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W. H. NORTON

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HEATING ELEMENT

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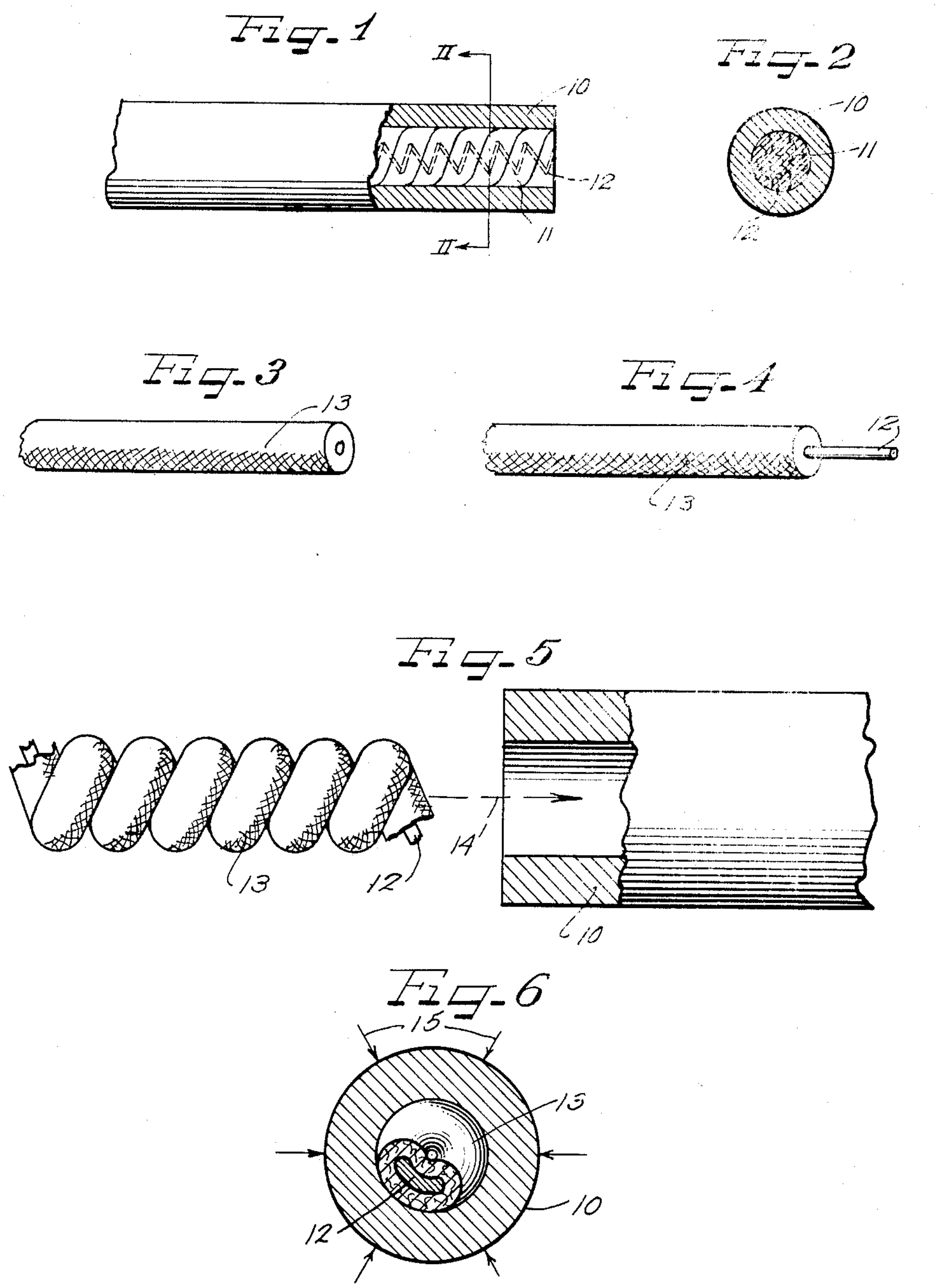

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HEATING ELEMENT

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The present invention relates to a heating device and more particularly to an electric heating unit and the method of making the unit.

The type of unit to which the present invention pertains is generally known as a tubular unit or metal sheath unit wherein an electrical resistance wire is covered by a heat resistant insulation and enclosed in a surrounding tubular metal sheath. Such units enjoy considerable popularity because of their comparative high efficiency and speed of operation. The units are employed industrially as a heating unit for various purposes and are mounted in units for transmitting heat to areas or to products being processed.

A conventional structure consists of an outer tubular sleeve formed of metal such as stainless steel with a helically shaped resistance wire therein surrounded by an electrically insulative refractory particulate material such as magnesia which fills the sleeve and is compacted therein to hold the wire in place insulatively spaced from the sheath. The coils of the helical wire are also insulatively spaced from each other and at the end of the sheath the ends of the wire are connected to terminals for connection to an electrical circuit.

Difficulties occur in the manufacture of this type of unit in that during manufacture or during use the coils of wire may shift within the particulate magnesia and short against each other or short against the sheath. This can be caused by voids in the magnesia or caused during compacting of the magnesia when the wire necessarily has to shift with the particulate magnesia as it is being compacted. One method of compacting the magnesia is by radial compaction such as obtained by swaging the surrounding tube as disclosed in my U.S. Patent 2,875,312.

A problem is encountered in the use of magnesia as an insulation in that its resistance properties diminish at elevated temperatures. At 2000° F. magnesia or magnesium oxide disintegrates. At 1500° F. magnesium oxide has 30 ohms resistance per mil of thickness. At 1800° F. its electrical resistance drops to 3 ohms per mil of thickness. Thus operation at elevated temperatures is impractical. Another disadvantage of magnesium oxide is that it does not readily pass radiant heat and depends upon conduction for transmitting the heat from the resistance wire to the metal sheath. This of course reduces efficiency of operation and reduces the capacity of a heater of a given size.

A feature of the present invention is the use of quartz or refrasil material as an insulator. This material can be particularly advantageous in cloth form wherein threads are woven to form refrasil cloth. This material will pass 90% of the radiant heat. The refrasil cloth is utilized in tubular form to form a sleeve for insulating the resistance wire, and a high temperature resistance wire is utilized such as formed of an alloy of nickel, steel and aluminum, commercially available and known as Canthal wire. This wire is capable of operations at very high temperatures, and has a maximum recommended operating temperature of 2,460° F. which is substantially higher than Nichrome wire, for example.

A further feature of the invention resides in the method of making the electrical heaters by covering the wires

with a tubular insulated sleeve and forming them into helical shape, inserting them axially into a tubular sheath and radially compressing the tube forcing the individually covered helical coils of wire together to compact the insulation. This operation can be accomplished with the dangers of shorting of individual wires against the tube or against adjacent coils being substantially eliminated since each coil is individually covered and individually held within the insulative covering.

It is accordingly an object of the present invention to provide an improved electrical heating element well suited for operating in higher temperature ranges.

A further object of the invention is to provide an improved heating element having a greater efficiency and having a more effective heat transmission for a given size.

A further object of the invention is to provide an electrical heating element of the type enclosed in a tubular sheath wherein the element effectively passes an increased quantity of radiant heat from the electrical resistance wire within the element.

A still further object of the invention is to provide an improved method of making an electrical tubular type resistance element wherein problems and dangers of shorting and displacing of the wires during manufacture are eliminated.

A further object of the invention is to provide an improved tubular heating element using a helically shaped resistance wire wherein the unit has a longer and more safe operating life and the dangers of individual wires shorting from rough handling and from bending the tube are eliminated.

Other objects, advantages and features will become more apparent with the teaching of the principles of the invention in connection with the disclosure of the preferred embodiment thereof in the specification, claims and drawings, in which:

FIGURE 1 is an elevational view, with portions broken away, of an electrical heater constructed in accordance with the principles of the present invention;

FIGURE 2 is a vertical sectional view taken substantially along line II—II of FIGURE 1;

FIGURE 3 is a perspective view of an insulation sleeve;

FIGURE 4 is a perspective view of the insulation sleeve covering an electrical resistance wire;

FIGURE 5 is a perspective view shown somewhat schematically and illustrating the manner in which elements are assembled; and

FIGURE 6 is an end elevational view illustrating the swaging of the metal tube.

As shown on the drawings:

As illustrated in FIGURES 1 and 2, the electrical heater has an outer tubular sheath **10** of heat conducting material such as metal. This forms a protector and a housing for the electrical wire **12** enclosed therein and insulated from the metal housing by insulative material **11** which is in the form of quartz cloth which is also known as refrasil cloth.

The outer tubular sheath **10** is formed of a material such as stainless steel and has some flexibility for shaping to the desired conformation for the installation in which it will be used.

The electrical wire **12** is helically shaped so as to increase the heat emission per unit of length of tube. The wire is preferably of a material which can operate at high operating temperatures, such as known as Canthal wire formed of a composition of nickel, steel and an aluminum, as will be appreciated by those versed in the art. It will of course be understood that the principles of the invention may be used with other types of wire such as Nichrome wire, but inasmuch as the other features of the invention are well adapted to use at high operating temperatures a resistance wire capable of operating at high temperatures is advantageously utilized.

The quartz material 11 which surrounds and insulates the wire is compacted around the wire and within the tube. The wire is uniformly spaced with uniform thicknesses of quartz insulative material surrounding each of the wires and with each coil of the helically shaped wire being a uniform distance from the inner surface of the tube 10 completely around each of the coils. There is no accidental or inadvertent displacement of the coils such as may occur in a construction where a particulate insulative material is employed as will become clear.

The quartz or refrasil material for insulating the wire is preferably formed in the form of a cloth woven of refrasil threads and shaped into a sleeve as shown particularly at FIGURE 3, and as also illustrated in FIGURES 3 through 5. The insulative sleeve 13 is made to surround the wire 12. It will of course be understood that other forms of refrasil material could be employed such as cords helically wrapped around the individual wire or by layers wrapped around the wire but the woven cloth covering is additionally advantageous in that it resists forces which tend to displace it or open it to expose the wire, and this resistance is utilized when the outer tube is swaged inwardly to compact the refrasil insulative material.

The covered wire is formed into a continuous helical shape as shown by the coil in FIGURE 5. While the insulative sleeve 13 could be stripped onto the wire with the wire being previously helically shaped, it is advantageous to utilize a straight covered wire such as illustrated in FIGURE 4 and form the covered wire into a helical shape.

The helixes of the coil are preferably closely formed with an outer diameter substantially the same or very slightly less than the inner diameter of the tube 10 so as to be readily axially passable or slidable into the tube. The helical coil is then slid completely into the tube in an axial direction as indicated by the arrowed line 14 to fill the tube. The resistance wire 12 of course keeps completely insulated and covered during this operation and any rubbing of the outer surfaces of the helical coils against the inner surface of the tube is not sufficient to displace the insulation. This provides a much more simple and less expensive operation than attempting to place bare helically coiled wire within the tube surrounded by particulate material in such a manner that the coils remain evenly spaced from the inner surface of the tube and remain spaced from each other. The wire is necessarily lightweight and the coils are easily shifted or bent, but in the form shown in FIGURE 4 they readily maintain their shape since they are supported in an axial direction by the insulation between adjacent coils of wire. Further they receive support in their radial direction from the inner surface of the tube as they are slid therein thus insuring that the assembly will be made successfully and a minimum amount of rejects will occur due to manufacturing accidents.

As illustrated in FIGURE 6, the tube 10 is then swaged or radially compressed inwardly to reduce its diameter. This compacts and compresses the refrasil cloth to provide a firm insulation surrounding each of the helical coils of the wire 12. The refrasil cloth covering will actually assume a rectangular shape as it fills in the voids, but each coil of wire is fully protected and surrounded and held in its spaced position during compacting.

The swaging is accomplished by the application of radially inwardly directed forces as indicated by the arrowed lines 15. The application of impact in high pressure forces around the outer periphery of the tube will reduce its circular cross-section and the inner surface will move inwardly against the insulative material. If desired the compacting can be conducted to completely close the space at the center of the helical coils or a very small space can remain. If desired, an axial force can be applied to the ends of the coils before compacting so that the insulative material will be somewhat tightly compacted in an axial direction before the radial compacting occurs.

The swaging should be on the order to decrease the diameter of the tube between 10% to 40%. The swaging is of course accomplished by applying a force completely around the periphery of the tube and for its entire length and this may be done by placing the tube between mating metal dies having substantially semi-cylindrical grooves therein.

The resultant product will have the appearance as described in connection with FIGURES 1 and 2, and each of the coils of the wire will be very firmly held and will be completely uniformly spaced in both an axial and a radial direction by the compacted refrasil material.

The refrasil material is well adapted to operating at high temperatures in the range of the Canthal wire which can operate at 2460° F. It will pass 90% of the radiant heat from the wire 12.

The heater is well adapted for various uses, and can, for example, be shaped and supported with molten metal poured around the tube to form a heater block or plate with the cast metal in intimate contact with the metal of the sheath but separated from the insulated wire by the tubular sheath 10. Since the wires are uniformly held and spaced by the insulative material which is held compacted by the tube, forces of the metal poured around the tube, and forces of expansion and contraction will have no adverse effects.

In summary, as shown in FIGURE 1, the electrical resistance wire 12 is held within a sleeve of woven refrasil cloth 13 which is compacted and compressed in an amount approaching unit density by the swaging of the outer metal sheath 10.

Thus it will be seen that I have provided an improved electrical heater which meets the objectives, advantages and features above set forth, and which is capable of efficient high temperature operation and of producing and distributing heat energy at a greater rate per unit of length and size.

The drawings and specification present a detailed disclosure of the preferred embodiments of the invention, and it is to be understood that the invention is not limited to the specific forms disclosed, but covers all modifications, changes and alternative constructions and methods falling within the scope of the principles taught by the invention.

What is claimed is:

A heating element comprising in combination, an elongate circular tubular bendable metal outer enclosure, a helically coiled resistance wire within the enclosure with the coils of the wire uniformly spaced from each other and uniformly spaced from the inner surface of the tubular enclosure, a wire cover of woven refrasil heat resistant insulating material being initially tubular and uniformly woven around the wire and being of uniform thickness around the wire and shaped helically with the wire, said wire being radially compressed within the tubular enclosure with the cover being deformed and compacted to fill substantially all of the voids within the enclosure so that the helical wire coils are positively held in their spaced relationship with bending of the tubular enclosure along its axis and so that there will be uniform heat transferral to the outer surface through the refrasil material.

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