in order to obtain full contact with the slider or contact element of the finished resistance unit. Both of the foregoing problems may, according to a further object and feature of the invention, be solved by a single expedient which includes applying to the inner periphery only of the annular film an additional coat of paint relative to the number of coats applied to the entire film. This prevents excessive reduction in the thickness of the inner portion of the film when using the thinning down process. In the narrowing down process the foregoing expedient is coupled with the additional expedient of erasing from the inner toward the outer periphery of the annular film, which prevents excessive narrowing of the film for two reasons, first, the rapid rise in resistance obtained when erasing the double thickness inner portion of the film, and secondly, the greater resistance for a given width of the outer compared with the inner periphery of the film, owing to the greater length of the former.

It has previously been explained that important objects of our invention are to obtain accurate results, and at the same time to make possible rapid production. To the accomplishment of both of these objects, and with the further object in view of making the operation as nearly automatic as possible, we provide means for constantly measuring the resistance of the resistor during the erasing operation, and, if desired, we provide further means for automatically stopping the operation of the erasing machine when the resistance has been raised to precisely the desired value.

To the accomplishment of the foregoing and such other objects as will hereinafter appear, the invention consists in the method steps and apparatus elements 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 schematic diagram explanatory of the invention;

Fig. 2 illustrates the thinning down process applied to a resistor having a single coat of resistance paint;

Fig. 3 illustrates the thinning down process applied to a resistor having a plurality of coats of resistance paint of selected characteristics;

Fig. 4 is a development taken in section around a resistance unit having a non-linear resistance variation obtained by the thinning down process;

Fig. 5 is a section through a resistor preparatory to the erasing operation;

Fig. 6 is an enlarged section of a resistor at one terminal thereof;

Fig. 7 illustrates a resistance film made non-linear by the narrowing down process;

Fig. 8 is a similar illustration of a film narrowed down with non-radial templets;

Fig. 9 is a plan view of a portion of the erasing machine showing it used for burnishing the metallic terminals of the resistor;

Fig. 10 is a plan view of an erasing machine embodying features of our invention;

Fig. 11 is a vertical section taken in the plane of the line 11-11 in Fig 10;

Fig. 12 is a vertical section taken in the plane of the line 12—12 in Fig. 10;

Fig. 13 is a horizontal section taken in the plane of the line 13—13 in Fig. 11;

- 5 Fig. 14 is a detail of the slip rings and brushes providing external contact with the resistor; and
Fig. 15 is a section taken through an eraser.

The method of our invention may be generally explained by reference to the schematic showing 10 in Fig. 1 in which the plate of the resistor, the resistance of which is to be adjusted, is illustrated as comprising an insulation base 2 preferably formed of enameled sheet iron, an annular resistance film 4, and metallic terminals 6. The 15 construction and manufacture of variable resistance units embodying such a plate is disclosed in the above referred to copending applications of Lester L. Jones and of Joseph A. Flanzer, (joint inventors herein). As is explained in the said 20 applications, the nature of the resistance film 4 is such that it is not abraded or worn away by sliding contact thereon of a preferably silver slider or movable contact forming part of the finished resistance unit. This fact seems to be due to the 25 carbonaceous or graphitic nature of the resistance film, making it somewhat self-lubricating, but in any event, regardless of cause, the film is capable of indefinite wear without noticeable change in resistance value.

30 We have discovered that although the film is not worn away by sliding contact with a metal such as silver, it may rather readily be removed by a rubber eraser, which seems to lift and absorb some of the resistance material, just as when used 35 in connection with pencil marks on paper. The eraser is preferably made in the form of a disc 8 and is rapidly rotated through a pulley 10 and belt 12 by an electric motor 14.

40 The surface of the eraser soon becomes charged or loaded with resistance material, and its erasing ability falls off rapidly, so that an erasing operation which ordinarily takes a few minutes may take a number of hours. To avoid this result, the eraser 8 is constantly cleaned during the 45 erasing operation, and this may be accomplished in a simple manner by the provision of a cleaning wheel 16 which is rotated by the eraser 8, and which cleans the same in a manner later described in detail, but it may briefly be mentioned as including positioning of the axis of the cleaner 50 wheel at a slant or bias relative to the axis of the eraser, as is most clearly evident in Figs. 2, 3, and 10, so as to provide a transverse cleaning component of motion.

55 The resistor plate 2 is mounted on a resistor turntable for rotation about an axis 18, and additional means, not shown, are provided to reciprocate the eraser 8 radially of the plate 2 for the width of the resistance film, so that the entire 60 surface of the film may be erased.

Referring now to Fig. 2, a metallic plate 20 is coated with enamel 22 to provide an insulation base. This is painted with a coat of resistance 65 paint 24. The paint consists of a carbonaceous or graphitic material suspended in an acid vehicle, and firmly adheres to the enamel 22, probably because of chemical reaction between the acid vehicle and the basic enamel. The details of drying and baking the paint form no part of the 70 present invention and need not be described here.

In accordance with the present invention, a paint is selected which will give the resistance film 24 a lower specific resistance, by which I 75 mean the resistance per unit of length or per degree rotation, than that desired in the finished

resistor. The film 24 is then thinned down by erasing it with a rubber eraser 8 cleaned by a cleaning wheel 16.

The resistance paint 24 is characterized by a 80 relatively hard and tenacious surface which is exceedingly difficult to erase. This is so because the paint is selected with the primary object of securing effective adhesion to the enamel 22. It is impracticable to erase such a paint with a pure rubber eraser, and the eraser 8 is preferably load- 85 ed with an abrasive material such as finely divided ground glass, carborundum, or emery.

To provide for more rapid adjustment of the resistance, we prefer to follow a method, illustrated in Fig. 3, in which a metallic plate 30 is coated 90 with enamel 32, which then has applied thereto a first resistance coat 34 and a second resistance coat 36. The first resistance coat 34 is selected with the particular object of adhering well to the enamel, and a thin, relatively acid paint is used 95 which bakes hard and has a high resistance, far higher than the desired resistance for the unit. The second coat 36 preferably consists of a thicker, less acid paint which adheres well to the first coat 34 and which does not bake as hard as the 100 first coat. The resistance properties of the two coats are so selected that the total resistance is somewhat lower than the desired resistance for the unit. This may be done by making the base 105 coat 34 of such high resistance as to be of but slight significance, and predetermining the desired resistance by selection of a proper second coat 36, or by selecting a first coat the resistance of which is sufficiently low to provide a useful 110 component of the total resistance. This total resistance is afterward raised to the desired value by erasing the entire surface of the compound resistance film with the eraser 8, as was before 115 described. For this purpose, the eraser may be plain rubber or, for the sake of very rapid production, may be rubber loaded with finely ground glass. Loading with carborundum or emery is unnecessary.

The manner in which a non-linear or non-uniform variable resistance may be obtained is illustrated in Fig. 4, in which a metallic plate 40 120 is coated with enamel 42 to which a first or base coat of resistance paint 44 is applied. One or more additional coats of more readily erasable resistance paint are then superimposed on the base 125 coat 44, as is here indicated by the single, relatively heavy layer 46. In the specific problem here considered, the resistance is to be divided in four sections, each having different resistance 130 values. The problem is preferably solved by selecting the base coat 44 of a resistance paint having a specific resistance about equal to the resistance desired in the high resistance portion of the unit. The coat 46 is obtained by using a paint 135 selected to result in a specific resistance lower than that desired in the lowest resistance portion of the finished unit. The entire resistance film is then thinned down from the line 48 to the line 50 140 to obtain the exact specific resistance desired for the low resistance portion of the unit. The low resistance portion of the unit is then covered up, and the remainder of the film is thinned down from the line 50 to the line 52 until the specific 145 resistance is that desired in the next higher resistance portion of the unit. The two portions of the unit so far finished are then protected by stencil or templet means subsequently described, and the remainder of the film is thinned down from the line 52 to the line 54 until the desired 150 specific resistance for the next higher resistance

portion of the unit is obtained. All of the unit except the highest resistance portion is next protected, and the erasing proceeds from the line 54 to the line 56 until the specific resistance for the highest resistance portion of the unit is reached, at which time the unit is finished.

It will be noted that the transition between the different portions of the unit is gradual, as is indicated by the sloping lines 58, and this desirable result is obtained in a manner later described in connection with the erasing machine. It will be understood, of course, that for the sake of clarity the various thicknesses involved have been greatly exaggerated, and also that for illustration the annular resistance film has been straightened out or developed so that the section lies in a plane.

In the method so far described, the resistance has been raised by thinning down or erasing the surface of the resistance film. The thinning down method has the advantage of retaining the full width of the film and therefore making full contact with the movable slider of the resistor, but suffers from the disadvantage that excessive erasing wears the paint down to the enamel in spots, probably due to irregularities in the surface of the enamel. This mars the appearance and the electrical reliability of the unit, and consequently the thinning down method is best limited in ordinary practice to resistance units in which the ratio of the resistances of the high and low resistance portions does not exceed four to one. Another method of accomplishing the desired result is by narrowing down or changing the width of the resistance film. Referring to Fig. 7, a resistance film of uniform width is first applied to the insulation base, this film being defined by the outer circle 60 and the inner circle 62. The film is reduced in width entirely around its circumference until the specific resistance is equal to the desired resistance for the low resistance portion of the unit. This reduction in width, or narrowing down, is preferably made at the inner periphery of the film, changing its dimension from the line 62 to the line 64. The low resistance portion of the unit is then protected by a suitable stencil or templet, and the narrowing down process continued until the inner edge of the film is changed from the line 64 to the line 66, at which time the resistance film has a specific resistance equal to that desired for the next higher resistance portion of the unit. The first two sections of the unit are then protected by a suitable stencil or templet, and the narrowing down process continued until the inner boundary of the film is changed from the line 66 to the line 68, and this cycle of operations is repeated until finally the desired high resistance portion is obtained, at which time the film has been narrowed to the line 70. This narrowing down process should not be carried too far because it is desirable that a substantial width of film remain for contact with the movable slider of the finished resistance unit. It is for this reason that the narrowing down preferably proceeds from the inside toward the outside of the film, inasmuch as a greater width of film remains for a given resistance when the film is located at the outer periphery rather than at the inner periphery of the ring, because of the greater circumferential dimension near the outer periphery. Looked at from a different viewpoint, it is preferable to narrow down from the inside of the resistor because this raises the resistance of the unit at a faster rate than would be the case if it were narrowed down from the outside of

the unit. It may also be pointed out that it is desirable to work on the low resistance portion of the resistor first, when employing the thinning down or narrowing down process, particularly if the resistance is tested by measurement, because after the high resistance sections are brought up to full resistance value small variations in the resistance of the low resistance section will be greatly reduced in proportion to the total resistance and are not nearly so measurable and significant as when compared with an overall low resistance.

When a high ratio of resistance between the low and high resistance portions of the unit is necessary, it may be found desirable to adopt the expedient illustrated in Fig. 5. In this figure it will be observed that the enameled base 72 is provided with a resistance film comprising a first resistance coat 74 on which there is next superimposed, but only at the inner periphery thereof, a coat of paint 76, after which the entire resistance film has applied thereto an additional coat of point 78. It will be understood that the steps of drying and baking the film may in this case, as in the preceding cases, be suitably conducted, particularly by having only a single baking step for the finished film, so that no sharp lines of division or demarcation between successive coats of resistance paint will exist. This results in the resistance film being much thicker near the inner circumference of the film than at the outer circumference of the film.

It is evident that with a film of this nature the resistance material is concentrated toward the inner edge, and as this is erased the rise in resistance is very rapid. Consequently, a high ratio between the high and low resistance portions of the unit may be obtained without excessively narrowing the resistance film. The use of the additional coat 76 is also desirable in the thinning down process for reasons later explained in connection with the erasing machine.

In Fig. 7 the steps 72 between the different resistance portions of the resistor are radial, and this arrangement is desirable because of the resulting simplicity of the stencils or templets used in connection with the erasing machine. If a more gradual transition between portions of the resistance is desired, the steps may be sloped, as is indicated by the lines 74 in Fig. 8, by appropriately shaping the stencil or templet. The latter precaution need not be taken ordinarily because the change between the resistance portions in the arrangement shown in Fig. 7 is not nearly as abrupt as might be expected from the drawing. The reason for this is that the thickness of the film just in front of each of the steps 72 is gradually reduced to zero instead of ending abruptly, because of a property of the erasing machine subsequently described.

The erasing machine is illustrated in a preferred form in Figs. 10 through 15 of the drawings, and will next be described with reference to these figures. The machine comprises generally, means A for supporting a resistor, an eraser mechanism B, and means including a reciprocable carriage C permitting relative movement of the resistor supporting means A and the eraser B. The desired reciprocation of the carriage C may be obtained automatically through mechanical means D, or manually through the agency of a crank E. The machine further comprises means F for effectively protecting a desired portion of the resistor from the eraser, preferably by separating or lifting the eraser from the resistor. The eraser

means B is driven through a belt 12, while the remainder of the mechanism of the erasing machine is driven through a belt 80, and both the belts 12 and 80 are preferably driven from a single source, such as the electric motor 14 in Fig. 1.

The resistor supporting means A in this case comprises a turntable 82 fixed to the upper end of vertical shaft 84. Shaft 84, like much of the additional mechanism to be described, is carried by an upper plate 200 supported by depending legs 202, and a lower plate 204 spaced from upper plate 200 by spacers 206. Shaft 84 is rotated by means of belt 80 running on pulley 86, which drives worm 88 meshing with worm gear 90 mounted on shaft 84.

Turntable 82 is perhaps most clearly shown in Fig. 9, in which it will be observed that the turntable includes a central projection 92 which mates with a central aperture in the resistor plate 2 and therefore centers the same. It should be understood that the resistance film 4 is initially applied to the plate 2 by rotating the plate about its central aperture, so that the annular resistance film and the aperture are concentric. The resistor turntable 82 carries suitable means to prevent rotation of the plate 2, exemplified in this case by a pair of upstanding screws 94 acting as abutments for engaging the marginal lugs or ears on the plate. The turntable is further provided with a cutaway portion or recess 96 which facilitates the insertion and removal of resistor plates.

The eraser mechanism B comprises an eraser which is best shown in Fig. 15. The eraser is in the form of a disc 8 which is permanently mounted on a bushing 98 and clamped between flange 100 and a washer 102 by a nut 104. With this construction, the eraser may be trued up in any suitable machine and thereafter be applied at will to the present erasing machine so that a considerable number of erasers may be available at the machine for replacement purposes or to change the abrasiveness of the eraser being used.

The eraser assembly previously described is mounted on one end of a shaft 106 which is carried in bearings 108. The eraser assembly is readily removable from the end of shaft 106 by removing a nut 110 which holds the eraser on the shaft. Bearings 108 are preferably made integral with a yoke 112 which is rigidly fixed on the ends of forwardly extending rods 114, the other ends of which are rigidly mounted in a somewhat similar yoke 116, fixed on a rod 118 by pins 117.

Eraser shaft 106 carries a pulley 120 which is driven through a belt 122 by a pulley 124 made integral with a pulley 126 which in turn is driven by a belt 12 extending to the driving motor. Pulleys 124 and 126 are made integral and rotate freely on rod 118 between the bifurcated ends of yoke 116.

With this construction it is obvious that the entire eraser mechanism is oscillatable about rod 118, and that the drive of eraser shaft 106 through belt 122 is not interfered with by upward or downward oscillation of the eraser. In fact, when a resistor is to be removed from turntable A and replaced, the eraser supporting mechanism is swung backwardly out of the way, and a finger piece 128 is provided for this purpose. A stop member 130 is rigidly affixed to yoke 116 and limits the permissible backward oscillation of the eraser supporting arms 114 to the position of rest 114' indicated in broken lines in Fig. 11.

The eraser mechanism further includes cleaning means for constantly cleaning the eraser during use. This is most simply provided in the form

of a cleaning wheel 16 freely rotatable in a yoke 132 carried at the end of an arm 134 oscillatable about a bearing 136 carried by the rods 114. Arm 134 is urged toward the eraser by a tension spring 138 which is best shown in Fig. 11. The yoke 132 is supported on arm 134 through the agency of a thumb nut 140, and loosening of thumb nut 140 permits the yoke 132 to be rotated about the axis of the nut, thereby making the axis of rotation of the cleaning wheel 16 extend at a bias with respect to the axis of rotation of the eraser. With this construction the cleaning wheel is energized and rotated by the eraser itself, and yet the wheel has a sideward component of motion which causes a sweeping or brushing action across the periphery of the eraser, which effectively removes the resistance material picked up by the eraser. The degree of slope of the axis of cleaning wheel 16 determines the rapidity of the cleaning action, and this may be made sufficiently great to keep the eraser clean. It should not be made unnecessarily great, for otherwise the eraser itself may be worn away. The cleaning wheel, if used with a rubber eraser or an eraser loaded with ground glass, may be made of steel, and in such case is preferably provided with fine knurling or with helical teeth. An eraser loaded with emery or carborundum wears such a steel cleaning wheel too rapidly, and in such case it is found that a cleaning wheel made of a relatively coarse grade of carborundum, in order to obtain a rough surface, is very satisfactory. The carborundum cleaning wheel also operates well with an eraser made of rubber or rubber loaded with ground glass, and therefore is most suitable for universal use.

Movement of the eraser mechanism B relative to the resistor turntable A is obtained through carriage C. The latter comprises a base plate 142, bearing at its ends upwardly extending arms 144. Rod 118 is reciprocally carried in rigid pedestal bearings 146 which are fixedly mounted on the upper plate 200 of the machine. Pedestal bearings 146 are cut away at their lower ends to provide recesses 150 in which base 142 of carriage C is reciprocable, as is clearly shown in Fig. 12. The upwardly extending arms 144 of carriage C act as thrust bearings for the end of rod 118. To this end, each end of rod 118 is provided with a ball bearing 152, and one of the arms 144 is provided with an adjusting screw 154 permitting close adjustment of the thrust bearings so as to obviate any noticeable end play.

With the recited construction, it will be obvious that any reciprocable motion applied to the carriage C will immediately and accurately be transferred to rod 118 and through it to yoke 116, rods 114, and the entire eraser mechanism. Pulleys 124 and 126, of course, move with yoke 116, so that pulleys 120 and 124 are kept in accurate alignment. The permissible motion is not sufficiently great to disturb the operation of belt 12 running to the driving motor. This arrangement provides parallel motion for the eraser mechanism, which is important for reasons later set forth in connection with the templet mechanism F. The arrangement possesses the further advantage of extreme rigidity and vibrationlessness which is exceedingly important in order to prevent chattering of the eraser wheel during operation. To this end, the yokes 112 and 116, and the interconnecting arms 114, are made strong and rigid, and eraser shaft 106 is preferably mounted in ball bearings set in the arms 108 of yoke 112. The rod 118 is very rigidly and

effectively supported by the massive bearings of pedestals 146. Any tendency to chatter acts as a thrust in the direction of rods 114, and this thrust is amply taken care of by the disclosed construction. The machine is so free from vibration and chattering that should chattering appear, it is a sure sign to the operator of the machine that the eraser has worn out of round, and it is immediately replaced with another one.

10 The removed eraser may readily be trued up in a separate machine, inasmuch as it carries its own bushing and supporting discs with it, as was explained in connection with Fig. 15.

Appropriate mechanism D is provided for causing an automatic reciprocation of carriage C, and consequently an automatic movement of the eraser with respect to the resistor supporting means. The base 142 of carriage C carries a cam follower roller 160, best shown in Figs. 11, 12, and 13. This roller is mounted for free rotation on a spindle 162 which may be locked to base 142 by means of a nut 164. Roller 160 cooperates with a cam 166 mounted on a vertical shaft 168 and supported in the upper and lower plates 200 and 204. Shaft 168 also carries a sprocket 170 which is positively rotated by a chain 172 which in turn meshes with a small sprocket 174, mounted on a shaft 176, which is also carried between upper and lower plates 200 and 204. Shaft 176 and associated mechanism have been omitted from the drawing except in Fig. 13, for the sake of clarity. In Fig. 13 it will be observed that shaft 176 also carries a gear 178 meshing with a pinion 180 which is mounted on shaft 84 which carries the resistor turntable. It is evident that rotation of pulley 86 during the operation of the machine causes a relatively slow rotation of turntable shaft 84, due to the reduction caused by the worm and gear mechanism 88, 90, and that during the rotation of turntable shaft 84, the cam 166 is also rotated in positive relation and at a still further reduced rate.

Reverting now to Fig. 12, the base 142 of carriage C carries a depending screw or abutment 182 which is constantly urged toward the right, as viewed in the drawing, by an arm 184, pivoted at 186 (see Fig. 13), which is itself drawn in the same direction by a tension spring 188. The desired movement of abutment 182 with carriage C is permitted by a slot 190 in the upper plate 200 of the machine. Movement of spindle 162 carrying roller 160 is similarly permitted by a slot 192 in upper plate 200.

It will now be clear that carriage C and with it the cam follower 160 are always resiliently urged into engagement with the cam 166. Rotation of the cam causes movement of the carriage and consequently of the eraser with respect to the resistor being operated upon. In the present case, cam 166 is shaped with uniformly increasing and decreasing radii, that is, in the form of an Archimedian spiral, which results in movement of the eraser across the width of the resistance film at a uniform rate. This uniform movement is simple and satisfactory, but leads to a slight disadvantage when considerable thinning down is to be done, inasmuch as the inner periphery of the resistor is erased further than the outer periphery of the resistor, due to its smaller circumferential dimension. This difficulty may be overcome by suitably altering the shape of cam 166 so as to obtain a more rapid movement of the eraser near the inner periphery of the resistor and a less rapid movement of the eraser near the outer periphery of the re-

sistor. In the present case, uniform movement is retained, and if considerable thinning down is to be done, it is recommended that the resistance film initially applied to the enameled plate be of the nature described in connection with Fig. 5 of the drawing, in which the film is thicker at the inner periphery than at the outer periphery, thereby adapting it to take the greater wear caused by the present machine at the inner periphery.

In the thinning down process the eraser is moved to and fro across the width of the film as the turntable is rotated, so that the eraser traces a fine spiral on the film. If the gear ratio or reduction between turntable shaft 84 and cam shaft 168 is made a whole number, the eraser follows the same spiral path during each erasing cycle, and the resistance film is worn away in the form of a spiral, which may tend to slow down the rate of increase in resistance of the unit being treated. In extreme cases the spiral lines may be cut down to the enamel base, with bad electrical and mechanical effect, as well as spoiled appearance. This difficulty is overcome by establishing a fractional ratio of reduction. For example, in the present case the gear ratio between gear 178 and pinion 180 is three and one-fifth to one, while the ratio between sprockets 170 and 174 is eight to one. This produces an overall ratio of twenty-five and three-fifths to one, which results in a slight staggering of the spiral of each cycle with respect to the preceding cycle. In this machine, if the ratio were twenty-five to one, the pitch of the spiral would be about one-twenty-fifth of an inch, whereas by having the ratio twenty-five plus a fraction which is expressed in fifths, the pitch of the spiral becomes only one-fifth as great, or about one one hundred and twenty-fifth of an inch, which is sufficiently fine to avoid noticeable lines of erasure and consequent difficulty.

The carriage C may be reciprocated under manual control instead of under automatic control whenever desired, and this feature is of particular value when using the narrowing down rather than the thinning down process. To change from automatic to manual movement, the nut 164 is loosened, thereby releasing cam follower 160 from the carriage C. Continued rotation of cam 166 is of no consequence because the follower is merely moved to the furthest point and remains there. A slot 194 in the base 142 of carriage C insures that there will be no interference between the cam follower and any desired manual movement of the carriage. Manually operable means E, best shown in Figs. 10 and 12, comprises a crank handle 210 preferably mounted on a fly wheel 212 which rotates with a shaft 214 rotatable and reciprocable in a fixed bearing 216 mounted on the upper plate 200 of the machine. The end of shaft 214 is threaded at 218 and mates with a thread cut in the upstanding thrust arm 144 of carriage C. When the machine is used for automatic operation, the crank and fly wheel may be readily removed from the machine entirely, or if preferred, the crank may be turned to bring the thread 218 back to the position shown in Fig. 12, at which time it does not interfere with reciprocation of carriage C, for the crank is merely reciprocated in bearing 216 with the carriage. For manual operation, the cam follower is released and crank 210 is turned to cause the thread 218 to project beyond the arm 144 until it strikes the fixed pedestal 146. It is evident that continued rotation of the crank will cause the carriage to be moved away from the turntable axis against

tension spring 188, while rotation of the crank in the crank in the opposite direction will permit the spring to move the carriage toward the turntable axis.

5 As so far described, the eraser remains in contact with the entire circumference of the resistor. The templet mechanism F will next be described. This makes it possible to separate the eraser from the resistor at any desired portion of the resistor, which is desirable, first, to protect the metallic terminals of the resistor, and second, to make it possible to obtain non-linear resistances. The templet mechanism comprises a templet turntable 220 which is mounted on the upper end of a shaft 222, the upper part of which is carried by plate 200, and the lower end of which is freely rotatable and reciprocable in a cup-shaped bushing 224 which is itself set into and carried by the lower plate 204 of the machine. Shaft 222 is arranged to rotate simultaneously with and at the same speed as the turntable shaft 84, and this desired movement is most readily accomplished by providing shaft 222 with a pinion 226 which is cut identically with pinion 180 and is arranged in mesh with gear 178, as is best shown in Fig. 13. It will be understood that as between gears 180 and 226 the gear 178 is merely an idler, so that the number of teeth in gear 178 is of no consequence and does not affect the one to one ratio between the resistor turntable and the templet turntable. At the same time the provision of an odd number of teeth in gear 178 makes it possible to obtain the desired fractional reduction ratio between the resistor turntable shaft 84 and the cam shaft 168, the desirability of which was previously outlined.

10 Templet turntable 220 carries a readily removable central screw 230 and a fixed pin 232. The latter is properly located to be equivalent to a position between the metallic terminals of a resistor on the resistor turntable 82. The templets are cut from sheet metal and take the form of the part of the resistor which is to be protected from the eraser action. For example, the templet 234 in Fig. 10 evidently covers approximately the area taken by the metallic terminals of the resistor, and it may therefore be anticipated that the entire resistance film will be subjected to the erasing action. By releasing the screw 230 the templet may readily be removed and replaced with another of different shape. The proper location of the templet is insured by reason of a pilot hole provided in each templet which fits over the fixed pin 232.

15 The eraser mechanism, and more specifically the arms 114 are provided with a follower cooperating with the templet. This follower has here been illustrated in the form of an accurately cut disc or wheel 236 which is relatively large in diameter. The templet follower is located halfway along the eraser mechanism, and any vertical movement imparted thereto is doubled at the eraser itself. The templets are preferably made from sheet metal about one-sixteenth of an inch thick, which makes possible an eraser lift of one-eighth of an inch. However, an eraser lift of one-sixteenth of an inch is ample, and therefore a one-thirty-second of an inch clearance between the follower and the templet turntable may be employed, which insures that the gravity pressure of the eraser on the resistance film will not be interfered with, and which also makes possible an adjustment of the effective size of the templet, which is subsequently explained.

In operation, it will be evident that a rapidly spinning eraser is brought into contact with a portion of a relatively slowly rotating resistor being treated, and that whenever a portion of the resistor which is not to be treated approaches the eraser, the leading edge of the templet also approaches the wheel 236, causing the eraser to be lifted from the resistor until the trailing edge of the templet is reached, at which time erasing contact is again established. The operation is exactly equivalent to mounting a protective stencil over a desired portion of the resistor, and the templet may therefore be thought of as a stencil, but the present arrangement has the advantage of protecting the eraser from rubbing against a stencil when not in use, and additional advantages next described. Incidentally, the parallel motion of the eraser mechanism B on carriage C, and the one to one ratio of the resistor and templet turntables are all preferred in order that the templets may be cut as simply as though they were to be used as stencils, and without necessitating allowances for angularity of moving parts and the like.

20 The leading and trailing edges of the templet may be given a slope or incline toward the surface of the templet turntable in order to obtain a gradual rise and fall of the eraser. This would be particularly necessary if a fixed follower were employed. However, in the present machine it is preferred to permit the templets to have simply square edges which make them exceedingly economical to prepare, and to employ a follower wheel 236 of relatively large diameter which in operation is equivalent to inclined leading and following edges. This follows because the upper edge of the templet first meets with a portion of the periphery of the wheel higher than the lowest point on the wheel, and the lift then proceeds gradually until the lowest point on the wheel is riding on the upper surface of the templet. The same applies to the departure of the wheel from the trailing edge of the templet. In fact, the lift is so gradual that the junction points between different portions of a non-linear resistor treated by the thinning down process are abraded gradually, as is indicated by the sloping lines 58 in Fig. 4 of the drawing. Also, the steps indicated by the lines 72 in Fig. 7, and the lines 74 in Fig. 8 come down to zero thickness in a very gradual manner. This desirable result is enhanced by the elastic nature of the eraser wheel itself, for it is slightly compressed during use and gradually restores its original dimension as it is lifted, thereby obtaining a gradual trailing-off of the erasing action.

25 The height of the templet table 220 is made adjustable through a manually operable capstan screw 240 (see Fig. 11) threaded in the lower end of bushing 224. The upper end of screw 240 takes the downward thrust of shaft 222 through a ball bearing 242. The adjustment of screw 240 is retained by a compression spring 244. The width of pinion 226 is sufficiently great to permit the desired movement without causing disengagement of the gearing. The resulting adjustment is useful in order to compensate for eraser wear. As the eraser diameter is diminished, the table 220 must be lowered in order to provide a clearance between the table and the follower wheel 236. However, as was before explained, this adjustment is permissible within relatively wide limits, because the thickness of the templet permits excessive movement of the eraser. Adjustment within these limits may be taken ad-

vantage of to vary the effective size of any given templet without varying the actual dimension of the templet. This may be explained by supposing the square edged templet and wheel 236 replaced by an inclined edge templet and a follower point. It would then be evident that raising the table 220 would increase the effective area of the templet because the follower point would strike the inclined edge of the templet at a point lower down than would be the case if the table 220 were lowered. By slightly varying the height of the table 220, the exact effective area of the templet would be adjustable. However, the wheel 236 cooperating with a square edged templet is equivalent to the mechanism just described, so that in the present machine variation of the table height varies the effective area of the templet so that accurate adjustment is possible. In passing, it may be mentioned that for further refinement of the machine, templets having inclined edges may be used in combination with the wheel 236, and that this refinement is dispensed with in the present case in order to economize the manufacture of the templets.

The optimum erasing speed or rotation of the eraser may be determined by experiment and is a compromise on the one hand between a desire for rapid erasing action, and on the other hand, a desire to avoid vibration, chattering, or similar phenomena. In the present machine the eraser is one and one-quarter inches in diameter and is rotated at a speed of eight hundred revolutions per minute. The speed of rotation of the resistor turntable is kept low rather than high in order to avoid inertia effects of the eraser mechanism when following the templet, or in other words, in order to permit the eraser mechanism to follow the control of the templet closely and accurately. In the present machine the table speed is fifty revolutions per minute. The relation between the reciprocation of the eraser and the table speed has already been set forth.

The resistance may best be brought to its correct value by measurement, and we prefer to arrange the machine so as to permit of continuous measurement of the resistance during the erasing operation so that the machine may be stopped either by manual or automatic means as soon as the resistance has been raised to the exact value desired. In Figs. 10 and 11 it will be noticed that the resistor turntable 82 carries a pair of spring contacts 250 adapted to bear against the metallic terminals 6 of the resistor. Leads run from contacts 250 through hollow shaft 84 and are connected to slip rings 252. The latter are engaged by fixed brushes 254, best shown in Fig. 14, which are mounted upon an insulation block 256 attached to the lower plate 204 of the machine.

Referring to Fig. 1 it will be noted that the brushes 254 may be connected to an ohmmeter circuit excited by a source of fixed potential 260 so that the resistance may be determined by watching the indication of the ohmmeter. A switch 262 may be provided which permits either ohmmeter 264 or ohmmeter 266 of different range to be connected in circuit when making a non-linear resistance, should the change in resistance be too great to be accommodated by a single meter.

This figure also indicates how the resistance may be measured on a Wheatstone's bridge, and the latter used, if desired, for automatically stopping the machine. The brushes 254 are connected so that the resistor comprises one arm of

the bridge. Adjustable resistance 268 may be given a value equal to that desired for the resistor, and resistances 270 are then made equal. The bridge may be energized by closing a switch 272, and an indicator 274 will then come to balance when the resistor has been raised to the desired resistance. If the bridge is to be employed for automatic operation, a relay is used in place of a visual indicator, and this relay is connected in the supply circuit 276 of the driving motor 14. Switch 278 is opened. When the erasing operation is begun switch 280 is closed and, the bridge being unbalanced, relay 274 is closed and the motor is energized. When the resistance reaches the desired value the bridge comes to balance and the relay is opened, thereby stopping the motor circuit. When the resistor is removed from the machine, switch 280 is opened in order to prevent the motor 14 from being prematurely started. Switch 278 may be closed when manual operation is preferred.

The operation of the machine for thinning down will next be described. The manual control mechanism E is retracted from operative position. The automatic cam mechanism D is made effective by tightening nut 164 on the cam follower spindle. The adjustment of the spindle within slot 194 before tightening nut 164 determines the location of the range of reciprocation of the eraser relative to the axis of the eraser turntable.

If a linear resistor is desired, the insulation plate is first coated with one or more suitable layers of paint, as was before explained, to obtain a resistance slightly lower than the desired resistance, after which the unit is baked and provided with metallic terminals, and open circuited between the terminals. The templet turntable is provided with a templet having an area just sufficient to protect the metallic terminals of the unit. A resistor is slid into position on the resistor turntable, and the machine is set into operation. When the resistance has been raised to the correct value the machine may be stopped either manually or automatically, as was previously explained.

If the resistor is to be non-linear, suitable templets are prepared in accordance with the specifications of the purchaser of the resistors. The unit is first thinned down to the proper resistance for the low resistance portion. Thereafter a larger templet is employed to protect the terminals and the low resistance portion, and the unit is again thinned down to obtain the correct resistance for the next higher resistance portion. While it is perfectly feasible to change templets in order to make the resistor in a single machine, in manufacturing units under production conditions, it is preferred that a number of machines be employed equal to the number of resistance portions to be provided. Each machine is fitted with a different templet, and each machine is preferably arranged to automatically stop at the proper resistance for a different one of the stages of the resistor. A single operator may attend the entire group of machines, and he simply transfers the resistors from machine to machine until the finished resistors leave the last machine. In this way, the operation may be made exceedingly rapid, and yet accurate results are insured.

To operate the machine for the narrowing down method, the automatic means D for reciprocating carriage C is made inoperative by releasing nut 164, and manual means E is instead employed. If a linear resistor is to be made, a

5 painted plate such as has before been described is inserted in the machine. A templet is used which protects only the terminals of the resistor, or, if desired, the templet may be entirely dispensed with, although this is not recommended. The manual means E is manipulated until the eraser is moved beyond the inner periphery of the film. An emery or carborundum loaded eraser should be employed, inasmuch as it is desired to entirely remove the film. The machine is started, and the eraser is very gradually moved outward by the crank E at a speed sufficiently low to insure complete removal of the resistance film. When the unit reaches the desired resistance, the machine is stopped either manually or automatically, as was explained in connection with Fig. 1.

10 If a non-linear unit is to be provided by the narrowing down process, the operation is preferably performed in a single machine. A plurality of templets are kept available for protecting each of the resistance portions in progression. The procedure outlined in the preceding paragraph is followed until the resistance equivalent to the desired resistance for the low resistance portion is reached, at which time the machine is stopped. The eraser mechanism is lifted out of the way and the templet is changed to the next templet without meanwhile disturbing the position of crank E. The machine is again started, and the eraser may be moved further outward to make the next higher resistance portion. This operation is repeated until the resistor is finished. In each case the crank E is left untouched between steps of the operation, so that the eraser is moved only once from the inside toward the outside of the resistance film. If automatic stopping of the machine is desired the resistance 268 of the Wheatstone's bridge should be provided with suitable taps so that the necessary different resistance values may rapidly be selected for each stage of the operation. While it is possible to narrow down a non-linear resistor by employing a plurality of machines, the present method is preferred because it dispenses with tedious adjustment of the position of the eraser between the different erasing stages. The task of changing templets is not difficult, and merely replaces the task of changing resistor units, which would be needed were a plurality of machines employed.

45 The same erasing machine may also be used to furnish the silver terminals of the resistor. This operation is illustrated in Fig. 9, referring to which the templet table 220 has been provided with a templet 225 which protects all of the area of the resistor except for the metallic terminals 6. The resistor plate 2 is put into position on the resistor turntable 82 in reversed position, that is, with the terminals 6 away from the contacts 250 instead of under the contacts 250. When the machine is started, the eraser will bear against the silver terminals and bring the same to the desired finish without meanwhile contacting with the resistance film. It may be mentioned that it is preferable to finish the terminals before erasing the resistor, so as to insure that the resistance measurement obtained during the erasing operation will be an accurate one and not spoiled by poor contact between the spring contacts 250 and the terminals 6.

75 It has been explained that the resistor may be given a desired value whether linear or non-linear by either the thinning down or narrowing down processes. It should further be understood that to meet the problem of a non-linear resistor

which is to have an exceptionally high ratio between the high and low resistance portions, it is possible and may be found desirable to employ both the thinning down and narrowing down processes on a single resistance unit. This makes it possible to obtain the desired high ratio without on the one hand carrying the thinning down process so far as to cut through the film, and on the other hand, carrying the narrowing down process so far as to spoil effective contact between the film and the slider of the resistor.

In the thinning down process the initial film is preferably made of uniform thickness, even though this necessitates erasing a large volume of resistance material. It is possible to initially paint the resistance unit with a greater number of coats of paint at the low resistance portion than at the high resistance portion thereof, and so reduce the amount of erasure necessary. However, this method is not recommended because it necessitates perfect synchronism or coincidence between the portions of the resistor as defined by the painting operation and as subsequently defined by the erasing operation. Any deviation from coincidence will cause either a very high resistance point between the resistor portions, or a low resistance point preventing resistance change between the resistor portions. This difficulty never arises when erasure is carried from a uniform film, because the machine establishes its own line of division between the resistor portions.

However, the application of extra paint by hand may be of considerable value to obtain a very low resistance hop-off or step-off from the metallic terminals at the beginning of the resistor. This is indicated in Fig. 6, in which it will be observed that the approach to the metallic terminal 6 is filled in with a body of resistance material 232. This is applied as smoothly as possible with a small brush and, if necessary, may be subsequently smoothed down by a hand eraser such as is used on lead pencils.

The method of our invention, and the manner of constructing and using the apparatus for practicing the invention, as well as the many advantages thereof will, it is thought, be apparent from the foregoing description. It will be appreciated that the eraser need not be rotatable and further, that if the resistor being treated is not circular, the supporting means therefor need not be rotatable. In fact the precise manner in which the relative movement of the erasing mechanism and the resistor supporting means is obtained will depend upon the type of resistor being treated and the manner in which it is desired to make its resistance vary. In general, our invention makes it possible to obtain exceedingly accurate resistance values in a rapid and economical manner under production conditions and with results checked by actual measurement during the process.

It will be apparent that while we have shown and described our invention in the preferred form, many changes and modifications may be made in the method and structure disclosed without departing from the spirit of the invention, defined in the following claims.

We claim:

1. An erasing machine for adjusting the electrical resistance of painted resistors comprising a disc-like rubber eraser, means to rotate the same in contact with a resistor, and abrasive means substantially harder than the eraser and

bearing against the eraser to simultaneously clean the same during its rotation.

2. An erasing machine for adjusting the resistance of painted resistors comprising a disc-like rubber eraser, means to rotate the same in contact with a resistor, and means to simultaneously clean the same during its rotation including a relatively roughly surfaced cleaning wheel substantially harder than the relatively soft eraser which bears against the eraser and is freely rotatable about an axis inclined relative to the axis of the eraser.

3. An erasing machine for adjusting the resistance of painted electrical resistors comprising resistor supporting means, a rotatable rubber eraser, means to rotate the eraser, and means to relatively move the eraser and the resistor supporting means.

4. An erasing machine for adjusting the resistance of painted electrical resistors comprising rotatable resistor supporting means, a rotatable rubber eraser, means to rotate the eraser at a relatively high speed, means to rotate the supporting means at a relatively low speed, and means to relatively move the eraser and the resistor supporting means.

5. An erasing machine for adjusting the resistance of painted resistors comprising resistor supporting means, a rotatable eraser, means to rotate the eraser at a relatively high speed, means to relatively move the eraser and resistor supporting means so as to erase the surface of a resistor and then to repeat the erasing operations and so on in successive cycles, to prevent the eraser from traveling over the same path on the resistor in successive erasing cycles.

6. An erasing machine for adjusting the resistance of painted resistance units comprising rotatable resistor supporting means, a rotatable eraser, means to rotate the eraser at a relatively high speed, means to rotate the supporting means at a relatively low speed, and means to automatically relatively move the eraser and the supporting means to erase the surface of a resistor in a spiral path, and then to repeat the erasing operation, said means causing the eraser to travel over different spiral paths in successive erasing operations.

7. An erasing machine for adjusting the resistance of painted resistors comprising resistor supporting means, an eraser, means for causing relative movement of the eraser and a resistor on the resistor supporting means, and means to separate the eraser and the resistor over a desired portion of the resistor in order to completely prevent erasure and change of resistance of said resistor portion.

8. An erasing machine for adjusting the resistance of painted resistors comprising resistor supporting means, templet supporting means, a rotatable eraser for erasing a resistor on the resistor supporting means, means to rotate the eraser at a relatively high speed, means causing relative movement of the eraser and resistor supporting means, and means cooperating with a templet on the templet supporting means for lifting the eraser from a desired portion of the resistor in order to completely prevent erasure and change of resistance of said resistor portion.

9. An erasing machine for adjusting the resistance of painted resistors comprising resistor supporting means, an eraser, means for causing relative movement of the eraser and a resistor on the resistor supporting means, a stencil or

templet, means cooperating therewith to separate the eraser and the resistor over a portion of the resistor determined by the dimension of the templet, and means to slightly vary the effective dimension of the templet to accurately define the said portion of the resistor, without varying the actual physical size of the templet.

10. An erasing machine for adjusting the resistance of painted resistors comprising a resistor turntable, a templet turntable, means to cause simultaneous rotation of the resistor and templet turntables, an eraser for erasing a resistor on the resistor turntable, means causing movement of the eraser over the resistor on the resistor turntable, and means cooperating with a templet on the templet turntable for lifting the eraser from a desired portion of the resistor in order to completely prevent erasure and change of resistance of said resistor portion.

11. An erasing machine for adjusting the resistance of painted resistors comprising a resistor turntable, a templet turntable, means to cause simultaneous equal rotation of the resistor and templet turntables, a rotatable eraser for erasing a resistor on the resistor turntable, means to rotate the eraser at a relatively high speed, a follower wheel cooperating with a templet on the templet turntable for lifting the eraser from a desired portion of the resistor, a reciprocable carriage so mounted as to afford parallel movement of the eraser and follower wheel respectively over the resistor on the resistor turntable and a templet on the templet turntable, and means to vary the height of the templet turntable.

12. An erasing machine for adjusting the resistance of painted resistance units having an insulation base, a resistance film, and metallic terminals at the ends of the resistance film, said machine comprising means for rotatably supporting the resistance unit, a rubber eraser arranged to rub against the resistance film, a roughly surfaced cleaning wheel substantially harder than the eraser and bearing against the same, a pair of resilient contacts on the supporting means bearing against the terminals on the resistor, and slip rings and brushes connected therewith and permitting the resistance of the resistor to be measured while the resistor is being erased in the machine.

13. An erasing machine for adjusting the resistance of painted resistance units having an insulation base, a resistance film, and metallic terminals at the ends of the resistance film, said machine comprising means for rotatably supporting the resistance unit, a rotatable rubber eraser arranged to rub against the resistance film, means to rotate the eraser, a pair of contacts on the supporting means bearing against the terminals on the resistor, slip rings and brushes connected therewith and permitting the resistance of the resistor to be measured while the resistor is being erased in the machine, and means to automatically stop the operation of the machine when the resistance has been raised to a predetermined desired value.

14. An erasing machine for adjusting the resistance of painted resistors comprising a rotatable resistor supporting means, a rotatable eraser, means to rotate the eraser, automatically operable means to relatively move the eraser and the resistor supporting means transversely of the axis of rotation of the support means in successive cycles, manually operable means to relatively move the eraser and the resistor supporting means

in a similar direction, changeable templet means for separating the eraser and the resistor over a desired portion of the resistor, and means for selectively making either the automatically or manually operable means operative.

15. An erasing machine for adjusting the resistance of painted resistors comprising resistor supporting means, eraser mechanism, a templet for separating the eraser mechanism and the resistor supporting means, a follower wheel of relatively large diameter carried by the eraser mechanism for engaging the templet, and means for relatively moving the templet and follower wheel in a direction lying in the plane of the follower wheel.

16. In combination, a rotatable abrasive wheel, a rotatable table for receiving an element to be operated upon thereby, means to rotate the abrasive wheel at a relatively high speed, means to rotate the table at a relatively low speed, means to automatically relatively reciprocate the wheel and the table in order to rub the surface of the element in a spiral path and then to repeat the rubbing operation and so on in successive cycles, said means causing the wheel to travel over different spiral paths in successive rubbing cycles.

17. An erasing machine for adjusting the resistance of resistance units, said erasing machine comprising a work table, a templet table arranged to receive and hold a sheet metal templet defining portions of the resistance unit upon which erasure is to be prevented, a frame, an eraser rotatably mounted on said frame near the work table, a follower wheel of relatively large diameter mounted on said frame near the templet table, and means for causing high speed rotation of the eraser and relative movement of the frame and tables in such direction as will cause the follower wheel and the templet edges to roll one across the other.

18. An erasing machine for adjusting the resistance of resistance units, said erasing machine comprising a work table, a templet table arranged to receive and hold a sheet metal templet defining portions of the resistance unit upon which erasure is to be prevented, an eraser rotatably mounted on said frame near the work table, a follower wheel of relatively large diameter mounted on said frame near the templet table, means for causing high speed rotation of the eraser and relative movement of the frame and tables, and means to adjust the height of the templet table in order to vary the effective area of the templet and to compensate for wear of the eraser.

19. An erasing machine for adjusting the resistance of resistance units, said erasing machine comprising a work table, a templet table arranged to receive and hold a templet defining portions of the resistance unit upon which erasure is to be prevented, a frame, an eraser rotatably mounted on said frame near the work table, a follower mounted on said frame near the templet, means for causing high speed rotation of the eraser and relative movement of the frame and tables, and means to continuously clean the eraser during its rotation.

20. An erasing machine for adjusting the resistance of electrical resistance units, said erasing machine comprising a work table, a frame movable toward and from said work table, an eraser rotatably mounted on said frame near the work table, templet means to move the frame in order to separate eraser from the resistor over desired portions of the resistor, a roughly surfaced freely rotatable cleaning wheel substantially harder than the eraser, and means mounting the same on the

frame and yieldably urging the same into contact with the eraser.

21. An erasing machine for adjusting the resistance of resistance units having a circular film of resistance, said erasing machine comprising a work table rotatable on a vertical shaft and arranged to detachably receive and hold a resistance unit, a templet table rotatable about a vertical shaft and adapted to detachably receive and hold a sheet metal templet defining portions of the resistance unit upon which erasure is to be prevented, means coupling said shafts for simultaneous and equal rotation, a frame located above said tables, an eraser rotatably mounted on said frame above the work table, a follower mounted on said frame above the templet table, and means causing high speed rotation of the eraser and slow speed rotation of the tables.

22. An erasing machine for adjusting the resistance of resistance units having a circular film of resistance, said erasing machine comprising a work table rotatable on a vertical shaft and arranged to detachably receive and hold a resistance unit, a templet table rotatable about a vertical shaft and adapted to detachably receive and hold a sheet metal templet defining portions of the resistance unit upon which erasure is to be prevented, means coupling said shafts for simultaneous and equal rotation, a frame located above said tables, an eraser rotatably mounted on said frame above the work table, a follower mounted on said frame above the templet table, means causing high speed rotation of the eraser and slow speed rotation of the tables, and means supporting the frame for upward movement away from the tables in order to permit change of the work or of the templet.

23. An erasing machine for adjusting the resistance of resistance units having a circular film of resistance, said erasing machine comprising a rotatable work table arranged to detachably receive and hold a resistance unit, a frame arranged for reciprocation transversely thereof, an eraser rotatably mounted on said frame at the work table, means for causing high speed rotation of the eraser and slow speed rotation of the table, and additional means geared to said table for causing a slow reciprocation of the frame during the erasing operation, said gearing providing an odd fractional ratio of movement causing successive erasing cycles to follow different spiral paths.

24. In combination, a work table rotatable on a vertical shaft, a templet table rotatable on a vertical shaft and adapted to receive and hold a sheet metal templet, means coupling said shafts for simultaneous and equal rotation, a frame located above said tables and arranged for reciprocation transversely thereof, an abrasive wheel rotatably mounted on said frame above the work table, a follower wheel of relatively large diameter mounted on said frame above the templet table, means causing high speed rotation of the eraser and slow speed rotation of the tables, and additional means geared to said tables for causing a slow reciprocation of the frame during the abrading operation.

25. An erasing machine for adjusting the resistance of resistance units having a circular film of resistance, said erasing machine comprising a work table rotatable on a vertical shaft and arranged to readily detachably receive and hold a resistance unit, a templet table rotatable on a vertical shaft and adapted to readily detachably receive and hold a templet defining portions of

5	the resistance unit upon which erasure is to be prevented, means coupling said shafts for simultaneous and equal rotation, a frame located above said tables and arranged for reciprocation transversely thereof, an eraser rotatably mounted on said frame above the work table, a follower mounted on said frame above the templet table, means causing high speed rotation of the eraser and slow speed rotation of the tables, and additional means geared to said tables for causing a slow reciprocation of the frame during the erasing operation.	sistance of painted electrical resistors comprising rotatable resistor supporting means, a rotatable rubber eraser, means to rotate the eraser at a relatively high speed, means to rotate the supporting means at a relatively slow speed, means to relatively move the eraser and the resistor supporting means, and means to continuously clean the eraser during its rotation, including a relatively roughly surfaced cleaning wheel bearing against the eraser and freely rotatable about an axis inclined relative to the axis of the eraser.	80
10	26. An erasing machine for adjusting the re-	JOSEPH A. FLANZER. LESTER L. JONES.	85
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