May 8, 1928. **1,669,385**

E. L. WIEGAND ET AL

METHOD OF PRODUCING ELECTRICAL HEATING ELEMENTS

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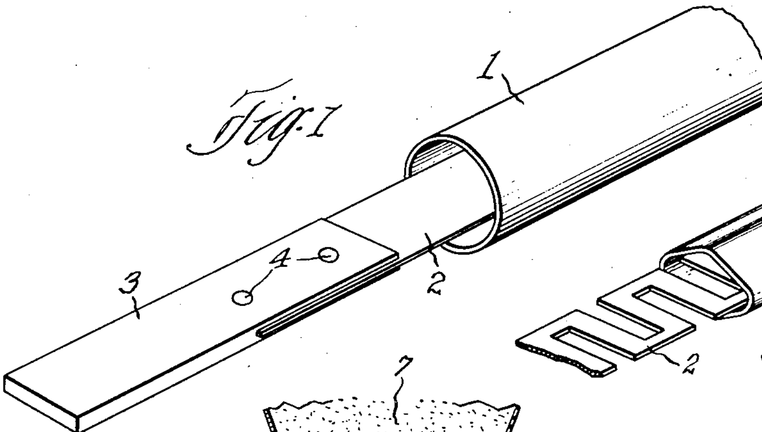

Fig. 1

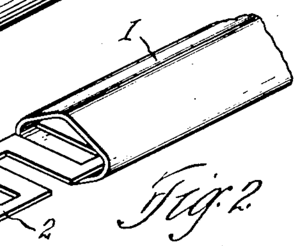

Fig. 2

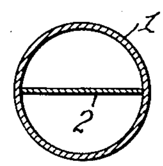

Fig. 3

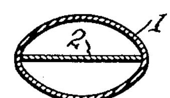

Fig. 4

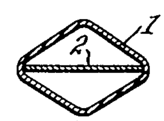

Fig. 5

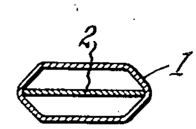

Fig. 6

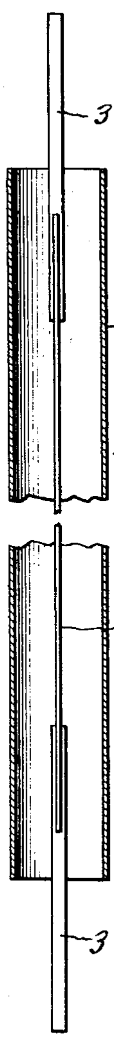

Fig. 7

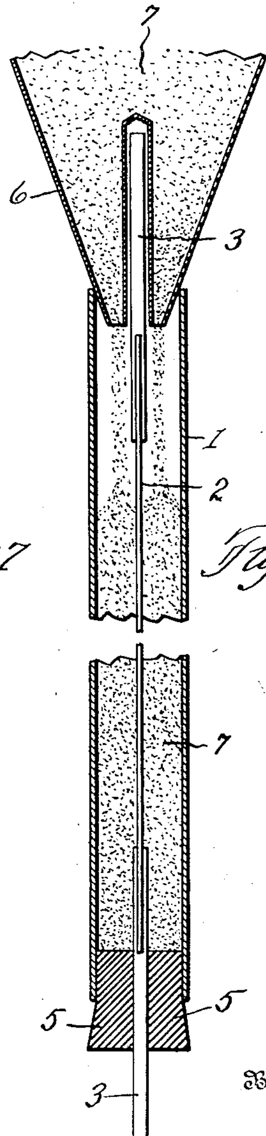

Fig. 8

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Fig. 9

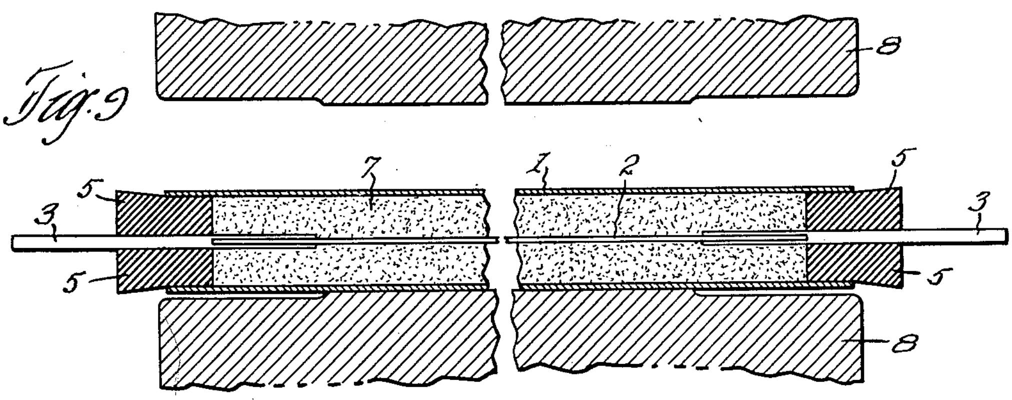


Fig. 10

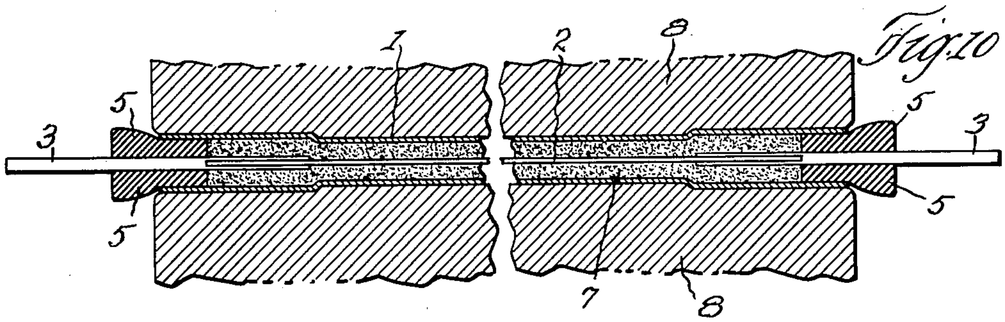
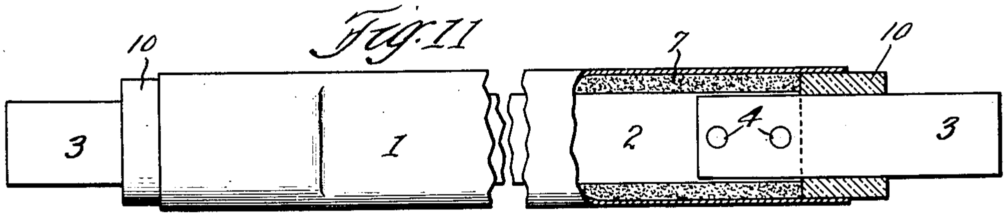


Fig. 11



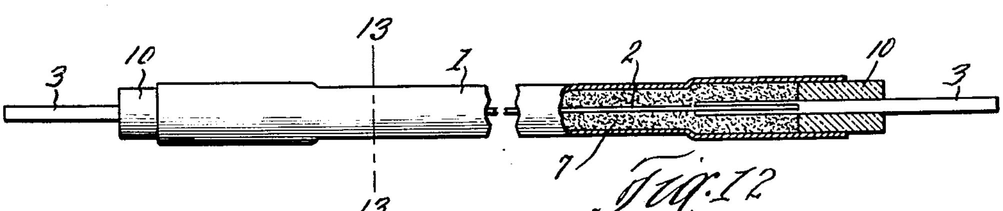


Fig. 12

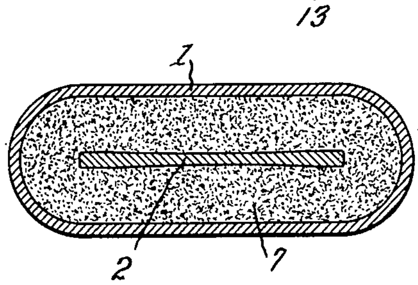


Fig. 13

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METHOD OF PRODUCING ELECTRICAL HEATING ELEMENTS

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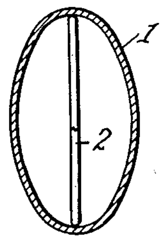

Fig. 14

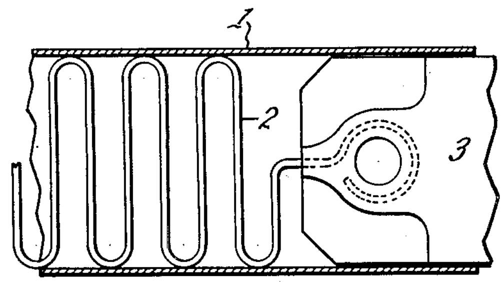

Fig. 15

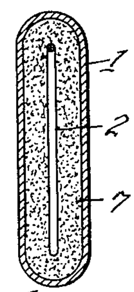

Fig. 16

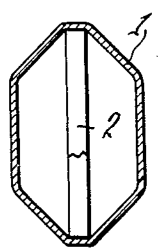

Fig. 17

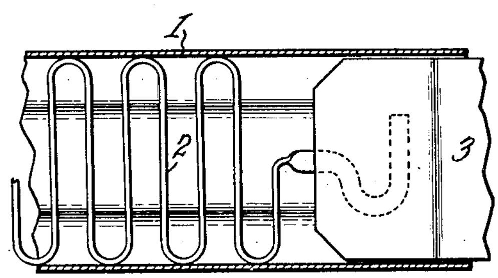

Fig. 18

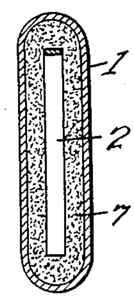

Fig. 19

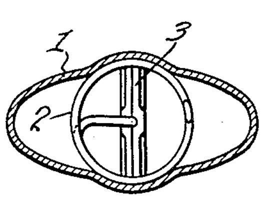

Fig. 20

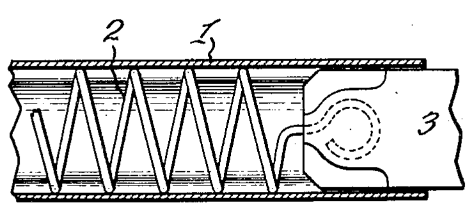

Fig. 21

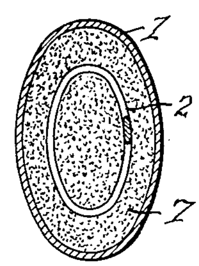

Fig. 22

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Patented May 8, 1928. 1,669,385

UNITED STATES PATENT OFFICE.

EDWIN L. WIEGAND, OF DORMONT BOROUGH, AND ALBERT P. WIEGAND, OF CRAFTON, PENNSYLVANIA, ASSIGNORS TO EDWIN L. WIEGAND COMPANY, OF PITTSBURGH, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

METHOD OF PRODUCING ELECTRICAL HEATING ELEMENTS.

Application filed June 4, 1927. Serial No. 196,456.

This invention pertains to a method of manufacturing electrical heating elements, the same being especially applicable to the production of the so-called tubular heater that consists of an elongated resistor supported within and spaced from the wall of a tubular sheath or casing by a compact mass of granular refractory insulating material.

The fundamental purpose of our invention is to provide a process by which electrical heating elements of the character of that above described and which are of very high quality and efficiency may be expeditiously and cheaply manufactured, and that is peculiarly suited to quantity production in that comparatively few steps are employed and these are of such nature as to be especially convenient of execution.

Broadly, the invention consists in placing a resistor in a suitable sheath or casing and properly locating or supporting it therein temporarily by contact with parts of the sheath; filling the space between the non-contacting parts of the resistor and the sheath with suitable refractory electrical insulating material as by depositing a quantity of such material on opposite sides of the resistor—or, to state it differently, between the opposite sides of the resistor and the opposed walls of the sheath—and compressing the assembly in a direction substantially perpendicular to the plane of the spaced points or regions of contact between the resistor and sheath thereby to thoroughly compact the insulating material and so change the shape of, or flatten, the sheath as to cause it to withdraw from the resistor, leaving the latter completely surrounded by insulating material and thus thoroughly insulated from the sheath and supported solely and effectively by the compact mass of insulating material.

The many advantages accruing from this improved method of manufacture will reveal themselves as this description proceeds, reference being had to the accompanying drawings wherein Fig. 1 is a fragmentary perspective view of a cylindrical sheath and a flat strip resistor in the process of assembly; Fig. 2 is a similar view showing a tubular sheath that is substantially diamond-shaped in cross section and a flat leaf resistor of sinuous formation; Fig. 3 is a cross sectional view of the sheath and resistor of Fig. 1; Fig. 4 is a similar view showing a sheath that is elliptical in cross section; Fig. 5 is a section through the sheath and resistor of Fig. 2; Fig. 6 is a view, similar to Fig. 5, showing a further modification of the sheath; Fig. 7 shows a sheath in longitudinal section with a resistor properly positioned therein by contact of its lateral edges with the opposed walls of the sheath; Fig. 8 is a view, similar to Fig. 7, showing the lower end of the sheath closed by suitable plugs and granular refractory insulating material in the form of loose powder being introduced by suitable means into the upper end of the sheath on opposite sides of the resistor; Fig. 9 is a longitudinal section through the filled sheath, closed at both ends, and disposed between the platens of a suitable press; Fig. 10 is a view, similar to Fig. 9, showing the sheath flattened between the opposed platens of the press and the insulating material compressed; Figs. 11 and 12 are, respectively, a plan view and a side elevation of the completed element, one end of the sheath and the adjacent insulating bushing being shown in section; Fig. 13 is an enlarged transverse section through the element on the line 13—13 of Fig. 12; Fig. 14 is a transverse section, and Fig. 15, a fragmentary longitudinal section, through a sheath enclosing a flat serpentine resistor formed of suitable wire; Fig. 16 is a transverse section through a completed element formed of the parts shown in Figs. 14 and 15; Figs. 17, 18 and 19 are views similar to Figs. 14, 15 and 16, respectively, of an element involving a flat ribbon wire resistor: and Figs. 20, 21 and 22 are further views of like character showing the application of our process to an element incorporating a helical or spiral resistor.

The same reference characters designate corresponding parts throughout the several views, and for the purpose of the present disclosure it may be assumed that the sheath and resistor that are shown in Figs. 7 to 13 inclusive are of the nature of those illustrated in Figs. 1 and 3—that is, the sheath is cylindrical in its initial form and the resistor is in the nature of a flat strip. So far as the process is concerned, it is substantially the same regardless of which form of sheath is used of those illustrated in the drawings, or of what the exact nature of the resistor is, so long as the resistor has a transverse dimension that will cause it to fit reasonably snugly between the opposed walls of the sheath. Obviously sheaths of many cross sectional shapes might be employed in lieu of the ones illustrated, those selected for the purpose of the present disclosure being chosen merely as examples. It may be stated that varying the sectional shape of the sheath is useful in controlling the capacity of insulating material.

The sheath 1 may consist of a piece of tubing, preferably seamless, of any desired length, and of suitable material such as copper, steel, nickel or iron, or alloys of them, and the same may be plated, coated or not, as the circumstances of use dictate. The resistor 2 may be made of any metal that is suitable for the purpose, such as nickel chromium, or nickel-chromium-iron alloy, and, as above stated, the resistor is preferably formed to a width that will cause it to fit relatively snugly between opposed walls of the sheath so that when it is inserted endwise into the sheath it will be supported by frictional contact therewith in a position to provide spaces on its opposed sides. Suitably secured to the ends of the resistor are terminal members 3. In the present instance each of these members consists of a relatively heavy plate that is kerfed at one end for the reception of the end of the resistor, and rivets 4 are inserted through aligned apertures in the interengaged parts. The resistor, with the terminal members attached thereto, is inserted into the sheath far enough to dispose its opposite ends substantially equal distances from the corresponding ends of the sheath, as illustrated in Fig. 7.

Plugs 5 of compressible material are then inserted in one end of the sheath on opposite sides of the adjacent terminal member 3, and, by suitable means, such as a double spout or funnel 6, granular refractory electrical insulating material 7 is introduced into the sheath on opposite sides of the resistor, as in the manner shown in Fig. 8. This insulating material is in the nature of a dry powder, and may consist of zirconium silicate, magnesium oxide or pure fused silica, preferably calcined, and with or without ceramic binding admixtures.

The upper end of the sheath is now closed by suitable means, such as additional plugs 5, so as to confine the granular insulating material within the sheath, and, according to the present disclosure, the filled sheath is next placed between the platens 8 of a suitable high powered press. The press is then operated to advance the platens relatively toward each other so as to flatten the sheath and intensely compress the insulating material, and in practice we have used a pressure of substantially 20 tons per square inch of platen contact area, so that the mass of insulating material is condensed to stone-like solidity. The pressure which can be employed is governed largely by the nature and thickness of the sheathing material, and the pressure is limited, we believe at this time, only by the resistance of the sheath to bursting, and by the extent to which it is permissible to deform the resistor. In placing the assembly between the press platens it is so positioned as to dispose the plane of the resistor substantially normal to the lines of compressive force and as a consequence when the sheath is flattened its opposed walls withdraw from the lateral edges of the resistor and the insulating material is displaced into the space between said edges and said walls.

After the assembly is removed from the press, the plugs 5 are withdrawn and bushings 10 of suitable insulating material are forced into the ends of the sheath about the terminal members 3. These bushings may consist of tightly wrapped sheet mica or the like.

It has been found upon a careful examination of a completed element incorporating a strip resistor like that shown in Figs. 1, 11 and 13 that, due to the great pressure to which the element is subjected, the longitudinal central portion of the resistor is actually compressed to a lesser cross section than the edge portions, as is brought out in the enlarged sectional detail of Fig. 13, and this brings about a very desirable condition in heaters involving a strip resistor, in that it avoids overheating throughout the longitudinal central portion of the element. (This, of course, does not apply to elements having resistors like those shown in Figs. 2 and 14 to 22 inclusive.) Because of the cross sesctional shape of the resistor of the completed device shown in Fig. 13 there is a greater amount of current carried by the edge portions of the resistor than by its central portion, and while this defines zones of greater heat generation along the sides of the element, a large amount of the heat from these zones is dissipated outwardly and some is conducted to the longitudinal center of the element where it joins that emitted from the longitudinal central zone of the resistor, resulting in a substantially uniform output of heat throughout the entire area of the element. With resistors of sinuous or serpentine formation, or where relatively thin sheaths, or sheaths of such material as copper, are employed, pressures sufficiently high to appreciably change the uniform thickness of the resistor, or such as might be liable to rupture the sheath, are avoided. The very high pressure hereinbefore specified is limited to elements where the resistor is in the form of a straight strip, giving exclusive longitudinal current travel, and where the sheath is of high tensile strength, as in the case of steel tubing or chrome alloy tubing.

Electrical connections, through the use of binding posts or other means, may be made with the protruding portions of the terminal members 3; and such portions also provide convenient means for supporting the elements in various installations.

As previously stated, the process remains substantially the same regardless of the cross sectional shape of the sheath, or the formation and exact nature of the resistor and insulating material, the invention being characterized, first, by the manner in which the resistor is initially or temporarily positioned or supported in the sheath; and, secondly, by the reshaping of the sheath so as to cause it to withdraw from the resistor and leave the latter surrounded and supported by the insulating material.

The invention is thus distinguished from the prevailing method of producing tubular heaters which requires that the resistor be initially supported out of contact with the tubular sheath throughout its length and, after the sheath has been filled with granular insulating material that the whole structure be drawn through swaging dies to considerably reduce its cross sectional area thereby to compact the insulating material. Such a process, however, is quite variable in its results and operates well only in the production of elements that are circular in cross section, that is, that are in the nature of round tubes, whereas heating elements having flat faces have applicational virtues not found in those of circular cross section.

In the production of the element that is shown in cross section in Fig. 16, a sheath 1 is used that is, according to Fig. 14, of elliptical cross section, and the resistor 2 is formed of suitable wire that may be either square or circular in cross section, or of any other desired cross-sectional shape, and each of its ends may be attached to a terminal member 3 by forming an eye on such end and engaging it within the kerf of the terminal member and depressing the opposed sides of the terminal member about such eye, as clearly brought out in Fig. 15.

The element illustrated in Fig. 19 is produced from a sheath whose cross sectional shape may be described as an elongated octagon, as shown in Fig. 17, and the resistor 2 is formed of flat ribbon wire that is bent back and forth to effect a substantially flat resistor of sinuous formation whose ends are turned into planes parallel to those of the terminal members and formed with hooks that are clamped between the pressed together opposed sides of the kerfed ends of the terminal members.

The element shown in cross section in Fig. 22 incorporates a resistor of helical form which, in its original shape, is cylindrical and fits between the opposed curved sides of a sheath having the initial cross sectional form shown in Fig. 20; and the ends of the resistor may be secured to the terminal members 3 in substantially the same manner as that described in connection with the element illustrated in Figs. 14 to 16.

Having thus described our invention, what we claim is:

1. The method of producing an electrical heating element which consists in introducing electrical insulating material and a resistor into a sheath so that the resistor is supported by and between opposed parts of the sheath, and reshaping the sheath so as to cause said parts to withdraw from the resistor.

2. The method of producing an electrical heating element which consists in introducing granular refractory electrical insulating material and a resistor into a sheath so that the resistor is supported by and between opposed parts of the sheath, and reshaping the sheath so as to cause said parts to withdraw from the resistor.

3. The method of producing an electrical heating element which consists in introducing refractory electrical insulating material and a resistor into a sheath so that the resistor is supported by and between opposed parts of the sheath, and reshaping the sheath so as to cause said parts to withdraw from the resistor and the insulating material to be distributed about the same.

4. The method of producing an electrical heating element which consists in introducing refractory electrical insulating material and a resistor endwise into a tubular sheath and so that the resistor is supported within the sheath by contact with opposed parts thereof, and reshaping and compressing the sheath so as to cause said opposed parts to withdraw from, and the insulating material to be compacted about, the resistor.

5. The method of producing an electrical heating element which consists in inserting a resistor into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts thereof, introducing granular refractory electrical insulating material into the space between the non-contacting parts of the resistor and the wall of the sheath and reshaping the sheath so as to cause said opposed parts to withdraw from, and the insulating material to be distributed about, the resistor.

6. The method of producing an electrical heating element which consists in inserting a resistor endwise into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts of the sheath, introducing granular refractory electrical insulating material into the space

between the non-contacting parts of the resistor and the wall of the sheath, and reducing the sheath in a direction substantially perpendicular to the plane occupied by the regions of contact between the resistor and sheath thereby to increase the dimension of the sheath at substantially right angles to said direction and cause the aforesaid opposed parts of the sheath to withdraw from, and the insulating material to be distributed about, the resistor.

7. The method of producing an electrical heating element which consists in introducing refractory electrical insulating material and a resistor into a sheath so that the resistor is supported by and between opposed parts of the sheath, and compressing the sheath in a direction substantially normal to the plane occupied by said opposed parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor.

8. The method of producing an electrical heating element which consists in introducing refractory electrical insulating material and a resistor endwise into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts thereof, and compressing the sheath in a direction substantially normal to the plane occupied by said opposed parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor.

9. The method of producing an electrical heating element which consists in inserting a resistor into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts thereof, introducing refractory eletcrical insulating material into the sheath on opposite sides of the resistor, and compressing the sheath in a direction substantially normal to the plane occupied by said opposed parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor.

10. The method of producing electrical heating elements which consists in inserting a resistor endwise into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts thereof, closing one end of the sheath, introducing through the other end thereof granular refractory electrical insulating material on opposite sides of the resistor, closing said other end, and compressing the sheath in a direction substantially normal to the plane occupied by said opposed parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor.

11. The method of producing an electrical heating element which consists in inserting a substantially flat resistor endwise into a tubular sheath so that the resistor is supported within the sheath by contact of its lateral edges with opposed parts of the sheath temporarily closing one end of the sheath, introducing through the other end thereof granular refractory electrical insulating material on opposite sides of the resistor, temporarily closing said other end, compressing the sheath in a direction substantially perpendicular to the plane of the resistor whereby the aforesaid opposed parts of the sheath are caused to withdraw from, and the insulating material is compacted about, the resistor, and inserting insulating bushings within the ends of the sheath.

12. The method of producing an electrical heating element which consists in introducing a resistor endwise into a tubular sheath so that the resistor is supported within the sheath by contact with opposed parts thereof, closing one end of the sheath by suitable means, introducing through the other end thereof graular refractory electrical insulating material on opposite sides of the resistor, closing said other end by suitable means, compressing the sheath in a direction substantially normal to the plane occupied by the aforesaid opposed parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor, removing the aforesaid closing means from the ends of the sheath, and inserting insulating bushings within said ends.

13. The method of producing an electrical heating element which consists in forming a sheath with opposed resistor supporting and positioning parts, inserting into the sheath a resistor with its opposed sides supported by said parts, filling the space left within the sheath with refractory electrical insulating material, and compressing the sheath in a direction substantially perpendicular to the plane occupied by the aforesaid resistor supporting and positoning parts whereby said parts are caused to withdraw from, and the insulating material is compacted about, the resistor.

14. The method of producing an electrical heating element which consists in forming a tubular sheath with opposed resistor supporting and positioning parts, inserting into the sheath a substantially flat resistor with its lateral edges supported by said parts, filling the space on opposite sides of the resistor with refractory electrical insulating material, and compressing the sheath in a direction substantially perpendicular to the plane of the resistor thereby to cause said parts to withdraw from, and the insulating material to be compacted about, the resistor.

15. The method of producing an electrical heating element which consists in forming a tubular sheet metal sheath into a shape defining opposed resistor supporting and positioning parts, inserting into the sheath a

substantially flat resistor with its lateral edges supported by said parts, temporarily closing one end of the sheath, introducing through the other end thereof granular refractory electrical insulating material on opposite sides of the resistor, temporarily closing said other end, compressing the sheath in a direction substantially perpendicular to the plane of the resistor thereby to cause the aforesaid parts to withdraw from, and the insulating material to be compacted about, the resistor, and inserting insulating bushings in the ends of the sheath.

16. The method of producing an electrical heating element which consists in forming a tubular sheet metal sheath into a shape defining opposed resistor supporting and positioning parts, inserting into the sheath a resistor with opposed parts thereof supported by the aforesaid parts of the sheath, temporarily closing one end of the sheath, introducing through the other end thereof granular refractory electrical insulating material, temporarily closing said other end, reshaping the sheath to cause the aforesaid parts thereof to withdraw from, and the insulating material to be distributed about, the resistor, and inserting insulating bushings in the ends of the sheath.

In testimony whereof, we hereunto affix our signatures.

EDWIN L. WIEGAND.
ALBERT P. WIEGAND.