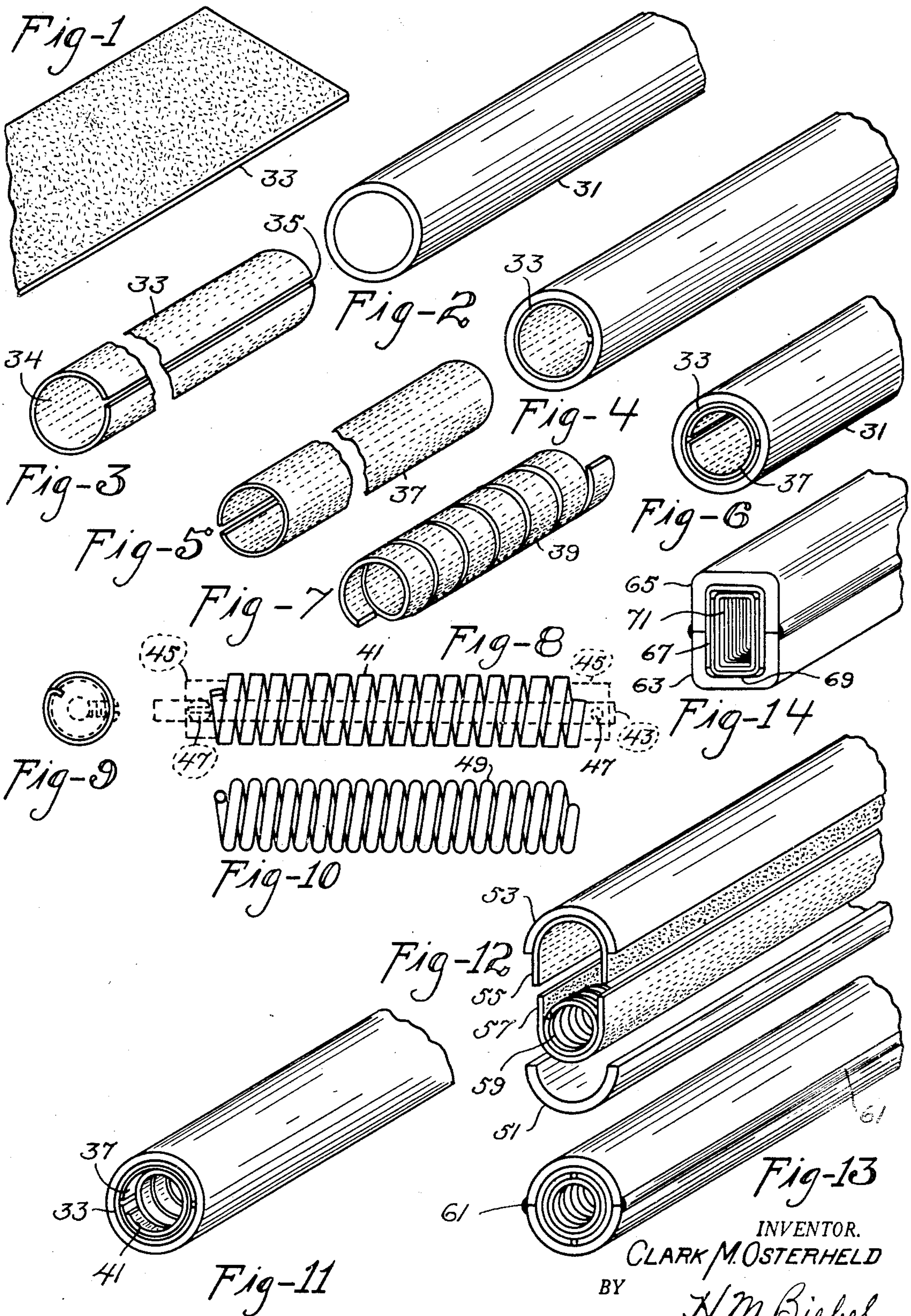
Sept. 12, 1944. C. M. OSTERHELD 2,357,906
ELECTRIC RESISTOR UNIT
Filed Nov. 2, 1942 2 Sheets-Sheet 1



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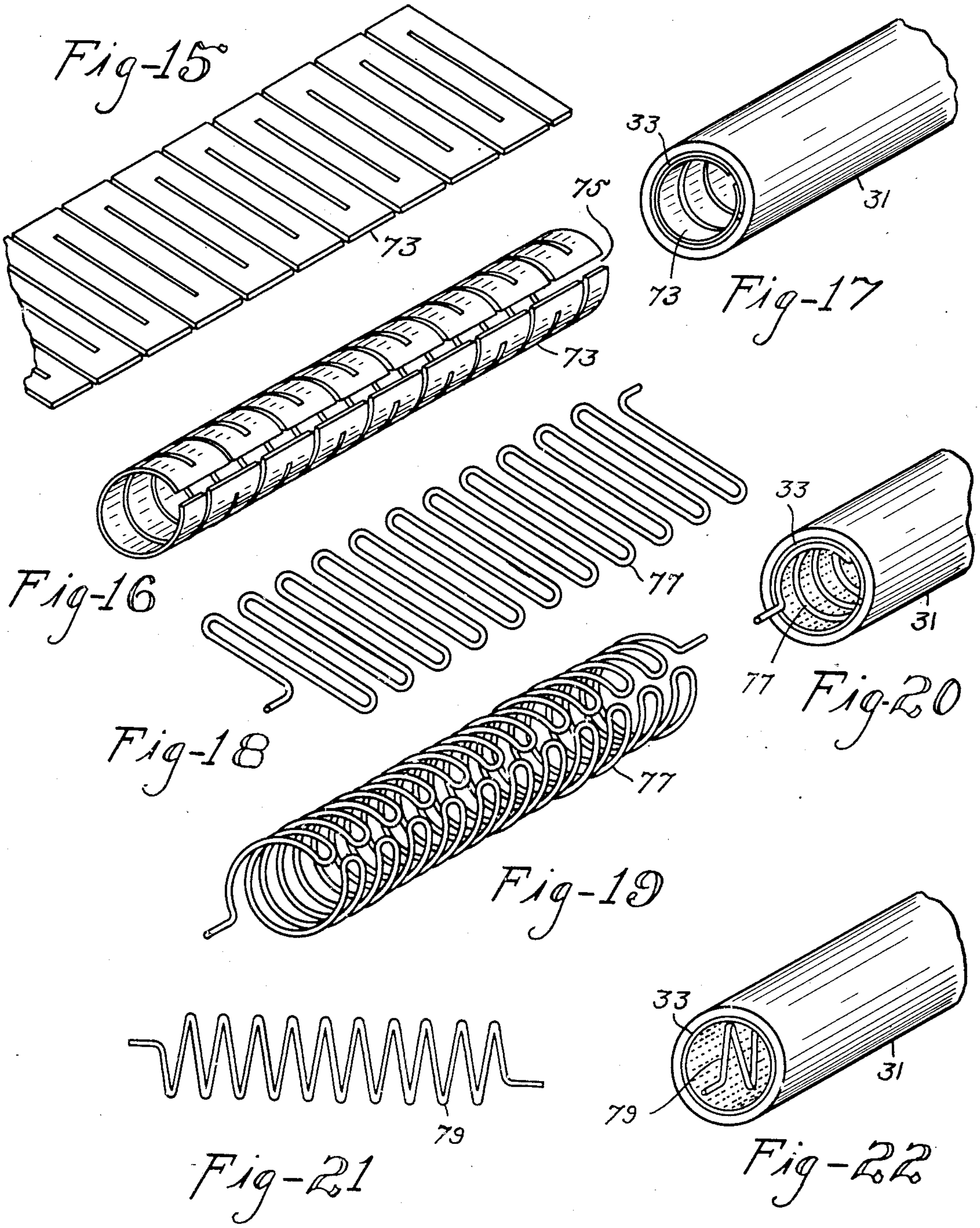

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Patented Sept. 12, 1944

2,357,906

UNITED STATES PATENT OFFICE

2,357,906

ELECTRIC RESISTOR UNIT

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Application November 2, 1942, Serial No. 464,204

12 Claims. (Cl. 201—67)

My invention relates to encased electric resistor and heating units.

Among the objects of my invention are the following: to provide a resistance unit of relatively simple, inexpensive and easily assembled construction; to provide a resistance unit having a layer of electric-insulating characteristic between the resistor conductor and the outer casing which is of extreme thinness, is heat-conducting, is integral with one of the elements of the unit and is inorganic; to provide a resistance unit having relatively small heat storage capacity; to provide a structure that shall have low thermal reluctance and high heat conductivity; to provide a resistor or heating unit that shall permit of operating the resistor conductor itself at relatively low temperature to thereby obtain longer life of the unit and, finally, to provide a resistor or heater unit that shall be inexpensive and have a relatively long life.

Other objects of my invention will either be apparent from a description of various forms and modifications of my invention or will be pointed out in the course of such description and set forth particularly in the appended claims.

In the drawings,

Figure 1 is a fragmentary view in perspective of one element of a resistor or heating unit embodying my invention, in its initial form,

Fig. 2 is a fragmentary perspective view of an outer preferably metallic casing therefor,

Fig. 3 is a perspective view of the element of Fig. 1 shown in its formed shape,

Fig. 4 is a perspective view of the elements shown in Figs. 2 and 3 when assembled in proper operative relation,

Fig. 5 is a perspective view of an element similar to Fig. 3 but adapted to be inserted therein,

Fig. 6 is a fragmentary perspective view of the parts shown in Figs. 4 and 5 when assembled,

Fig. 7 is a view showing another form of an electric-insulating element or sheath having the same object as the one shown in Fig. 5, but of different construction,

Fig. 8 is a view, in side elevation, of a helically wound resistor strip,

Fig. 9 is an end view thereof,

Fig. 10 is a view, in side elevation, of a helically wound resistor wire,

Fig. 11 is a fragmentary perspective view of an assembled resistor or heating unit,

Fig. 12 is an exploded view in perspective of another modification of resistor or heating unit embodying my invention,

Fig. 13 is a fragmentary perspective view thereof when finaly assembled,

Fig. 14 is a fragmentary perspective view of another modification of resistor or heating unit embodying my invention,

Fig. 15 is a fragmentary perspective view of a flat resistor strip having alternately oppositely extending slits therein to increase the length of curent path therein,

Fig. 16 shows the element of Fig. 15 in an intermediate stage of manufacture where it has been shaped to substantially circular form in lateral section,

Fig. 17 is a fragmentary perspective view of a tubular outer casing with a single coated liner therein,

Fig. 18 is a perspective view of a convoluted resistance conductor in the first stage of its manufacture,

Fig. 19 is a perspective view thereof shown in an intermediate stage where the substantially parallel-extending convolutions thereof have been formed to substantially circular shape,

Fig. 20 is a fragmentary perspective view of an outer tube and a metallic electrically insulated lining therein ready to receive the member shown in Fig. 19,

Fig. 21 is a view, in side elevation, of another form of resistance conductor in its first stage of manufacture, and,

Fig. 22 is a fragmentary perspective assembled view showing the element of Fig. 21 in its proper operative position within an outer casing and an electric insulated liner therein.

Methods of producing on aluminum or aluminum alloy surfaces, very thin coatings of electric-insulating characteristic have long been known and reference may be had to Patent No. 1,526,127 for one method of producing such coatings, usually termed or called "anodic" coatings. Preferably, anodic coatings may be produced by making the aluminum or aluminum alloy article the anode in an electrolytic solution of the proper characteristic so that upon passage of current of a given voltage for a given time, a relatively very thin coating will be produced upon the surface. This inorganic coating is, as is now well known, coherent or integral, of extreme thinness, which may be on the order of .0001" or more, is heat-conducting, high temperature-resisting, and what is of particular importance for my use of such coated articles, is electric-insulating. Some of these coatings will withstand relatively high break-down voltages, the upper limits of which may be on the order of 30,000 volts. It is also possible to provide or produce such electric-insulating coatings having all of the other hereinbefore mentioned characteristics, by immersion of an aluminum article in certain kinds of solutions which are clearly set forth in various patents to which reference may be had but since my invention does not relate to the production of such coatings but only to the use of metallic articles of different forms to be hereinafter described, no specific mention is made of these patents. I may further point out here that while my invention is embodied preferably in aluminum elements of the kinds to be hereinafter set forth, it is not limited thereto since other metals which may have produced thereon, by suitable means, an integral or coherent, heat-conducting, inorganic high temperature-resisting, and electric-insulating coating may be substituted therefor.

Referring now to the drawings, I have there illustrated, in Fig. 2, a circular tubular member 31 which, while preferably made of metal such as aluminum, is not limited thereto but may be made of a high temperature-resisting material having high heat-conducting characteristics. Located within the outer tubular casing member 31 is a liner 33 which may initially be of elongated sheet or strip shape as shown in Fig. 1 of the drawings and may be bent to substantially circular shape, as shown in Fig. 3 of the drawings. This liner 33 is preferably made of aluminum or an aluminum alloy and has, on at least its inner surface thereof, a coating of the kind hereinbefore described but may have a coating on both surfaces thereof, as is indicated by the broken lines 34 in Fig. 3 of the drawings. The thickness of this liner is also relatively small and, for illustrative purposes, may have a thickness of .015" and, further, it is so dimensioned that when the tubular liner is compressed to cause the edges 35 to meet, the liner can be easily and quickly inserted in or telescoped with the outer tubular member 31. It is possible to cause the shaped tubular liner shown in Fig. 3 to have inherent outwardly-acting springiness so that when it has been introduced into the outer casing member 31, it will, by its inherent resilence or springiness, closely engage the inner surface of the tubular member 31 to provide a relatively large area of heat flow path outwardly from a resistor conductor located therein, all as will be hereinafter set forth.

If an encased or sheathed resistor or heating unit of the kind embodying my invention is to be subject to a relatively high break-down voltage, I may provide a second liner 37 shown in Fig. 5 of the drawings, made by the same method as set forth for the outer electrically insulated liner 33 but of slightly smaller dimensions. When the second liner 37, shown in Fig. 5 of the drawings, is slightly pinched and then inserted within the outer liner in the outer casing 31 to provide the structure shown in Fig. 6 of the drawings, and if both surfaces of the liners have thereon an electric-insulating coating of the kind hereinbefore described, there will be four such coatings between a resistor conductor to be located therewithin and the inner surface of the outer tubular metal member 31.

In Fig. 7 of the drawings I have shown another form of liner made by using a flat strip 39 of coated metal wound into helical shape. It is to be understood that this liner is also relatively thin, say on the order of .015" and, when using such a helically wound liner member it is only necessary to provide additional stress upon one end of the helically coiled member 39 relatively to the other end thereof to slightly decrease the outer diameter thereof and permit of its easy introduction into a tubular member 31 or into an outer liner 33.

The resistor conductor adapted to be positioned within the single or plural liner members is shown in one form thereof in Fig. 8 and comprises a helically wound strip or strand 41 of any suitable material such as Nichrome. However, I do not desire to be limited to the resistor conductors heretofore used but may use, for instance, an aluminum conductor which may be also provided with a coating of electric-insulating characteristic and having also the other characteristics above described in connection with the liner.

In order to provide a relatively easy and simple means for and method of reducing the external diameter of the helically coiled conductor 41 I have shown generally a rod 43 having bushings 45 thereon at its opposite ends which bushings may be engaged by the respective ends of the resistance conductor 41 to permit of relative twisting of the two bushings and holding them in desired fixed position temporarily on the rod 43 by screws 47 to cause the outer diameter of the helical coil to be less than that of the inner surface of the single or the inner of a plurality of liners. This permits of easy introduction of the helically coiled resistor into the lined outer casing and release of the screws 47 will permit of removal of the members 43, 45 and 47 so that the heating unit will be in its proper assembled condition.

While a resistor strand of the strip or flattened strand type will provide relatively large area of engagement of the resistance conductor with the liner, my invention is not limited thereto but I may use a resistance conductor of wire shape as shown at 49 in Fig. 10 of the drawings. Such a helically coiled resistor wire may be temporarily wound more tightly or twisted a little more to permit of its easy introduction into the lined outer tubular member, all as above described.

Referring now to Fig. 12 of the drawings, I have there shown another modification or resistor or heating unit comprising a semi-circular outer casing member 51, a complementary semi-circular casing member 53, each of these members having therein a coated aluminum liner of substantially semi-circular shape, the upper member 53 having a liner 55 therein while the lower member will have therein a liner 57, both initially of channel shape. It is to be noted that I may position the shaped liner 55 in one of the semi-circular casing members such as member 53, but prefer to assemble the complementary liner member 57 on a helically wound resistor conductor 59, which latter may be of the kind shown in Figs. 8 or 10. With the members 51, 53, 55, 57 and 59 assembled in substantially the relative positions shown in Fig. 12 of the drawings, it is only necessary to apply pressure to the upper casing member 53 to cause these members to be assembled in substantially the relative positions shown in Fig. 13 of the drawings after which a welding seam 61 may be provided for each of the two engaging edge portions of the members 51 and 53. It is obvious, in a resistor or heating unit such as shown in Figs. 12 and 13, that it may be preferable to make the outer casing members 51 and 53 of iron or steel in order to permit of easy, quick and efficient provision of seams 61 thereon.

Referring now to Fig. 14 of the drawings, I have there shown a further modification of encased heating unit in its assembled form. It embodies a casing member 63 which is of substantially channel-shape in cross section, a complementary casing member 65 of channel shape so that when the two are positioned in proper operative position relatively to each other a substantially rectangular outer casing will be provided thereby. A liner 67, which is preferably of anodically coated thin aluminum, as has hereinbefore been set forth, may be located therein and a second liner member 69 is provided and it is to be understood that these liners are preferably of aluminum and have at least the inner surface of the inner liner coated as above described. A helically formed resistance conductor 71, which is of substantially rectangular or square shape in lateral section, is positoned within the liner or liners as above described, and since this conductor is so constructed and treated during manufacture thereof that it has inherent springiness, at least the corner portions of each turn of the resistance conductor will be in close operative engagement with the integral electric-insulating coating on the liner immediately surrounding the same.

Referring now to Fig. 15 of the drawings, I have there shown another form of resistance conductor which is initially of a type which has been used in the art heretofore. It includes a strip 73 of a suitable resistance material which is provided with laterally extending slots which slots reach to the edges thereof alternately so as to provide a relatively long current flow path and it is, of course, well known that variations in the dimensions of the strip, the number of slots and the width of the conductor therebetween will permit of obtaining a wide range of ohmic resistance therein.

Fig. 16 shows the second step in the manufacture of the resistance conductor 73 which consists in shaping the same, as around a rod, to substantially circular shape in lateral section. Here again diametral compression on the circular member at a point 90° in either direction from the gap 75 will slightly reduce the outer diameter and permit of easy introduction into a lined casing such as shown in Fig. 17. Here again it may be pointed out that the area of heat-conducting path between the conductor 73 and the inner coated surface of the liner in an outer casing is relatively large, therefore providing a very efficient and effective heat flow path therebetween.

Referring now to Fig. 18 of the drawings, I have there shown a conductor 77 which is initially shaped to provide convolutions which extend substantially parallel and laterally of the length of the resistor member itself, all as shown in Fig. 18.

Fig. 19 shows the second step in the manufacture of such resistor member as by shaping the convoluted conductor 77 on a rod to a substantially circular form laterally of the length of the resistor member. A slight pressure, as hereinbefore described in connection with resistance member 73, will permit of easily and quickly inserting the conductor 77 into a lined casing shown in Fig. 20 of the drawings.

Referring to Fig. 21 of the drawings, I have there shown another form which the resistance conductor may take and a conductor 79 is shown which is also of convoluted shape but instead of the individual convolutions being parallel to each other, the adjacent convolutions extend slightly angularly relatively to each other. When using a conductor of this kind it is only necessary to provide a slight temporary tension on the ends of the conductor to cause the return-bend or side parts thereof to be spread slightly farther apart whereby the lateral overall width of the resistance conductor will be slightly decreased thereby permitting of inserting the conductor 79 easily and quickly in a lined outer casing, as shown in Fig. 22 of the drawings. It may be here pointed out that the area of the heat-flow path between the conductor 79 and the lining, only one of which is shown in Fig. 22, is, of course, relatively small, particularly as compared to that provided by resistance conductor 41 or 73. However, since the conductor is tightly encased in the lined outer casing member, the heat which is not transmitted by conduction will reach the liner by radiation and will then be transmitted to the outer surface of the casing member by conduction.

Where, in the claims, I have used the word convoluted, I desire to cover all of the forms shown, for instance, in Figs. 8, 10, 16, 19 and 21 of the drawings. It is possible, in the manufacture of resistance conductors to be used in the device embodying my invention, to cause the conductor, when shaped as hereinbefore described, to have an inherent radially outwardly acting or effective springiness and while the liner or liners are also preferably but not necessarily inherently radially outwardly springy, it is evident that the inherent springiness in the conductor will force the outer surface of the conductor into close operative engagement with the liner and will also force the liner into close operative engagement with the inner surface of the outer casing. It is thus evident that the inherently springy resistor conductor will not only hold the liner or liners in proper operative engagement with the casing but will also hold itself in proper heat-conducting operative engagement with the liner or liners.

Heretofore, in many applications and uses of heating units, it has been found desirable or even necessary to operate resistance conductors used therein at relatively high temperatures, on the order of 1200° F. I have found it possible to so design the various parts of devices disclosed and claimed in the instant application and embodying my invention that the resistance conductor may be operated at incipient red heat or even at dark heat. This makes it possible to operate a heating unit of the kind herein disclosed at a temperature which is only slightly higher than that of the mass surface or area to be heated, that is, on the order of say 200° or 300° F. excess of temperature.

The device embodying my invention as hereinabove set forth, includes an outer heat-conducting tubular casing which may preferably be made of suitable metal, having therein a relatively thin liner or liners which have thereon very thin, integral, inorganic, electric-insulating, heat-conducting, and high temperature-resisting coatings and a resistance conductor therein which may be either of the kind heretofore used, such as Nichrome, or may even be of aluminum. It is noted that aluminum has a relatively large positive temperature coefficient of resistance but I believe that this would be an added advantage in heating units embodying my invention because it would cause quicker heating up of the heating unit than might otherwise be the case.

It is further to be noted that the heat storage mass of heating units embodying my invention can be made much smaller than has been possible heretofore and, further, the high heat-conducting characteristic of the coating or coatings of electric-insulating characteristic makes possible better heat flow than has heretofore been the case. It is further to be pointed out that the integral coatings of the kind above described permit of the shaping of coated resistance conductors without danger of break down or cracking of the electric-insulating coating thereon, but even if the coating on the aluminum resistance conductor should break, the double or quadruple coatings provided on one or several liner members will effectively prevent break down between the conductor and the outer casing.

It may be noted that the various forms of encased resistor or heating elements may be bent or otherwise formed into any desired shape to adapt them to any desired application. It is further to be understood that while I have shown a substantially circular outline of outer casing, I may make the cross sectional shape other than circular, that is, I may flatten a part of the periphery, if desired.

While no details are shown or described as to a terminal structure it is to be understood that such structures will be provided, but they form no part of my invention.

Various modifications may be made in the system embodying my invention as herein shown and described and all such modifications clearly coming within the scope of the appended claims are to be considered as being covered thereby.

I claim as my invention:

1. An encased resistor unit comprising an outer tubular heat-conducting casing, a liner of thin metal within the tubular casing having an integral, inorganic, heat-conducting, high temperature-resisting, electric-insulating coating on at least its inner surface and a convoluted resistor strand within the liner having an inherent outwardly-acting spring effect adapted to operatively engage the liner to hold the liner in close operative engagement with the tubular casing and to hold itself in proper operative position in the liner.

2. An encased resistor unit comprising an outer tubular metal casing, a liner of thin metal within the tubular casing having an integral, inorganic, heat-conducting, high temperature-resisting, electric-insulating coating over substantially its entire surface and a convoluted resistor strand within the liner having inherent resiliency to provide an outwardly-acting spring effect on the liner to hold the latter in close operative engagement with the tubular casing and to hold itself in proper operative position in the liner.

3. An encased resistor unit comprising an outer tubular metal casing, at least one liner of relatively thin spring sheet metal within the casing extending around substantially the entire inner periphery of the casing and having an integral electric-insulating, heat-transmitting and high temperature-resisting coating on its surface and a coil of resistor strand within the liner expanded in two different directions to maintain the adjacent turns out of engagement with each other and to hold each turn in close operative engagement with the inner surface of the liner and to hold the liner in close heat-transmitting engagement with the inner surface of the tubular casing.

4. An encased resistor unit comprising an outer tubular metal casing, a lining member of relatively thin aluminum within the tubular casing having an integral, inorganic, electric-insulating, heat-conducting and high temperature-resisting oxide coating on at least its inner surface, a convoluted resistor strand within the lining member having inherent resiliency to provide an outwardly-acting spring effect on the lining member to hold the latter in close operative heat-transmitting engagement with the tubular casing and to hold itself in proper operative position in the liner.

5. An encased resistor unit comprising an outer tubular metal casing, a lining member of relatively thin springy sheet metal within the casing adapted to conform closely to the shape of the inner surface of the casing and operatively engage therewith over substantially the entire periphery of the inner casing and a convoluted inherently-resilient resistor member within the lining member in operative engagement therewith, one of said members having an integral, inorganic, electric-insulating, heat-conducting and high temperature-resisting coating on the engaging surface thereof, the inherently-resilient resistor member being effective to hold the lining member in close heat-transmitting engagement with the inner surface of the casing and to hold itself in predetermined position within the lining member.

6. An encased resistor unit comprising an outer tubular high temperature-resisting heat-transmitting casing, a relatively thin metal liner therein conformant to the shape of the inner surface of the casing and embodying an integral electric-insulating, high temperature-resisting coating on at least the inner surface thereof and an inherently-resilient formed resistor member within the liner, engaging therewith and acting thereon to effect good heat-transmitting engagement between the liner and the casing and between the resistor member and the liner.

7. An encased resistor unit comprising an outer tubular metal casing, a liner therein comprising a helically wound strip of aluminum embodying an integral coating of high temperature-resisting heat-conducting coating on at least the inner surface thereof, a convoluted inherently-resilient resistor within the liner adapted to hold the liner in close heat-transmitting engagement with the casing and to hold itself in predetermined position within the liner.

8. An encased resistor unit comprising an outer tubular heat-transmitting casing, a relatively thin metal liner therein conformant to the shape of the inner surface of the casing, an inherently resilient convoluted metallic resistor conductor within the liner adapted by its inherent resiliency to hold itself in good heat-transmitting engagement with the liner and to hold the liner in good heat-transmitting engagement with the casing, the liner and the resistor conductor having on their surfaces a coating of an inorganic, integral, heat-conducting, high temperature-resisting electric-insulating character.

9. An encased resistor unit comprising an outer tubular heat-transmitting casing, a plurality of relatively thin aluminum liners coaxially positioned in the casing, an inherently resilient convoluted metallic resistor member coaxially positioned within the liners adapted by its inherent resiliency to hold itself in good heat-transmitting engagement with the inner liner, to hold the inner liner in close heat-transmitting engagement with the outer liner and to hold the outer liner in close heat-transmitting engagement with the inner surface of the outer casing, the surfaces of the resistor member and of the liners having thereon an integral, inorganic, heat-

transmitting, high temperature-resisting and electric-insulating coating.

10. An enclosed heating unit comprising an outer tubular metal casing, a liner of thin sheet metal within the casing having an integral, inorganic, heat-conducting, high temperature-resisting, electric-insulating coating on at least its inner surface, the thickness of this coating being on the order of .0001'' and a convoluted resistor strand within the liner having inherent resiliency to provide an outwardly-acting spring effect on the liner to hold the latter in close operative engagement with the casing and to hold itself in close heat-transmitting engagement with the liner, the thermal reluctance of the thin liner and of the coating thereon being such that the excess of temperature of the resistor over that of the outside of the casing will be on the order of not to exceed 300° F.

11. An enclosed heating unit comprising an outer tubular aluminum casing, a liner of thin sheet aluminum having a thickness on the order of .015'' extending around substantially the entire inner periphery of the casing having an integral, inorganic, heat-conducting, high temperature-resisting, electric-insulating coating on each surface thereof, the thickness of the coatings being on the order of .0001'' and a convoluted resistor strand of aluminum within the liner having inherent resiliency to provide an outwardly-acting spring effect on the liner to hold the latter in close operative engagement with the casing and to hold itself in close heat-transmitting engagement with the liner, the thermal reluctance of the liner and of the coatings thereon being such that the excess of the temperature of the resistor over that of the outside of the casing will be on the order of not to exceed 300° F.

12. An encased heating unit comprising an outer tubular aluminum casing, a liner within the casing consisting of a thin helically-wound aluminum strip, the thickness of which is on the order of .015'' and having an integral, inorganic, heat-conducting, high temperature-resisting, electric-insulating coating over its entire outer surface, the thickness of which is on the order of .0001'' and a convoluted inherently-resilient resistor member within the liner effective to hold the liner in close heat-transmitting engagement with the inner surface of the casing and to hold itself in close heat-transmitting engagement with the liner, the thermal reluctance of the liner and of the coatings thereon being such that the excess of temperature of the resistor over that of the outside of the casing will be on the order of not to exceed 300° F.

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