May 1, 1945. E. L. WIEGAND 2,375,058

ELECTRICAL HEATING ELEMENT AND PROCESS FOR PRODUCING THE SAME

Filed Sept. 5, 1941

FIG. 1.

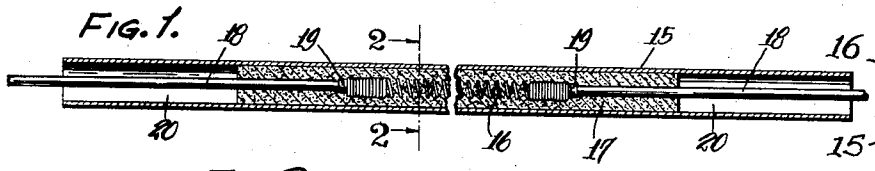


FIG. 2.

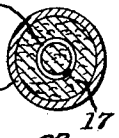


FIG. 3.

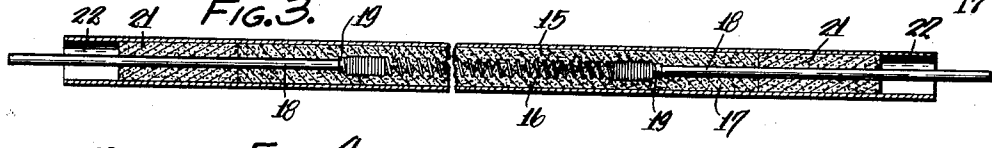


FIG. 4.

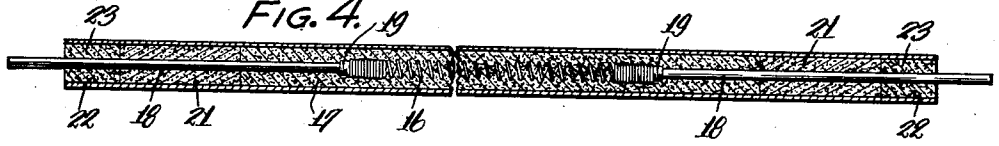


FIG. 5.

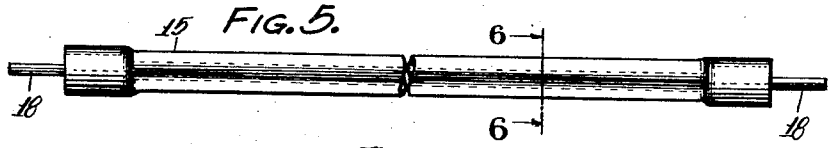


FIG. 6.

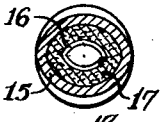


FIG. 7.

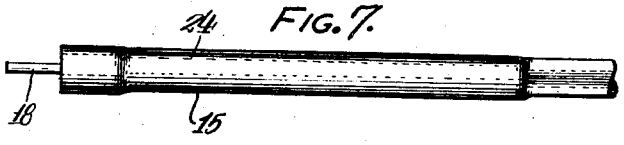


FIG. 8.

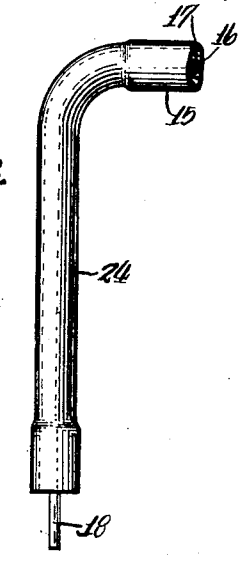


FIG. 9.

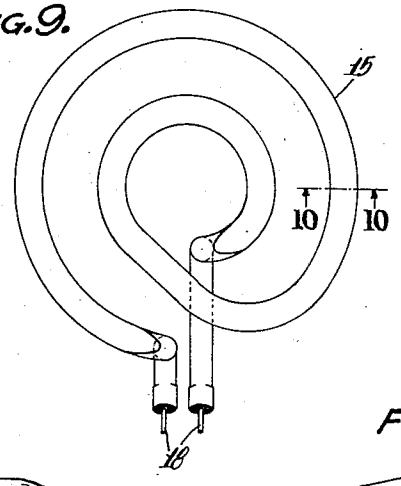


FIG. 10.

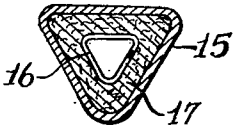


FIG. 12.

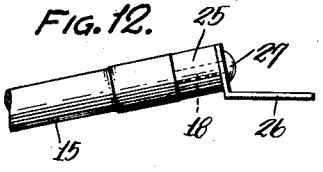
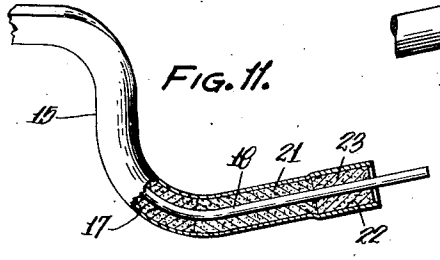


FIG. 11.



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Patented May 1, 1945

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UNITED STATES PATENT OFFICE

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ELECTRICAL HEATING ELEMENT AND PROCESS FOR PRODUCING THE SAME

Edwin L. Wiegand, Pittsburgh, Pa., assignor to Edwin L. Wiegand Company, Pittsburgh, Pa., a corporation of Pennsylvania

Application September 5, 1941, Serial No. 409,624

13 Claims. (Cl. 201—67)

My invention relates to electrical heating elements and the process for producing the same, and the principal object of my invention is to provide new and improved electrical heating elements, and a new and improved process of producing electrical heating elements.

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

Figure 1 is a broken sectional view of an embodiment, showing a stage of manufacture,

Figure 2 is a transverse sectional view corresponding generally to the line 2—2 of Figure 1,

Figures 3 and 4 are sectional views similar to Figure 1, but showing subsequent stages of manufacture,

Figure 5 is a broken elevational view showing a method which may be used in the forming of the heating element,

Figure 6 is a transverse sectional view corresponding generally to the line 6—6 of Figure 5,

Figures 7, 8, and 9 show other methods which may be used in the forming of the heating element,

Figure 10 is an enlarged transverse sectional view corresponding generally to the line 10—10 of Figure 9,

Figure 11 is a fragmentary elevational view, partly in section, showing a terminal portion of the heating element, and

Figure 12 is a fragmentary elevational view of the terminal portion when finally completed.

Referring to the drawing, the embodiment of the invention herein shown comprises a sheath 15, preferably formed of a metal capable of withstanding high temperatures, such for example as "inconel." In this embodiment, the sheath has a circular cross-section, as best seen in Figure 2. Within the sheath 15 is a resistor 16 of desired form, in this instance a helix of electrical resistance wire. The resistor 16 is embedded in refractory electrical-insulating heat-conducting material 17, and is desirably uniformly spaced from the inside wall of the sheath 15. The insulating material 17 may be of any suitable type, preferably being in a granular, comminuted, or powdered state, and introduced into the sheath 15 in any suitable manner, and compacted to any desired degree.

The resistor 16 is of less length than the sheath 15, and has terminals 18 extending outwardly of each open end of the sheath. As here shown, each terminal has an inwardly disposed screw-threaded head 19, and the adjacent end of the resistor is threaded thereon.

The insulating material 17 does not fill the sheath 15 over the entire length, and preferably the inner part of each end zone 20 of the sheath 15 is occupied by an end zone filling 21, which comprises a suitable stable insulation material which meets the requirements for terminal zone conditions. As an example, a mixture of zircon, magnesium oxide, and clay, has been found suitable. The end zone filling 21 is preferably compacted a desired amount in any suitable manner, and as best seen in Figure 3, each end zone filling 21 stops short of the adjacent end of the sheath 15, forming a space 22, which desirably has a length of approximately twice the internal diameter of the sheath, although it will be appreciated that this length is not critical, and more or less length may be used to meet various requirements.

The space 22 is then substantially filled with an electrical insulating material 23 which has such qualities that under certain conditions it will become moldable. Preferably the material 23 should have such characteristics that upon application of a predetermined amount of heat it will become plastic. For this result I have found it preferable to use a granular or powdered insulating material combined with a fusible binder, and as an example, the following composition has been found suitable:

	Parts
—150 mesh zircon containing about 30% —200 mesh, including fines	70
Air floated plastic kaolin, for which a high grade Florida plastic kaolin has been found suitable	15
and	
Lead borate, screened to about —100 mesh, including fines	15

The materials and their proportions herein given may be varied. For example, the fusible portion of the binder may be as low as 10 parts lead borate, or as high as 20 parts, and under certain conditions even this differential does not represent the extremities. Also, the size of the zircon granules may be finer, or even as coarse as —60 mesh, and still produce very desirable results. Further, although it has been found preferable to use zircon (zirconium silicate) as the base material for the terminal composition, any equivalent material can be used which has the desired electrical resistivity at the tempera-

ture to which the terminal portion of the heater is normally subjected. This temperature is relatively low, being usually from approximately 250° F. to approximately 600° to 800° F.

As an example of a substitute for the base material, I have found that crystalline aluminum oxide in powdered or granular form produces good results, and other oxides or silicates may be used as the base material for the terminal composition, so long as the particles are sufficiently refractory and are stable in the presence of heat and moisture, or other agencies, and so long as they are capable of being wet by the lead borate or other suitable fusible binder.

The terminal composition is preferably prepared into a uniformly dry mixed powder which is introduced into the space 22 and packed snugly in any suitable manner, as for instance by hand ramming or with a small bench press. However, it is to be understood that the composition may be formed into a pellet of a size substantially equal to the size of the space 22, and with an aperture to pass the terminal 18, and in such case the pellet may be slipped over the terminal 18 and into the space 22. Also, the composition may be introduced into the space 22 practically dry, either in powder or pellet form, but good results are also obtained with the powder or pellet slightly moistened. In any event, whether powder or pellet, and whether dry or moist, it is preferable to compact the material 23 within the space 22.

The heating element produced thus far is then preferably dried, as for instance by leaving the element in a heated zone at a suitable temperature, for example 300° to 350° F., for a period sufficient to thoroughly dry the element.

After the drying operation, the heating element is preferably baked, at a suitable temperature, for example, a red heat, for a period sufficient to drive out any moisture and excess air.

Preferably, the element is then swaged or pressed, and this operation further drives out moisture or gases contained in the insulating material within the sheath.

The element may be straight, or it may be formed to any special shape. As an illustration of the pressing and shaping operations, attention is directed to Figures 5 through 10 of the drawing. In the embodiment herein shown, the element is bent to a generally spiral shape having an active portion, triangular in cross-section, disposed in a general plane, and having terminal portions extending from this plane. However, it will be understood that the element may have any form or any cross-section desired or found suitable for any particular application.

In the embodiment shown, the element after it has been baked, is swaged or pressed, as between dies (not shown), so that the portion intermediate the ends containing the insulating material 23 is pressed to generally elliptical shape, as seen in Figures 5 and 6. Then a portion 24, extending inwardly from each end, as seen in Figure 7, is further pressed, preferably to substantially circular cross-section but to a reduced diameter with respect to the original diameter of the sheath 15, so as to form the terminal portions of the element. The terminal portions 24 are then bent at an angle to the intermediate portion, as seen in Figure 8, and the intermediate or active portion may be coiled to the generally spiral shape shown in Figure 9. In the particular embodiment shown, the intermediate or active portion of the element is further pressed or swaged, as seen in Figure 10, to triangular cross-section.

Whether the element is straight or is bent to any special form or pressed to any special cross-section, it is desirable as soon after the baking operation as is practical, to perform the conditions which make the material 23 moldable. In the embodiment herein disclosed, the ends of the element are heated sufficiently so that fusible aggregate becomes plastic, and in accordance with the proportions hereinbefore given, it has been found that heating the ends of the element to about 1500° to 1700° F. is sufficient to soften the aggregate. Then, when the composition is plastic, it is rammed thoroughly into the space 22, so as to densify the composition and completely fill any voids that may exist, while at the same time driving the composition in substantially "wetting" relation with respect to the adjacent inner surface of the sheath and the adjacent outer surface of the respective terminal 18. Upon subsequent cooling the composition completely and effectively seals the ends of the element and is substantially impervious to moisture, oil, grease, or other deleterious materials. Also, the terminal structure thus formed possesses very high electrical resistivity and great mechanical strength. Thus the terminals 18 are not only well insulated from the sheath 15, but also, these terminals are well anchored against movement.

After the material 23 has been heated, rammed, and cooled, as seen in Figure 11, an insulating bushing 25 may be slipped over the projecting end of the terminal 18, and a terminal clip 26 (see Figure 12) may be attached to the end of the terminal in any suitable manner, as for instance by welding, as shown at 27.

From the foregoing it will be apparent to those skilled in the art that I have accomplished at least the principal object of my invention, and it also will be apparent to those skilled in the art that the embodiment herein described may be variously changed and modified, without departing from the spirit of the invention, and that the invention is capable of uses and has advantages not herein specifically described; hence it will be appreciated that the herein disclosed embodiment is illustrative only, and that my invention is not limited thereto.

I claim:

1. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation consisting principally of particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and distributed substantially uniformly through said mass, said particles being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material only, said bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively.

2. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation approximately 70% of which consists of particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and distributed substantially uniformly through said mass, said particles being bonded into a coherent sealing mass by solidified

fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material only, said bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively.

3. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation consisting principally of particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and distributed substantially uniformly through said mass, said particles being in a size range of from approximately —150 mesh to approximately 60 mesh and being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material only, said bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively.

4. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation approximately 70% of which consists of particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and distributed substantially uniformly through said mass, said particles being in a size range of from approximately —150 mesh to approximately 60 mesh and being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material only, said bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively.

5. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation consisting principally of particles of refractory electrical-insulating material of substantially higher specific electrical resistivity relatively to the remainder of said mass and having a relatively high fusion temperature and being distributed substantially uniformly through said mass, said particles being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material at a temperature substantially below the fusion temperature of the sheath, the terminal and said particles respectively, said bonding material comprising kaolin and lead borate.

6. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation approximately 70% of which consists of particles of refractory electrical-insulating material of substantially higher electrical resistivity relatively to the remainder of said mass and having a relatively high fusion temperature and being distributed substantially uniformly through said mass, said particles being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of effective fusion of said bonding material at a temperature substantially below the fusion temperature of the sheath, the terminal and said particles respectively, said bonding material comprising approximately 15% kaolin and approximately 10% to approximately 20% lead borate.

7. A sheathed-resistor electric heating element provided with a terminal seal comprising a coherent mass of insulation approximately 70% of which consists of particles of refractory electrical-insulating material of substantially higher electrical resistivity relatively to the remainder of said mass and having a relatively high fusion temperature and being distributed substantially uniformly through said mass, said particles being in a size range of from approximately —150 mesh to approximately 60 mesh and being bonded into a coherent sealing mass by solidified fused bonding material adhering to the sheath and the terminal and said particles by reason of the effective fusion of said bonding material at a temperature substantially below the fusion temperature of the sheath, the terminal and said said particles respectively, said bonding material comprising approximately 15% kaolin and approximately 10% to approximately 20% lead borate.

8. The process of making a sheathed-resistor electric heating element provided with a terminal and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture the major part of which is particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and a minor part of which is bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively, said bonding material when effectively fused wetting the sheath and the terminal and said particles, and subjecting said mass to heat sufficient effectively to fuse said bonding material only.

9. The process of making a sheathed-resistor electric heating element provided with a terminal and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture the major part of which is particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and a minor part of which is bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively, said bonding material when effectively fused wetting the sheath and the terminal and said particles, and subjecting said mass to pressure to compact said mass and subjecting said mass to heat sufficient effectively to fuse said bonding material only.

10. The process of making a sheathed-resistor electric heating element provided with a terminal and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture the major part of which is particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and a minor part of which is bonding material having a fusion temperature substantially below that of the sheath, the terminal and said particles respectively, said bonding material when effectively fused wetting the sheath and the terminal and said particles, and subjecting said mass to heat sufficient effectively to fuse said bonding material only while subjecting said mass to pressure to compact said mass.

11. The process of making a sheathed-resistor electric heating element provided with a terminal

and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture the major part of which is particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and having a relatively high fusion temperature, said remainder comprising a bonding material which when effectively fused wets the sheath and the terminal and said particles, said remainder comprising kaolin and lead borate, and subjecting said mass to a temperature which is substantially below the fusion temperature of the sheath, the terminal and said particles respectively, and is of the order of approximately 1500° to 1700° F.

12. The process of making a sheathed-resistor electric heating element provided with a terminal and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture approximately 70% of which is particles of refractory electrical-insulating material of substantially higher specific electrical resistivity than the remainder of said mass and having a relatively high fusion temperature, said remainder comprising a bonding material which when effectively fused wets the sheath and the terminal and said particles, said remainder comprising approximately 10% to approximately 20% lead borate and approximately 15% kaolin, and subjecting said mass to a temperature which is substantially below the fusion temperature of the sheath, the terminal, and said particles respectively, and is of the order of approximately 1500° to 1700° F.

13. The process of making a sheathed-resistor electric heating element provided with a terminal and seal therefor which comprises emplacing within the sheath about the terminal a mass consisting of a mixture approximately 70% of which is particles of refractory electrical-insulating material in a size range of from approximately —150 mesh to approximately 60 mesh and of substantially higher specific electrical resistivity than the remainder of said mass and having a relatively high fusion temperature, said remainder comprising a bonding material which when effectively fused wets the sheath and the terminal and said particles, said remainder comprising approximately 10% to approximately 20% lead borate and approximately 15% kaolin, and subjecting said mass to a temperature which is substantially below the fusion temperature of the sheath, the terminal, and said particles respectively, and is of the order of approximately 1500° to 1700° F.

EDWIN L. WIEGAND.