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TUBULAR HEATING UNIT

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Fig. 1.

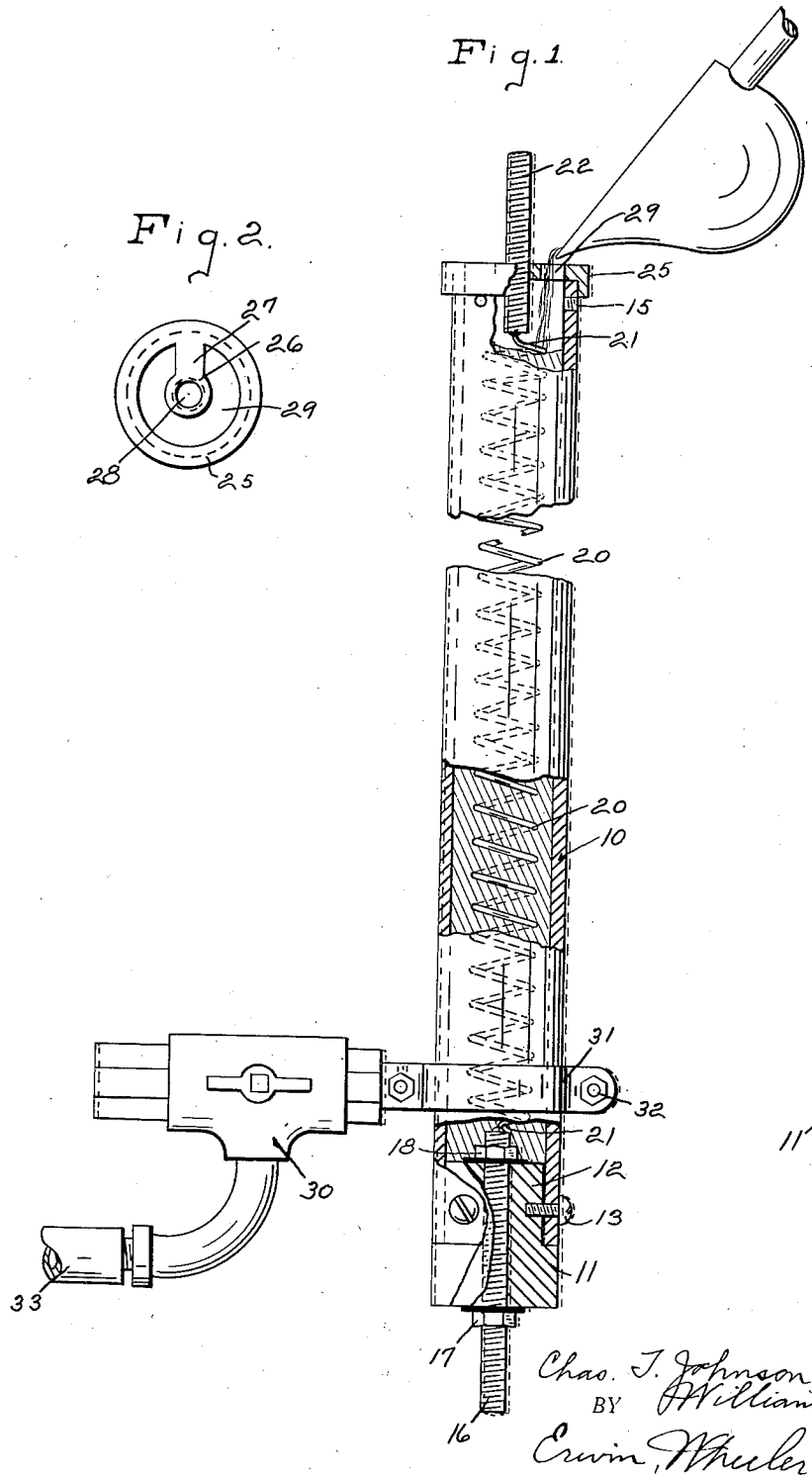
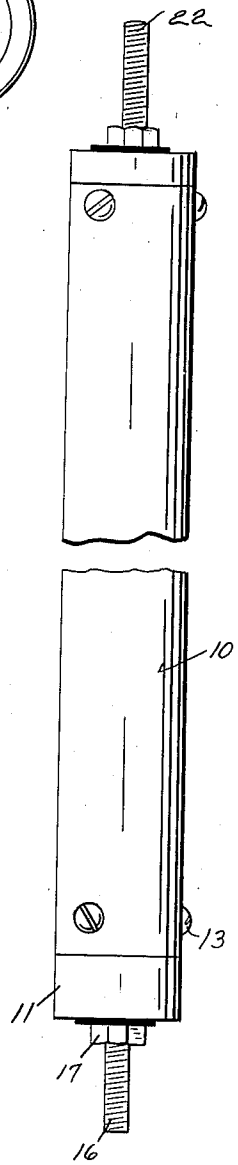


Fig. 2.

Fig. 3



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TUBULAR HEATING UNIT

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Our invention relates to improvements in electrical heating units and methods of making the same, with particular reference to the manufacture of tubular heating units in which a helical coil or convoluted resistance member is embedded in granular material associated with a suitable binder.

The object of this invention is to provide an improved tubular heating unit in which the number of voids are reduced to a minimum and the contacts of the grains of embedding material with each other and with the resistance element and the tube are substantially at maximum,—the resistance element, embedding material and tube being formed as nearly as possible into one non-hygroscopic solid, highly resistant to mechanical abuse and capable of being used with uniform efficiency for long periods of time.

More specifically stated, the object of this invention is to provide an improved tubular heating unit in which a resistance element is embedded in a mass of granular material having high dielectric strength, the voids between the grains being filled, in part, by a more finely divided granular bonding material and the smaller voids thus created being, in turn, filled with boracic acid applied in the form of a dried powder which, when heated, melts and oxidizes and constitutes a flux for the bonding material, whereby the entire mass becomes cohesive and solid, being bound together and converted from a mechanical mixture in which the parts are consolidated by vibration into a mechanical combination of unitary character.

A further object is to provide an improved method of manufacturing heating units having the above mentioned characteristics, whereby such manufacture may be expedited and the cost thereof reduced to a minimum.

In the drawings:

Figure 1 is an elevational view illustrating the improved process, showing a partially completed heating unit and an associated vibrator employed for compacting the embedding material.

Figure 2 is a plan view of the centering cap for holding the upper binding post and resistance element in place during the operation of pouring and compacting the embedding material.

Figure 3 is a side elevation of the completed heating unit.

Like parts are identified by the same reference characters throughout the several views.

In the practice of the improved process, a metal tube 10 is fitted with a cap 11 having a plug 12 adapted to enter the tube in closely fitting relation to its walls and having threaded apertures to receive the screws 13, which pass through apertures formed in the tube 10 near its end. The opposite end of the tube is formed with similar apertures 15 whereby a similar cap may be secured to the opposite end of the tube after the latter has been properly filled with the embedding material. A threaded binding post 16 passes through a central aperture in the cap 11 and its reduced portion or plug 12, and is secured in position by inner and outer nuts 17 and 18 respectively.

A convoluted resistance element 20 has terminals 21 axially secured respectively to the binding post 16 and to binding post 22 at the opposite end of the tube 10. The resistance element preferably has the form of a helical coil of the required cross section and length to develop the desired number of heat units when an electrical current of predetermined volume and pressure is passed through it.

In the manufacture of the unit, the binding post 22 is centered and held in position with the axis of the coil 20 substantially coinciding with the axis of the tube, this being accomplished by means of the temporary cap ring 25, (Figure 2), this ring having a central annulus 26 supported by the inwardly projecting web 27. The aperture 28 in the annulus is threaded and is adapted to receive the binding post 22 as clearly illustrated in Figure 1, whereby the binding post may be held in the proper position while the embedding material is being poured into the tube through the arcuate opening 29 in the cap ring 25.

The tube is then held in an upright position, with the cap 11 at the bottom, and connected with a motor actuated vibrator. In

the drawings I have illustrated an air engine 30 of an ordinary type provided with clamping members 31 to engage the tube under pressure exerted by the clamping screw 32. The engine is supplied with air through the flexible hose 33. The construction of such air engines being well understood, it is sufficient to say that when set in operation, its piston will reciprocate the clamping members 31 with great rapidity, thereby causing the tube 10 to vibrate rapidly in a horizontal plane. The clamping members 31 are preferably engaged with the tube 10 near its lower end whereby the upper end of the tube is permitted to vibrate freely with a slightly arcuate movement due to the yielding of the parts. While the tube is being thus vibrated, the embedding material, hereinafter described, is poured into the upper end of the tube through the arcuate opening 29. This embedding material is preferably composed of finely divided granular fused aluminum oxide mixed with a suitable binder such as clay, (the form of clay known as Klingenberg clay being preferred), and a quantity of dry powdered boracic acid. The rapid vibration of the tube causes the granular particles to settle under the influence of gravity, whereby intimate contacts are secured between each particle and the adjacent particles and between particles and the resistance element and tube. The particles or granules are caused to readjust and impact upon each other in a manner to reduce the voids to a minimum. In general, the granular aluminum oxide grains will be larger than those of which the binder is composed, although the latter may contain some large grains and some which are exceedingly small and have the characteristics of particles of dust. The powdered boracic acid is composed of still smaller grains and much of it has the characteristic of flour. Some of it is so fine as to be substantially impalpable. Therefore, the vibration of the particles causes the bonding particles to settle into and partially fill the voids between the granular aluminum oxide and these, in turn, present smaller voids which are filled by the particles of boracic acid, thereby producing an exceedingly thorough mixture and distribution of the boracic acid throughout the mass, but also producing an embedding mass which has substantially the dielectric strength of the fused aluminum oxide, since there remains no direct flux paths from the resistance element and the walls of the container which are not intercepted by the aluminum oxide grains. Such paths as might be established through the bonding material and boracic acid are so increased in length as to afford the requisite dielectric strength even though the resistance may be less than that of the aluminum oxide for a flux path of any given length and cross section.

The rapid vibration also causes portions of the mixture to work into the coil and into the interstices and completely fill the same to the exclusion of air therefrom, thereby developing an exceedingly dense pack in the portion of the tube occupied by the resistance member or coil. The particles particularly tend to develop wedging pressures along the oblique metal surfaces. The operation of pouring the embedding material into the tube may be continued until the tube has been filled with compacted material to the upper end of the coil or the lower end of the binding post 22. If desired, water may be added to the mixture and the mixture converted into a paste-like mass before pouring it into the tube, whereupon the particles may be compacted by gravity and the interstices also filled, in part, by flotation. Where water is used, the surplus liquid may be allowed to flow away from the top of the tube while the particles are being compacted. If desired, the vibration of the tube may be stopped and the tube held at rest for a short interval before releasing it from the clamp and pouring off the liquid from the upper end, thereby allowing the compacted material to set sufficiently to retain its position. The boracic acid and the bonding material tends to become adhesive and coherent under such conditions.

Either before or after the tube has been released from the vibrator clamp, the binding post may be connected in an electrical circuit and current passed through the heating element or coil 20 to dry and bake the embedded material into a solid mass. The boracic acid may be utilized as a flux to partially soften the binding materials when heated by the current in the coil and cause them to adhere more effectively to the highly refractory granular material,—i. e., to the finely divided fused aluminum oxide granules. The boracic acid will fuse and the clay referred to will soften to some extent at a temperature of about 1000° F. This temperature is considerably below that which would fuse or impair the resistance element and is also below the fusing point of the aluminum oxide grains.

The boracic acid, when introduced into the mixture, is in the state known as H_3BO_3. When the unit is heated, the boracic acid constituent is melted, forming boric oxid (B_2O_3), and this coats the resistance wire and the inner surfaces of the tube. It mixes with the binding material and fills the interstices between the granules, thereby forming an exceedingly dense mass which becomes largely impervious to water and not only prevents oxidation, but also prevents the loss of dielectric strength which would otherwise occur through moisture absorption.

The specific composition of embedding material herein described is not essential to the method herein described, it being obvious

that any granular embedding material may be similarly vibrated and compacted within the tube and about the resistance element preparatory to allowing it to harden or preparatory to baking it, if it contains boracic acid or an equivalent finely divided flux. Specific proportions of the highly dielectric material, the bonding material, and the boracic acid are not essential, but it will ordinarily be found desirable to employ a mixture in which the fused aluminum oxide comprises from 70 to 90 percent of the total volume. Substantially equal parts in volume of bonding material and boracic acid may be employed. These proportions relate to the materials as mixed preparatory to the heating or melting stage of the process.

After the drying, hardening and baking operations have been completed, the temporary cap ring 25 may be removed and a permanent cap similar to the cap 11 may be applied to the binding post 22, thereby completing the unit.

We are aware of the fact that in the molder's art it has for many years been common practice to vibrate molds in order to compact the grains of molding sand upon each other and upon the pattern, and therefore no claim is made herein for the mere compacting of substantially dry granular material in this manner. But we believe we are the first to vibrate a container while it is being filled with a mixture of granular material composed of dielectric and bonding materials in grains or particles of different sizes and combined with a chemical agent, whereby the mass may be converted into a non-hygroscopic unit solidified by drying and baking it after the granular particles have been compacted by gravitation, or by gravitation and partial flotation, to form a mass of considerably greater density and freedom from voids than is possible to produce by vibration of a homogeneous material. By the process herein described, the embedding material bakes into a stone-like mass, substantially impervious to moisture and the particles are incapable of shifting upon each other while confined in the tube even though the tube may be subjected to blows or bending stresses.

We claim:

1. The method of making tubular heating units consisting in suspending a resistance element axially within a tube, providing the same with suitable terminals such as binding posts, closing one end of the tube and supporting it in an upright position with the other end uppermost and open, vibrating the tube in a horizontal plane and simultaneously filling it with an embedding material composed of a mixture of granular materials of different sizes and having different melting points whereby the material is capable of being converted into a unitary stone-like non-hygroscopic mass when heated without melting the more refractory portion of said material, and then heating the tube and its contents to melt the less refractory portions of said material and subsequently capping the uncapped end of the tube with the terminals exposed.

2. The method of making encased tubular heating units, consisting in preparing a mixture of a quantity of granular dielectric material, a more finely divided quantity of bonding material, and a still more finely divided quantity of boracic acid, compacting said material about an electric resistance element by vibration in an enclosing casing containing such unit in a manner to cause the bonding material to fill voids between grains of dielectric material and to further cause the boracic acid particles to fill the smaller voids, and then raising the temperature of the unit sufficiently to cause the mixture to bake into a stone-like non-hygroscopic mass under the influence of the boracic acid.

3. The method of making encased tubular heating units, consisting in preparing a mixture of a quantity of granular dielectric material, a more finely divided quantity of bonding material, and a still more finely divided quantity of boracic acid with sufficient water to form a flowing pasty mass, compacting said material about an electric resistance element by vibration in an enclosing casing containing such unit, and then raising the temperature of the unit sufficiently to cause the mixture to bake into a stone-like non-hygroscopic mass under the influence of the boracic acid.

4. The method of making tubular heating elements, consisting in supporting a resistance element axially within a casing in spaced relation to the walls thereof, filling the space with a mixture of highly refractory granular dielectric material, a void filling bonding material, and a more finely divided material fusible at a lower temperature than that of the resistance element, vibrating the casing to cause the smaller particles to settle into the voids between the larger particles, and then heating the unit to a temperature where the less refractory material will soften and unite the other materials.

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