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SHEATHED HEATING ELEMENT

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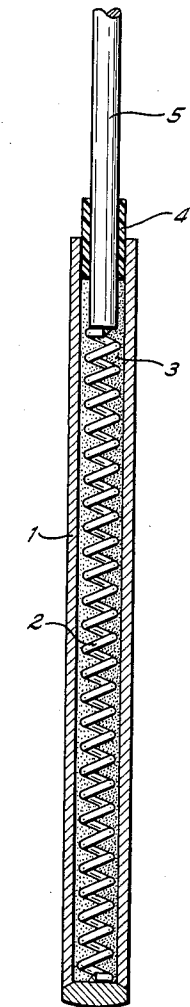


Fig. 1

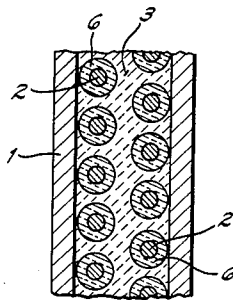


Fig. 2

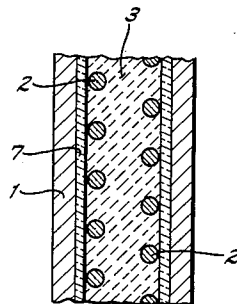


Fig. 3

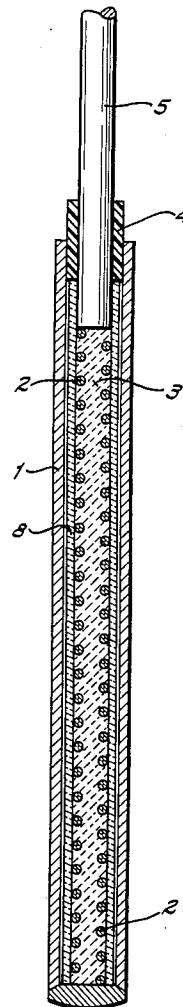


Fig. 4

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SHEATHED HEATING ELEMENT

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1 Claim. (Cl. 338-243)

This invention relates to sheathed electric heating elements and their method of manufacture, and has more particular application to glow-plugs as used in compression ignition engines and their manufacture.

In the manufacture of sheathed electric heating elements it is common practice to place an electric coil within a tubular sheath and then to fill the sheath with a refractory material, such as magnesium oxide. The magnesium oxide completely fills the sheath and surrounds the coil to provide an electrically insulating and yet heat conducting medium between the coil and sheath. Further, although the magnesium oxide which is disposed between the electric coil and the sheath is a good heat conductor it is very advantageous, from a heat transfer standpoint, to position the electric coil as near as possible to the tubular sheath. Theoretically, the ideal relationship between electric coil and sheath is to have the electric coil disposed concentrically within the sheath and as near as possible to the sheath. Generally, after insertion of the magnesium oxide, a swaging operation is performed on the sheath to reduce its diameter. When a sheathed electric heating element is manufactured in accordance with the just outlined procedure, it is possible for the electric coil to be displaced from its concentric relationship with the sheath and contact the sheath to short out a length of the coil and render the heating element inoperative, necessitating rejection of the shorted heating element.

This problem of maintaining adequate spacing between the electric coil and the sheath is inherent in any tubular sheathed electric heating element. However, the problem is further aggravated in the manufacture of glow-plugs because of the necessity for making the glow-plug as small as possible. This necessity is dictated by the fact that space in a combustion ignition engine is at a premium and the smaller the glow-plug can be made the greater will be its application in a combustion ignition engine. Therefore, the problem of spacing between the electric coil and the tubular sheath becomes quite critical and where a swaging operation is performed the danger of contact between coil and sheath is much greater because of the limited amount of clearance between the coil and sheath.

To more particularly point out the problem involved, and which this invention solves, application to a typical glow-plug design will be discussed. In a typical glow-plug the tubular sheath has an outside diameter of .250 of an inch and an inside diameter of .200 of an inch. The electric coil used in the glow-plug has an outside diameter of .145 of an inch leaving a peripheral clearance between the electric coil and the inner surface of the tubular sheath of .0275 of an inch. This assumes that the coil is disposed concentrically within the tubular sheath. As can be seen any minor deviation of the electric coil from the axis of the tubular sheath may bring a portion thereof into contact with the tubular sheath. Moreover, any irregularity in the outside diameter of the coil may also bring a portion of the electric coil into engagement with the sheath. By providing a permanent electrically insulating and heat conducting spacing medium between the electric coil and the tubular sheath we positively insure the maintenance of a minimum spacing therebetween and a concentric relationship between elec-

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tric coil and sheath. Therefore the fabrication of the electric coil need not be as accurate as it is not necessary to maintain close tolerances on the outside diameter thereof, and moreover the assembly of the electric heating element is facilitated in that the electric coil is held spaced from and in substantial concentric relationship with the sheath by virtue of the permanent spacing medium.

We have discovered that by permanently interposing an electrically insulating and heat conducting material between the electric coil and sheath it is possible to insure a predetermined minimum spacing and a concentric relationship between the coil and the sheath. The spacing material is used in addition to the commonly used magnesium oxide and will maintain spacing during assembly and further during any swaging operation. Any one of a number of suitable materials can be used as the spacing material, the prime requirements being that it be compatible in function to the magnesium oxide so as not to lower the overall efficiency of the final heating element and that it be stable at high temperatures so that a permanent spaced relation is maintained in the heating element.

One substance which has worked particularly well in practice is a ceramic cement consisting of finely divided magnesium oxide in a suitable binder. V-gum binders have been proven to possess the necessary characteristics for use in the spacing material.

In accordance with our invention the electrically insulating and heat conducting material is so disposed with relation to the electric coil and the sheath as to prevent any contact therebetween. Hence it would be entirely adequate to coat that portion of the electric coil which might normally contact the sheath, namely the outer periphery thereof. However, for production reasons it is more advantageous to coat the entire coil. The coating of the electric coil can be accomplished in any one of a number of well known ways, for example by dipping the electric coil in unset ceramic cement and allowing the cement to set and completely enclose the coil prior to insertion of the coil into the tubular sheath. Alternatives, which have worked equally as well, are to coat the inner surface of the tubular sheath or to provide a tube of ceramic cement which fits over the coil and between it and the sheath. Either expedient provides a spacing medium intermediate the electric coil and sheath to maintain a permanent substantially concentric spaced relationship therebetween. The practice of our invention makes it possible for the first time to manufacture electric heating elements of any size without the fear of shorting out a length of the electric coil through contact of the coil and the tubular sheath. Particularly, it is possible to manufacture sheathed electric heating elements, such as glow-plugs, of reduced diameter without the danger of numerous rejects and/or unnecessary reassembly of heating elements.

Accordingly, it is an object of our invention to provide a new and improved electric heating element and method of manufacturing such an electric heating element.

Another object of our invention is to provide a permanent spaced relation between the electric coil and sheath of a sheathed electric heating element.

A further object is to provide a method of manufacturing a heating element where the electric coil is placed in closer proximity to a tubular sheath, as compared to prior art methods, to insure efficient heat transfer relation therebetween and without the danger of shorting out a length of the electric coil.

A still further object is to provide a sheathed electric heating element and a method of manufacturing such a heating element wherein a spaced substantially concen-

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tric relationship is maintained between the electric coil and sheath.

In order to more completely disclose the characteristics of our invention the following specific description thereof will be made in connection with the drawings in which:

FIG. 1 illustrates a heating element embodying our invention;

FIG. 2 is a partial cross sectional view of the heating element of FIG. 1;

FIG. 3 is a partial cross sectional view of an alternative embodiment of our invention; and

FIG. 4 illustrates a still further embodiment of our invention.

Since our invention has particular application to glow-plugs and the manufacture thereof, it is described in relation to a typical glow-plug construction. However, it should be noted that the teachings of our invention are equally applicable to the manufacture of any tubular electric heating element. For convenience only the tubular electric heating element portion of the glow-plug is illustrated in the drawings and the plug body has been omitted.

Referring to FIG. 1, a generally tubular metallic sheath 1 is illustrated as having an electric coil 2 disposed therein. The electric coil 2 is surrounded by a refractory material such as magnesium oxide 3 which substantially fills the interior of the metallic sheath 1. General practice is to fill the tubular sheath 1 with magnesium oxide so that the coil 2 is completely embedded therein. The upper end of the sheath 1 is preferably sealed by a silicone plug 4.

The electric coil 2 is preferably welded to the lower end of the tubular sheath 1. The opposite end of the electric coil 2 is suitably connected to a terminal member 5, which is in turn connected to a source of electric energy (not shown). Since the metallic sheath 1 will be in electrical engagement with the engine block (which is at ground potential) through the plug body, an electric circuit is established which permits current to flow through the electric coil.

As more clearly illustrated in FIGS. 2, 3 and 4, a portion of the electric coil 2 is disposed adjacent to a portion of the tubular sheath 1, which portions may come into engagement and short out a length of electric coil and render the electric heating unit useless. To maintain a predetermined minimum spacing and substantial concentric relationship between the electric coil 2 and the tubular sheath 1 a heat conducting and electrically insulating material is disposed therebetween. As shown in FIG. 2 this material, preferably a high temperature ceramic cement, takes the form of a coating 6 completely surrounding the electric coil 2. This coating maintains the electric coil and the tubular sheath in substantially concentric spaced relation. Thus, regardless of any tendency for the electric coil to be displaced, a minimum spacing is maintained between the coil and the tubular sheath.

The method of manufacture in accordance with our invention is then to dip the electric coil in unset ceramic cement; allow the cement to set; insert the coated electric coil into the sheath; connect one end of the coil to the sheath and the other end to an electrical terminal member; fill the sheath with magnesium oxide; seal the open end of the sheath; and, if desired, swage the tubular sheath to reduce its diameter to any suitable size.

An alternative embodiment of this invention is illustrated in FIG. 3. In this alternative a portion of the tubular sheath 1, the inner surface thereof, adjacent the

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electric coil is provided with an electric insulating and heat conducting coating 7. The coating 7, again of a high temperature ceramic cement, is applied to the inner surface of sheath 1 in any suitable manner. Here also the coating 7 prevents any contact between the electric coil and the tubular sheath and maintains a substantially concentric spacing therebetween. The method of assembly of this embodiment is identical to that of the embodiment of FIG. 2 with the exception that here it is the inner surface of the sheath which is coated prior to insertion of the coil.

In the embodiments illustrated in FIGS. 2 and 3 the thickness of coating is preferably maintained at approximately .022 to .025 of an inch after setting.

A still further embodiment is illustrated in FIG. 4. Here a tube 8 is disposed over the coil and between it and the sheath to maintain a permanent concentric spaced relationship therebetween. The tube 8 consists of finely divided magnesium oxide in a suitable binder and is fired at a predetermined temperature which is above the normal operating temperature of the glow-plug so that the tube will not break down during operation.

The method of assembly of the embodiment of FIG. 4 is as follows, finely divided magnesium oxide in a suitable binder is fired at a predetermined temperature to form a hollow tube preferably .020 thick; the tube is inserted in the sheath and fits to within .003 or .004 of an inch of the inner surface of the sheath (the spacing between sheath and tube has been exaggerated in the drawing for convenience); the electric coil is connected to its terminal and inserted in the tube; the free end of the coil is welded to the sheath; and the sheath is filled with magnesium oxide.

The description of this invention in relation to specific embodiments thereof is intended for illustrative purposes only and accordingly it is intended, in the appended claim, to cover all modifications and embodiments of our invention as fall within the true spirit and scope thereof.

What we claim is:

The method of manufacturing a small diameter sheathed heating element having a heater coil disposed within a tubular electrically conductive sheath for the glow plug assembly of a compression ignition engine, comprising the steps of forming a thin-walled tube of magnesium oxide adapted to fit closely within said sheath, firing said tube at a temperature higher than the temperature of operation of said glow plug assembly within said compression ignition engine, inserting said tube within said sheath, inserting said heater coil within said tube, whereby said coil is retained with accurate concentricity within said sheath, closing one end of said sheath and simultaneously electrically connecting said one end of said sheath to one end of said heater coil, filling the interior of said sheath having said tube and said coil therein with magnesium oxide, closing the other end of said sheath with a member electrically insulating said heater coil from said sheath, and swaging said sheath to reduce its diameter and minimize the thickness of heat conducting and electrically insulating material between said coil and said sheath.

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