Feb. 15, 1966 R. D. BAXTER 3,234,633

METHOD OF MAKING A SHEATHED ELECTRIC HEATING UNIT

Filed Sept. 28, 1962

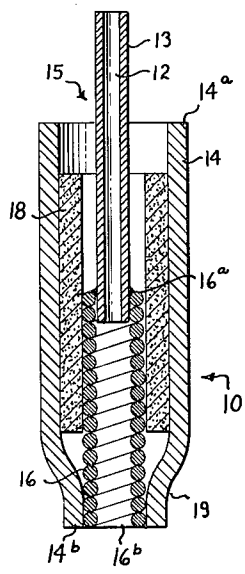


FIG. 1

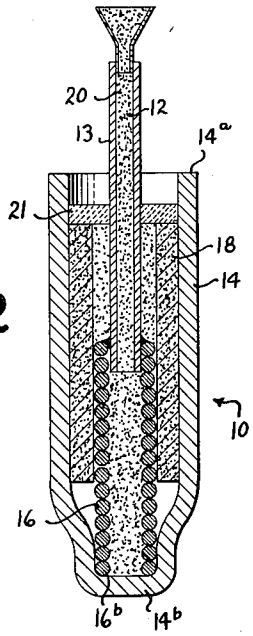


FIG. 2

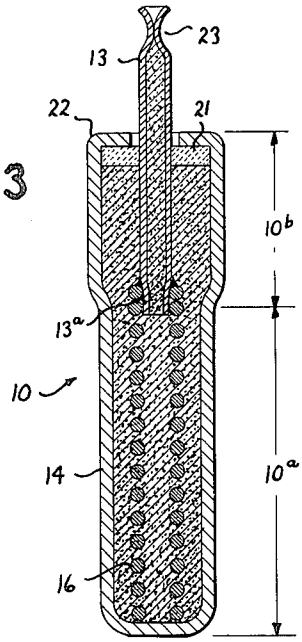


FIG. 3

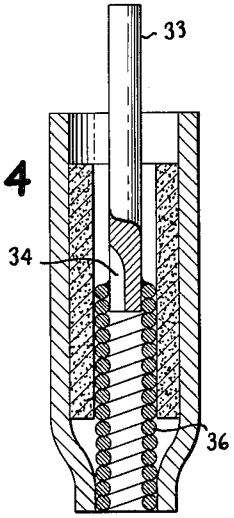


FIG. 4

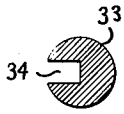


FIG. 5

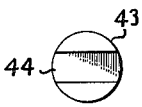


FIG. 7

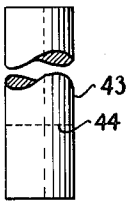


FIG. 6

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METHOD OF MAKING A SHEATHED ELECTRIC HEATING UNIT

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This invention relates to a sheathed electric heating unit and to a method of making the same. It is particularly applicable to glow plugs which are commonly used in ignition systems such as, for example, in the ignition systems of diesel engines.

In the typical glow plug design, a heating element, usually in the form of a coil of resistance wire, is imbedded in compacted insulating material within an outer metallic sheath. One end of the heating coil is electrically connected to the tip end of the sheath, typically by welding the end of the coil to the sheath at that point, and the other end of the coil is electrically connected to a terminal which extends from the sheath at the end of the plug opposite the tip.

It is important in such a unit from the standpoint of ensuring adequate operating life that the coil of resistance wire be properly centered in the sheath to prevent the development of a short circuit between the coil and the sheath, and also that the diameter of the wire be selected in light of the other design parameters to avoid operation of the coil at excessively high temperatures. In general, it is desirable that the diameter of the resistance wire be as large as possible within the physical confines of the design, taking into account, of course, the other design parameters involved. For a given heat dissipation rate, a larger wire diameter provides a greater wire surface area and therefore reduces the heat dissipation rate per unit surface area of the wire. This permits the attainment of a longer operating life for the unit.

In addition to the foregoing factors, it is also important that the spacing between adjacent turns of the heating coil be uniform along the length of the sheath, particularly near the tip end of the plug. Uneven spacing of the coil turns causes some portions of the unit to run hotter and others to run cooler than the desired temperature, although a slightly closer coil spacing may be desirable near the terminal end of a glow plug because in the typical installation some of the heat is usually conducted away from the plug through the terminal end. It is particularly important, however, to avoid excessive spacing near the tip of the plug because this causes the tip or working end of the plug to run cooler than the rest of the unit.

A typical method which has been heretofore used to manufacture glow plugs involves welding a coil of resistance wire to one end of a sheath, attaching a terminal to the opposite end of the coil and then stretching the coil longitudinally within the sheath to center it while granulated insulating material is loaded into the sheath. Stretching of the coil permits it to be held in a center position in the sheath and it also allows the granulated insulating material to flow into the center of the coil through the resulting spaces between the coil turns.

The welding of the coil to the sheath, however, anneals and softens that end of the coil so that the above-mentioned stretching technique causes the coil to stretch by a greater amount near the tip end of the plug, thus producing a greater spacing between adjacent coil turns and causing the tip end of the plug to run cooler than the rest of the unit. In addition, the requirement for stretching reduces the diameter of the resistance wire which can be accommodated because the spaces between the adjacent coil turns produced by the stretching represent spaces which could at least partially be occupied by wire of a greater diameter.

Attempts to avoid these problems by reducing the amount of tension applied to the terminal have, however, met with difficulties because the problem of centering the coil in sheath becomes more acute and the reduced spacing between the adjacent coil turns impedes the flow of granulated insulating material into the center of the coil. Attempts to compromise between the foregoing factors have produced difficulties with respect to cooler than desired operating temperatures near the tip of the plug, adequate centering of the coil in the sheath and the attainment of proper operating life through the use of optimum resistance wire diameters.

Accordingly, it is an object of this invention to provide an improved sheathed heater of the glow plug type having an increased operating life.

It is another object of this invention to provide an improved sheathed heater of the glow plug type having a more uniform spacing between coil turns, particularly near the tip end of the unit, while retaining accurate centering of the coil within the sheath.

It is still another object of this invention to provide an improved method of manufacturing a sheathed heater of the glow plug type which avoids the necessity for stretching the heating coil or displacing adjacent turns of the coil from each other during the loading of insulating material into the unit.

Briefly stated, these and other objects of this invention are accomplished, in one embodiment thereof, by placing a frangible tube of solid insulating material between the outer diameter of a heating coil and the inner wall of a sheath to center the coil in the sheath. Granulated insulating material is then loaded into the center of the coil through a duct, which in one embodiment extends through a hollow terminal which is connected to the coil. The frangible tube of insulating material is then crushed and compacted along with the granular insulating material in the final compression of the unit.

Because stretching of the coil is not required, a more uniform spacing between the coil turns, particularly near the tip end of the unit, is obtained. In addition, since the granulated insulating material is not required to flow between the adjacent coil turns into the center of the coil, a closely wound coil may be used, thus permitting the utilization of a maximum wire diameter.

For a thorough understanding of this invention, reference may be had to the following description, taken in connection with the accompanying drawing in which:

FIG. 1 is a cross-sectional view of a glow plug, at an intermediate stage of manufacture, embodying this invention and illustrating the initial steps of the method of this invention.

FIG. 2 is a cross-sectional view of the glow plug of FIG. 1 at a subsequent stage of manufacture and during the insulation loading operation.

FIG. 3 shows the glow plug of FIGS. 1 and 2 in its completed form.

FIG. 4 shows, in vertical cross-section, a glow plug similar to that of FIGS. 1–3 but embodying a modified terminal arrangement.

FIG. 5 shows an enlarged coil-end view of the terminal of FIG. 4.

FIG. 6 shows, in enlarged front view, a second modified terminal structure.

FIG. 7 shows an enlarged coil-end view of the terminal of FIG. 6.

Referring to the drawing, there is shown in FIG. 1 a partially completed glow plug **10** of this invention prior to the process step in which powdered insulating material is loaded into the unit. At this stage of the manufacturing process the glow plug assembly **10** comprises an outer sheath **14**, normally constructed of metal or other

electrically conductive material, in which is disposed a heater assembly shown generally at **15**. The heater assembly **15** comprises a heating element in the form of a coil **16** of resistance wire and a terminal **13** which is attached to one end **16***a* of the coil **16**. A tube **18** of frangible insulating material is slidably mounted between the inner wall of the sheath **14** and the outer diameter of the coil **16** to center the coil in the sheath. The tube **18** may be of any suitable insulating material, such as magnesium oxide.

A duct **12** extends through the terminal **13** and is shown in FIGS. 1–3 in the preferred form of a passageway extending through the center of the terminal **13**. In other words, the terminal **13** is hollow or tubular. The duct **12** provides a communicating passageway between the exterior of the coil **16** and its central or core portion through one end of the coil and, as will be explained later on in greater detail, the duct **12** may take other forms than the particular one illustrated.

To reach the point in the assembly shown in FIG. 1, the terminal **13** is attached to the upper end of the coil **16***a* by welding or in any other suitable manner and the assembly thus formed is then inserted in the open end of the sheath **14**. The sheath is crimped as shown at **19** to hold the lower end **16***b* of the coil tight and flush with respect to the end **14***b* of the sheath. The tube **18** of insulating material is placed in the sheath as shown in FIG. 1 to center the coil in the sheath. The lower end of the tube **18** bears against the reduced diameter portion of the crimped section **19** of the sheath.

At this point in the process, the lower end **14***b* of the sheath is welded closed, simultaneously joining the end **16***b* of the coil to the sheath so as to make an electrical connection therebetween as can be seen in FIG. 2. The steps of connecting the lower end **16***b* of the coil to the sheath and of closing the lower end of the sheath may of course be accomplished in any suitable fashion although I have found it convenient to accomplish both of these steps with a single welding operation as described above.

With the coil **16** remaining in its normal unextended position, accurately centered by the tube **18** of compressed insulating material, powdered insulating material **20** is introduced into the interior of the coil **16** through the top or open end of the duct **12** in the terminal **13**. For satisfactory loading and subsequent compacting, the heating unit is preferably vibrated during the loading process. Any suitable powdered material may be used, magnesium oxide being very satisfactory. It has been found desirable to fill the interior of the duct **12** with powdered insulation also since this prevents a void through which the powdered insulating material could otherwise flow from the center of the coil during subsequent swaging and compression of the sheath. The space at the top of the coil between the terminal **13** and the tube of insulating material **18** is also filled with powdered insulating material.

A closure member, which is shown in FIG. 2 in the form of a disk **21** of insulating material, may then be inserted in the open end **14***a* of the sheath **14** although it will be appreciated that with the duct **12** in the form shown in FIGS. 1–3, the loading of the powdered insulating material through the duct **12** may be accomplished with the disk **21** in place. With this latter approach, the disk **21** may be utilized to center the terminal **13** during the loading operation.

To complete the production of the heating unit, the upper end of the sheath is bent at **22**, as shown in FIG. 3, to hold the disk **21** firmly in place and the upper portion **23** of the terminal **13** is crimped or plugged to prevent loss of insulating material from the unit. The unit is then swaged or otherwise compressed down to its final dimensions.

The final swaging or compression operation crushes the tube of insulating material **18** and compacts this crushed insulation along with the powdered insulating material which has been loaded into the sheath. In the production of the heater shown in FIG. 3, the diameter of the unit is reduced to two different dimensions. The portion **10***a* which includes the coil **16** is reduced to a smaller diameter than the remaining portion **10***b*. It should be noted at this point that the hollow terminal **13** provides a secondary advantage in that the terminal is squeezed down to a smaller diameter along with the coil **16** to provide additional radial clearance between the upper end of the coil and the sheath than would otherwise be available with a solid terminal where no similar reduction in diameter would occur. In the past it has been found necessary in some designs to utilize a smaller diameter wire around the terminal in order to avoid the problem of reduced radial clearance between the coil and the sheath at this point but the adaptability of the hollow terminal to a reduction in diameter avoids this necessity.

The compression and reduction of diameter of the unit elongates and spaces the turns of the coil **16**. The turns are uniformly spaced except that a slightly closer spacing is obtained near the coil-terminal joint because of the transition to the upper area where the degree of compression and elongation is less than at the lower end of the unit. This closer spacing at the coil-terminal joint has been found to be advantageous in that it increases the density of heat generation at this end of the unit where in the typical installation some of the heat is usually conducted away from the plug through the terminal end.

FIGS. 4 through 7 reveal two modified terminals providing ducts through which powdered insulating material may be introduced into the interior of the heating coil unit. In FIG. 4 a solid rod-type terminal **33** having a duct or keyway **34** formed therein is shown affixed to one end of a coil **36**. This modification is more clearly shown in the coil end view of the terminal **33** in FIG. 5. The slot **34** forms a passageway communicating with the interior of the coil **36** through the upper end of the coil and through which powdered insulating material may be loaded into the center of the coil.

Another alternative arrangement is shown in FIGS. 6 and 7. In this embodiment the coil end of a rod-type terminal **43** is provided with a duct or slot **44** which forms a passageway through which insulating material may flow into the interior of the heating coil.

It should be noted that in the embodiments of FIGS. 4 through 6 the ducts which communicate with the center of the coil do not extend externally from the sheath and, accordingly, need not be externally closed off prior to the final swaging operation. On the other hand, with this type of duct structure, the loading of the insulating material into the center of the coil must be accomplished before the open end of the sheath is closed off. Such alternative duct arrangements may be extended, of course, beyond the open end of the sheath but the extended duct portion should then be closed off or suitably plugged before the final swaging operation as is done in the case of the embodiment shown in FIGS. 1–3.

It will be observed that the foregoing method avoids the necessity for stretching the heating coil to center it in the sheath during the loading operation. Accordingly, the problem of excessive stretching of the coil near the welded end is avoided. In addition, it will be noted that with the use of duct means communicating with the center of the coil through one end thereof to accommodate the loading of the powdered insulating material into the center of the coil, the need for stretching the coil to permit the insulating material to flow between adjacent turns of the coil is also eliminated. Such a technique therefore permits the use of a closely wound coil with the turns of the coil being closely adjacent or even touching each other in the unstretched state, thereby allowing the use of a maximum resistance wire diameter. In other words, the use of a space wound coil, that is, a coil in which the turns are spaced relatively far apart in the unstretched state to permit insulating material to flow into the center of

the coil through the spaces between the turns, is not required.

It will thus be observed that my invention produces an improved heating unit in which the heating coil is accurately centered within the sheath with the adjacent turns of the heating coil being more uniformly spaced and with a greater amount of heating wire being accommodated in the unit. The foregoing advantages take the form of a heating unit of substantially improved quality with a significantly increased operating life capability.

It will be appreciated, of course, that various modifications may be made in the structures and in the process steps which I have described. For example, the tube **18** of insulating material may be made up of a number of separate elements and may be in a different form than the particular one which I have illustrated. In addition, various alternative methods of securing the terminal to the heating coil and of closing the ends of the sheath may be employed. The duct which communicates with the center of the coil to accommodate the loading of the powdered insulating material into that area may, of course, take various forms and I have illustrated several alternative approaches in this regard. Another approach would be to provide duct means into the coil through one end thereof independently of the terminal structure, although I prefer to combine the duct with the terminal.

Thus, while I have described several embodiments of my invention in considerable detail it should be appreciated that I have done this for purposes of presenting a full and clear description and that my invention is not limited to the particular details which I have presented. Accordingly, it is to be understood that various changes, modifications and substitutions may be made in the subject matter presented herein without departing from the true scope and spirit of my invention as I have defined it in the appending claims.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of making a sheathed heating unit comprising the steps of:

(a) attaching a generally hollow open-ended unextended helical heating element to a terminal having a duct which communicates with the interior of the element to form a heater assembly,

(b) inserting said assembly in a sheath,

(c) placing at least a portion of a frangible cylindrical member of insulating material between the inner wall of the sheath and the heating element to center the heating element with respect to the sheath,

(d) closing one end of said sheath,

(e) introducing insulating material through said duct of said terminal into the interior of said element,

(f) closing the other end of said sheath, and

(g) compressing the unit to extend said heating element and compact said insulating material.

2. A method of making a sheathed heating unit comprising the the steps of:

(a) attaching one end of an unextended coil to a terminal having a duct which communicates with the interior of said coil to form a heater assembly,

(b) inserting said assembly in a sheath,

(c) placing at least a portion of one frangible member of compressed insulating material between the coil and the inner wall of the sheath to center the coil in the sheath,

(d) closing one end of said sheath while simultaneously joining the free end of said coil to said one end of said sheath,

(e) introducing insulating material through said duct of said terminal into the interior of said coil,

(f) closing the other end of said sheath, and

(g) compressing the unit to extend said coil and compact said insulating material.

3. A method of making a sheathed heating unit comprising the steps of:

(a) attaching one end of an unextended coil to a terminal having a duct which communicates with the interior of said coil to form a heater assembly,

(b) inserting said assembly in a sheath so that the other end of said coil is adjacent one end of said sheath,

(c) inserting at least one frangible member of compressed insulating material between said coil and the inner wall of said sheath so as to surround at least a portion of said coil,

(d) closing said one end of said sheath while simultaneously joining said other end of said coil to said one end of said sheath,

(e) introducing insulating material through said duct of said terminal into the interior of said coil,

(f) closing the other end of said sheath,

(g) closing one end of said duct, and

(h) compressing the unit to extend said coil and crush said member of insulating material and compacting all of said insulating material.

4. A method of making a sheathed heating unit comprising the steps of:

(a) attaching one end of an unextended coil to a tubular terminal to form a heater assembly,

(b) inserting said assembly in a sheath so that the other end of said coil is adjacent one end of said sheath,

(c) inserting at least one frangible member of compressed insulating material between said coil and the inner wall of said sheath so as to surround at least a portion of said coil,

(d) closing said one end of said sheath while simultaneously joining said other end of said coil to said one end of said sheath,

(e) introducing insulating material through said terminal into the interior of said coil,

(f) closing the other end of said sheath,

(g) compressing the unit to extend the coil, to reduce the heating coil portion of said unit to one dimension and to reduce the remainder of said unit to a second, greater, dimension whereby said member of insulating material is crushed, all of said insulating material is compacted and the portion of said terminal attached to said coil is constricted to increase the clearance between said terminal and the inner wall of said sheath.

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