June 29, 1943. E. L. WIEGAND 2,322,988

ELECTRIC HEATING

Filed Feb. 6, 1941

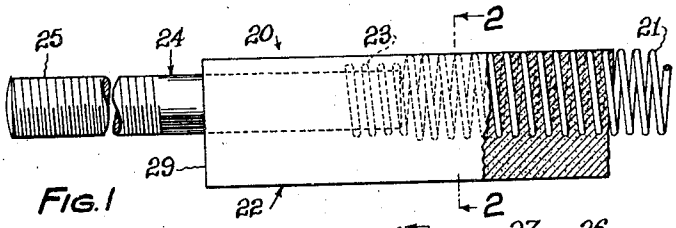


FIG. 1

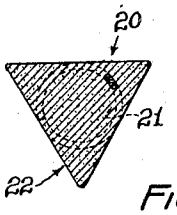


FIG. 2

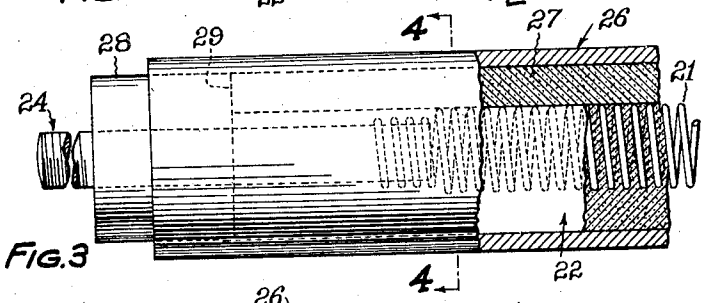


FIG. 3

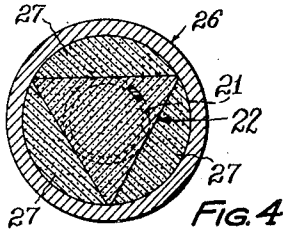


FIG. 4

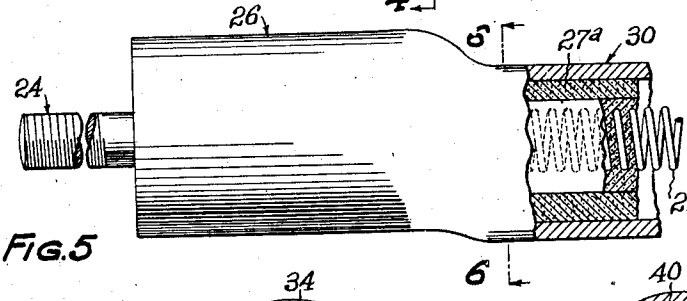


FIG. 5

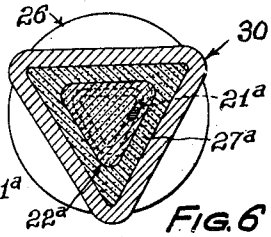


FIG. 6

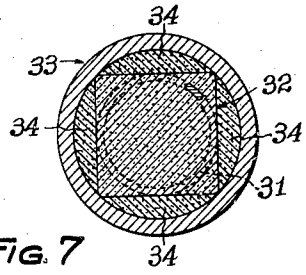


FIG. 7

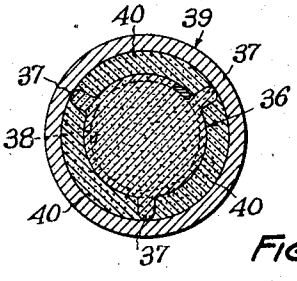


FIG. 9

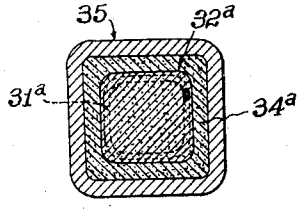


FIG. 8

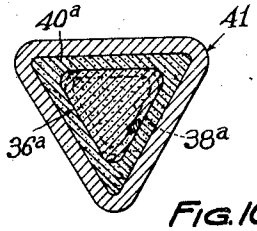


FIG. 10

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ELECTRIC HEATING

Edwin L. Wiegand, Pittsburgh, Pa.

Application February 6, 1941, Serial No. 377,625

15 Claims. (Cl. 201—67)

This invention relates to electric resistance heating, and the principal object of the invention is to provide new and improved electric heating elements and new and improved methods of making the same.

In the drawing accompanying this specification and forming a part of this application, I have shown for purposes of illustration, several forms which my invention may assume, and in the drawing:

Figures 1, 3, and 5 are fragmentary side views, partly in longitudinal section, illustrating steps in the method of producing an electric heating element in accordance with my invention, Figures 2, 4, and 6 being cross-sections taken on correspondingly numbered lines of Figures 1, 3, and 5 respectively.

Figures 7 and 8 are cross-sectional views illustrating steps in the method of producing another embodiment of an electric heating element in accordance with my invention, and

Figures 9 and 10 are cross-sectional views illustrating steps in the method of producing still another embodiment of an electric heating element in accordance with my invention.

Referring first to Figures 1 and 2, in carrying out my method I first provide an assembly 20 comprising a resistor 21 of any desired suitable form and a body of insulating material 22 of any desired suitable form. In this instance the resistor 21 is in the form of a helix of resistance wire and the body of insulating material 22 is in the form of a triangular prism. In cross-sectional aspect the outline of the helical resistor 21 is inscribed in the triangular cross-sectional outline of the prism as shown, but the diameter of the helix may be greater or less than shown. Permanently mechanically and electrically connected to an end portion 23 of the resistor is a terminal 24 of any suitable form, here shown as a round metal rod coaxial with the resistor 21, the rod having threads 25 if desired. The body of insulating material 22 is desirably longitudinally coextensive not only with the resistor 21 but also with a portion of the terminal 24. It will be understood that the other end of the assembly 20 may be constructed similarly to the end shown in Figure 1, so that it comprises a terminal for the other end of the resistor 21, which terminal may be similar to the terminal 24.

The assembly 20 may be produced by disposing the resistor 21, with the terminals attached thereto, in a mold (not shown) providing a cavity of triangular cross-sectional outline and introducing into the mold electrical-insulating heat-conducting material comprising any desired suitable granular, comminuted, or powdered refractory material, mixed with any desired suitable bonding material. For the sake of brevity, the single term comminuted will be used hereinafter as referring to granular, comminuted, or powdered. If desired, the material comprising the body 22 may be compacted to a desired extent in any suitable way. The consistency and state of the material comprising the body 22 is such that the body when removed from the mold is in self-sustaining condition, and of course the entire assembly is in self-sustaining condition.

The material of the body 22 usually contains a certain amount of moisture and accordingly the assembly 20 desirably is dried, but preferably it is not baked. The drying step leaves the body 22 in a friable condition.

The assembly 20 is then inserted endwise into a tubular sheath 26. The body 22 is so constructed that it is readily slidable into the sheath and preferably so that the peripheral portions or corners of the prism by engagement with the inside surface of the sheath position the assembly within the sheath, the resistor being thus centrally located. The sheath 26 may be of any desired length and ordinarily the body of insulating material 22 will be of somewhat less length than the sheath, so that the ends of the body may be spaced from the respective ends of the sheath, but this is not essential. The length of the terminals 24 is such that when the assembly 20 is disposed in the desired position in the sheath 26, the terminals will project a desired distance beyond the respective ends of the sheath.

The body 22 and the inside surface of the sheath 26 have cross-sectional outlines which are non-complementary, the sheath in this instance being of circular cross-section, and into space between the body and the inside surface of the sheath I introduce additional insulating material 27 which may be the same kind of material as that constituting the body 22. However, preferably the additional material 27 is a kind different from that comprising the body 22, and preferably the electrical properties, and particularly the electrical insulating properties, of the additional material are better than those of the body. The latter condition may be attained, by way of example, by making the body 22 of a desired comminuted insulating material mixed with a desired bonding material, the additional material 27 being a desired unbonded com-

minuted insulating material which preferably is introduced into space between the body 22 and the sheath in a dry condition. It will be understood that the usual bonding materials such as clay, for example, may affect properties of a mass of insulating material. By the omission of such a bonding material, any effect it might have on the electrical-insulating, heat-conducting, or other properties of the additional material 27 will of course be eliminated.

In the process of introducing the additional material 27 into space between the body 22 and the sheath 26, the escape of this material from the end of the sheath opposite from the end of introduction may be prevented in any desired way, for example by a centrally apertured plug 28 passed over the terminal 24 and inserted into the end of the sheath 26 so that the end 29 of the body 22 and the end of the plug 28 abut each other.

If desired the material 27 may be compacted by vibration or in any other desired suitable way. The plug 28, if used, may be removed and any suitable insulating material may be introduced into the space left by the plug. The article in the forms hereinbefore described is utilizable as an electric heating element, and it and the method of producing it have advantages, but by a further step, now to be described, a great further improvement is attained.

After the article has been brought to the state shown in Figures 3 and 4, a desired portion of it is preferably placed in a generally V-shaped groove of a die (not shown) the sheath being so positioned in the groove that the sides of the groove are respectively substantially parallel to the two lower sides of the body 22, as viewed in Figure 4. Another die (not shown) which may have a flat face parallel to the upper side of the body 22, is then brought down on the upper part of the sheath, so that when the dies are brought together the sheath will have a portion 30 of triangular cross-sectional outline as shown in Figure 6. One of the results is that the insulating material within the sheath is redistributed and greatly densified and the resistor 21 is reformed so that its cross-sectional aspect 21*a* is generally triangular, the outline of the resistor being substantially similar to and substantially uniformly spaced from the outline of the inside surface of the sheath portion 30, the apexes of the triangle defined by the resistor being somewhat more rounded. Furthermore, the cross-sectional area of the body 22 has been reduced so that the material of the body (as will more fully appear) is in a core 22*a* the sides of the cross-sectional outline of which are substantially uniformly spaced from the respectively adjacent sides of the inside surface of the sheath portion 30. The resistor 21*a* is substantially uniformly embedded in the core 22*a*. Furthermore, the core 22*a* is surrounded by a layer or coating 27*a* which is of approximately uniform thickness. Except as may be the case as hereinafter noted, the coating 27*a* consists of the insulating material 27. The apexes of the section of the core 22*a* are not necessarily well defined as shown in Figure 6, because there is a little tendency for the more or less sharp edges of the body 22 to be crushed and intermingled with the material 27, the sharpness of definition of the apexes of the section of the resulting core 22*a* being thereby lost. Nevertheless, even in such case, the amount of contact there may be between the inside of the sheath and any bonded material, or the amount of bonded material there may be in the apex portions of the coating 27*a*, is so small that from a practical standpoint the coating 27*a* may be regarded as in effect a substantially uniformly insulating coating of unbonded material. The foregoing applies also to other embodiments of the invention hereinafter described and accordingly is not there repeated.

It will be evident that if (as is the case in the preferred form) the insulating coating 27*a* is unbonded material, or, in general, is of better insulating value than the core 22*a*, the resistor 21*a* will be better insulated from the sheath 26.

It will be understood that only a high temperature zone of the heating element is formed in the triangular section shown in Figure 6. The terminal zone, being a low temperature zone, need not be so formed and preferably is not so formed. In general, any low temperature zone need not be so formed. Such a low temperature zone may exist where a considerable length of an end portion of the heating element contains only a small amount of resistor per unit of length, the central portion of the element being the active or high temperature portion.

It has been hereinbefore assumed that the longitudinal axis of the heating element is rectilinear but it will be evident that after the article has been brought to the form shown in Figures 3 and 4 it may be bent to spiral form, for example, and then the spiral portion formed to triangular cross-section, the end portions of the element being of desired suitable length so that they may be bent out of the plane of the spiral and so that the end portions extend to a desired location. Accordingly, the end portions in such case are preferably of circular section or any section which is readily bendable. The finished element may, of course, have an active portion the longitudinal axis of which is of non-rectilinear form other than spiral.

As shown in Figures 5 and 6 the element has an active portion 30 the flat sides of the cross-sectional outline of which define an equi-angular triangle, and these flat sides being equi-lateral, but the flat sides may define an equi-angular triangle without the sides being equilateral, or any other desired suitable generally triangular form may be adopted, if a triangular form is desired, depending upon the use to which the element is to be put. In general, in an element triangularly formed, even if the angles of the defined triangles are not all 60°, there is a minimum of undesirable flowing or displacement of the insulating material, so that there is a minimum of displacement of the resistor from a symmetrical and uniform position with respect to the triangular outline of the inside surface of the sheath.

Referring now to Figure 7 there is here shown a section of another embodiment, the section corresponding to the section shown in Figure 4, but in this instance there is an assembly which, while it is of the same type of construction as the assembly 20, comprises a body of insulating material the cross-sectional outline of which is generally square instead of triangular. As here shown the assembly comprises a helical resistor 31 which in cross-sectional aspect is inscribed in the generally square cross-sectional outline of a body of insulating material 32. The body 32 is constructed so that it may be slipped endwise into a sheath 33 here shown as of circular cross-section, the corners of the body positioning the assembly within the sheath, so that the resistor 31

is centrally located. As in the case of Figures 3 and 4, additional insulating material **34** is introduced into space between the body **32** and the inside surface of the sheath **33**, and compacted if desired. Thereafter a desired longitudinal portion of the article shown in cross-section in Figure 7 may be side-pressed in suitable die means to bring it to the square cross-sectional form **35** shown in Figure 8. Analogously to the results described in connection with Figure 6, the insulating material within the sheath **33** is redistributed and densified and the resistor **31** is reformed so that its cross-sectional aspect **31***a* is generally square, the outline of the resistor being substantially similar to and substantially uniformly spaced from the outline of the inside surface of the sheath portion **35**. Furthermore, the insulating material **34** now constitutes a continuous and substantially uniform coating **34***a* about the re-formed body **32***a* which is a core the cross-sectional outline of which is substantially similar to and substantially uniformly spaced from the outline of the inside surface of the sheath portion **35**. The resistor **31***a* is substantially uniformly embedded in the core **32***a*, to a somewhat less extent than is the case of the resistor **21***a* with respect to the core **22***a*. Also, the coating **34***a* is somewhat thinner than the coating **27***a*.

Referring to Figure 9 there is here shown a section of still another embodiment, this section corresponding to the section shown in Figure 4, but in this instance there is an assembly which, while it is of the same type of construction as the assembly **20**, comprises a body of insulating material **36** the cross-sectional outline of which is generally circular provided with a plurality of spaced peripheral portions **37**, in this instance three in number. The portions **37** may be somewhat like fins extending longitudinally of the generally cylindrical part of the body **36**, or in the form of radially extending projections of any desired kind. As here shown the assembly comprises a helical resistor **38** which in cross-sectional aspect is inscribed in the circular part of the outline of the body of insulating material **36**. However, the diameter of the helix may if desired be larger or smaller. The body **36** is constructed so that it may be slipped endwise into a sheath **39** here shown as of circular cross-section, the peripheral portions **37** of the body positioning the assembly within the sheath, so that the resistor **38** is centrally located. As in the case of Figures 3 and 4, additional insulating material **40** is introduced into space between the body **36** and the inside surface of the sheath **39**, and compacted if desired. Thereafter, a desired longitudinal portion of the article shown in cross-section in Figure 9 may be side-pressed in suitable die means to bring it to the triangular cross-sectional form **41** shown in Figure 10. The results are similar to those already described in connection with Figure 6. The principal differences are that in Figure 10 the re-formed resistor **38***a* is embedded less deeply in the re-formed body **36***a*, and the coating **40***a* formed by the material **40**, while also of substantially uniform thickness, is thinner than the coating **27***a* formed by the material **27** in Figure 6.

In general, a thinner coating is desirable because heat is more rapidly transmitted from the resistor to the sheath. Of course the coating must be thick enough to provide the desired insulation between the resistor and the sheath.

My invention may be applied in the manufacture of heating elements of the type used in electric ranges, the circular section sheath used to make this type of element being approximately $\frac{5}{16}$ to $\frac{1}{2}$ of an inch outside diameter and having a wall thickness of approximately .030 of an inch. However, my invention is not limited to any particular dimensions.

I prefer to side-press or press-forge the heating element to its final cross-sectional form because this method of deforming or re-forming the sheath has many advantages, but other suitable methods may be used.

The particular geometrical figure to be used as the cross-sectional outline of the core depends upon and varies with the perimeter of the sheath used and the thickness of the insulating coating desired around the resistor in the ultimate product. The triangle gives the heaviest insulating coating around the resistor for a relatively small internal diameter sheath, and as the perimeter of the sheath increases, the square figure gives a better proportion, and as the perimeter of the sheath increases still further, a pentagonal or hexagonal figure may be employed. In any instance the sides of the sheath need not be flat or plane pressed but may be cambered or hollowed to secure any desired relationship between the resistor coil diameter and the insulating coating around the resistor.

It will be evident that the sheath, on the one hand, and the assembly comprising a resistor and body of insulating material, on the other hand, may be of other desired and suitable initial and final cross-sectional forms; that the sheath may be made of metal or metal alloy, for example, nickel, nickel chrome, "inconel," etc., capable of withstanding elevated temperatures, or of any material capable of withstanding whatever temperature of operation may be selected; that the resistor may be of any desired suitable composition, and of any desired suitable form; and that the refractory insulating material may be, or may include, for example, silica, or silicates, or magnesium oxide, or aluminum oxide, or any other suitable refractory material desirably of a mineral character; and that the refractory material occupying a selected part or selected parts of the sheath may be a mixture of a selected refractory material with a bonding or cementing material, or a mixture with clay, or any other suitable binder.

From the foregoing it will be apparent to those skilled in the art that each of the illustrated embodiments of my invention provides new and improved electric heating elements and new and improved ways of producing them, and accordingly, the principal object of my invention is accomplished. On the other hand, it also will be obvious to those skilled in the art that the described and illustrated methods and heating elements may be variously changed and modified, or features thereof, singly or collectively, embodied in other methods or embodiments than those described and illustrated, without departing from the spirit of my invention, or sacrificing all of the advantages thereof, and that accordingly, the disclosure herein is illustrative only, and my invention is not limited thereto.

I claim:

1. A tubular electric heating element, comprising: a tubular sheath; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and

unbonded comminuted refractory electrical-insulating material disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said resistor section.

2. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced peripheral portions of said body with the inside surface of said sheath; and filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body.

3. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material molded to and coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced peripheral portions of said body with the inside surface of said sheath; and filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body.

4. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced peripheral portions of said body with the inside surface of said sheath; filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body; and re-forming said sheath over at least a part of said longitudinal extent of said resistor means by so changing the cross-sectional shape of said sheath that at said re-formed portion said heat-conducting material is re-distributed to form a circumferentially substantially continuous coating about said assembly where said heat-conducting material was previously discontinuous circumferentially by reason of said spaced peripheral portions.

5. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced peripheral portions of said body with the inside surface of said sheath; filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body; and re-forming said sheath over at least a part of said longitudinal extent of said resistor means by changing the cross-sectional shape of said sheath by pressing said sheath inwardly locally at places circumferentially between said spaced peripheral portions.

6. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath of substantially circular cross-section a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material having a cross-sectional outline in effect polygonal, said body being coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced apex portions of said body with the inside surface of said sheath; filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body; and re-forming said sheath over at least a part of said longitudinal extent of said resistor means by changing the cross-sectional shape of said sheath by pressing said sheath inwardly locally at places circumferentially between said spaced apex portions.

7. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath of substantially circular cross-section a self-sustaining assembly comprising resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material having a cross-sectional outline in effect polygonal, said body being coextensive with the longitudinal extent of said high temperature portion of said resistor means, said resistor means being positioned in said sheath by said body by engagement of circumferentially spaced apex portions of said body with the inside surface of said sheath; filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body; and re-forming said sheath over at least a part of said longitudinal extent of said resistor means to reduce the inside cross-sectional area of said sheath by pressing said sheath inwardly locally at places circumferentially between said spaced apex portions so as to re-shape said sheath to a generally polygonal cross-sectional inside outline spaced from and substantially symmetrical with the generally polygonal cross-sectional outline defined by said body as reduced by said re-forming.

8. The method of producing a tubular electric heating element, which comprises: disposing in a tubular metallic sheath a self-sustaining assembly comprising resistor means having terminal studs connected thereto, said resistor means having its high temperature portion extending longitudinally of said sheath and being supported by a unitary body of electrical-insulating refractory material coextensive with the longitudinal extent of said high temperature portion of said resistor means, said body also extending over and embedding the connections between said resistor

means and said terminal studs, said assembly being positioned in said sheath by engagement of spaced peripheral portions of said body with the inside surface of said sheath; and filling with heat-conducting electrical-insulating refractory material at least the space within said sheath around said coextensive part of said body and said sheath.

9. A tubular electric heating element, comprising: a tubular sheath; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and a layer of unbonded comminuted refractory electrical-insulating material of substantially uniform thickness disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said resistor section.

10. A tubular electric heating element, comprising: a tubular sheath the inner surface of which is generally polygonal; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and unbonded comminuted refractory electrical-insulating material disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said resistor section.

11. A tubular electric heating element, comprising: a tubular sheath the inner surface of which is generally polygonal; a correspondingly generally polygonal core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and a layer of unbonded comminuted refractory electrical-insulating material of approximately uniform thickness disposed between said core and tne inner surface of said sheath approximately throughout the circumferential extent of said resistor section.

12. A tubular electric heating element, comprising: a tubular sheath; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and unbonded comminuted refractory electrical-insulating material disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said core.

13. A tubular electric heating element, comprising: a tubular sheath; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and a layer of unbonded comminuted refractory electrical-insulating material of approximately uniform thickness disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said core.

14. A tubular electric heating element, comprising: a tubular sheath the inner surface of which is generally polygonal; a core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and unbonded comminuted refractory electrical-insulating material disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said core.

15. A tubular electric heating element, comprising: a tubular sheath the inner surface of which is generally polygonal; a correspondingly generally polygonal core of bonded comminuted refractory electrical-insulating material disposed within said sheath; a section of resistor extending longitudinally of said core at least partially submerged in the material of said core; and a layer of unbonded comminuted refractory electrical-insulating material of approximately uniform thickness disposed between said core and the inner surface of said sheath approximately throughout the circumferential extent of said core.

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