Dec. 14, 1948. W. R. TUTTLE 2,456,343

ELECTRIC HEATER AND METHOD OF MAKING SAME

Filed Dec. 6, 1944 4 Sheets-Sheet 1

Fig. 1.

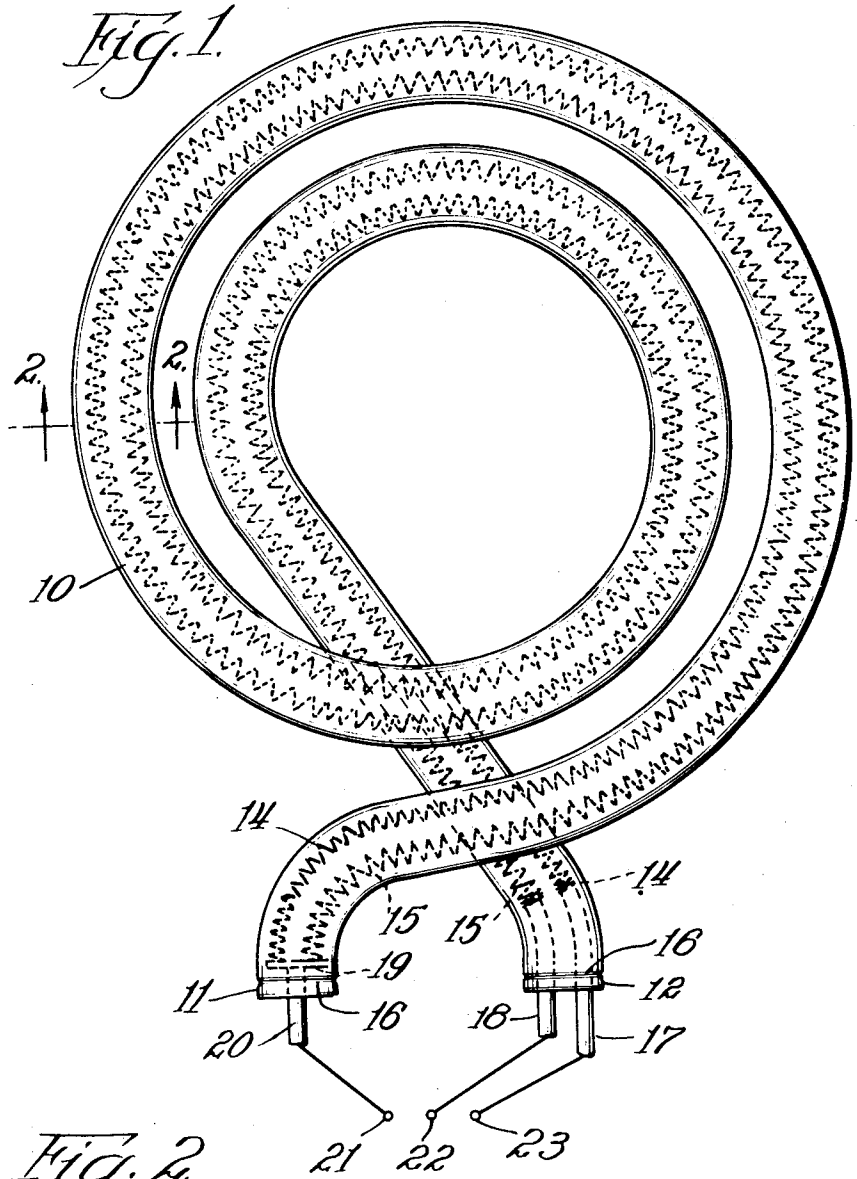
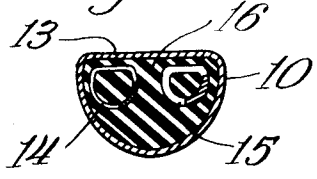


Fig. 2.



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Fig. 3.

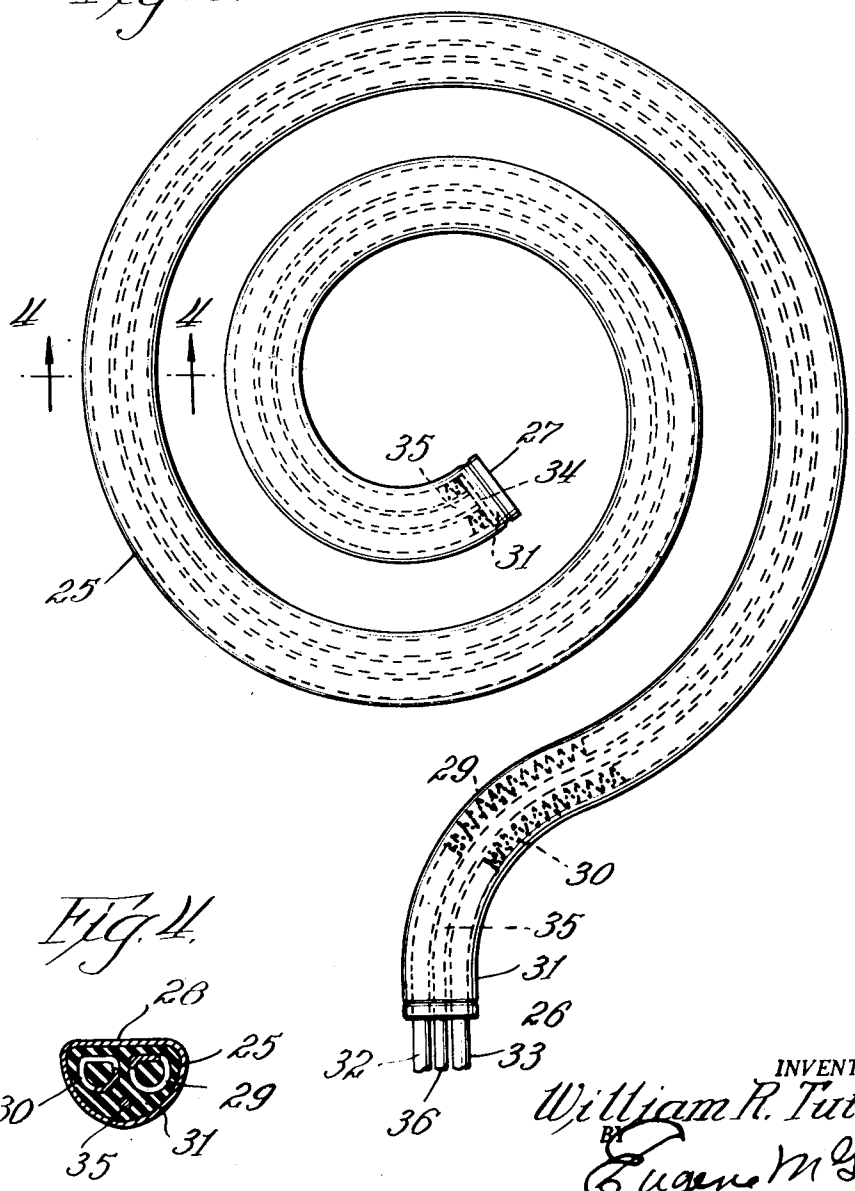


Fig. 4.

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Fig. 5.

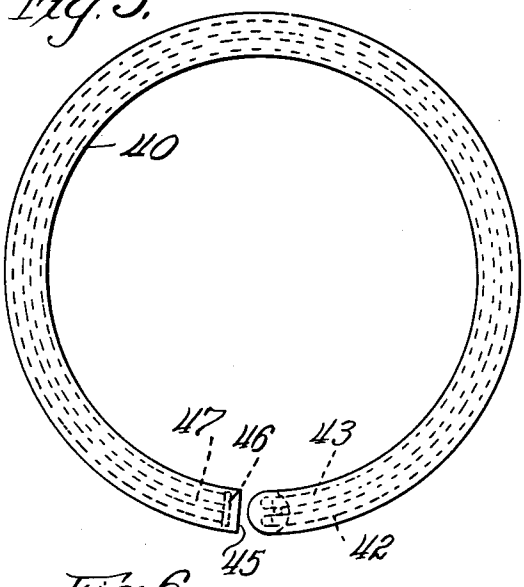


Fig. 6.

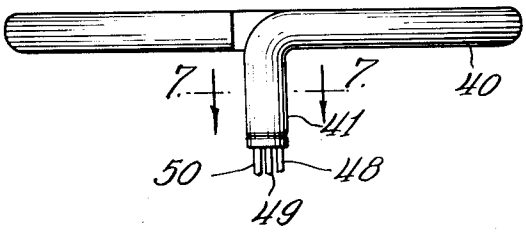


Fig. 7.

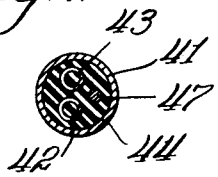


Fig. 9.

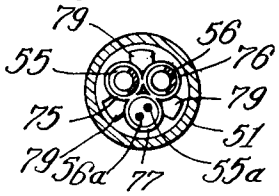
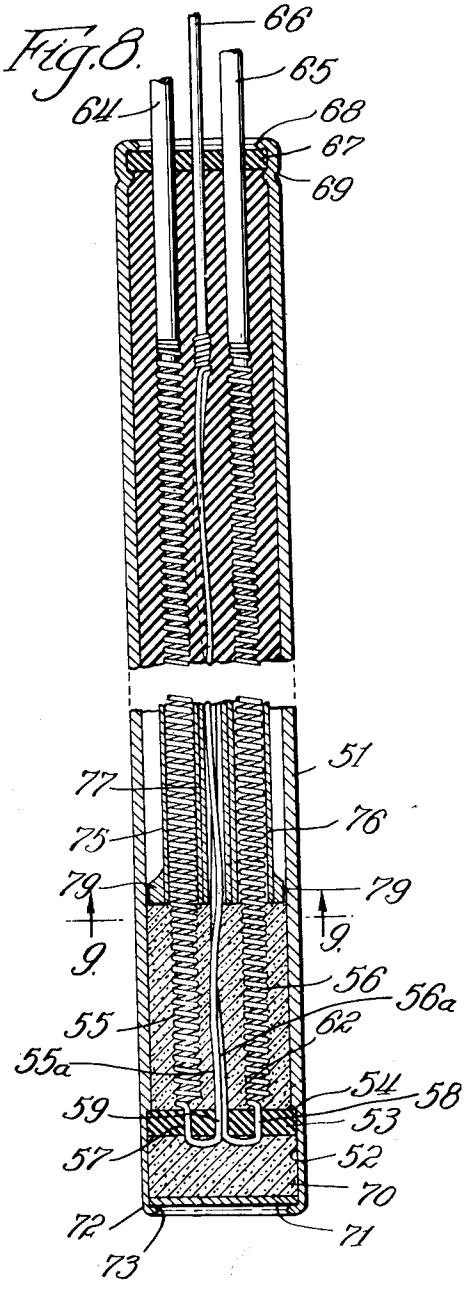


Fig. 8.



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ELECTRIC HEATER AND METHOD OF MAKING SAME

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Fig. 10

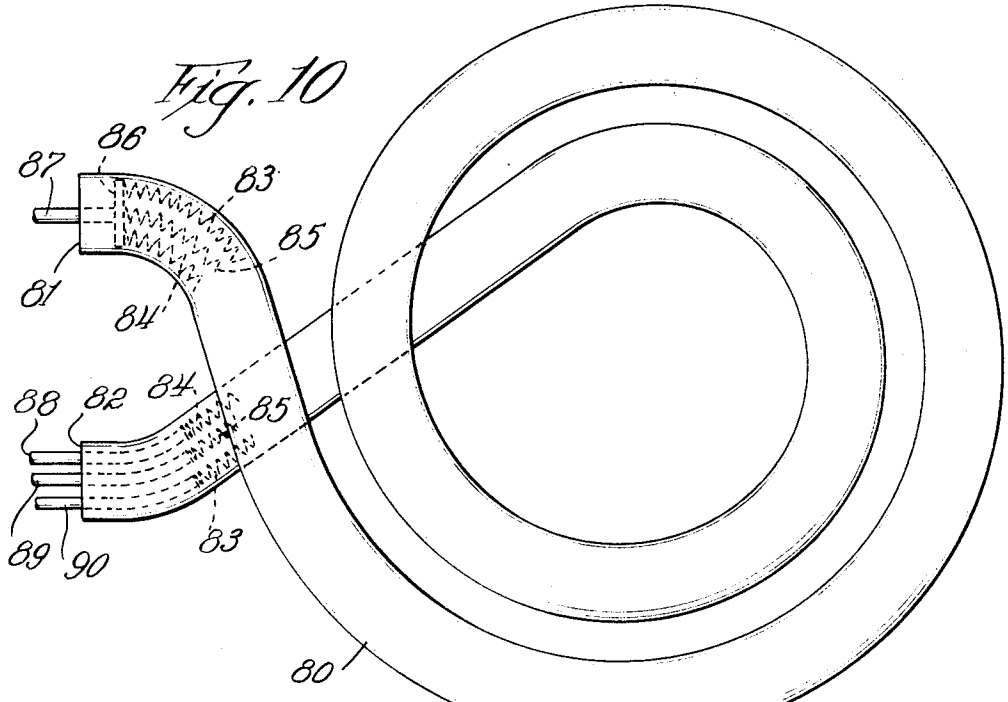
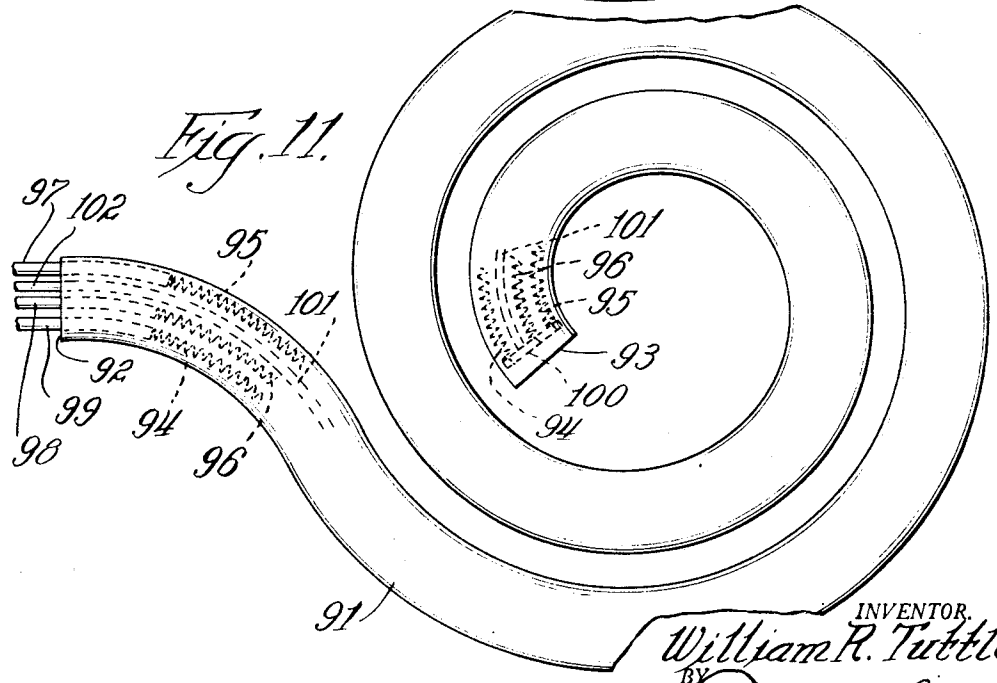


Fig. 11.



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Patented Dec. 14, 1948 2,456,343

UNITED STATES PATENT OFFICE

2,456,343

ELECTRIC HEATER AND METHOD OF MAKING SAME

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Application December 6, 1944, Serial No. 566,855

14 Claims. (Cl. 201—67)

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This invention relates to electric heaters and more particularly to electric heating units of the sheathed resistor type.

Such heaters have been used for a great many years and commonly comprise a helical resistance wire extending centrally through a metal tube which constitutes the sheath, the resistance being insulated from the sheath by a mass of dielectric material which is compacted tightly within the sheath and around and within the helical resistance. The sheath is usually of seamless or similar circumferentially unified tubing, such as butt welded tubing, which is preformed so that the resistance and insulation must be introduced therein from the end, such seamless or similar tubing which requires such end introduction being referred to hereinafter as preformed.

As is well known such sheathed resistances, after assembly thereof with the resistance embedded in insulation in the tube, are frequently bent or formed into various shapes and configurations peculiarly suited to particular service requirements such as car heating, water tank heating, cooking range usage, and the like. The invention hereof, which pertains to such electric heaters, has particular advantage in the domestic cooking field, although it will be apparent that its advantages will extend to other fields where such sheathed resistor heaters may be employed. For the purpose of convenience, however, the invention will be described in its adaptation in connection with domestic cooking facilities.

The conventional hot plate or electric range heating unit comprises one or more of the above described sheathed resistor heaters bent or coiled in a horizontal plane into more or less serpentine form. Where, as is almost always the case, a plurality of heating stages is desired, at least two such sheathed resistor heaters are usually employed and their terminal ends are connected with power supply lines through a switch which provides selective connection of the resistors in a number of different relationships to provide different intensities of heat, such switches usually affording connection of the resistors optionally in series or in parallel or at least one individually with the power supply, and if a three wire feed is employed with high and low potential, either potential may also be optionally impressed on the series, parallel or individual resistors to give additional heat variations, all as disclosed in W. R. Tuttle Patent No. 2,317,967.

In some cases, however, heat variation has been effected by a timing control in which the current to the resistor is repeatedly interrupted at regular intervals of selectively changeable duration (in which case only a single resistor is required and a terminal at one end thereof is led through the timing control to one power supply line and a terminal at the other end is connected with the other power supply line.

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Now the present invention, as previously mentioned, relates to sheathed resistor heaters, particularly of the preformed tubular sheath type and employs two or more resistance helices or one or more resistance helices and a return conductor encased within a single sheath. The two or more helices may be of substantially the same resistance and energizable in various degrees by different connections with the power source in the manner above explained or the helices may possess widely different resistance characteristics for furnishing additional stages of heat. Various other modifications and combinations are possible, using a plurality of resistors in a single sheath, and these and the many advantages to be derived will become apparent as the description proceeds.

A prime object of the invention is to provide a plurality of resistances or one or more resistances and a return conductor all encased within a single preformed tube sheath.

Another object is to provide an electric heater having all of the properties and advantages of a plurality of individually sheathed resistors but embodied in one single sheath, and which may be bent, together with the resistors therein, into serpentine or other shapes as required without relative displacement of the resistors therein.

A further object is to provide a heater embodying a plurality of resistors, which is adaptable to all the uses of a plurality of sheathed resistance heaters, and which is simpler and more economical to produce and which is more compact.

Another object is to permit all the terminals to be located at one end of the sheath in a preformed tubular sheathed heating unit and to permit the other end of the sheath to be completely closed.

Another object is to provide a plural resistance single preformed sheath heater of extreme flexibility in adaptation, of long life, particularly advantageous in the domestic cooking field, and utilizable with various conventional control devices.

Another object is to provide a sheathed resistance which is more conveniently adaptable to pivotal mounting than sheathed resistors heretofore available.

A still further object of the invention is to provide a method of filling or loading the en-

casing sheath with a plurality of resistance helices and dielectric material in a manner to assure accurate location of the resistors within the sheath and adequate insulation between the respective current conductors and also between the same and the metallic sheath.

Yet another object is to provide methods for the manufacture of the novel heater thereof in simple, expeditious and economical fashion.

With these and other objects in view the invention comprises the novel combination and arrangement of parts, and manners of effecting the same, hereinafter fully described, illustrated in the accompanying drawings and particularly pointed out in the appended claims, it being understood that the invention is not to be limited to the specific embodiments shown and described but that many variations and modifications thereof are possible, within the scope of the claims, without departing from the spirit of the invention or sacrificing any of the advantages thereof.

In the drawings:

Fig. 1 is a plan view of a range top electric heating unit embodying features of the present invention, according to a simple form thereof;

Fig. 2 is a vertical section on the line 2—2 of Fig. 1;

Fig. 3 is a plan view of a stove top unit, similar to Fig. 1, but embodying the invention in a modified form;

Fig. 4 is a vertical section on the line 4—4 of Fig. 3;

Fig. 5 is a plan view of a heating unit embodying the features substantially as shown in Fig. 3, but wherein the unit is particularly adapted as a coffee maker heater or similar household appliance;

Fig. 6 is a side elevational view of the unit of Fig. 5;

Fig. 7 is a section on the line 7—7 of Fig. 6 looking in the direction of the arrows;

Fig. 8 is a composite vertical sectional view on an enlarged scale, showing a manner of constructing the heating units hereof and loading the same with the conducting elements and dielectric material;

Fig. 9 is a horizontal cross sectional view on the line 9—9 of Fig. 8 looking in the direction of the arrows;

Fig. 10 is a plan view of a range top heating unit, according to a modified form of the invention, employing three resistance helices in a single sheath; and

Fig. 11 is a plan view showing a still further modification wherein three resistance helices and a low resistance return wire are all enclosed within a single sheath.

As previously indicated, the essence of the invention hereof resides in the employment of two or more resistance helices or one or more resistances and a return conductor within a single preformed tubular metallic sheath. In the simplest aspect, as in Fig. 1, the heating unit may have two open or terminal ends with the resistances connected together within the sheath to a single terminal which projects beyond the end of the sheath so that a single lead may be employed therefrom to the appropriate connection of the control switch, the terminals of the resistances at the other end of the unit being separate and separately connected to the switch. In other instances, as in Figs. 3 and 5, all the terminals may be located at one end in which case

the opposite end of the unit is sealed with the resistances connected together within that end and connected also to a return conductor which is also encased within the single sheath and emerges from the other or terminal end of the unit to form the third terminal. It is also possible, within the scope of the invention, to employ a third resistance helix either with or without a low resistance return wire, as in Figs. 10 and 11.

For an understanding of the invention in its simplest aspect reference may be had to Figs. 1 and 2 of the drawings. Therein is shown a single preformed tubular metallic sheath 10 coiled in serpentine form and having two open terminal ends 11 and 12 respectively. This unit is shown as coiled in serpentine manner to provide a horizontal heating unit for use in the stove top openings of electric ranges. According to customary practice the unit is preferably flattened on its upper surface as indicated at 13.

Positioned within the sheath 10, in the present embodiment, are two helically formed resistance wires 14 and 15, which are of relatively high electrical resistance and formed of a suitable metal such as the well known Nichrome. The resistances 14 and 15 extend throughout the length of the sheath 10 in substantial parallelism and are completely embedded in a mass 16 of dielectric or insulating material such as the commonly employed magnesium oxide or periclase. The dielectric 16 is originally placed within the sheath 10, after positioning of the resistances 14 and 15 therein, in the form of a powder or finely divided aggregate and completely fills all of the space between the resistances and between and within the coils thereof and also between the resistances and the metallic sheath 10. By suitable processing steps the dielectric is compacted into a hard dense mass and maintains suitable insulating conditions between the respective resistances, the coils thereof, and between the resistances and the sheath. This compacting to a hard dense mass may be accomplished while the structure is in a straight length, after which the structure is bent in the serpentine or other form, but I prefer, while the structure is in the straight length, to merely compact the insulation sufficiently to hold the resistances in place in bending into the serpentine or other form and to fully compact the insulation after the bending by flattening the unit.

At one terminal end 12 of the heating unit, each of the resistances 14 and 15 is connected, within the mass of dielectric 16, with a low resistance terminal wire designated by the numerals 17 and 18 respectively which project beyond the end of the tube. At the other terminal end 11 of the heating unit the ends of the respective resistances 14 and 15 are suitably connected together, as by a low resistance strap or wire 19, to which is electrically connected a low resistance terminal wire 20 which projects beyond that end of the tube. As will be appreciated all of the connections with the projecting terminal wires 17, 18 and 20 are located within the mass of dielectric 16 in order that the energizable elements of the device are completely embedded within the insulating material.

As clearly shown in Fig. 1, the three terminal wires 17, 18 and 20 are adapted to be connected with the binding posts of a three terminal switch or control device, these connections being diagrammatically indicated at 21, 22, and 23. When

so connected to a proper control device, such as the switch disclosed in the Tuttle Patent No. 2,317,967 above referred to, a number of different heat intensities are obtainable. In other words, the unit of Fig. 1 is connectible to a three terminal switch and utilizable in the same manner as the customary range top heating device employing two separate sheathed resistor heating elements. In such employment the present device is capable of all the functions and possesses all of the advantages of the former units and is much more compact and economical to manufacture.

In Figs. 3 and 4 of the drawings there is shown a modification of the arrangement just described, applying the same general principle however. In these figures there will be seen a single metallic sheath 25 coiled horizontally in substantially serpentine fashion with an open terminal end 26 and a closed end 27, the latter preferably terminating adjacent the center of the coil. For best effect this unit is also preferably flattened along its top surface as indicated at 28.

The present unit likewise has at least two resistance helices 29 and 30 extending in parallel relationship throughout its length and embedded in and insulated by the dielectric material 31. At the open terminus 26 of the unit the resistances are attached in the customary manner to the low resistance terminal wires 32 and 33.

The opposite or inner end of the sheath 25 is completely closed and sealed, as by a metallic cap indicated at 27. Adjacent this closed end and within the unit, the ends of the resistances 29 and 30 are electrically connected by a suitable strap or other conducting means 34 to one another and to a low resistance return wire 35 which extends the length of the unit, being completely insulated from the helices 29 and 30 and the tube 25 by the dielectric material 31, and at the open end 26 of the unit is connected to a third terminal 36 this low resistance return wire 35 being preferably a helix stretched out so that the successive coils or convolutions are widely spaced somewhat as shown in Fig. 8.

There is thus provided a two resistance heating unit wherein one end of each resistor, 32 and 33, is connectible to terminals of a switch and wherein the helices have their other ends connected together at 34 and to the return wire 35, which provides the third terminal 36 for connection to a suitable three terminal control device. In this instance the connections and operation of the heating unit are identical with those explained in connection with Fig. 1 and a suitable switch, such as that of the aforesaid Tuttle patent, will connect the resistances 29 and 30 in various relationships to provide different intensities of heat.

In either instance there is provided a simple single sheath heating element or unit which has all of the flexibility and attributes of a conventional element composed of separate individual cores and which is simpler, more compact and more economical.

A further adaptation of the invention is illustrated in Figs. 5, 6 and 7 of the drawings which illustrate a heating element particularly suitable for employment in connection with domestic appliances such as the well known glass coffee makers. In such cases it is desirable to provide high heat for boiling and low heat for maintaining a warming temperature but because of the small heating area and the practical limitations in the bending of the sheathed resistance it has been impractical to employ two separately sheathed resistances so as to provide these two desired heating conditions and accordingly most of the heating devices for this purpose have been capable of only a single high heat stage.

The present invention, however, adapts itself quite nicely to the providing of a single heating unit which will provide the desired high and low heat stages for a coffee maker or like appliance while employing only the conventional two wire 110 volt household current supply which is ordinarily available. Thus the present embodiment employs a single metallic preformed tube sheath 40 coiled horizontally in circular manner and having an open terminal end bent downwardly as indicated at 41. This unit employs two resistance helices 42 and 43 which extend throughout the length of the element and are embedded within the dielectric material 44 in the manner previously described. The opposite end of the unit is preferably in the plane of the circle and is closed and sealed as at 45 preferably by a metallic cap welded thereon. As explained in connection with the previous modification, the helices 42 and 43, at their ends adjacent the closed terminus 45 of the unit, are connected together by a suitable electric connection 46 which, in turn, is connected to the inner end of a low resistance return wire 47 which is preferably a stretched helix such as shown in Fig. 8 and extends throughout the length of the unit and emerges from the open end 41 as the return wire terminal 48.

Similarly protruding from the end 41 of the unit are the terminal wires 49 and 50 of the respective helices 42 and 43. Thus there is provided an arrangement which, in mechanical structure, is substantially the same as illustrated in Fig. 3, in that there are employed two resistance helices extending throughout the unit and both connected at their inner ends to a common return conductor also extending throughout the unit and providing a third terminal at the open end thereof. When employed as a coffee maker, however, the unit of the present embodiment employs helices 42 and 43 of widely different electrical resistance characteristics. In this connection it has been determined that an electrical energy output from about 660 to 700 watts is desired for boiling purposes, while an output of only about 70 watts is suitable for maintaining a warming temperature. Consequently, in the present embodiment, the resistance characteristics of the two helices 42 and 43 are gauged so that these two approximate energy outputs can be realized by connections with a two wire 110 volt power supply.

In one such arrangement the innermost coil 43 may possess a resistance such that when connected alone to a current supply of 110 volts its capacity will be approximately 660 to 700 watts. Under such an arrangement the other helix 42 would be of a relatively higher resistance to afford, when connected alone to the current source, a capacity of about 70 watts. Thus, by merely manipulating either a simple toggle switch, or a selective two socket connection with the supply line, the high heat helix 43 can be energized by connecting the return wire terminal 48 and the terminal 50 of the helix 43 with the power supply. By the switch or changing the socket connection the resistance 43 can be cut out of the circuit and the lower heat resistance 42 energized by connecting the terminal 48 of the return wire and the terminal 49 of the resistance 42 with the power source. Thus, by simple manipulation, a high heat is supplied by the resistance 43 and a low heat by the resistance 42.

In some instances it may be desirable for high

heat to energize both resistances in parallel, thereby affording a slightly higher heat than with the resistance 43 alone and the two resistances could be energized in series to give a slightly lower heat than the resistance 42 alone and these heating arrangements can be provided with the three terminals of Figs. 5 and 6.

In any event there is provided a compact and efficient heating element employable with a simple two wire current source and capable of supplying at least two desired stages of heat.

In producing units of the present invention the insulating resistances and return conductors are installed in the tubular sheath while the latter is in a straight length, and before the assembly is coiled in the serpentine, circular or other form, and if flattened, the unit is usually flattened after such coiling. In the proceeding the resistances and return conductors are inserted through the straight tube and while the resistances and return conductors are supported at their opposite ends to hold them in substantially the position they are to occupy, the insulation is gradually supplied to the upper end of the tube, and a tamper with openings therethrough to accommodate the resistors and return conductor and locate them accurately in the tube, is reciprocated and gradually elevated to pack the insulation in and around the resistors and conductor in substantially the same manner that the single resistance is packed in insulation in a tube in Lightfoot Patents Nos. 1,359,400 and 1,547,335.

Thus referring to the unit of Fig. 1, assuming the sheath 10 to be in the form of a straight open ended tube, the latter is placed within the loading machine and the two helices 14 and 15, with their ends joined by a strap as at 19, are placed within the sheath and anchored by the anchoring device of the loading machine through the medium of the terminal 20. There are then employed two centralizing tubes, preferably joined together longitudinally like the double barrel of a shotgun, one to surround each of the resistance helices 14 and 15, and the unit is loaded with the insulating material, the two centralizing tubes being progressively withdrawn as the unit is filled, according to the same procedure followed when constructing a single resistance unit. The sheath will, of course, after loading be temporarily sealed or capped at both ends, in the customary maner, and then swaged to further compact the insulating material, after which the unit may be formed into the shape and arrangement as shown in Fig. 1. Thereafter, in accordance with known practice, the coiled unit may be flattened on its top by being struck with a power hammer, and the sealing elements then removed in the usual manner. In this flattening the resistances which were originally cylindrical, are deformed transversely somewhat as shown in Figs. 2 and 4 in conformity to the transverse deformation of the sheath.

However, different problems are encountered when producing the units of Figs. 3 and 5 wherein one end of the coil is permanently sealed, and wherein all terminals emerge at one end of the coil. The following will describe, by reference to Figs. 8 and 9, a simple and expeditious procedure for filling and loading the sealed end units and also will present a particular construction of sealed end unit which is both novel and advantageous.

In Fig. 8 there is illustrated in somewhat enlarged fashion, a heating unit which may ultimately be shaped into either of the forms shown

in Figs. 3 and 5, or into any other desired configuration. This unit is shown as a composite development and depicts the unit in that stage of manufacture where it has been loaded, capped, and is ready for the usual swaging operation to compact the insulation, except that in the lower half of said figure the centralizing tubes and tamper are shown as they operate during the filling procedure. The description will delineate the steps in manufacture which have resulted in the condition of the unit as seen in Fig. 8.

This figure shows the straight tube or sheath 51 which is originally a tube open at both ends. In initiating the construction of this unit the tube 51 is counterbored at one end as indicated at 52 to receive a plug or washer 53 formed of a ceramic material or other substance having insulating properties. As clearly seen the plug 53 bears against a shoulder 54 formed as a result of the counterbore.

In this heating unit of Fig. 8 a pair of resistance helices 55 and 56 are employed, each with a return conductor 55*a* and 56*a* respectively which is merely a straight or nearly straight portion of the respective helix wire and which may be provided by making the helix with a straight length of wire at one end of sufficient length to extend back through the sheath 51 to the other end thereof.

Preferably however, the helix is made of slightly greater length than required with a sufficient number of extra convolutions at the end so that these extra convolutions may be pulled out nearly straight to serve as the return conductor, a slight twist or spiral being retained in the return conductor to accommodate any elongation strains that may occur in the further manufacture of the heater or in the use thereof.

The ceramic washer 53 is provided with an opening 57 in line with the resistance 55 to receive the return wire 55*a* thereof and with another opening 58 in line with the resistance 56 to receive the return wire 56*a* thereof, and this washer has another opening 59 therethrough, properly spaced from the openings 57 and 58, through which the two return wires 55*a* and 56*a* are conjointly bent back to return conjointly to the other end of the sheath 51 where they are attached conjointly to the terminal 66.

The opposite ends of the resistors 55 and 56 are electrically connected with low resistance terminal wires 64 and 65 in customary manner, these terminals extending beyond the end of the sheath 51, as does also the terminal 66 of the two return wires 55*a* and 56*a*.

The assembled resistors, return wires, ceramic washer and terminals are inserted in the sheath 51 with the washer 53 seated against the shoulder 54 of the counterbore 52 and the terminals 64, 65 and 66 projecting from the opposite end of the sheath, after which the counterbored opening beyond the ceramic washer 53 may be packed with insulation 70 and closed by a metal washer or cap 71 over which the edges of the sheath may be crimped as at 73 to hold the washer in place.

The assembly is then placed in a suitable loading machine, the upper end of the sheath being unobstructed as will be readily appreciated. In the loading machine suitable counterweighted or spring devices are connected through the respective centralizer tubes with the terminals 64, 65 and 66 and hold the respective resistances 55 and 56 and the return wires 55*a* and 56*a* under tension so that they will extend through the sheath in parallel relationship. Suitable centralizing

tubes or tampers, such as are customarily used in loading a single resistance unit, surround each of the resistance helices and a similar centralizer tube surrounds the two return wires. In the loading machine the powdered magnesium oxide flows into the sheath at the top and falls to the bottom of the tube around the outside of the centralizing tubes. As previously explained, these centralizing tubes are progressively withdrawn as the sheath fills up with the powdered insulation from the bottom so that, upon completion of the operation, the sheath 51 has been filled with powdered magnesium oxide approximately to its upper end and the centralizing tubes have been completely withdrawn. Incident to the vibration or agitation provided by the loading machine and to the tamping effects customarily produced by the centralizing tubes, the powdered insulation completely fills the sheath and the interior of the resistance helices and between the coils thereof.

The preferred arrangement of the centralizing tubes has been shown fragmentarily in Fig. 8 and in Fig. 9. This arrangement consists of three tubes 75, 76 and 77 placed together in parallel relationship and provided at the lower ends with a tamper head 78 having openings therethrough in which the lower ends of the tubes 75, 76 and 77 are secured. These tubes respectively surround the helices 55 and 56 and the return wires 55a and 56a. This tamper head 78 is of skeleton form with radially projecting fins or lugs 79 which serve to hold the tamper head and tubes 75, 76 and 77 in proper position in the sheath 51 and, when reciprocated, tamps the insulating powder compactly thereunder, the spaces between the lugs or fins 79 permitting the powder to pass down below the tamper which progressively rises as the powder accumulates and is tamped thereunder. Thus the powder is supplied and compacted within and around the coils of the helices and around the return wires to completely fill the space in the sheath and hold the resistances in predetermined spaced relation to one another and to the return wires and the resistances and return wires in predetermined spaced relation to the sheath. During operation of the loading machine the sheath 51 is vibrated and the centralizers or tamping tubes 75, 76 and 77 alternately lifted and dropped, while being gradually withdrawn from the sheath as the same fills up, and thus the powdered insulation is both shaken and tamped to make the mass as dense as possible.

Upon completion of the loading operation a metallic washer 67, having suitable openings to accommodate the terminals 64, 65 and 66, is inserted in the upper end of the sheath against the top of the compacted insulation and the walls of the sheath are crimped on each side of the washer 67, as indicated at 68 and 69, to hold the washer securely in place during the subsequent swaging operation. This completes the formation of the straight loaded unit, ready for swaging, as illustrated in Fig. 8.

The loaded unit is then subjected to a swaging operation which reduces the diameter of the unit and also causes some elongation of the sheath. This is a customary operation and serves to compact the insulating material into a hard dense mass. It is usually accomplished in a swaging machine or by drawing through a suitable die. After completion of the swaging operation the upper end of the sheath is cut off at the crimped area 69 and that portion together with the metallic washer 67 is removed from the unit, leaving the upper end of the unit open, but filled substantially to the end with the insulating material which has become such a hard solid mass that no retaining member is required therefor in the end of the tubular sheath, and having the terminals 64, 65 and 66 protruding therefrom. The straight unit may then be bent into any desired form, such as that shown in Figs. 3 and 5, and may be flattened on top if desired. It forms a simple compact unit in the form of a single heating element which, however, contains a plurality of resistances and is adaptable in any of the manners heretofore described to provide a plurality of stages of heat. It is found that, due to the hardness and density of the compacted insulation, the resistances and the return wire, despite bending of the unit into various shapes, retain their relative spacing and parallelism and do not contact or become shorted in any way.

In addition to the forms of the invention heretofore described the principles thereof may also be employed in providing a single sheath heater having more than two resistors, as illustrated in Figs. 10 and 11 of the drawings which show range top units employing three resistors.

Referring to Fig. 10 the unit shown is a coiled range top heater employing the single metallic sheath 80 leaving two open or terminal ends 81 and 82. Extending through the sheath are three resistance helices 83, 84 and 85, the sheath being filled with compacted insulation as previously described. Inside one terminal end 81 of the unit the three resistors are electrically connected together, as by a connector member 86, to which is in turn connected a low resistance terminal wire 87 forming one of the terminals of the unit. At the other end 82 of the heater the three resistors are provided with the separate terminal wires 88, 89 and 90 respectively, and these wires project from the end of the unit as three separate terminals. Thus the unit of the present embodiment has four separate terminals and these are connectible to known control devices which will energize the resistors 83, 84 and 85 in many different relationships from a three wire power source.

Fig. 11 shows an adaptation of the invention similar to Fig. 10 but wherein a return wire as well as three resistors extend through the unit, all four of the terminals emerging from one end of the sheath.

Thus, in Fig. 11, the sheath 91 has an open terminal end 92 and is closed or sealed at its other end, as indicated at 93. The three resistance helices 94, 95 and 96 extend through the sheath and are provided, at the open end 92 of the unit, with separate terminal wires 97, 98 and 99 which protrude from the said open end. Within the closed end 93 of the unit the three resistors are electrically connected together, as by a connector member 100, and to a low resistance return wire 101. The latter extends through the sheath along with the three resistors and emerges at the open end of the unit as a fourth terminal 102. The four terminals 97, 98, 99 and 102 are adapted to be connected to a control device in the same manner described in connection with the heater of Fig. 10.

In employing three or more resistors, as in the adaptations of Figs. 10 and 11, it will be advantageous if at least one of the resistors has markedly different electrical resistance properties than the others. In this way an increased number of variations in heat output may be realized by different connections with the power source.

It will also be understood that a sheathed re-

sistor of the above type may be made with only a single resistor and a low resistance return wire which are connected together at one closed end of the sheat and have their two terminals at the other end of the sheath. Such unit would be usable with ordinary switch for single heat or with intermittent control, such as disclosed in Potter Patent 2,294,573 for infinitely variable heat.

Heating units such as described above are advantageous not only because of the economies occasioned by the use of a single tube instead of the several tubes heretofore used in the individual sheathing of each resistance, and the economies in operations in producing, forming and assembling a single multiple resistance unit instead of a number of separate individual resistance units, but there are fewer unit ends to be extended away from the immediate heating zone to the place of electrical connection with the terminals of the resistances and a resultant economy therefrom in the length of tubing and resistances and the amount of insulation that is required. Moreover with the resistances contained in a single tube there is an increased heating efficiency because of the lesser surface area to be cooled by the surrounding air.

Furthermore the adaptation of the invention of the form shown in Figs. 3, 11 and 12 in which the sheathing tube has all of the terminals located at one end and is closed at the other end, not only effects an added economy because of the saving of the length of tubing, resistances and the amount of insulation that would otherwise be required to extend the latter end to a suitable place for making electrical connections with the terminals at that end, but it also affords a more convenient coiling arrangement.

In addition to the above noted advantages of the closed end unit, such unit because its terminals are all at one end is adaptable to a simple and convenient pivotal mounting which will permit the unit to be lifted from its normal operative position to an elevated position affording underneath access which is required with the usual cooking units for cleaning the unit and the structure thereunder, an exemplification of such simple and convenient pivotal mounting being disclosed in a separate application #566,856 filed by me on December 6, 1944.

While I have shown and described my invention in preferred forms, various changes and modifications may be made therein without departure from the principles of my invention, the scope of which is to be determined by the appended claims.

What is claimed is:

1. An electric heater of the class described comprising a metal sheath of preformed tubing which is bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has at least two conductors therein correspondingly bent and extending lengthwise thereof, said tubing having insulating powder compressed therein into a hard dense mass within which said conductors are embedded in spaced apart relation throughout their length, and said conductors being connected together within one end of the tubing and each having at the other end of the tubing a separate terminal extending therefrom through that end of the tubing, at least one of said conductors being a helical resistance, said insulating powder and conductors conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the conductors.

2. An electric heater of the class described comprising a metal sheath of preformed tubing which is bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has at least two conductors therein correspondingly bent and extending lengthwise thereof in separate zones substantially parallel with and spaced apart transversely of the longitudinal axis of the tubing, said tubing having insulating powder compressed therein into a hard dense mass within which said conductors are embedded, and said conductors being connected together within one end of the tubing, and each having at the other end of the tubing a separate terminal extending therefrom through that end of the tubing, at least one of said conductors being a helical resistance, said insulating powder and conductors conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the conductors.

3. An electric heater of the class described comprising a metal sheath of preformed tubing which is closed at one end and bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has at least two conductors therein correspondingly bent and extending lengthwise thereof, said tubing having insulating powder compressed therein into a hard dense mass in which said conductors are embedded in spaced apart relation throughout their length, and said conductors being connected together within the closed end of the tubing and each having at the other end of the tubing a separate terminal extending therefrom through that end of the tubing, at least one of said conductors being a helical resistance, said insulating powder and conductors conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the conductors.

4. An electric heater of the class described comprising a metal sheath of preformed tubing which is bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has at least three conductors therein correspondingly bent and extending lengthwise thereof, at least two of which said conductors are helical resistances, said tubing having powder compressed therein into a hard dense mass in which said conductors are embedded in spaced apart relation throughout their length, and said tubing being closed at one end and at the other end thereof each of said conductors having a separate terminal extending therefrom through that end of the tubing, and each of said conductors having the end thereof remote from its respective terminal connected within the tubing with another one of said conductors, said insulating powder and conductors conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the conductors.

5. An electric heater of the class described comprising a metal sheath of preformed tubing which is closed at one end and bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has therein a wire resistance helix correspondingly bent and extending lengthwise thereof, said helix having an outstretched continuation of the wire thereof extending back through the tubing from the closed end thereof to the other end thereof, insulating powder in the tubing compactly confined thereby in a hard

dense mass in which said helix and outstretched continuation are embedded in spaced apart relation throughout their length, and two separate terminals leading respectively from said helix and continuation and projecting from the last mentioned end of the tubing, said insulating powder, helix and continuation thereof conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of said helix and the continuation thereof.

6. An electric heater of the class described comprising a metal sheath of preformed tubing which is closed at one end and bent into a crooked form having a correspondingly crooked non-rectilinear longitudinal axis and has therein at least two wire resistance helices correspondingly bent and extending lengthwise thereof, each of said helices having an outstretched continuation of the wire thereof extending back through the tubing from the closed end thereof to the other end thereof, insulating powder in the tubing compactly confined thereby in a hard dense mass in which the two helices are embedded in spaced apart relation throughout their length from one another and from both continuations, and three separate terminals projecting from the last mentioned end of the tubing, two of which said terminals lead respectively from the helices and the other of which leads from both outstretched continuations, said insulating powder, helices and continuations thereof conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of said helices and the continuations thereof.

7. An electric heater comprising a length of preformed metal tubing having therein a plurality of helical resistors extending lengthwise thereof separately in side by side relation, and insulating powder in said tubing compactly confined thereby in a hard dense mass within which said resistors are embedded and by which the resistors are separated and insulated from one another and from the tubing throughout their length, at least a portion of the length of the tubing and of the insulated resistors therein being bent in longitudinally curved form, and said resistors having at one end of the tubing separate terminals leading respectively therefrom and projecting from said end of the tubing, said insulating powder and resistors occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the resistors.

8. An electric heater comprising a length of preformed metal tubing having therein a plurality of helical resistors extending lengthwise thereof separately in side by side relation, an insulating powder in said tubing compactly confined thereby in a hard dense mass within which said resistors are embedded and by which the resistors are separated and insulated from one another and from the tubing throughout their length, and terminals leading respectively from the resistors and all projecting from the same end of the tubing, said tubing, resistors and compacted insulating powder being conjointly bent in flat serpentine form, said insulating powder and resistors occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the resistors.

9. An electric heater of the class described comprising a metal sheath of preformed tubing bent in flat serpentine form and having therein at least two conductors extending lengthwise thereof and joined together within one end of the tubing, said conductors having separate terminals leading therefrom respectively through the other end of the tubing, and insulating powder in the tubing compactly confined thereby in a hard dense mass in which said conductors are embedded in spaced apart relation throughout their length, one of said conductors being a helical resistance, said insulating powder and conductors conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the conductors.

10. An electric heater of the class described comprising a metal sheath of preformed tubing closed at one end and coiled in flat serpentine form, said tubing having therein two resistance helices extending lengthwise thereof in laterally spaced relation to one another and both lying in substantially the same plane, said helices being joined together at the closed end of the tubing and each having a separate terminal leading therefrom through the other end of the tubing, and insulating powder in the tubing compactly confined thereby in a hard dense mass in which the resistance helices are embedded in substantially parallel spaced apart relation throughout their length, said insulating powder and resistors occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the resistors.

11. An electric heater of the class described comprising a metal sheath of preformed tubing closed at one end and coiled in flat serpentine form, said tubing being flattened at one side of the plane of the flat serpentine form and having therein two resistance helices extending lengthwise thereof in laterally spaced relation to one another, and both lying in substantially the same plane, and a return conductor in the tubing leading from the ends of the helices at the closed end of the tubing to the other end of the tubing, insulating powder in the tubing compactly confined thereby in a hard dense mass in which the helices and conductor are embedded in substantially parallel spaced apart relation throughout their length, and three separate terminals projecting from the last mentioned end of the tubing and leading respectively from the two helices and the conductor, said insulating powder and helices conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the helices.

12. A metal sheathed electrical heater of the class described comprising a preformed metal tube flattened along one side and coiled in a flat serpentine winding with the flattened side of the tubing lying in the plane of one side of the serpentine winding, a pair of laterally spaced helical resistances in the tubing and extending lengthwise of and in substantially equal proximity to the flattened side of the tubing, said tubing being closed at one end and each resistance having a separate terminal projecting therefrom through the other end of the tubing, and powdered insulation in the tubing and confined thereby in a hard dense mass within which the resistances and the inner ends of the terminals are embedded, said powdered insulation and resistances conjointly occupying and completely filling the interior of the metal tube throughout the length of the latter between the ends of the resistances.

13. The method of making a metal sheathed plural resistance electrical heater which comprises inserting a plurality of helical resistances in side by side relation endwise into a length of preformed metal tubing, and supporting the resistances at their ends in separated relation so

that they extend lengthwise in the tubing in substantially parallel side by side relation, then gradually introducing an insulating powder into one end of the tubing, and at the same time progressively packing said insulating powder around and within all of the resistors simultaneously so as to hold the resistors in predetermined separated relation from one another and from the tubing solely by the compacted insulating powder, then swaging the tubing transversely to a reduced size and thereby further compacting the insulating powder therein, and thereafter coiling the tubing and contents into flat serpentine form.

14. The method of making a metal sheathed electrical heater of the class described which comprises inserting two helical resistances endwise into a length of preformed metal tubing through an end of the latter, supporting said inserted helices at the opposite ends thereof in a manner to hold the resistances outstretched respectively at opposite sides of the interior of the tubing and while thus supported progressively filling the tubing with powdered insulation and packing the powdered insulation in and around the resistances progressively throughout their length so as to embed the resistances within compacted insulation and thereby hold the resistances away from the tubing wall and in parallel spaced apart relation at opposite sides respectively of the interior of the tubing solely by the compacted insulating powder, then bending the tubing with

the insulation and helices therein into a flat serpentine winding wherein both helices lie substantially in the same plane between the opposite sides of the flat serpentine winding, and thereafter flattening the tubing transversely in a direction perpendicular to said last mentioned plane of one side of the serpentine winding and simultaneously deforming and flattening both helices at the sides thereof nearest the latter plane.

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