M. L. SEVERY.

METHOD OF MAKING RESISTANCE ELEMENTS.

APPLICATION FILED JAN. 15, 1914.

1,225,368.

Patented May 8, 1917.

3 SHEETS—SHEET 1.

Fig. 1.

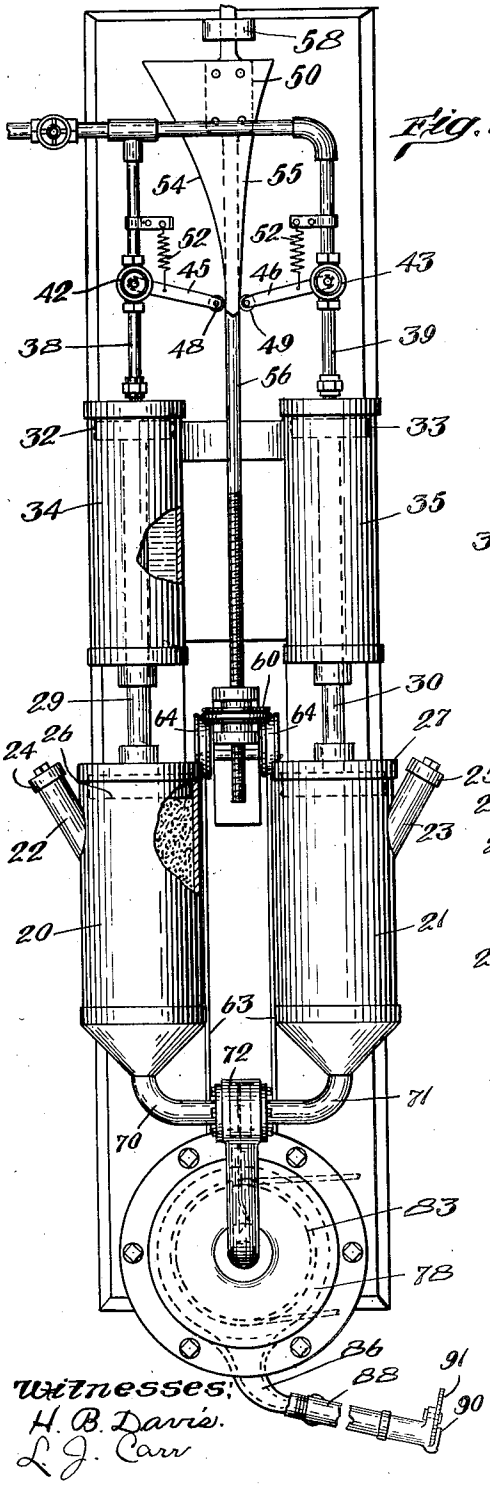
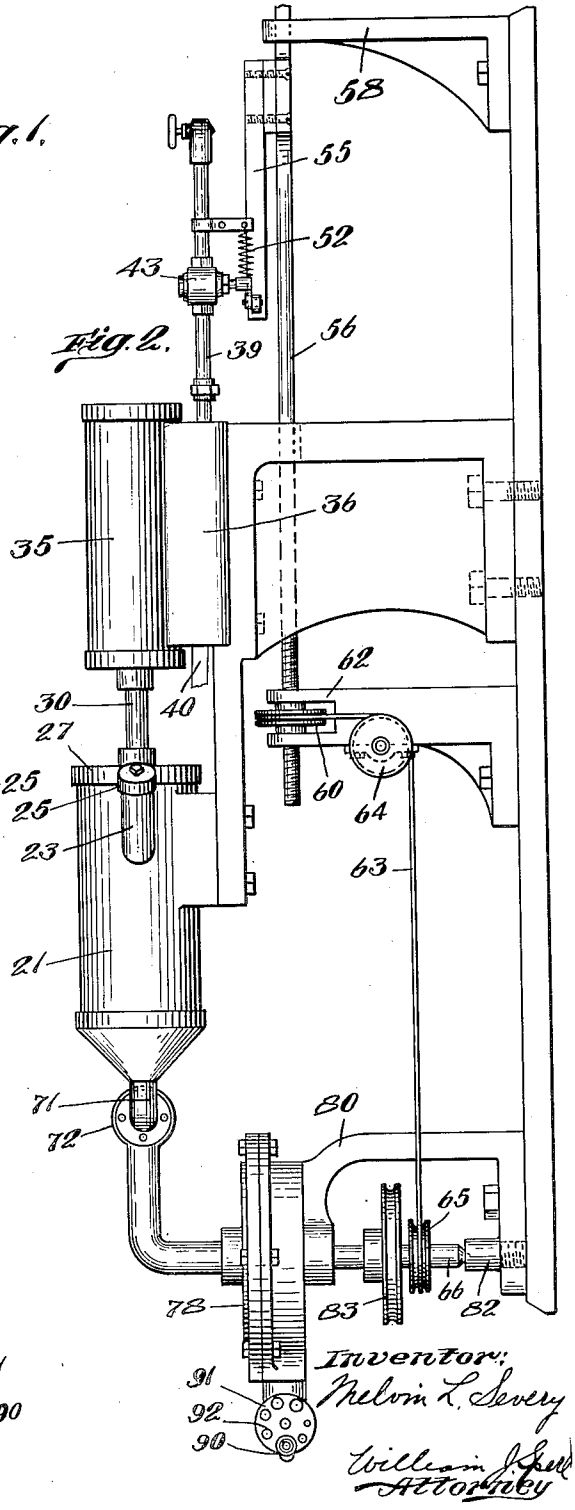


Fig. 2.



Witnesses:
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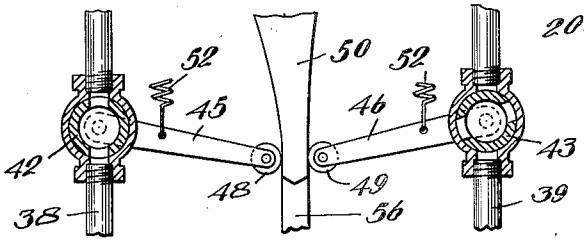


Fig. 3.

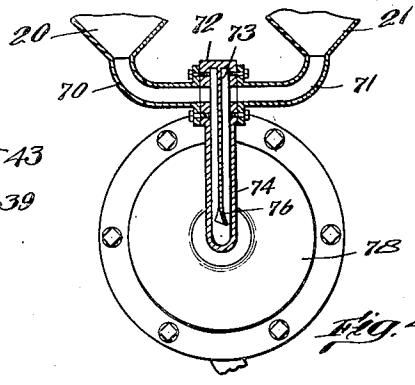


Fig. 4.

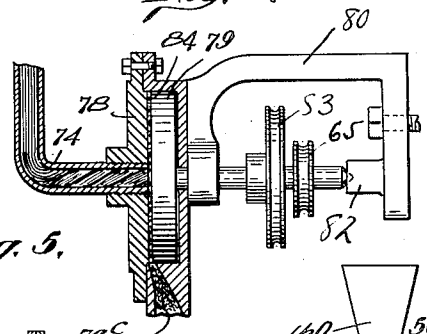


Fig. 5.

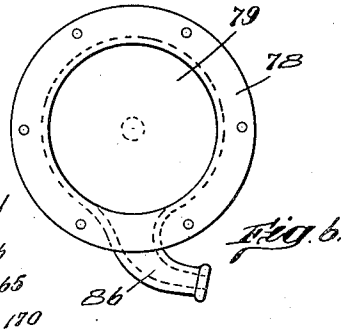


Fig. 6.

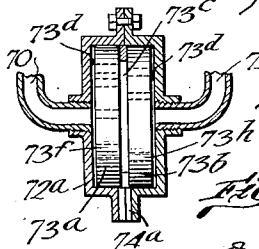
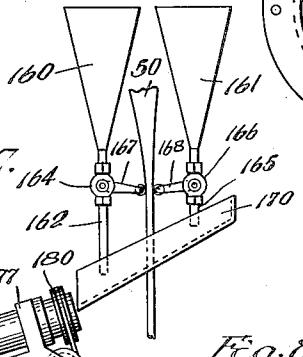
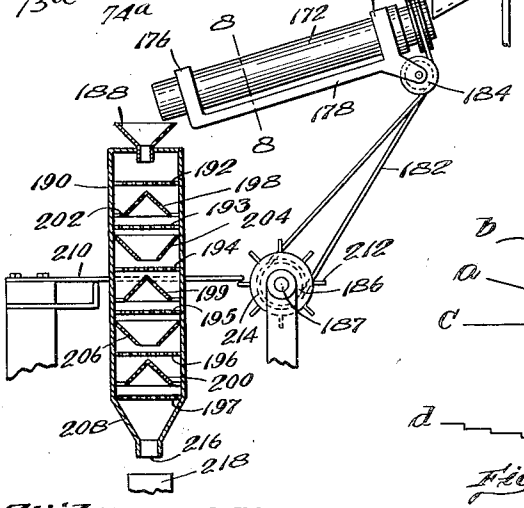


Fig. 7.





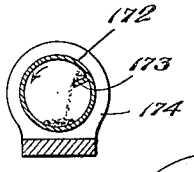


Fig. 8.

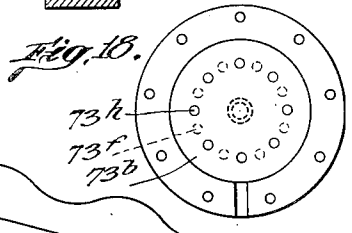


Fig. 18.

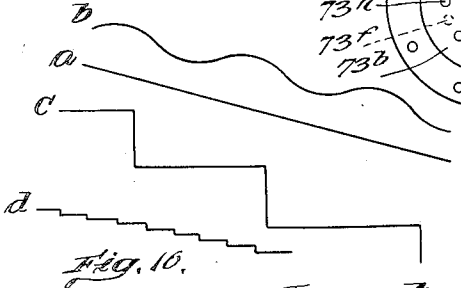


Fig. 16.

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3 SHEETS—SHEET 3.

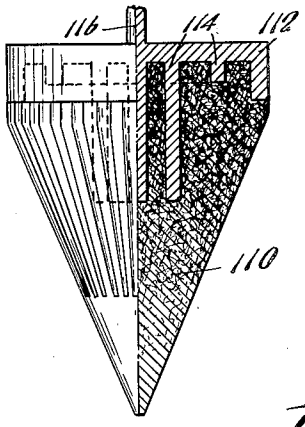


Fig. 9.

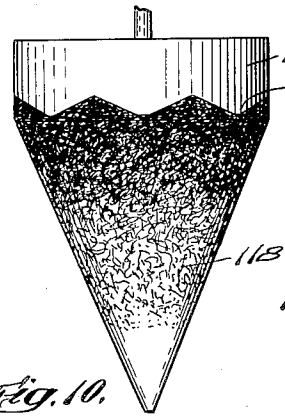


Fig. 10.

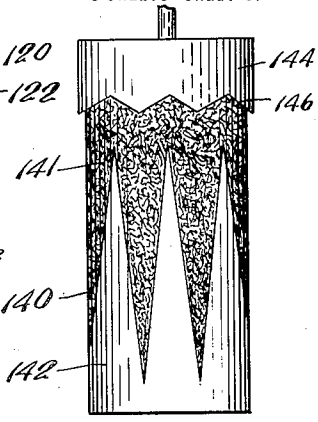


Fig. 11.

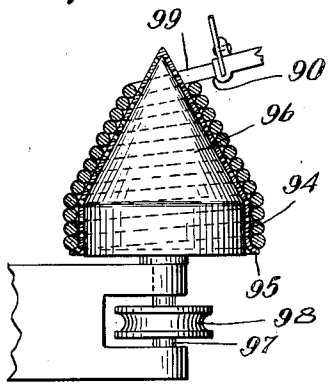


Fig. 12.

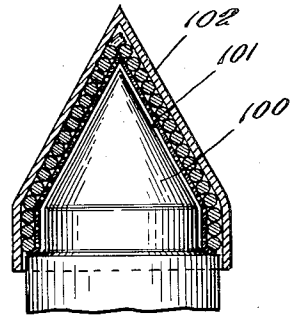


Fig. 13.

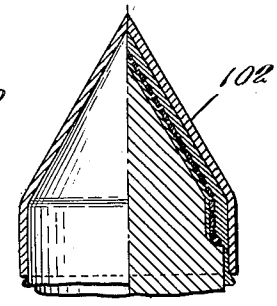


Fig. 14.

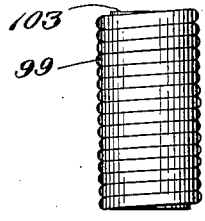


Fig. 15.

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UNITED STATES PATENT OFFICE.

MELVIN L. SEVERY, OF ARLINGTON HEIGHTS, MASSACHUSETTS, ASSIGNOR TO SEVERY MANUFACTURING COMPANY, OF BOSTON, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

METHOD OF MAKING RESISTANCE ELEMENTS.

1,225,368. Specification of Letters Patent. Patented May 8, 1917.

Application filed January 15, 1914. Serial No. 812,238.

To all whom it may concern:

Be it known that I, MELVIN L. SEVERY, of Arlington Heights, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Methods of Making Resistance Elements, of which the following is a specification.

This invention relates to resistance elements and the method or process of producing the same, and includes features of invention claims for which were canceled under requirement for division from my copending application for patent Serial No. 777,873, filed July 8, 1913. The present application is a continuation of the above application as to this subject matter.

The object of the invention is to provide resistance elements, the resistance curves of which may be made to vary in anv desired manner. As resistance members are ordinarily constructed they vary in resistance, other things being equal, in proportion to the length of the resistance in circuit. Of course where other things are not equal, as when the resistance varies in size of cross-section, the resistance will not be as the length in circuit; but in the case of the resistances forming the subject of this application where other things are equal, that is where the cross-section remains constant, the curve of resistance may be made to vary in practically any desired way irrespective and largely independent of the length of the resistance in circuit, by which I mean that a portion of one of my resistance members one-half inch long might show one ohm resistance, while the next half-inch might show ten ohms resistance, the next half-inch a hundred ohms, and, if desired, the next half-inch one tenth ohm; or these gradations might merge into each other imperceptibly, or by steps sufficiently small considered in relation to the use to which the member is to be put to be practically negligible. In short, the shape, direction, and inclination of the resistance curve can be controlled according to my invention.

I wish to have the term "practically negligible" gradations considered or interpreted in connection with the character of the resistance member in each case in question. For example, it is obvious that for certain uses a resistance member might be formed so that its resistance would vary in steps of say an ohm each, and be for every practical purpose just as good as if these variations were by a hundredth of an ohm each, while members intended for other uses could not vary even a hundredth of an ohm a step without impairing the perfection of their operation; while still other members would require for perfect work a truly insensible gradation. It is necessary, therefore, that the use be taken into consideration in the determination of what constitutes a "practically negligible" gradation. It is to be understood also that while the resistance curve may be controlled by my invention without changing the cross-section or shape of my members as between their parts, it will often be convenient and desirable to change said size of cross-section and said shape as well as the specific resistance, and I hold all of these changes to be well within the province of my invention.

These elements for some purposes would be preferably conical in form, while for other purposes they will preferably be cylindrical or of other shapes, and they may be hollow or solid.

In the present application I have shown various forms of apparatus for use in the process of making the resistance elements, and I have also shown several forms of elements, although the scope of the invention is not limited to any or all of the illustrative embodiments herein disclosed.

The invention will be readily understood from an inspection of the accompanying drawings, in which Figure 1 is a front elevation of an illustrative embodiment of an apparatus for mixing the ingredients and delivering them for use in forming the resistance elements. Fig. 2 is a side elevation of the same, Fig. 3 is a fragmentary sectional elevation of the valves and cam for controlling the mixture of the ingredients, Fig. 4 is a central vertical section through the lower ends of the material-conveying pipes and through the baffle plate, Fig. 5 is a central longitudinal vertical section through the mixing chamber, showing the shaft and bearings in elevation, Fig. 6 is a front elevation of the mixing chamber, Fig. 7 is a sectional side elevation of a modified form of mixing apparatus, Fig. 8 is a section taken on the line 8—8 in Fig. 7, Figs. 9, 10 and 11 are views showing various forms of resistance

element, Fig. 12 shows how the resistance material may be laid around a conical form, Fig. 13 is a sectional view showing the material in place on the conical form before said material is anchored, Fig. 14 is a view showing the material pressed and anchored on the form, Fig. 15 is an elevation of a cylindrical resistance element, before the material is anchored or its spiral pressed into more intimate union, Fig. 16 is a view showing four plottings of resistance curves of resistance members more or less desirable according to the uses to which they are to be put. Fig. 17 is a central vertical section of a modified form of mixing chamber, Fig. 18 is an end elevation showing the perforated plates with one end of the casing of the chamber removed.

As illustrated in the drawings, the process of manufacture may be carried on by the aid of the following apparatus;—A pair of cylinders 20, 21 are provided, the latter containing a relatively high resistance material, and the former a relatively low resistance material. I do not confine myself to the use of any particular materials, but the high resistance material may be conveniently composed of graphitized clay, or clay sufficiently admixed with graphite to produce the highest specific resistance desired, and the former may contain a low-resistance material composed of clay with a much higher per cent. of graphite. The ingredients of both cylinders are preferably mixed with water, a binder, or any suitable material, so that the mixture in each cylinder is of such a consistency as to enable it to be manipulated and squirted or otherwise formed as will be hereinafter explained. The cylinders 20, 21 are filled through pipes 22, 23, having their outer ends closed by caps 24, 25.

Within the cylinders 20, 21, are pistons 26, 27 mounted upon the lower ends of rods 29, 30, and these rods are provided at the upper ends with pistons 32, 33 which travel within hydraulic cylinders 34, 35, respectively. The cylinders 34, 35 are provided with valve chambers 36, which are connected to supply pipes 38, 39, through which the motive fluid for the cylinders 34, 35 is supplied. This fluid may be water or oil, or any other suitable fluid, and said valve chambers may be provided with discharge pipes 40. The valve mechanism need not be described, as any suitable form of hydraulic cylinder may be employed.

The amount of motive fluid supplied to the cylinders 34, 35 is controlled by valves 42, 43, having operating arms 45, 46, provided at their free ends with cam rollers 48, 49 adapted to coöperate with a cam 50, and which rolls are held in engagement with said cam by springs 52 attached to said arms. The roll-engaging surfaces 54, 55 of the cam may be formed as required to produce the desired resultant mixture for the resistance element, and the cam may be detachably mounted upon a rod 56, which is slidably mounted in a suitable bearing 58, near its upper end. The lower end of said rod is screw-threaded within a sheave wheel 60 held in a bifurcated bracket arm 62. A belt 63 passes over the wheel 60 and a pair of idlers 64, and also over a sheave wheel 65 on a shaft 66. The rotation of the wheel 60 causes the rod to be moved longitudinally and with it the cam 50, thus regulating the valves 42, 43, and consequently regulating the downward movement of the pistons 32, 33. The relative rates of downward movement of said pistons determines the relative amounts of discharge of the materials from the lower ends of the cylinders 20, 21, and consequently determines the character of the resultant mixture.

The materials in the cylinders 20, 21 are forced through pipes 70, 71 into a chamber 72, having a baffle plate 73 by which the streams of material from the pipes 70, 71 are deflected at substantially right angles into a pipe 74, and this baffle plate is twisted at its lower end 76 to form a spiral stream at each side thereof, so that the two streams mingle somewhat like the strands of a rope, as shown in Fig. 5.

A modified form of mixing device is shown in Figs. 17 and 18 which comprises a chamber 72^a having a pair of disks 73^a, 73^b which are separated from each other by a short space 73^c, and from the end walls of the casing by short spaces 73^d. The disks 73^a and 73^b are provided with apertures 73^f, 73^h, which are offset with respect to each other so that the material coming in through the pipes 70, 71 enters the spaces 73^d and then passes through the apertures 73^f and 73^h, the streams from one set of apertures passing between the streams of the other set and engaging the opposed inner faces of the disks 73^b and 73^a, respectively, in the space 73^c. These streams are thus intimately mixed in striations and pass from the space 73^c into the pipe 74^a, which is free from baffle plates. Thence the commingled materials pass on as will be explained.

The stream of commingled materials passes from the pipe 74 into a chamber 78 having a rotating disk 79 which is fast on the shaft 66. The shaft 66 is journaled in a bracket 80 and has one end pointed to fit an adjustable step bearing 82 on said bracket, this step bearing being arranged to resist the thrust exerted upon the disk 79 by the material fed from the pipe 74. A driving pulley 83 is also fast on the shaft 66. The disk 79 is separated from the left hand wall of the casing 78 slightly to provide a shallow space 84, the depth of which may be adjusted by the step bearing into which space the materials from the pipe 74 are discharged

said materials being engaged by said disk and thoroughly mixed thereby, then the thoroughly mixed mass is discharged from the chamber 78 through a pipe 86, which may be connected to a flexible pipe 88 having an adjustable nozzle 90. This nozzle may comprise a pivoted plate 91 having orifices 92 of various sizes, which may be brought into alinement with the mouth of the nozzle to regulate the size of the stream discharged therefrom, or it may consist of a nozzle with a single orifice the size of which may be changed after the manner of a camera shutter or otherwise during operation to squirt a stream of conical or other shape. It will be noted that the stream of material enters the comparatively wide upper end of the pipe 86 in a thin stream, which is then converted into a round stream as it passes through said pipe into the flexible pipe 88.

The stream which is discharged from the nozzle 90 is composed of a mixture of the low resistance material from the cylinder 20 and the high resistance material from the cylinder 21. When it is desired to produce a resistance element having its specific resistance varying gradually from a very low to a very high resistance, the valves 42, 43 are set as shown in Fig. 3, with their stems under the control of the cam 50, the valve 42 being wide open and the valve 43 being closed. With the parts in this position the pistons 32 and 26 would be lowered, but the pistons 33 and 27 would remain stationary, thus the stream discharged from the nozzle 90 would be of very low resistance. As soon as the cam roller 49 engaged the curved portion 55 of the cam 50, the valve 43 would start toward its open position, and would be increasingly opened as the cam was lowered, thus increasing gradually the amount of motive fluid admitted to the cylinder 35 and consequently increasing the travel of the pistons 33 and 27. In the meantime the valve 42 would be gradually closing, thus gradually reducing the amount of movement of the pistons 32 and 26, and thereby gradually reducing the amount of material forced out of the cylinder 20 into the pipe 70, while on the other hand the piston 27 would be forcing out material from the cylinder 21 in constantly increasing proportions, until finally when the upper end of the cam 50 is reached the valve 42 is completely shut off and the valve 43 is wide open. Thus the resultant mixture consists entirely of low-resistance material at the commencement and practically entirely of high resistance material at the end of the feeding movement, the variation in the proportions of each kind of material being dependent upon the shape of the cam surfaces 54 and 55. Obviously, if it be desired to have the specific resistance of an element remain constant throughout, the cam could be so made as to keep the valve positions constant at the relative predetermined degrees of opening. By means of different cams not only can varying resistances of all types be made but also constant resistances of all manner of specific resistances can be produced at will.

In building up the hollow conical forms of resistance element, shown in Figs. 12–14, I may use a conical shell 94, preferably of wire gauze or foraminous sheet metal, having a curved lip or roll 95 at its lower edge, and adapted to fit upon a conical support 96 carried by a shaft 97 driven by a pulley 98. I may also use any other suitable support, or I may form the squirted material of such dimensions as to be self-supporting. The support 96 and shell 94 may be rotated slowly and with suitably varying speed, or the squirted stream itself may be used to rotate the shell, and the stream 99 from the nozzle 90 is laid around the shell upon the lip 95 and then in spiral convolutions until the apex of the cone is reached, the cam 50 in the meantime controlling the relative amounts of high and low resistance material in the mixture. When the cone has been formed the next cone may be started at the apex, and the direction of movement of the pistons reversed so that the cam 50 rises and a mixture of constantly decreasing resistance is formed.

After the mixture has been squirted upon the foraminous shell or holder, a conical plug 100 is inserted in the holder, leaving a space 101 between said plug and holder. Then a hollow conical member or cap 102 is placed over the outside of the soft spiral convolutions of resistance material, as shown in Fig. 13. Then the member 102 is forced down upon the resistance material, and the latter is forced through the meshes or apertures in the conical shell or holder 94 against the plug 100, and is spread out by the latter against the inside of said holder. Thus the material is locked upon the holder and its outside surface is rendered smooth and continuous. Where the material squirted is of an adhesive nature I may use a protecting cover of paper over the plug 100 and as an inner lining to the cap 102, this paper being burned during carbonization. If desired the stream 99 may be wound spirally about a cylindrical holder 103, as seen in Fig. 15, which where desired may be subsequently treated in a manner analogous to that described above.

The resistance element may also be solid and constructed in several ways: for example, in Fig. 9 is shown a generally conical element 110, having its conical surface fluted to a greater or less extent, but preferably without flutes near its apex. This element may be composed of resistance material hav-

ing a varying specific resistance from its base to its apex, as heretofore explained, and it may be electroplated at its base and fitted with a metal cap 112. This cap may be formed with several internal annular ribs 114 to increase the surface contact between the cap and resistance material, said contact being made as intimate as possible between the electroplated coating and the metal cap. A stem 116 may also be provided on the cap, to which a wire may be connected in any suitable manner.

As shown in Fig. 10, the resistance element may consist of a conical mass of resistance material 118, which is of varying specific resistance, that is, the ingredients of the material are such that the specific resistance is highest at the apex of the cone, and gradually diminishes toward its base. This, like Fig. 9, may be more or less fluted where desired. A metal cap 120 is affixed to the base of the cone and may be provided with a scalloped edge 122, to provide a gradually varying surface of metal contact when the element is immersed in or withdrawn from a conductive liquid.

In Fig. 11 is shown a resistance element which is composed of a cylindrical member 140, having a low-resistance portion 141 and a high-resistance portion 142, these portions tapering gradually in opposite directions, so that the resistance decreases gradually from the face of the element toward the cap 144, which cap may be affixed as described above, and may have a serrated edge 146 to vary more gradually the extent of metal contact when immersed in a liquid.

Thus in each of the elements above enumerated the specific resistance may be highest at the apex or entering end of the element, and gradually diminish toward the other end, and at the same time in the conical elements the area of the surface contact is gradually increased as the element is moved into contacting position or immersed, or vice versa.

In many cases it is desirable to subject the resistance member to more or less heat at some stage of the process, either for the purpose of improving its conductivity, or to render the article stronger and less liable to fracture, or for both reasons.

In Figs. 7 and 8 I have shown another form of apparatus in which the ingredients are mixed in a dry state. As here shown the apparatus comprises a pair of conical receptacles 160, 161, the former containing low-resistance material, and the latter containing high-resistance material, as described above. These materials are in a dry state, instead of being mixed with a liquid for the purpose of squirting.

A discharge pipe 162 communicates with the lower end of the receptacle 160 and is provided with a valve 164, and the receptacle 161 is provided with a discharge pipe 165 having a valve 166. The stems of the valves 164, 166 are provided with arms 167, 168, having rollers at their ends which engage the faces of a cam 50, as described above, whereby the relative amounts of material fed from the receptacles 160, 161 are regulated.

The pipes 162, 165 discharge into an inclined chute 170, which in turn discharges into a rotary inclined mixing tube 172. This tube is provided with an internal longitudinally extending fin 173 by which the material 174, which has been fed from the receptacles 160, 161, is lifted a short distance and then allowed to drop back into said tube, partially to mix the materials. The tube 172 is rotatably mounted in a pair of bearings 176, 177 on a frame 178, and is provided on one end with a pulley 180, over which a belt 182 passes. The belt 182 passes over a pair of idlers 184, by which it is given a quarter turn, and also over a driving pulley 186 on a shaft 187. The tube 172 is rotated to raise the materials therein and drop them repeatedly, each time a little nearer the hopper 188, so that when they are discharged from the lower end of the tube into said hopper they are mixed to quite an extent.

The tube 172 discharges into a hopper 188 which is mounted at the upper end of a vertical receptacle 190. The receptacle 190 is divided into a series of compartments by horizontal screens 192 to 197. Below the screens 192, 194 and 196 are conical distributers 198, 199, 200 having their apexes projecting upward, and having spaces 202 between their bases and the walls of the receptacle 190, whereby the material which falls through the screens 192, 194, and 196 is distributed by said conical members to the outer periphery of the screens. Below the screens 193, 195 and 197 are conical or funnel-shaped members 204, 206, and 208 respectively, the latter forming the lower end of the receptacle 190. These funnel shaped members concentrate the materials toward the center of the receptacle, whereas the upwardly projecting conical members distribute the materials toward the outer walls of said receptacle. The receptacle 190 may be carried by a vibratory arm 210, which is intermittently engaged by arms 212 on a wheel 214 carried by the shaft 187. By this construction the receptacle 190 is periodically agitated, and the materials passing therethrough are alternately thrown outward and inward thus thoroughly mixing them by the time they reach the opening 216 at the lower end of said receptacle.

The proportions of the ingredients having been regulated by the cam-controlled valves 164, 166 as already explained with the other form of apparatus, they are discharged

from the opening 216 into any suitable receptacle 218, after which they are compressed with any suitable means and then carbonized, or otherwise treated in any suitable manner as already explained.

Resistance elements made according to the most refined application of my invention are capable of varying the current by imperceptible gradations, thus sensibly attaining the ideal plotting *a* shown in Fig. 16. Even if the curve were composed of gradual undulations such as the curve *b*, it would not be fatal in certain cases, but a declivitous curve such as *c* with high declivities is highly objectionable in the overwhelming majority of cases and must be avoided. The plotting *d*, however, having declivities of a height as to be in many cases practically negligible, illustrates a curve of considerable practical utility, though none of these latter plottings is so ideal as that of my most refined device shown by the line *a*.

Having thus described my invention, what I claim is:—

1. The method of making resistance elements having a progressively varying conductivity in different portions thereof, which consists in feeding two substances having different degrees of conductivity, at relatively varying rates, to a mixing device, effecting a progressive and localized mixing of the material as it passes through said mixing device, discharging the mixed material progressively into a mold or former of the desired shape, and finally compacting the material in said mold or former to produce a completed resistance element of the desired shape.

2. The process of forming a resistance element having a progressively varying conductivity in different portions thereof, which consists in feeding two plastic materials having different degrees of conductivity, at relatively varying rates to a mixing device, performing a progressive and localized mixing action upon the material passing through said mixing device, discharging the resulting mixed material progressively to a mold or former, and finally pressing the same to shape.

3. The method of forming resistance elements having a progressively varying conductivity in different portions thereof which consists in feeding two plastic resistance substances having different degrees of conductivity, at relatively varying rates, to a mixing device, performing a progressive localized mixing action in said device, discharging the resulting mixed stream in the form of a compact thread or pencil into a former, arranging said thread or pencil in said former in adjacent and contacting layers or convolutions, and finally pressing the resistance material so deposited to final form.

4. The method of forming a resistance element which consists in feeding two plastic resistance elements having different degrees of conductivity at relatively varying rates to a mixing device, performing a progressive and localized mixing action in said device, progressively ejecting said material under pressure from said mixing device, in the form of a thread or pencil, to a supporting surface, forming a layer thereof on said surface, said layer comprising adjacent and contacting convolutions of said thread or pencil, and finally subjecting the material while so supported to a compressing operation to compact the same and transfuse or amalgamate said convolutions of said thread or pencil.

5. The method of making resistance elements having a progressively varying conductivity in different portions thereof, which consists in feeding two substances having different degrees of conductivity, at relatively varying rates, to a mixing device, effecting a progressive and localized mixing action upon said material in said device, and ejecting the material in a continuous stream in said mixed condition.

6. The method of making resistance elements having a progressively varying conductivity in different portions thereof which consists in feeding two substances having different degrees of conductivity, at relatively varying rates, to a mixing device, effecting a progressive and localized mixing action on said material in said device, and continuously ejecting said material through an orifice under pressure to form a compacted pencil.

In testimony whereof I have affixed my signature in the presence of two witnesses.

MELVIN L. SEVERY.

Witnesses:

EDWARD S. CROCKET,

WILLIAM J. SPERL.