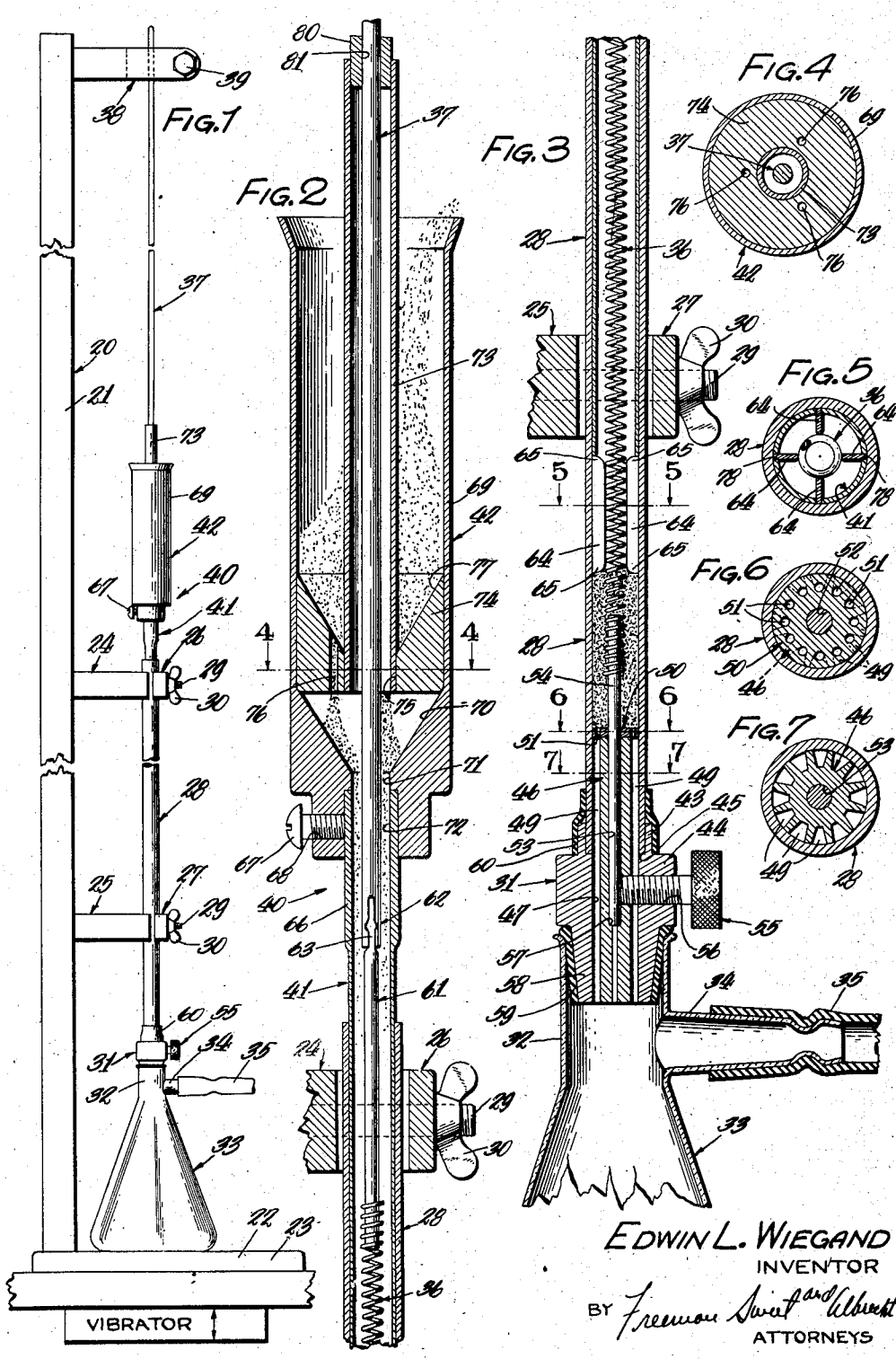
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MANUFACTURE OF ELECTRIC HEATERS

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MANUFACTURE OF ELECTRIC HEATERS

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My invention relates to the manufacture of electric heaters, and more particularly to the manufacture of electrical heating elements comprising a resistor disposed within and insulated from a tubular metallic sheath. The principal object of my invention is the provision of new and improved methods of producing such electric heaters and the provision of new and improved apparatus for carrying out such methods.

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

Figure 1 is a broken side elevation of apparatus embodying my invention with which is assembled a sheath to be filled,

Figure 2 is a vertical sectional fragmentary view, enlarged, of an upper portion of the assembly shown in Figure 1,

Figure 3 is a vertical sectional fragmentary view, enlarged, of a lower portion of the assembly shown in Figure 1,

Figure 4 is a section taken on the line 4—4 of Figure 2, and

Figures 5, 6, and 7 are enlarged sectional views taken on the lines 5—5, 6—6, and 7—7 respectively, of Figure 3.

Referring to Figure 1, there is here shown apparatus embodying my invention, comprising a supporting means 20 which includes a vertical standard 21 mounted on a base 22. The base 22 may be fastened to table 23 with which may be associated a vibrator indicated by the legend. Secured to the vertical standard 21 in any suitable way are arms 24, 25 which may include or serve to support V-clamps 26, 27 adapted to rigidly clamp and hold in an approximately vertical position a metallic tube or sheath 28. The tubular sheath 28 may be of any sectional area, size, or shape, so long as it is adapted to end-filling with comminuted insulating material. In the illustrated embodiment it is shown as of circular cross-sectional shape. The parts of each V-clamp 26, 27 are adapted to be drawn together by means of screw bolts 29 and cooperating wing nuts 30. Plug means 31 has its upper end disposed in the opening at the lower end of the sheath 28 and the lower end of the plug means 31 may be disposed in the neck 32 of a reservoir or flask 33, the reservoir having a nipple 34 connectable to a conduit 35 which is desirably reinforced and flexible, and connected through any suitable valve means to any suitable vacuum pump (not shown), all for purposes hereinafter to be described. As will hereinafter more fully appear, a resistor 36 is disposed within the sheath 28 and is held at one terminal end by the plug means 31 and at the other terminal end by an anchor rod 37, the anchor rod being tightly adjustably held in a suitable clamp 38 tightenable by a nut 39, the clamp 38 being in turn secured to the vertical standard 21. Means 40 for introducing comminuted electrical-insulating material into the sheath 28 is provided, this means, in this instance, including what may be termed a filler tube or a lead tube 41 insertable in the sheath 28, the lead tube 41 carrying at its upper end funnel means 42 from which comminuted insulating material may flow into the lead tube 41.

In Figure 2 is shown the upper portion of the sheath 28 and parts of the apparatus associated therewith, and in Figure 3 is shown the lower portion of the sheath 28 and parts of the apparatus associated therewith. Referring first to Figure 3 the lower end of the sheath 28 is disposed within a collar 43 extending upwardly from the body 44 of the plug means 31, the lower end of the sheath 28 abutting the shoulder 45 at the bottom of the collar 43. The plug means 31 includes means for preventing comminuted insulating-material from being discharged from the lower end of the sheath 28 while at the same time permitting discharge of air through this means. In the illustrated instance this means comprises a plug member 46 the lower end of which fits and is fastened in a central cylindrical hole 47 through the body 44 of the plug means, the hole 47 being of the same diameter and registering with the opening at the lower end of the sheath 28. The plug member 46 is provided with a plurality of longitudinally extending air passages 49, desirably equally circumferentially spaced. The plug member 46 is conveniently made of pinion rod so that the teeth provide the plurality of circumferentially spaced longitudinally extending passages 49. It is of course evident that the outer peripheral surface of the plug member 46 fits slidably into the inside surface of the sheath 28. The upper end of the plug member 46 has fastened thereto what may be termed a filter disc 50 provided with a plurality of circumferentially equally spaced small holes 51 of the same number as the passages 49. The disc 50 slidably fits the inside surface of the sheath 28 and is fastened to the upper end of the plug member 46, so that the holes 51 register with, in this instance, the radially inner end portions of the passages 49. The disc 50 is provided with a central aperture 52 registering with and of the same size as a cen-

tral hole 53 in the plug member 46. The resistor 36 has a terminal member 54 permanently secured to its lower end and this terminal member may be inserted into the holes 52, 53 and securely held in the plug member 46 by means of a set screw 55 cooperating with a threaded aperture 56 in the body 44 of the plug means 31. The extent to which the terminal 54 may be inserted in the plug member 46 is limited by reason of a shoulder 57. Accordingly, the distance which the end of the terminal 54 extends below the lower end of the sheath 28 is gauged.

The lower end 58 of the body 44 of the plug means is of conical form and adapted to make air-tight connection with the neck 32 of the reservoir 33 which if desired may be made of glass or other transparent material, but this is not essential. If necessary or desirable the conical end 58 of the body may be provided with a rubber bushing 59, to insure that the joint between the plug means and the neck of the reservoir is air-tight. A rubber collar 60 overlapping the lower end of the sheath 28 and the upwardly extending collar 43 on the plug means may also be provided to insure an air-tight joint at this point and if necessary or desirable to keep the end of the sheath assembled with the collar under certain conditions of operation.

The upper end of the resistor 36 has permanently fastened thereto a terminal member 61 which is temporarily secured to and coaxial with the anchor rod 37 in any suitable way as by a clamping means 62 formed at the end of the anchor rod 37, this clamping means being here shown as cooperating with a reduced end 63 of the terminal member 61. The adjustment of the anchor rod 37 is such that a desired amount of tension is placed on the resistor 36 so that it is centrally located with respect to the inside surface of the sheath 28.

The lead tube 41 is of such outside diameter that it fits closely but slidably within the inside surface of the sheath 28, and is made of such length that when the sheath has no insulating-material therein the lower end of the lead tube will reach at least to about the lower end of the resistor 36 or, if desired, down to the disc 50. The lower end of the lead tube is provided with a plurality of longitudinal fins 64, in this instance four, which are circumferentially spaced on the inside surface of the lead tube and extend radially inward, as may be seen in Figures 3 and 5. The tube 41 may be provided with slots 78 into which the fins 64 are fitted and fastened as by brazing or otherwise. The fins 64 extend radially inwardly sufficiently to engage peripheral surfaces of the resistor 36 at circumferentially spaced points. The fins 64 are desirably very thin so that the amount of contact is not much more than point or line contact so that the fins readily slide along the circumferentially spaced points of the peripheral surface of the resistor with a minimum of friction as the lead tube moves with respect to the resistor 36. The longitudinal ends 65 of the fins have the marginal corners relieved, in this instance by rounding off these corners, as may be seen in Figure 3. This insures that the fins 64 will not hook into convolutions of the resistor 36, if the resistor is helical or the like, and otherwise promotes sliding movement of the fins with respect to the resistor. Furthermore, the lower rounded ends 65 may promote better compacting of the comminuted insulating-material within the resistor, if the resistor is in the form of a helix, and if the lead tube is used to compact the material, but this is not essential.

The wall of the lead tube 41 being very thin, the upper end thereof has a portion 66 of larger outside diameter so as to provide a thickened wall which may be held by a set screw 67 in a threaded hole 68 in the lower end of the funnel means 42. The funnel means 42 has a cylindrical wall 69 the inside of which merges with a conical bottom 70 having a central outlet hole 71 in registry with the bore 72 of the lead tube 41. The funnel means 42 may include means for controlling the flow of comminuted insulating material into the conical portion 70, this means being here shown as comprising a tube 73 (freely surrounding the anchor rod 37), and a member 74 having a central aperture 75 in which the lower end of the tube 73 fits and is fastened, the member 74 being provided with a plurality of holes 76, in this instance three, extending through the member 74. The member 74 fits slidably in the cylindrical portion 69, and is provided with a conical recess 77, the holes 76 being desirably provided near the bottom of this recess. The holes 76 serve not only to control and limit the flow of the material but to provide a desired even distribution into the outlet 71. A bushing 80 fitting in and suitably held in the tube 73 may be provided, this bushing having a central bore 81 fitting slidably about the anchor rod 37. The bushing 80 serves to concentrate on the lower ends of the holes 76 a vacuum existing below the member 74.

The comminuted insulating material may be put into the cylindrical portion 69 of the funnel means 42 at one time or it may be fed progressively into the portion 69, and as soon as it falls in it starts to go through the holes 76 and at this time a vacuum should be established in the reservoir 33. It may be noted that there is only a relatively small amount of comminuted material in the space above the bottom 70 and this material is flowing downwardly in a fine stream or streams. The provision of a vacuum not only causes the comminuted material to flow through the holes 76 more rapidly but causes it to flow through these holes under feed conditions which, without a vacuum, might cause these holes to become clogged. For best results, in general, the comminuted material is preferably dry and hot.

Comminuted material fed into the sheath 28 by the feeding means 40 falls to the lower end of the sheath and is stopped by the screen disc 50. Very little of the material will pass through the very small holes 51 in the screen disc 50, because the material will quickly bridge the entrance to each hole 51 and constitute in effect a fine screen. As the comminuted material is progressively fed from the holes 76 through the lead tube 41 into the sheath, the material will accumulate at the lower end of the sheath, and the level of the accumulated material will gradually rise, and at the same time, by reason of the vacuum in the reservoir 33, air is being constantly drawn down through the sheath, through the accumulated comminuted material, through the screen member 50, through the passages 49 into the reservoir 33 from which this excess air may be continuously exhausted by the vacuum pump.

The foregoing is one way in which I may fill the sheath 28 with comminuted insulating material, and in this aspect of my invention the lead tube 41 may be entirely omitted and the funnel means 42 may discharge directly into the sheath

28, or both the lead tube 41 and the particular funnel means 42 may be omitted, and, in general, comminuted insulating material may be fed into the sheath by any other suitable means or in any other suitable way.

If desired, the sheath 28 may be tapped, to vibrate it, while comminuted material is being introduced, or the base 22 may be vibrated so as to vibrate the entire apparatus, in any desired suitable way.

By reason of the provision of the vacuum at the lower end of the sheath, the air displaced by the incoming comminuted material is removed downwardly, thus preventing the causing of upward air currents against the direction of movement of the comminuted material.

Such upward air currents, which are present without my invention, cause several difficulties which my invention removes. Upward air currents in the sheath 28 are objectionable because an upwardly moving air column tends to have a separatory effect on the fine and coarse particles of insulating material comprised in an aggregate which under prior practice included particles varying from —40 mesh to —200 mesh. My invention obviates this objection even when finer material is used as will appear. Furthermore, the upward air currents, present without my invention, may be in the nature of air bubbles which rise first at one side of the bore of the sheath and then at another side, or the uprising air may be otherwise non-uniformly and varyingly distributed over the cross-section of the bore of the sheath, thereby causing an irregular distribution of the insulating material, so that the filling is not uniformly dense around the resistor 36.

Besides obviating the difficulties and disadvantages caused by upwardly moving air currents, my invention, by eliminating these upward air currents and causing instead a down-draft within the sheath, results in further advantages.

For example, more uniform density and greater density of the filling is obtained because the smaller particles tend to be sucked into the voids between the larger particles.

Also, assuming that the resistor 36 is in the form of a helical coil, the inside of the coil is caused to fill up more completely and uniformly due to the down-draft and suction, particles being drawn into the inside of the coil through the adjacent convolutions thereof.

Furthermore, my method enables the use of more finely ground insulating material. For example, I may use comminuted material of —60 mesh, and this material may include all fines normally produced by grinding mineral material of the type useful for electric heater purposes, including even the fines of —400 mesh. Fines of a size smaller than 400 mesh may be removed, under some circumstances, but this is not in general essential. More finely ground material may be used with my vacuum method inasmuch as the suction and down-draft makes a finely ground material flow downwardly in the sheath, whereas such material would not be free flowing in the absence of the provision of a vacuum. The use of more finely ground material enables a more dense filling to be made. Also, this results in economies in the use of material, inasmuch as the relatively finer particles need not be removed from the ground aggregate, or at least not to as great an extent as they have been prior to my method. For example, in the case of ground fused magnesium oxide, under prior practice, the fines below a certain maximum, which are unavoidable in the grinding of the material, must be more or less removed. In order to make these removed fines available for use, they must be reprocessed as by re-fusion and comminution, to bring the particles to a desired larger size.

Also, I am enabled with equal facility to use an aggregate comprising smaller maximum size particles, because the necessity for making available the too fine material by expensive re-fusing and re-grinding is not involved, whereas, on the other hand, particles in the ground material which are larger than desired may be easily re-ground.

Furthermore, the provision of my vacuum filling method increases the speed with which the sheath may be filled, while at the same time enabling a more dense filling to be provided, the density being enhanced due to the use of finer materials. Greater density of the material before the usual compacting of the heating element, as by swaging, side pressing, or otherwise working the sheath, is desirable because, among other things, there is provided a greater amount and weight of insulating material within a given space, thereby supplying a better insulating coat for the resistor with less necessary reduction of the sectional area of the heating element.

In addition, my vacuum filling method enables the manufacture of a tubular or rod type of heating element having a greater maximum of resistor within a given space and also a greater ohmic resistance within a given available space. Also, with a given cubical and dimensional limitation it enables the use of a resistor made from resistance wire, for example, one to two sizes larger, for a given heating element the resistor of which is to have a given total resistance, thus providing a much stronger resistor with a much greater area for a specified wattage rating.

At the beginning of the filling process, the static vacuum required is not very high, but will increase as the level of the insulating material accumulated in the sheath rises. The amount of air which is drawn through the plug means 31 may readily be regulated in any suitable way so as to allow, at any static vacuum, as much or more air to be abstracted downwardly than is displaced by the incoming comminuted insulating material.

I have found that when the sheath 28 has become filled, in accordance with my vacuum method, so that the insulating material completely embeds the resistor and a desired portion of the terminal 61 within the sheath, a very substantial vacuum still is available at the upper end of the sheath, with a vacuum of about 10 to 13 pounds in the reservoir, even though the sheath is four feet long and only about $\frac{9}{32}$ of an inch inside diameter, using comminuted insulating material of 100% —60 mesh including 20% —200 mesh. Accordingly, even finer materials, for example, such as hereinbefore referred to, may be successfully used with this method. The foregoing figures and examples are given to illustrate better what may be accomplished and not by way of limitation.

The lead tube 41 may be used very advantageously without the use of a vacuum at the lower end of the sheath, but the conjoint use of the lead tube and a vacuum has even greater advantages. Assuming that a vacuum of desired amount is established in the reservoir 33, and that the lead tube 41 is in its lowermost position, as insulating material falls down through the lead tube, the tube may be raised manually as the insulating material accumulates and the level thereof rises. In this case the fins 64 only serve

positively to centrally locate the resistor 36 while the insulating material is accumulating. Positive location of the resistor permits of less tension on the resistor and hence less extension thereof.

I am aware of a long known and used way of locating a resistor which involves the use of a tube having an internal bore as closely as permissible fitting the diameter of the helical resistor to be located, this tube having an outside surface spaced from the inside surface of the sheath and the tube being located in the sheath by external circumferentially spaced fins or projections on the tube. In this instance the comminuted insulating material is introduced between the outside of the tube and the inside of the sheath, and due to the characteristics of this type of filling arrangement, and due to the relatively coarse comminuted material necessary to be used therewith to secure free flow conditions, considerable clearance is necessary between the outside ends of the fins or projections and the inside surface of the sheath, and considerable clearance is necessary between the inside surface of the tube and the outside surface of the helical resistor, so that the possibility of jamming of these surfaces is reduced. Owing to these necessary clearances, considerable lateral displacement of the resistor is able to take place, which is very objectionable because, among other reasons, the minimum distance between the resistor and the sheath may be reduced, and the maximum electrical value of a heating element is measured by the electrical value at the minimum point. Furthermore, there is considerable tendency for the resistor coil to be at times unduly extended and at other times duly condensed, due to excessive friction between the outside surface of the resistor and the inside surface of the lead tube, if not complete jamming of these surfaces due to larger particles becoming lodged therebetween.

A lead tube in accordance with my invention obviates these objections and provides additional advantages, for the following reasons. The inside surface of the lead tube 41 is spaced a distance from the resistor coil 36 which is almost as great as the distance from the outer periphery of the coil to the inside surface of the sheath 28, being less only by the thickness of the wall of the lead tube which may be as little as about .016 of an inch or even less. The outside surface of the lead tube 41 may be made to fit the inside surface of the sheath 28 snugly, friction between these surfaces being of much less importance than friction between a lead tube and a resistor, and any friction which may oppose relative movement of the outside surface of the lead tube 41 and the inside surface of the sheath 28 may be readily overcome and, also, will not have any objectionable results. Furthermore, with a lead tube 41 in accordance with my invention, provided with fins 64 as hereinbefore described, the fins closely contact circumferentially spaced outermost surfaces of the convolution of the resistor, the areas of contact being very small. Thus very little or no lateral movement of the resistor 36 at the zone of the fins is possible. The fins are very thin knife-like members, of a thickness, in the illustrated instance, about the same as the thickness of the wall of the lead tube 41, or thinner, and the edges of the fins may if desired be rounded or sharpened, as indicated, still further to reduce the areas of contact so that these areas are not much more than points. Accordingly, movement of the fins 64 along the resistor 36 is relatively frictionless, and, also, insufficient space is allowed for particles of comminuted material of any appreciable size to become lodged between the edges of the fins and the outer surface of the resistor, while at the same time lateral movement of the resistor at the zone of contact is prevented. It will be noted, moreover, that the resistor 36 is restrained against lateral movement at a local longitudinal zone which represents only a very small part of the whole length of the resistor, it being required, if the resistor is to be restrained against lateral movement, to restrain it only where the insulating material is building up around it.

From the foregoing it will be apparent that comminuted insulating material introduced into the upper end of the lead tube 41 has free access not only to the outer periphery of the resistor 36 along its entire length but may enter into the inside of the helical resistor between the convolutions thereof. This is true also at the longitudinal zone defined by the fins 64. Hence the comminuted material has the opportunity to build up efficiently not only outside of the helical resistor but inside thereof, since the fine particles have more opportunity to pass between the convolutions to the inside of the resistor coil, even though the convolutions may be of less extended pitch. This effect is accentuated when the lower end of the sheath 28 is subjected to a vacuum. In this case if the space outside of the resistor 36 tends to fill up a little faster than the space inside of the resistor, the vacuum causes a concentration of the down-draft in the inside of the resistor.

If the lead tube 41 is used and more compaction of the comminuted material is desired than is obtainable by merely allowing the material to flow into the sheath, or by compacting it by vibration, or by subjecting the lower end of the sheath to a vacuum, or by both vibration and vacuum, then under any of these conditions the lead tube may be manually or mechanically repeatedly raised a desired amount and brought down again so as to tamp the comminuted material as it accumulates and the level builds up, or, in general, relative reciprocal motion between the lead tube 41 and the sheath may be created by manually or mechanically moving either the lead tube 41 or the sheath 28, so as to provide desirable vibration and tamping action. If desired the lead tube 41 may be rotated as tamping proceeds, but that is not essential. The relieved or rounded lower corners 65 of the fins may aid in forcing the comminuted material between the convolutions into the inside of the resistor 36, but that is not essential.

With or without subjecting the lower end of the sheath 28 to a vacuum, the base 22, and hence the entire apparatus, may be longitudinally vertically reciprocated or vibrated, whereby the lead tube 41 will be gradually forced upwardly by the comminuted material as fast as comminuted material finds its way under the end of the lead tube 41 and the fins 64.

From the foregoing it will be apparent that while the vacuum filling method and lead tube herein disclosed mutually cooperate to produce new results, the vacuum filling method in itself produces new results and may be used without a lead tube or with other forms of lead tubes, and the disclosed lead tube in itself produces new results and may be used without the vacuum filling method, and that the comminuted insulating material may or may not be tamped, and that the

sheath or apparatus carrying it may or may not be tapped or vibrated.

It will be understood that after the filling operation of the heating element has been completed and the element has been removed from the filling apparatus, the space left by the plug means **46** may be filled with any desired suitable insulating material, and the same is true with respect to any space left at the other end of the sheath.

It will be apparent that the resistor **36** may be made of any desired suitable material, and of any desired suitable form; that the insulating material may be granular, comminuted or powdered, or any form permitting practice of the disclosed process, and that it is desirably refractory and heat-conducting and may be, or may include, for example, silica, or silicates, or magnesium oxide, or aluminum oxide, or any refractory oxide or combination of refractory oxides, or any other suitable refractory material, desirably of a mineral character; and that the sheath **28** may be seamless or seam-welded tubing made of a metal or metal alloy capable of withstanding temperatures of from 1200° F. to 1600° F. or higher or of any material capable of withstanding whatever temperature of operation may be selected.

From the foregoing it will be apparent to those skilled in the art that the disclosed embodiment of my invention provides for new and improved manufacture of electric heaters, and accordingly, accomplishes the principal object of my invention. On the other hand, it also will be obvious to those skilled in the art that the disclosed embodiment of my invention may be variously changed and modified, or features thereof, singly or collectively, embodied in other combinations than those disclosed, 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. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; and a plurality of longitudinal fins circumferentially spaced on the inside surface of said filler tube, said fins extending radially inward and being adapted to slidably to engage peripheral surfaces of said resistor.

2. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; and a plurality of longitudinal fins circumferentially spaced on the inside surface of said filler tube, said fins extending radially inward and being adapted to slidably engage peripheral surfaces of said resistor in a longitudinal zone of engagement which is relatively short with respect to the length of said resistor.

3. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; and a plurality of longitudinal fins circumferentially spaced on the inside surface of said filler tube, said fins extending radially inward and being adapted to slidably engage peripheral surfaces of said resistor, and the longitudinal ends of said fins having relieved marginal corners.

4. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; funnel means communicating with said filler tube and constructed and arranged for feeding comminuted insulating material into the upper end of said filler tube; and barrier means, disposed within said funnel means above the outlet thereof, constructed and arranged to control the flow of comminuted insulating material from above said barrier means into the space above said outlet, said barrier means comprising a barrier tube and a member having a central aperture fiting said barrier tube and having a plurality of circumferentially spaced perforations.

5. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; funnel means communicating substantially airtight with said filler tube, said funnel means having an outlet coaxial with said filler tube, for feeding comminuted insulating material into the upper end of said filler tube; means whereby a lower part of the space within said sheath may be subjected to a desired vacuum; means substantially preventing discharge of said material while permitting withdrawal of air; and barrier means disposed within said funnel means above the outlet thereof, said barrier means having passage means for permitting flow of comminuted insulating material from above said barrier means into the space above said outlet and being so constructed and arranged that said space is substantially sealed except for said passage means.

6. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; funnel means communicating with said filler tube, said funnel means having an outlet coaxial with said filler tube, for feeding comminuted insulating material into the upper end of said filler tube; perforated barrier means, disposed within said funnel means above the outlet thereof, constructed and arranged to control the flow of comminuted insulating material from above said barrier means into the space above said outlet; means, including a rod spaced from the margin of said outlet and extending freely therethrough, constructed and arranged to support said resistor; and said barrier means having wall means providing an elongated aperture coaxial with said outlet, said rod extending through said aperture, said barrier means being so constructed and arranged that said wall means prevents the entrance of insulating material between said wall means and said rod.

7. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; funnel means communicating with said filler tube, said funnel means having an outlet coaxial with said filler tube, for feeding comminuted insulating material into the upper end of said filler tube;

perforated barrier means, disposed within said funnel means above the outlet thereof, constructed and arranged to control the flow of comminuted insulating material from above said barrier means into the space above said outlet; means, including a rod spaced from the margin of said outlet and extending freely therethrough, constructed and arranged to support said resistor; and said barrier means including tubular means coaxial with said outlet, said rod extending through said tubular means.

8. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: a filler tube adapted to slidably fit the inside surface of said sheath; funnel means communicating substantially airtight with said filler tube, said funnel means having an outlet coaxial with said filler tube, for feeding comminuted insulating material into the upper end of said filler tube; means whereby a lower part of the space within said sheath may be subjected to a desired vacuum; means substantially preventing discharge of said material while permitting withdrawal of air; perforated barrier means, disposed within said funnel means above the outlet thereof, constructed and arranged to control the flow of comminuted insulating material from above said barrier means into the space above said outlet; means, including a rod spaced from the margin of said outlet and extending freely therethrough, constructed and arranged to support said resistor; and said barrier means having wall means providing an elongated aperture coaxial with said outlet, said rod extending through said aperture, said barrier means being so constructed and arranged that said wall means prevents the entrance of insulating material between said wall means and said rod, and substantially prevents the entrance of air from atmosphere through the space between said wall means and said rod into the space below said barrier means.

9. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: means connectable to the ends of said resistor, constructed and arranged to position said resistor spaced from the inside surface of said sheath; means for introducing comminuted electrical-insulating material into the upper end of said sheath; and means whereby a lower part of the space within said sheath may be subjected to a desired vacuum, comprising, a vacuum reservoir receptacle having an aperture, plug means having an end adapted to fit in said aperture, the other end of said plug means being adapted to fit in the lower end of said sheath, said plug means having air passages extending between the ends thereof and including means for substantially preventing passage of material while permitting passage of air, and means whereby said receptacle may be connected to means for exhausting air from said receptacle.

10. The method of producing a tubular electric heating element, which comprises: arranging a tubular sheath in an approximately vertical position; disposing a helical resistor longitudinally in said sheath into position spaced transversely from the inside surface of said sheath; progressively introducing comminuted electrical-insulating material into the upper end of said sheath while subjecting a lower part of the space within said sheath to a desired vacuum, thus to remove the air from among the particles of the material within the sheath; substantially preventing egress of said material while permitting such withdrawal of the air; and engaging said helical resistor, at circumferentially spaced points only, to restrain said resistor against lateral movement at least at approximately the level of the insulating material accumulated in said sheath.

11. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: supporting means; means, carried by said supporting means, constructed and arranged to hold said sheath in an approximately vertical position; means connectable to the ends of said resistor and carried by said supporting means, constructed and arranged to position said resistor spaced from the inside surface of said sheath; means for introducing comminuted electrical-insulating material into the upper end of said sheath; means substantially preventing discharge of said material; said material introducing means comprising a filler tube insertable in said sheath and freely movable up and down therein, and funnel means communicating with said filler tube and constructed and arranged for feeding comminuted insulating material into the upper end of said filler tube.

12. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular sheath to embed a resistor disposed in said sheath, comprising: first means for slidably engaging the inside surface of said sheath so as to be positioned within said sheath by said inside surface; second means positioned by and below said first means and having a portion for slidably engaging and positively positioning said resistor with respect to said inside surface at the zone of engagement; said first means being so constructed and arranged that access of said insulating material to said resistor above the zone of engagement of said portion is permitted; means whereby a lower part of the space within said sheath may be subjected to a desired vacuum; and means substantially preventing discharge of said material while permitting withdrawal of air.

13. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular metallic sheath to embed a resistor disposed in said sheath and having a terminal at its lower end, comprising: filler means for introducing comminuted electrical-insulating material into the upper end of the sheath; plug means adapted to be inserted endwise into the lower end of the sheath a desired distance, having an aperture for receiving said terminal of said resistor, and having air passage means extending through said plug means from one end thereof to the other; means to support said filler means and said plug means in operative position; means carried by said plug means for fastening said terminal to said plug means; and means connected to the outer end of said plug means whereby air is drawn from said sheath through said passage means and discharged therefrom.

14. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular metallic sheath to embed a resistor disposed in said sheath, comprising: positioning means, including an elongated member connectable to the upper terminal of said resistor, constructed and arranged to position said resistor spaced from the inside surface of said sheath; a filler tube separate from said positioning means

and constructed and arranged to be disposed about and so spaced from said resistor and from said elongated member as to provide for longitudinal movement of said filler tube relative to said resistor and said elongated member, said filler tube being constructed and arranged to slidably fit the inside surface of said sheath; funnel means having an outlet communicating with said filler tube and constructed and arranged for feeding comminuted insulating material into the upper end of said filler tube; perforated barrier means disposed within said funnel means above the outlet thereof and constructed and arranged to control the flow of comminuted insulating material from above said barrier means into the space above said outlet; and means to support said positioning means, said filler tube, said funnel means, and said barrier means, in operative position.

15. Apparatus for use in introducing comminuted electrical-insulating material endwise into a tubular metallic sheath to embed a resistor disposed in said sheath and having an upper terminal, comprising: positioning means, including an elongated member connectable to the upper terminal of said resistor, constructed and arranged to position said resistor spaced from the inside surface of said sheath; a filler tube separate from said positioning means and constructed and arranged to be disposed about and so spaced from said resistor and from said elongated member as to provide for longitudinal movement of said filler tube relative to said resistor and said elongated member, said filler tube being constructed and arranged to slidably fit the inside surface of said sheath; funnel means communicating with said filler tube and constructed and arranged for feeding comminuted insulating material into the upper end of said filler tube; and means to support said positioning means, said filler tube, and said funnel means, in operative position.

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