Feb. 24, 1959 W. H. NORTON 2,875,312

HEATING ASSEMBLY AND METHOD OF PRODUCTION THEREOF

Filed Sept. 27, 1956

2 Sheets-Sheet 1

Fig. 1

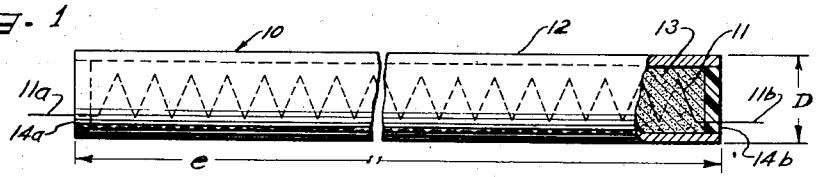


Fig. 2

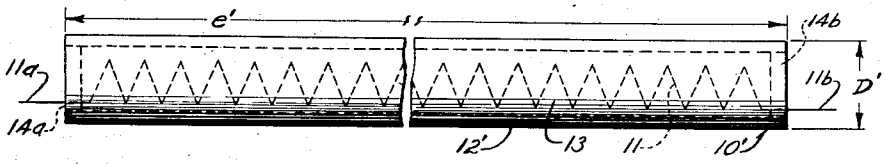


Fig. 3

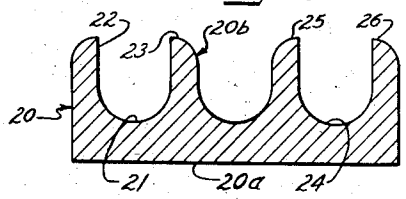


Fig. 6

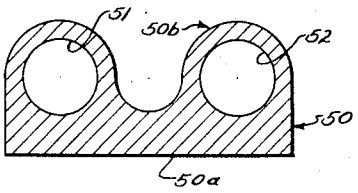


Fig. 4

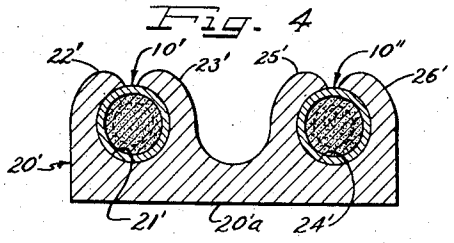


Fig. 7

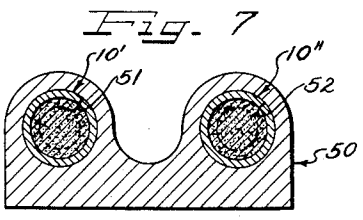


Fig. 5

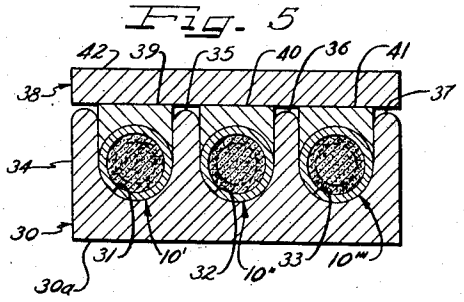
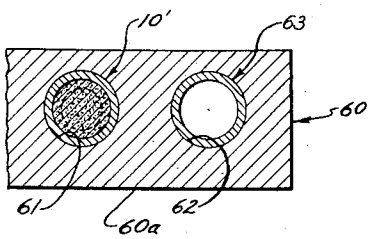


Fig. 8



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HEATING ASSEMBLY AND METHOD OF PRODUCTION THEREOF

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Fig. 9

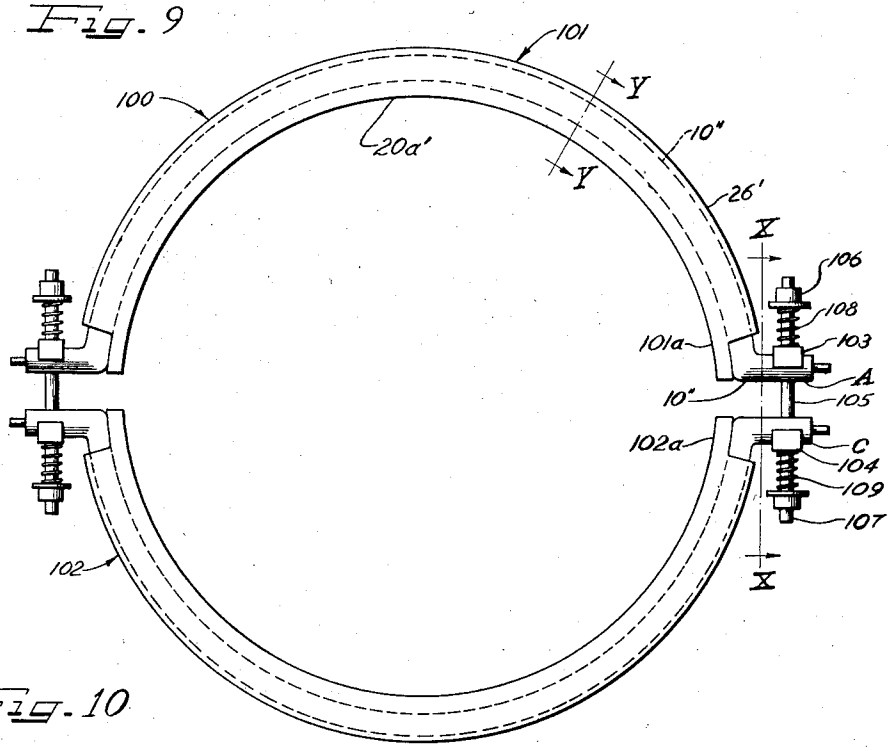


Fig. 10

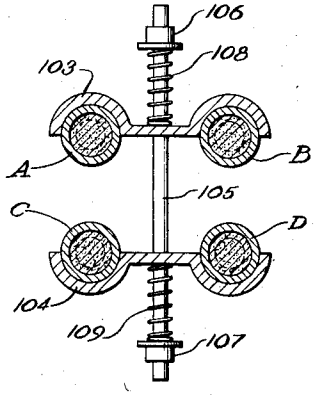


Fig. 11

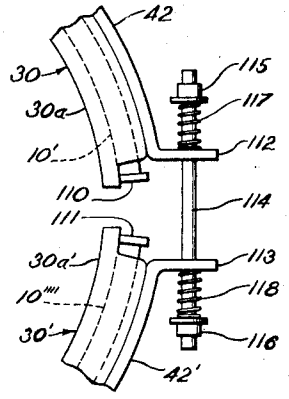
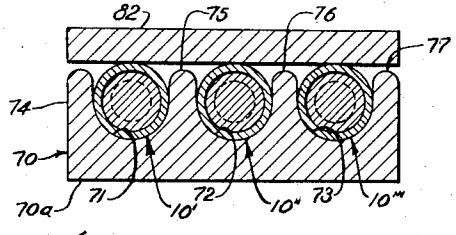


Fig. 12



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2,875,312

HEATING ASSEMBLY AND METHOD OF PRODUCTION THEREOF

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Application September 27, 1956, Serial No. 612,390

3 Claims. (Cl. 219—19)

This invention relates to a heating device, and more particularly, to an electrical heating unit adapted for cooking or similar heating operations.

In general, there are two types of cooking units employed. One type, known as the "surface" type, involves the use of a heating element mounted on a base of an open refractory support. This type of unit has interest and popularity with the development of refractory thermally conductive and electrically insulative cement, but almost invariably this unit leaves something to be desired particularly because of the tendency for the heating element to separate from the cement because of their differences in thermal expansion.

The other type of unit is known as the "metal sheath" unit wherein the heating element is encased in and insulated from a sheet of metal. Such units have enjoyed considerable popularity because of their comparatively high efficiency and their speed of operation. Also, these units are employed industrially as a heating sheath for a pipe or similar conduit carrying material to be heated. The units may also be employed in flat platen form. These units have certain drawbacks, however, in that they are expensive to manufacture and they have a tendency to warp under usage. Both of these difficulties are caused to a substantial extent by the problem of providing a suitable electrically insulative mounting for the resistor or electrical heating element.

The instant invention provides an improved and simplified mounting arrangement for the resistor in a metal sheath unit. The assembling expense is materially reduced in the instant invention by the provision of sleeve-like units which retain the resistor therein in an extremely sturdy mounting and which may be bent or otherwise shaped as desired to conform with the ultimate shape of the metal sheath. One important aspect of the instant invention resides in the compacting of the particulate mounting material which is used to maintain the resistor and the sleeve in closely spaced relationship; and such compacting is effected by filling the sleeve (with the resistor therein) with suitable particulate refractory material and then swaging the sleeve to increase the length thereof and reduce the diameter thereof. Such sleeves are then mounted on the back of a suitable retainer and, when desired, are formed while in firm assembly with the retainer into the ultimate shape desired for the heating device.

It is, therefore, an important object of the instant invention to provide an improved electric heater, and method of producing the same.

Another object of the instant invention is to provide an improved electric heater member that is durable, sturdy, well protected and is capable of prolonged operation.

A further object of the instant invention is to provide an improved electric heater comprising an elongated resistor, an electrically and thermally conductive sleeve closely surrounding the resistor, electrically insulative refractory particulate material filling the sleeve and maintaining the resistor therein in closed spaced relation to the sleeve, said particulate material being compacted by swaging the filled sleeve to elongate the same at least 10%, and an electrically and thermally conductive retainer having a heating surface and a back side opposed thereto retaining the sleeve in firm assembly on the back side thereof.

Yet another object of the instant invention is to provide an improved method of preparing an electric heater that comprises mounting an elongated resistor within an electrically and thermally conductive sleeve, filling the sleeve with electrically insulative refractory particulate material and swaging said sleeve by the application of impact and high pressure forces around the outer periphery thereof to lengthen the sleeve by at least 10% while maintaining the resistor spaced from the inner periphery of the sleeve, whereby the particulate material is compacted.

Other objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed disclosure thereof and the drawings attached hereto and made a part hereof.

On the drawings:

Figure 1 is a side elevational view, with parts broken away and parts shown in section, of a sleeve unit employed in the preparation of the heating device of the instant invention;

Figure 2 is an elevational view, comparable to Figure 1, showing the sleeve unit of Figure 1 after it has been swaged to the size desired;

Figure 3 is an elevational sectional view of a retainer employed in the practice of the instant invention for mounting the sleeve of Figure 2;

Figure 4 is a sectional elevational view showing the retainer of Figure 3 mounting the sleeve of Figure 2 in assembled form;

Figure 5 is a sectional elevational view, comparable to Figure 4, but showing an assembly providing a different retainer structure;

Figure 6 is a sectional elevational view, comparable to Figure 3, showing a different retainer structure;

Figure 7 is a sectional elevational view comparable to Figure 4 showing the sleeve of Figure 2 mounted in the retainer of Figure 6;

Figure 8 is a sectional elevational view comparable to Figures 4 and 7 showing still a different structure for the assembled retainer and sleeve;

Figure 9 is a top plan view of a sheath unit embodying the instant invention, comprising the retainer and sleeve assembly of Figure 4;

Figure 10 is a sectional detail view taken substantially along the line X—X of Figure 9;

Figure 11 is a fragmentary top plan view showing the connecting means and structure for a sheath unit made from the assembly of Figure 5; and

Figure 12 is a sectional elevational view comparable to Figure 5 showing a different structural arrangement for the assembly.

As shown on the drawings:

In Figure 1, the reference numeral **10** indicates generally a sleeve unit employed as a starting assembly in the fabrication of an electric heater embodying the instant invention. The sleeve unit **10** comprises an elongated helical resistor **11** (made of Nichrome or similar heating element wire), an electrically and thermally conductive sleeve **12** (made of stainless steel) closely surrounding the resistor **11**, and electrically insulative refractory particulate material (magnesia) **13** filling the sleeve **12** and maintaining the resistor **11** therein in closely spaced relation to the sleeve **12**. The opposite ends **11***a* and **11***b* of the resistor **11** are carried in the elec-

trically insulative plugs 14*a* and 14*b*, respectively, which also serve to close off the ends of the sleeve 12.

In assembling the sleeve unit 10, the resistor 11 is mounted within the sleeve 12 and in a plug 14*a* fitted at one end of the sleeve 12. The plugs 14*a* and 14*b* are preferably made of hard rubber or any insulative packing material. Electrical grade magnesia particles are then fed into the open end of the tube 12, while vibrating the tube 12 to compact the magnesia 13 as much as possible, until the magnesia 13 fills the tube 12. The plug 14*b* is then mounted to close the tube 12 and to maintain the resistor terminal 11*b* insulated from the sleeve 12.

The next step in the practice of the instant invention involves the swaging of the sleeve unit 10 so as to obtain a sleeve unit 10', shown in Figure 2, wherein the diameter D of the unit 10 has been reduced from 10 to about 40% to obtain the diameter D' of the swaged unit 10'. Also, the length of *l* of unit 10 has been increased at least 10% (and preferably from 10 to 40%) so as to obtain the length *l'* for the unit 10'. The swaging is accomplished by the application of impact and high pressure forces around the outer periphery of the unit 10. It is important to retain the substantially circular cross-section of the unit 10 in the swaged unit 10' (even though the diameter D' is reduced), so the impact and pressure forces are employed around the entire outer periphery and, of course, for the full length of the unit 10. In carrying out the swaging, the unit 10 is placed between mating metal dies having mating semi-cylindrical grooves therein of substantially the size and shape of the swaged unit 10', and the original unit 10 is subjected to hammering between these dies.

The effect of the swaging is to compact the particulate material 13 to its unit density, or substantially so. In other words, the magnesia 13 is compacted to substantially the density of magnesia per se. In fact, it is not until substantially this density is reached that reduction in the wall thickness of the tube 12 is obtained. This results in elongation to obtain the tube 12' in the unit 10', which is longer and has thinner walls as well as a reduced diameter D'. For the sake of convenience the resistor 11 is shown as a single line in Figures 1 and 2, and the resistor 11 remains substantially unchanged in helix diameter during the swaging operation. The walls of the tube 12' are moved only slightly closer to the resistor 11 in the finally swaged unit 10' and this reduction in spacing is effected during the actual compacting of the magnesia particles 13, rather than during the metal working which results in the reduction of the wall thickness and the elongation of the tube 12'. The extent of this reduction in spacing can be readily ascertained and the helix diameter of the resistor 11 and the tube diameter D may be computed accordingly. The important feature here is that swaging is carried out to an extent sufficient to actually work the metal to reduce the wall thickness and elongate the tube 12'. Swaging to this extent accomplishes maximum compacting. In addition, swaging around the entire periphery of the tube 12' affords uniform reduction in diameter D' and uniform centering or spacing of the concentrically aligned resistor helix 11. As will be appreciated, the individual loops of the resistor helix 11 must be spaced from each other and, more important, they must be spaced from the inside walls of the tube 12' in order to avoid shorting out the heater.

The next step in the practice of the instant invention involved providing an electrically and thermally conductive retainer 20 (Figure 3) having a heating surface 20*a* and a back side 20*b* opposed thereto and retaining means in the form of a groove 21 defined by closely spaced ridges 22 and 23. As will be noted from Figure 3 retaining means for a second sleeve unit (not shown) are also provided in the form of a second groove 24 defined by closely spaced ridges 25 and 26. The retainer 20 is preferably formed by extrusion and it may be made of aluminum, copper or some other conveniently extrudable metal. Most preferably, it is made out of aluminum or copper. In the extrusion of the retainer 20, the heating surface 20*a* is formed as smoothly as possible, since a smooth heating surface 20*a* has been found to be important (particularly for conduction heating through surface-to-surface contact with an object, not shown, to be heated). Also, the grooves 21 and 24 are formed with smooth surfaces for good surface-to-surface contact with the sleeve unit 10'. As will be appreciated, the retainer 20 has substantially the same cross-section throughout its length and is of sufficient length to receive the entire sleeve unit 10', or a plurality thereof in a plurality of grooves 21, 24.

As indicated in Figure 4, wherein the sleeve units indicated at 10' and 10'' are shown in cross-section, the retainer 20' is altered in shape. This results from the assembly operation which involves first placing sleeve units 10' and 10'' in grooves 21 and 24 of the extruded retainer element 20, followed by bending the ridges over to obtain retaining ridges 22' and 23' holding the unit 10' in firm assembly and ridges 25' and 26' holding the unit 10'' in firm assembly. It will be noted that the grooves 21' and 24' are matingly formed to fit the sleeve units 10' and 10'' for surface-to-surface contact throughout at least about 180° of the periphery of each of the units 10' and 10'', and preferably at least about 270° of the periphery of each. This affords a maximum amount of surface-to-surface contact so that the greater portion of the heat generated within the unit 10' will flow by conduction into the aluminum body of the retainer 20' and then out across the heating surface 20*a'*.

Referring now to Figure 5, which shows a plurality of swaged sleeve units 10', 10'', 10''', all of which have the same structure as the swaged unit 10' shown in Figure 2, it will be seen that these units 10', etc. are mounted in a retainer structure 30 differing from the retainer structure 20—20' shown in Figures 3 and 4. In the retainer structure 30, retaining means are provided in the form of grooves 31, 32, 33 matingly receiving the swaged sleeve units 10', 10'', 10''' and defined by closely spaced ridges 34, 35, 36 and 37. Again, the retainer 30 is preferably extruded aluminum. In the assembly of Figure 5, however, a backing member indicated generally by the reference numeral 38 is provided for closing the mouths of the grooves 31, 32, 33 to retain the sleeves 10', etc. in firm assembly therein. The backing member 38 comprises a matingly grooved backing strip 39, 40, 41 for each of the grooves 31, 32, 33. Each backing strip 39, etc. is in close fitting (sliding) relation to the immediately adjacent ridges 34, 35 so as to obtain surface-to-surface contact therebetween, and the strip 39 is matingly grooved to obtain surface-to-surface contact with the back of the swaged sleeve unit 10'. The same is true for the strips 40 and 41. The backing strips 39, 40, 41 are preferably also made of extruded aluminum (or the same material that the retainer 30 is made of) and the positioning of these strips 39, 40, 41 is such as to effect surface-to-surface contact between a highly conductive (aluminum) retainer body (composed of the retainer 30 and the strips 39, etc.) throughout the entire periphery of each unit 10'. This assures maximum heat conductivity from the unit 10' through the strip 39 and the retainer body 30 to a heating surface 30*a* on the retainer 30.

The backing member 38 is also formed of a backing band 42 urged against the back of each of the strips 39, 40, 41 and generally along the top of the ridges 34, 35, 36, 37. The backing band 42 is preferably made of a less conductive metal than that of the retainer 30 and strips 39, etc. Conductivity of heat is desired in the direction of the heating surface 30*a*. For this reason the backing band 42 is preferably made of stainless steel, which is of

appreciable structural strength to assist in retaining the firm assembly in the unit of Figure 5.

Referring now to Figure 6, it will be seen that an extruded aluminum retainer **50** is shown provided with retaining means in the form of elongated passages **51** and **52** of the size of the swaged sleeve **10'**. The elongated passages are provided generally on the back side **50***b* of the retainer **50** which is opposed to the heating surface **50***a*. In using the retainer **50**, swaged units **10'** and **10''**, again identical in structure to the unit **10'** of Figure 2, are forced into the passages **51** and **52** so as to obtain surface-to-surface contact substantially throughout the entire periphery of each of the swaged units **10'** and **10''**. Such surface-to-surface contact may be improved by a secondary swaging or hammering operation performed on the retainer **50** after the units **10'** and **10''** have been inserted in the passages **51** and **52**. In general, the assemblies of Figures 4 and 7 are relatively simple in structure and easily fabricated. The assembly of Figure 5, however, has the advantage that individual swaged units **10'**, etc. may be replaced without any difficulty or without substantial destruction of the assembly, merely by loosening the backing band **42** and removing a unit **10'** with the backing strip **39**, in order to replace the unit **10'**.

As shown in Figure 8, a retainer **60** (shown only partially) has a substantially rectangular cross-section with a plurality of circular elongated passageways, only two of which **61** and **62** are shown, formed therein opposite a heating surface **60***a*. Actually the retainer **60** is twice the width here shown having two additional passageways (not shown) which repeat the pattern of the structure shown in the passageways **61** and **62**. As shown, a swaged unit **10'** is snugly fit in the passageway **61** and a hollow tube of copper **63** or other suitable metallic conductor is snugly fit in the passageway **62**. The retainer **60** may be extruded with the empty passages **61** and **62** formed therein, so that these passages **61** and **62** may be subsequently filled by the unit **10'** and the hollow tube **63**; or the retainer **60** may be extruded over the unit **10'** and the hollow tube **63** (preferably using a stainless steel tube in this case) so as to provide a portion of the retainer **60** opposite the heating surface **60***a* with a sleeve unit **10'** and a hollow tube **63** embedded therein. This results in excellent surface-to-surface contact, because the extruded retainer **60** will cool and shrink slightly after the extrusion process. It will also be appreciated that the assembly of Figure 7 may be formed by extruding the retainer **50** over the units **10'** and **10''** (as mandrels in the extrusion process) in the same manner as that just described for the retainer **60**.

The retainer **60** is equipped with a plurality of heating units **10'**, etc., only one of which is here shown, so that the retainer **60** can function in substantially the same manner as the previously described retainers for heating purposes. In addition, the retainer **60** is provided with alternately positioned hollow tubes **63**, etc., only one of which is shown, so that rapid cooling can be effected. It will further be appreciated that a cooling tube such as the tube **63** can be mounted in the manner described in connection with the retainer **60** in place of any of the heating units in each of the various other retainers described herein, although this specific embodiment is shown here only in connection with the retainer **60**. The particular function of the cooling tube **63** is the rapid cooling of the retainer **60** and the material heated thereby. This is particularly useful, for example, in plastic injection molding machines, wherein a heating band formed from, for example, the retainer **60** is wrapped around the nozzle or feed portion of the molding machine whereat the plastic is fed into the dies, in order to maintain a desired high temperature at this location. The desired high temperature retains the necessary fluidity in the plastic material at this critical location; but many plastic materials tend to deteriorate quite rapidly if held at the high temperature employed at this specific location. Accordingly, whenever a machine is to be shut down temporarily, it is very difficult to prevent deterioration of the plastic material that happens to be at this critical location. The instant device **60** permits extremely rapid cooling, so that the deterioration of the plastic can be avoided.

Any suitable cooling fluid may be controllably connected to the tube **63**, so that the cooling fluid can be forced therethrough at the desired time, for example, when the electric current is taken off the heating tube **10'**. It will also be appreciated that the tube **63** in the embodiment of Figure 8 could be eliminated, because the passageway **62** is a closed passageway. In embodiments such as Figures 4 and 5, however, a tube would be necessary to retain the cooling fluid.

Referring now to Figure 9, there is shown a heating unit indicated generally by the reference numeral **100** which comprises a pair of allochiral semi-annular heating members **101** and **102** matingly mounted to define an annulus for receiving an article (not shown) to be heated. Such article may be a cooking pot which fits rather snugly in the annular heating device **100** and is supported thereby or it may be a section of a pipe conducting material to be heated. The shape of the cross-section Y—Y of the arcuate member **101** is shown in Figure 4, although it will be appreciated that the view shown of the arcuate member **101** would also permit it to have cross-sectional views such as those shown in Figures 7 and 8. The member **101** is formed by bending the sleeves **10'** and **10''** and retainer **20'** as assembled (in Figure 4) into an arcuate shape (of substantially a uniform radius) with the heating surface **20***a'* defining the inner periphery. Bending in this manner is of particular importance, because this forces the sleeves **10'** and **10''** to be urged more firmly into the grooves **21'** and **24'** for better surface-to-surface contact therebetween. In addition, during heating the retainer body **20'** tends to expand and further urge the retainer **20'** against the units **10'** and **10''** to improve the heat conductivity across contiguous faces thereof.

In order to complete the assembly **100**, it will be noted that at one end **101***a* of one arcuate member and one end **102***a* of the other arcuate member **102**, the sleeve units **10'**, **10''**, etc. are turned radially outwardly to provide clamping lugs, shown best in Figure 10, at A, B, C and D. A yoke member **103** is urged against the back side of the members A and B and a yoke member **104** is urged against the back side of the members C and D and a tie bolt **105** connects the yoke members **103** and **104** and mounts adjustable nuts **106** and **107** against which springs **108** and **109** are backed, respectively, so as to urge the yoke members **103** and **104**, respectively, toward each other and thus resiliently urge the arcuate members **101** and **102** together. The same mounting is shown at the left-hand side of Figure 9. In this way superior surface-to-surface contact may be maintained between the heating surface **28'** and an article to be heated during expansion and contraction of the arcuate members **101** and **102**.

A comparable mounting for the assembly of Figure 5 is shown in Figure 11. In this case, opposing equivalent elements are indicated by the same reference numeral primed. As will be seen the heating surfaces **30***a* and **30***a'* form the inner periphery. Opposed sleeve units **10'** and **10''''** are connected to bar contacts **110** and **111** connected to a suitable source of electrical energy (not shown) and the ends of the stainless steel backing bands **42** and **42'** are turned radially outwardly to define flange members **112** and **113** which receive a tie bolt **114** with lock nuts **115** and **116** at the extremities thereof each backing a spring **117** and **118**, respectively, urging the flange portions **112** and **113**, respectively, toward each other. This also affords compensation for expansion and contraction during heating and cooling, so that superior surface-to-surface contact may be maintained between the heating surfaces **30***a* and **30***a'* and an article (not shown)

to be heated. Also, it will be appreciated that the stainless steel backing bands 42 and 42' assist materially in urging the units 10' and 10'''' into surface-to-surface contact with the retainers 30 and 30'.

Referring now to Figure 12, it will be seen that a retainer 70 is shown which compares with the retainer 30 of Figure 5, except that the backing member 38 of Figure 5 is composed of separable units whereas only a backing band 82 is used in conjunction with the retainer 70. The retainer 70 mounts a plurality of swaged sleeve units 10', 10'', 10''', all of which have the same structure as the swaged unit 10' shown in Figure 2. In the retainer 70, retaining means are provided in the form of grooves 71, 72 and 73 matingly receiving the swaged sleeve units 10', 10'' and 10''' and defined by closely spaced ridges 74, 75, 76 and 77. Again, the retainer 70 is preferably extruded aluminum. In the assembly of Figure 12, as in the assembly of Figure 5, a backing strip 82 is provided for closing the mouths of the grooves 71, 72, 73 to retain the sleeves 10', 10'', 10''' in firm assembly therein. As mentioned, however, backing strips such as the strips 39, 40 and 41 are not employed in the assembly of Figure 5 and, instead, the backing strip 82 directly engages the sleeves 10', 10'', 10'''. The backing strip 82 (which is preferably formed of stainless steel) thus firmly urges the sleeves 10', 10'', 10''' against the bottoms of the grooves 71, 72, 73 so as to obtain best heat conductivity through the retainer 70. In order to assure contact between the backing member 82 and the sleeves 10', 10'', 10''' the grooves 71, 72, 73 are formed shallow enough, or the ridges 74, 75, 76 and 77 are short enough so as not to contact the backing member 82. Actually, there is a very close tolerance here to avoid appreciable heat losses through convection, but the contact is made between the backing strip 82 and the sleeves 10', etc. This provides a very simple and efficient unit which can be readily assembled and disassembled. In addition, the stainless steel backing strip 82 has a lower coefficient of expansion than the aluminum retainer 70, so that heating up of the aluminum retainer 70 merely results in tighter surface contact between the sleeves 10', etc. and the retainer 70.

It will be understood that modifications and variations may be effected without departing from the spirit and scope of the novel concepts of the present invention.

I claim as my invention:

1. In an electric heater, in combination, an elongated resistor, an electrically and thermally conductive sleeve closely surrounding the resistor, electrically insulative refractory particulate material filling the sleeve and maintaining the resistor therein in closely spaced relation to the sleeve, said particulate material being compacted by swaging the filled sleeve to elongate the same at least 10%, an aluminum retainer having a heating surface and a back side opposed thereto, means on said back side defining an open-topped groove receiving said sleeve, and a stainless steel backing band covering the open-topped groove and retaining the sleeve therein in firm assembly, said retainer, sleeve and backing band being bent into an arcuate shape with the heating surface on the concave side and the backing band on the convex side of the arc.

2. A heater as claimed in claim 1 wherein the backing band directly engages said sleeve.

3. A heater as claimed in claim 1 wherein a matingly grooved backing strip is interposed between and in direct contact with the backing band and said sleeve.

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