May 22, 1934. C. C. ABBOTT 1,959,776

ELECTRIC HEATING UNIT

Filed Dec. 3, 1929

Fig. 1.

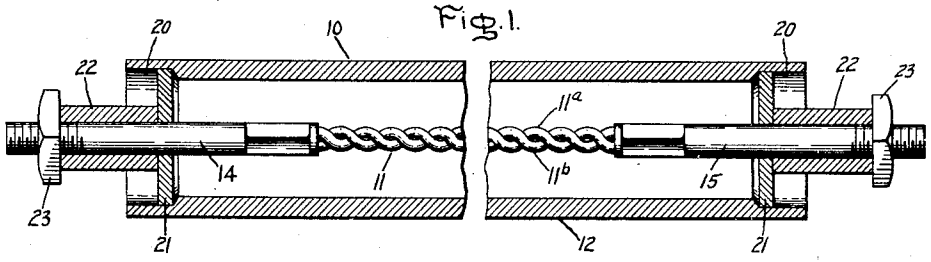


Fig. 2.

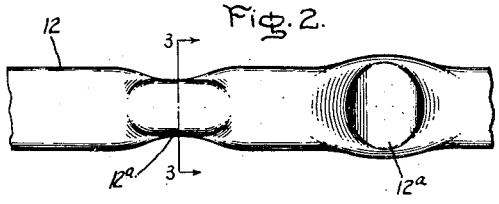
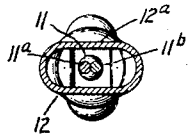


Fig. 3.



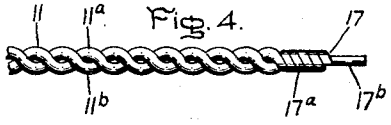


Fig. 4.

Fig. 5.

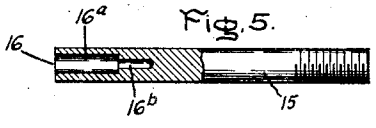


Fig. 6.

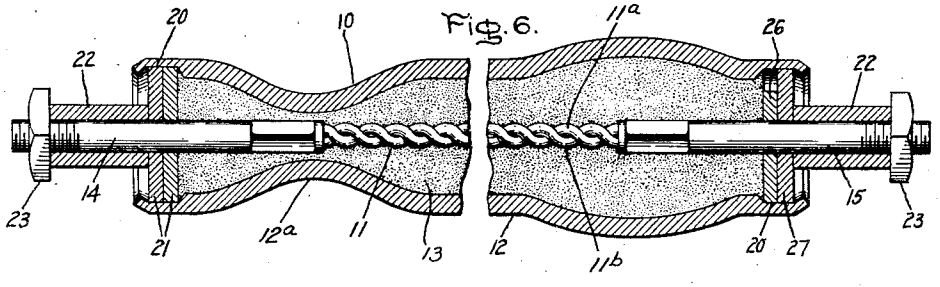


Fig. 8.

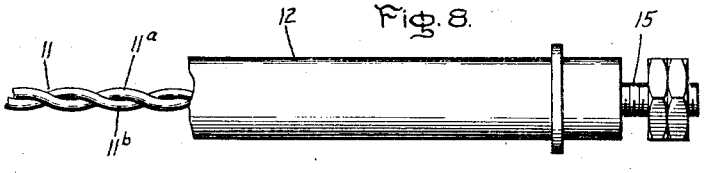
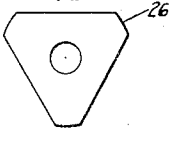


Fig. 7.



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UNITED STATES PATENT OFFICE

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ELECTRIC HEATING UNIT

Charles C. Abbott, Pittsfield, Mass., assignor to General Electric Company, a corporation of New York

Application December 3, 1929, Serial No. 411,372

4 Claims. (Cl. 201—67)

My invention relates to electric heating units, more particularly to electric heating units of the "sheath wire" type in which the resistance element is embedded in a compacted mass of insulating material enclosed by a metallic sheath, and has for its object the provision of an improved electric heating unit of this character, and a simple and efficient method of making it.

Electric heating units of the sheath wire type are now in common use in electric heaters and the like. Electric heaters of this type may have either a helical core of resistance wire or a straight core depending upon the service to which the heater is to be subjected. The resistance element or core generally is mounted centrally in the metallic sheath and is completely embedded in a powdered heat refractory insulating material, such as magnesium oxide, compacted around the resistance element in some manner as for instance by reducing the diameter of the sheath.

Often-times, particularly in relatively long heating units, it is desirable to use the straight core rather than the helical core as the resistance element because of the specific resistance required. However, it has been very difficult heretofore to make a relatively long continuous heating unit of this type with a straight core resistance element because during the swaging operation there was a considerable tendency for the straight core wire to break up into comparatively short lengths and thereby open circuit the heating unit.

This results from the fact that the metallic sheath stretches faster than the core wire resistance element and consequently, strains which often are sufficiently great to cause rupture, are set up in the core wire. Even though the core wire was not ruptured during the swaging operation, it was found that in the finished heater the core conductor often had a very irregular cross section, certain portions of the wire being reduced nearly to the breaking point thereby causing bad spots. The heating element in service frequently separated at these reduced portions because of the alternate extreme heating and cooling.

In an endeavor to overcome this difficulty, it has been customary to make the heating unit in several portions and join these portions so as to provide a unit having the requisite resistance and length. This practice proved to be more or less unsatisfactory because oftentimes the joints necessarily had to be located in very hot zones.

In one of its aspects, my invention contemplates the provision of a method for making an electric heater of the sheath core wire type whereby it is possible to form a continuous electric heating unit having any desired length within very wide limits.

In carrying my invention into effect in one form thereof, I provide a heating element of the core wire type by winding a plurality of electrical resistance conductors together in twisted form. During the swaging operation, the twist in the conductors will straighten out and thereby prevent an undue strain in the conductors. I have also provided suitable means for maintaining the elongated core wire resistance element central in the metallic sheath while the sheath is being loaded with the insulating material and during the initial swaging operation. For this purpose, I indent or otherwise shape the metallic sheath so as to provide flattened portions at a plurality of points. Preferably, the flattened portions will be positioned in the sheath in pairs, the portions forming each pair being positioned substantially at right angles to each other. It will be understood that the sheath at these flattened portions will be just large enough to receive the resistance element and thus, the element will be secured in its central position at a plurality of points spaced throughout the length of the sheath. After the sheath has been loaded with the magnesium oxide but before swaging, I compact the insulating material which is located between each pair of flattened portions so as to further insure the central location of the heating element.

I have further provided a simple and reliable connection between the terminal and the heating element whereby the unit may be swaged to any desired extent without injury either to the heating element or to the terminal. In carrying out this part of my invention, I have provided a recess in the terminal into which an end portion of the twisted element is inserted. Then the diameter of the terminal is reduced so that the metal of the terminal is forced into the spaces between the turns of the twisted element. This terminal connection is claimed specifically in my copending application, Serial No. 594,276, filed February 20, 1932, which is a division of this application.

For a more complete understanding of my invention reference should be had to the accompanying drawing in which Fig. 1 is a sectional view illustrating an electric heating unit constructed in accordance with my invention before the indenting operation; Fig. 2 is a fragmentary

view illustrating the metallic sheath after it has been indented so as to provide the flattened portions; Fig. 3 is a sectional view taken through the line 3—3 of Fig. 2; Fig. 4 is an elevation of a portion of the twisted heating element illustrating the element prepared for connection with its terminal; Fig. 5 is an elevation of the terminal partly in section illustrating the terminal prepared for connection with the heating element; Fig. 6 is a sectional view showing the assembled heating unit before the swaging operation; Fig. 7 is an elevation of one of the loading washers used in the insulating loading operation; and Fig. 8 is a partial elevation of the finished electric heating unit constructed in accordance with my invention.

Referring to the drawing, in one form of my invention the elongated heating unit 10 comprises a straight core wire resistance heating element 11 formed from a pair of twisted resistance conductors 11*a*, 11*b*, extending centrally of a metallic sheath 12. The resistance element is made from a suitable high resistance material having considerable resiliency, such as nickel-chromium alloy. The heating element 11 is embedded in a compacted mass of powdered heat refractory insulating material 13 such as magnesium oxide.

Metallic terminals 14 and 15 are provided for the heating element 11. Each terminal is provided with a stepped longitudinal recess 16 for receiving a correspondingly stepped portion 17 of the twisted heating element. The stepped terminal portion of the heating element is formed by a reduced twisted portion 17*a* of the end portion of the heating element and by the end portion 17*b* of one of the conductors which projects beyond the twisted portion, preferably in the axis of the element. It will be observed that when the terminal portion 17 is inserted in the stepped bore of the terminal, the reduced twisted portion 17*a* will be received in the larger terminal recess portion 16*a* and the projecting portion 17*b* will be received in the smaller recess portion 16*b*. Each terminal is compressed on its heating element terminal portion so that the metal of the terminal is forced into the spaces or grooves between the turns of the twisted core heating element. A very good electrical and mechanical connection is thus provided between the terminals and the heating element. It will be observed that before a terminal could be removed or pulled from the heating element, it would be necessary to strip the inner threads which are formed in the terminal recesses when the terminal is compressed on the unit.

In forming the heating unit in accordance with my invention, the electrical resistance elements 11*a* and 11*b* are loosely twisted together with a relatively short pitch to form the resistance heating element 11. While I have shown but two resistance strands wound about each other to form the twisted heating element, it is to be understood that several, as for instance three or four may be used if desired.

The terminals 14 and 15 are then attached to their respective end portions of the heating element 11. The heating element 11 is prepared for connection with the terminals 14 and 15 by providing the stepped end terminal portions 17. The projecting portion 17*b* may be formed by cutting off or otherwise detaching a portion of one of the conductors (11*a*, 11*b*) so as to leave the single strand. After this, the twisted end portion 17*a* of the heating element is swaged or otherwise reduced to approximately the diameter of the larger terminal recess portion 16*a*. It will be understood that the projecting portion 17*b* will be bent or twisted so as to lie in the axis of the heating element and further that the portion 16*b* of the terminal recess will have a diameter approximately equal to that of the projecting strand 17*b* so that it will just receive this portion. The terminal portion 17 is then inserted in the recess 16 of the terminal, after which the terminal is swaged or otherwise compressed, preferably to a square cross-section, so that its metal is forced into the grooves or spaces between the twisted conductors of the terminal portions 17*a* of the heating element.

This terminal arrangement is a very important feature of my invention. It will be understood that if the twisted core wire heating element were left full size to the end rather than having the stepped formation as shown, and the terminal were provided with a straight bore to receive it, the terminal would be so weak at the end of the core wire that it would practically draw in two at this point during the subsequent swaging of the assembled heating unit.

As has been pointed out, I provide the metallic sheath 12 with a plurality of flattened portions 12*a* positioned so as to maintain the heating element central during the insulating material loading operation and during the initial swaging operations. The sheath at these flattened portions will be sufficiently wide to receive the heating element but ordinarily will not be large enough for the terminals to pass through. Consequently it is generally necessary to assemble the heating element with the sheath before the indenting operation.

The metallic sheath 12 is prepared for the assembly of the heating element 11, first by providing its ends with counterbores 20 (Fig. 1) and then by thoroughly cleaning the interior of the sheath. The resistance element 11 with its terminals attached is then inserted lengthwise within the sheath as shown in Fig. 1 and preferably is placed under a slight tension to hold it straight within the sheath. It will be understood that the heating element will have a length sufficient to permit the terminals to project from the ends of the sheath. The heating element may be supported and tensioned in the sheath by placing washers 21 in the counterbores 20 and which fit on the terminal members so as to hold them centrally of the sheath. Suitable sleeves or collars 22 are then provided on the terminal members and are secured by means of nuts 23 which are turned on the threaded projecting end portions of the terminals. It will be understood that by turning the nuts 23 inwardly on the terminal portions, the heating element will be placed under a tension sufficient to hold it central within the tube and to prevent its kinking during the indenting operation.

After the heating element has been assembled with the sheath as shown in Fig. 1, the sheath is ready for the indenting operation. As shown (Figs. 2 and 3), the indents are placed in the metallic sheath so as to provide the flattened portions 12*a* in pairs with the axes of the adjacent portions positioned substantially at right angles to each other. It will be observed that by reason of this arrangement, the reduced portions of each pair taken together form a square-shaped retaining section around the resistance element (Fig. 3). It will be understood that a number of these pairs will be spaced at intervals along the length of the sheath.

It will be observed by reference to Fig. 3 that the passageway through the sheath at these flattened portions is sufficiently large to receive the heating element 11 and by reason of the fact that the adjacent flattened portions are arranged substantially at right angles to each other, the heating element will be secured centrally of the sheath at a plurality of points spaced at intervals throughout its length. However, it is very important that the reduced sections of the sheath be sufficiently large to prevent gripping of the resistance element at any point. Thus, generally there will be some clearance between the walls of the sheath and the element. It is preferable, therefore, to form each pair of flattened portions in the sheath at substantially 45° to the adjacent pairs. In other words one pair of indents will be formed with their axes substantially at 90° to each other. Then the sheath will be rotated about its longitudinal axis through 45° and another set of indents will be formed with their axes substantially at 90° to each other. In effect, therefore, the four indents of adjacent pairs taken together will form an octagonal shaped retaining section. This arrangement precludes any possibility of the element moving from its central position beyond the limits defined by the clearance between the resistance element and the side portions of the two square retaining sections formed by the adjacent pairs. It will be understood, of course, that if the axes of the flattened portions of each pair were not thus rotated relatively to the axes of the corresponding flattened portions of the adjacent pairs, the limits of the clearance would be defined by the distance between the surface of the resistance element and the corner portions of the square retaining sections.

It will be understood that the flattened portions will be spaced so that the heating element will be properly centered within the sheath but will not be positioned so close to each other that the passageway through the sheath will be restricted. Moreover, it will be understood that the indents will be placed in the sheath not only to maintain the heating element 11 central but also to maintain the terminal members 14 and 15 centrally of the sheath (Fig. 6).

After the sheath has thus been indented, the nuts 23, the sleeves 22 and the washers 21 are removed and the interior of the sheath is thoroughly cleaned so that any scale which might have become loosened by the indenting process is removed. The interior may thus be cleaned by blowing dry air through the sheath.

The sheath is now ready for the loading operation. The sheath is closed at one end, for example at the left hand end, as viewed in Fig. 6, by a pair of solid washers 21 which fit on the terminal 14 so as to hold the terminal centrally of the tube. These washers, as shown, are received in the left hand counterbore 20. The sleeve 22 is then positioned on the projecting end portion of the terminal 14 and is secured by means of the nut 23. The terminal 15 is secured in a similar manner centrally of the sheath by means of a triangular shaped washer 26 which is positioned in the counterbore 20 at the right hand end of the sheath. The resistance conductor 11 is placed under a slight tension by turning the nuts 23 inwardly on the terminals.

The sheath is now filled through the openings provided by the triangular washer 26 with the heat refractory powdered insulating material 13. To accomplish this, the sheath is held in an upright position in a special vibrating machine (not shown) with the end provided with the triangular washer uppermost. As the sheath is filled with the insulating material through the openings provided by the triangular washer, it is vibrated to shake the insulating material together and distribute it uniformly around the terminals and the resistance element. It will be understood that the powdered insulating material will readily pass through the flattened portions 12*a* to the lower portions of the upright sheath. When the sheath has been filled, a solid washer 27 which is similar to the washers 21 is inserted in place around the terminal 15 to close the sheath. The sleeve 22 and the nut 23 are then replaced and the core wire resistance element 11 is placed under a slight strain by turning the nut 23 inwardly on the terminal 15. The ends of the sheath are then turned over so as to secure the washers in the ends of the sheath.

After the sheath has thus been loaded with the powdered insulating material, I compact the magnesium oxide in these portions of the sheath between the flattened portions 12*a* around the core wire heating element. This further insures the central location of the heating element.

This compacting of the insulating material may be accomplished by striking the metallic sheath between each pair of flattened portions with a rather heavy impacting blow, as by hitting the sheath with a short split dye in a press. It has been found that this operation so compacts the magnesium oxide around the core wire that it will be held perfectly central within the sheath during the swaging operations. After the insulating material has thus been compacted, the nuts 23 and the sleeves 22 are again removed.

The entire unit is now passed through a swaging or rolling machine for the purpose of compacting the insulating material within the sheath to a hard dense mass, the swaging operation reducing the diameter and increasing the length of the unit. Several passes through the swaging machine generally will remove the flattened portions of the sheath bulging the flattened sides outward somewhat, and it has been found that the sheath will assume a complete cylindrical shape throughout its length. The sheath will lengthen somewhat faster than the core wire during the first two or three passes through the machine. In other words, the projecting terminals will be drawn within the sheath for a short distance. However, the insulating material will generally be sufficiently compacted by the first several passes to secure the terminals against further inward movement. The twisted core wire resistance during the swaging operation will be lengthened so that the original relatively short pitch of the wire will be greatly increased. Thus in one specific heating unit, the pitch which was approximately $\frac{3}{16}$'' before swaging was increased by the swaging operation to approximately $\frac{11}{16}$''. Moreover the terminals 14 and 15 are gradually reduced in diameter by the swaging, the recessed ends contracting arcund the resistance element.

It will be understood that if desired the heating unit may be annealed between successive swaging operations in order to prevent the resistance element and sheath from becoming hard and brittle.

By means of my invention, I have constructed heating units having comparatively long lengths. Thus, I have been able to construct heating units

having a final length of approximately 232" which were swaged from an original length of 112". The diameter of this heating unit was reduced by swaging from approximately ½" before swaging to .318" after swaging. It is to be understood, however, that units having much greater lengths may be constructed by my method.

After the unit has been swaged to the desired extent, the washers at each end are cut off or otherwise removed and the ends of the unit are squared off (Fig. 8). It will be understood that the terminals 14 and 15 will be held firmly in place by the compacted insulating material in which they are embedded. It also will be understood that the ends of the units may then be provided with any suitable terminal members such as those shown in the completed heater of Fig. 8.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The combination in an electric heating unit provided with a metallic sheath and powdered insulating material compacted in said sheath by reducing and elongating the sheath, of a resistance element embedded in said insulating material having substantially the relatively low resistance characteristics of a straight uncoiled resistance element, said resistance element being formed from a plurality of initially straight resistance conductors twisted together in electrical engagement with each other throughout substantially their entire lengths and being thereby longitudinally yieldable without deterimental effects on said resistance conductors when said sheath is reduced and elongated to compact said insulating material.

2. The method of making an electric heating unit having substantially the low resistance characteristics per unit length of a unit provided with a straight resistance element which comprises twisting a plurality of initially straight elongated resistance conductors together in electrical engagement with each other substantially throughout their entire lengths and with a relatively short pitch to form a resistance element, mounting said twisted conductors lengthwise in an elongated metallic sheath, filling said sheath with powdered insulating material and compacting said insulating material by elongating and reducing said sheath, the pitch of said twisted conductors increasing materially during said elongating and reducing operation to provide for elongation of said resistance element without excessive strains in and rupture of said conductors.

3. In an electric heating unit of relatively great length provided with a metallic sheath and powdered insulating material compacted in said sheath by reducing and elongating the sheath, a resistance element embedded in said insulating material having substantially the relatively low resistance characteristics of a straight uncoiled resistance element, and terminal members secured to the end portions of said element, said resistance element comprising a plurality of initially straight resistance conductors twisted together in electrical engagement with each other substantially throughout their entire lengths and being thereby longitudinally yieldable to provide for the reducing and elongation of said sheath sufficient to compact said insulating material without the detrimental effects on said resistance conductors due to excessive strains such as would be produced in a straight uncoiled resistance element having the same relatively great length.

4. The method of forming an electric heating unit which comprises winding a plurality of resistance elements together to form a twister resistance heating element, mounting said resistance heating element lengthwise within a metallic sheath, filling said sheath with powdered insulating material, swaging said sheath so as to compact said insulating material to a hard dense mass around said heating element with the end portions of said heating element released so as to prevent excessive strains in said resistance element during said swaging process.

CHARLES C. ABBOTT.