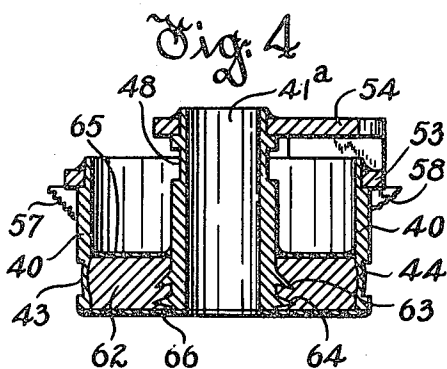
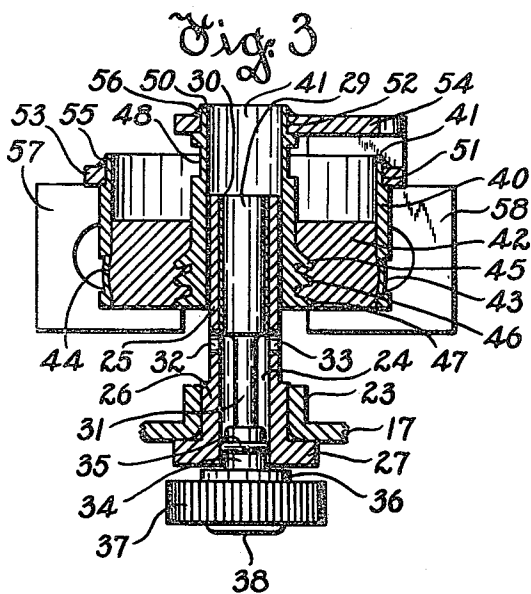
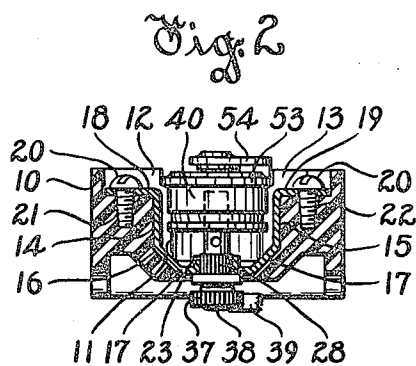
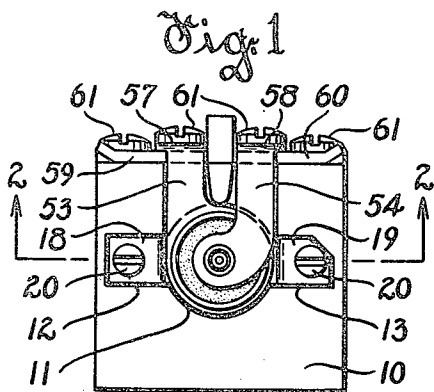


Aug. 23, 1949.

L. D. DRUGMAND ET AL
RESISTANCE HEATER UNIT FOR THERMAL OVERLOAD
DEVICES AND METHODS OF MAKING THE SAME
Filed Oct. 17, 1945

2,479,914



Inventors
Lester D. Drugmand
Edwin W. Seeger
By Frank H. Hubbard
Attorney

UNITED STATES PATENT OFFICE

2,479,914

RESISTANCE HEATER UNIT FOR THERMAL
OVERLOAD DEVICES AND METHOD OF
MAKING THE SAME

Lester D. Drugmand, Milwaukee, and Edwin W.
Seeger, Wauwatosa, Wis., assignors to Cutler-
Hammer, Inc., Milwaukee, Wis., a corporation
of Delaware

Application October 17, 1945, Serial No. 622,750

18 Claims. (Cl. 201-76)

1

This invention relates to improvements in resistance heater units for thermal overload devices and methods of making the same.

A primary object of the invention is to provide a resistance heater unit which will function in the desired manner to effect tripping of a thermally responsive circuit controlling device under predetermined overload conditions, while remaining substantially indestructible under extremely high overload conditions, as, for instance, a short circuit.

Another object is to provide such a unit wherein the resistance element itself is molded from a mixture of conducting and non-conducting ingredients in powder form in predetermined proportions, according to the operating characteristics and normal rating desired for the unit.

Another object is to provide such a unit which is interchangeable with and adapted to act as an improved substitute for the wire heater coils heretofore employed.

Another and more specific object is to provide a resistance heater element in the form of an annular disk which is molded in situ between a pair of inner and outer tubular metal members, whereby the latter are held in properly assembled relation.

Another object is to provide novel means for affording a good electrical and mechanical interlocking connection between the resistance heater element and said tubular metal members as an incident to the molding operation.

Another object is to provide a novel form of wiring terminals and novel means for attaching the same to the tubular members to act as a support for the unit as a whole.

Another object is to provide novel methods of making resistance heater units of the aforementioned character.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate certain embodiments of the invention which will now be described, it being understood that the embodiments illustrated are susceptible of modification in respect of certain structural details thereof without departing from the spirit of our invention or the scope of the appended claims.

In the drawings,

Figure 1 is a top plan view of a resistance heater unit constructed in accordance with our invention; the same being shown applied to a known form of electrical circuit-controlling device as a substitute for the usual resistance wire heater coil.

2

Fig. 2 is a sectional view, on the line 2-2 of Fig. 1; the parts of the resistance heater unit being shown in elevation.

Fig. 3 is an enlarged sectional view (about three times normal scale), showing the parts of the resistance heater unit in assembled relationship to each other, and in assembled relationship to a known form of thermally responsive latch-tripping device of the so-called eutectic alloy or self-soldering type, and

Fig. 4 is a sectional view similar to Fig. 3, showing a slightly modified form of the inner tubular member and the molded resistance heater element, but with portions of the respective terminal members broken away.

The resistance heater unit herein disclosed is adapted for use with any well-known type of electro-thermally responsive overload circuit breakers; as, for instance, an overload circuit breaker of the character disclosed in Patent No. 2,261,632, granted November 4, 1941, to T. F. Rosing and W. C. Stevens, for Electric circuit control mechanism, and assigned to the same assignee as the present application. The device herein disclosed would be substituted for the resistance wire heater coil (shown at 98 in Fig. 12) of said Patent No. 2,261,632. As is well known by those skilled in this art, resistance wire heater coils of the character disclosed in Patent No. 2,261,632 are satisfactory except under conditions of excessive overload, under which conditions they are very likely to fuse or burn out, thus producing a fire hazard. Even though the aforementioned resistance wire heater coils may in some instances withstand fairly high overloads, it is invariably found that such high overloads have a deleterious effect upon the resistance value or calibration of the coil; such high overloads in most cases causing a substantial drop in the resistance value of the heater coil. The undesirability of such a result is obvious.

We have found that resistance heater units produced in accordance with our invention have the very desirable characteristic that the normal resistance value and current rating thereof when completed will be substantially maintained both under the usual overload conditions encountered in practice, and under conditions of excessive overload, such as those incident to a short circuit, in which the unit may be called upon to withstand as much as twenty times its rated current. In practice it is possible to quite accurately insure the desired current rating of a given unit by carefully selecting and proportioning the powder ingredients of the resistance element,

3

and by properly controlling the molding pressure and the heat treatment to which the molded article is subjected.

Referring first to that form of our invention shown in Figs. 1, 2 and 3, the numeral 10 designates a molded insulating base section of a known form of electro-thermally responsive circuit breaker (as, for instance, one of the base sections 12, 12 shown in Figs. 1, 2 and 12 of the aforementioned Patent 2,261,632). Base section 10 is provided in its outer surface with an approximately cylindrical recess 11, said outer surface being provided with countersunk recesses 12 and 13, and the diametrically opposed side wall portions and the bottom wall of recess 11 being also countersunk at 14, 15 and 16, respectively, to accommodate an approximately U-shaped metal yoke member 17, whose outwardly bent end portions 18 and 19 are perforated (as shown in Fig. 2) to provide clearance for the shanks of a pair of so-called self-tapping metal screws 20; said shanks being formed in any well known manner to provide for tapping thereby of suitable recesses 21, 22 opening to said countersinks 12 and 13. The inner portion of yoke member 17 is provided centrally thereof with a circular opening surrounded by an upstanding annular flange 23.

A tubular metal member, having a bore 24 of circular cross section extending therethrough, includes a relatively long thin-walled portion 25, a relatively thick-walled portion 26, and an annular flange 27. As shown at 28 in Fig. 2 said portion 26 is longitudinally milled (or otherwise roughened in any suitable manner); the same being readily insertable within the upstanding flange 23, and the latter being then pressed or spun inwardly against the milled periphery of portion 26 to interlock said parts against rotary or longitudinal movement relatively to each other. As best illustrated in Fig. 3 the parts last mentioned are so assembled that the flange 27 will abut against the lower surface of the adjacent portion of metal support member 17.

Insertable upwardly into the bore 24 is a machined metal member having a cylindrical upper end portion 29, the upper end of which is adapted to be positioned in a substantially flush relationship to the upper end of portion 25 of the aforementioned tubular member; the outside diameter of said portion 29 being somewhat less than the inside diameter of bore 24 to insure that the former will be freely rotatable within the latter. However, a relatively thin or capillary film of eutectic alloy or solder 30 is interposed between the portions 29 and 26 to normally positively lock the former against rotation with respect to the latter. Adjacent portion 29 is a portion 31 of substantially reduced diameter, and the aforementioned portion 25 is preferably provided with a pair of diametrically opposed openings 32 and 33 at the line of junction of portions 29 and 31, the purpose of these openings being well known to those skilled in the art.

Adjacent the lower end of portion 31 is another portion 34 which is freely rotatable within bore 24. However, the portion 34 and the bore 24 are provided with transversely aligned peripheral grooves of segmental form in transverse cross section, which are jointly adapted to accommodate a split spring ring 35, which locks these parts against accidental longitudinal displacement, while permitting relative rotation thereof upon fusing or melting of the aforementioned solder film 30. Adjacent portion 34

4

is a flange portion 36, which is slightly spaced from the lower surface of flange 27 to afford rotary clearance between these parts. Below flange 36 is a portion of reduced diameter (not shown) upon which a perforated ratchet wheel 37 is adapted to be strung. The lower end of said last mentioned reduced portion is tightly riveted or upset over the lower end of ratchet wheel 37, as indicated at 38 in Figs. 2 and 3, to secure said parts against rotation relatively to each other. The numeral 39 in Fig. 2 designates a fragment of a resilient pawl carried by a movable member of suitable form (not shown), which member is normally biased to a given circuit-interrupting position and is restrained by ratchet wheel 37 against such biased movement pending fusion of the aforementioned solder film. The parts aforescribed are of known form, and the same form no part of the present invention.

As aforesaid, we substitute for the usual coiled wire heater element a device of the character now to be described. Our device comprises essentially an outer tubular metal member 40, the outside diameter of which is such as to permit ready insertion thereof into recess 11 and between the upstanding arms of the aforementioned metal supporting member 15; an inner tubular metal member 41 (Fig. 3) whose inside diameter is such that it is easily slidable downwardly over the upper end portion 25 of the member forming part of the aforescribed thermally responsive device. The lower ends of tubular members 40 and 41 are arranged in flush relationship to each other, and the same are rigidly mechanically connected to each other by an interposed annular or disk-like body 42 composed of a mixture of ingredients in powder form molded in situ under relatively high pressure and subjected to a suitable heat treatment as hereinafter described.

We prefer to provide the tubular member 40 with an external peripheral groove 43 adjacent the lower end thereof, thus forming a thinned and more readily deformable wall portion 44, which is bulged outwardly as shown as an incident to molding of the body 42, whereby a positive mechanical interlock is provided between the latter and member 40. Member 41 is likewise provided adjacent its lower end with a plurality of outwardly projecting annular ribs or vanes 45, 46, 47, which initially extend outwardly in planes at substantially right angles to the longitudinal axis of member 41; but the upper rib 45 is bent or deflected downwardly to a considerable extent, and the intermediate rib 46 is bent downwardly to a slight extent as an incident to application of the necessary molding pressure to the body of material 42. Such deformation of at least some of the ribs 45, 46 and 47 insures a good mechanical interlocking connection between tubular member 41 and the body 42 forming the heating resistor element of the device. The mechanical interlocking connections afforded between body 42 and each of the tubular members 40 and 41 also insure good electrical and thermal connections between these parts.

Member 41 is preferably provided exteriorly thereof from its upper end and the body 42 with a peripheral groove 48 which is adapted to act as a heat block to minimize the amount of heat transmitted through member 41 to its terminal end.

The members 40 and 41 are provided with exteriorly cut-away or reduced upper end portions

49 and 50 to respectively accommodate the circular openings 51 and 52 formed in a pair of terminal members 53 and 54; said terminal members being rigidly and permanently mechanically and electrically connected to the respective members 40 and 41 by soldering (preferably silver soldering), brazing, or welding the same, as indicated at 55 and 56 in Fig. 3. Terminal members 53 and 54 have perforated end portions 57 and 58 bent at right angles thereto to overlie the respective openings (not shown) in a pair of wiring terminal plates 59 and 60 (Fig. 1). Plates 59 and 60 are respectively provided with outer openings (not shown); and the two openings in each of plates 59 and 60 respectively overlie recessed and tapped metal inserts (not shown) in base section 10 to accommodate the shanks of a corresponding number of wiring terminal screws 61. Thus the outer screws 61 provide for electrical connection of the circuit wires to plates 59 and 60 while the inner screws 61 provide for electrical connection of the terminals 53 and 54 to the respective plates 59 and 60.

In the slightly modified form of our invention illustrated in Fig. 4 most of the parts may be identical with those aforescribed, and the corresponding parts have been given like numerals of reference. However, the molded and heat sintered body 62 is of substantially less thickness than that shown at 42 in Fig. 3. Therefore, although the member 41^a in Fig. 4 may be machined from the same metal blank or piece as the corresponding member in Fig. 3, we prefer to provide upon the member 41^a in Fig. 4 only two peripheral ribs or vanes, which are designated by the numerals 63 and 64; it being understood that the rib 63 is substantially deformed or bent downwardly as an incident to the molding pressure, to afford the aforementioned good mechanical, electrical and thermal connection between the molded body 62 and member 41^a.

Also as shown in Fig. 4, we prefer to coat or enamel the upper and lower surfaces of the molded body 62 with a suitable medium, such as blue frit, as indicated at 65 and 66; the coatings of blue frit in their final form acting to completely seal off the molded body 62 from contact with the surrounding atmosphere, thus assisting in stabilizing the operating and overload current controlling characteristics of the unit as a whole. It is to be understood that the molded and heat sintered body 42 in the device of Figs. 1 to 3 may likewise be provided with upper and lower protective and sealing layers of blue frit in a fused and hardened condition, as in Fig. 4, with consequent attainment of the desirable results aforementioned. On the other hand, many of the desirable operating characteristics of our device may be attained without the use of the aforementioned enamel coatings, especially in respect of certain uses of the device, and in certain installations where the variability of the operating conditions to be met with is at a minimum.

As a result of extensive experiments, we have found that many different conducting and non-conducting materials and binding agents may be employed in various different proportions, according to the operating characteristics (including resistance values) desired in the article in final form.

Thus, of the powdered metals which may be employed where a positive temperature coefficient of resistance is desired in the resistance element, we prefer to use a metal (or combinations of two or more of the metals) of the group comprising:

(1) iron; (2) nickel; (3) chromium; (4) tungsten; (5) silver; and (6) titanium.

Of the powdered materials which may be employed where a negative temperature coefficient of resistance is desired, we prefer to employ either: (1) carbon (preferably in the form of graphite), or (2) Carborundum.

As non-conducting ingredients of the resistance element we prefer to employ (in colloidal form) either: (1) bentonite; or (2) kaolin, or a mixture thereof.

As binding agents we prefer to combine with the molding mixture (when required) either: (1) sodium silicate; (2) chromic acid, or (3) magnesium oxychloride, or a mixture of any two or all of said materials. As will be noted from certain of the examples hereinafter set forth, it may not be necessary to employ any of the aforementioned binding agents, regardless of whether or not the resistance element is to be sintered before use thereof; such omission of the binding agent, of course, depending upon the particular character of the conducting and non-conducting materials employed in producing the element.

When it is desired to sinter the molded resistance element prior to use of the same, we prefer to include in the molding composition a predetermined proportion of a suitable frit or enamel (such as blue frit); although here again such a binder may or may not be required, but depends upon the particular character of the conducting and non-conducting ingredients of the molding mixture.

Whether or not such blue frit is included as a part of a particular molding mixture, we have found it desirable in most instances where the resistance element is to be sintered to provide the otherwise exposed faces of the body thereof with a coating of blue frit to be fused as an incident to the sintering operation. Such blue frit or enamel coating assists in stabilizing the operating characteristics of the element, and seals and strengthens the same.

The following is one method of producing a resistance element in accordance with our invention whereby an extremely low resistance value is provided:

Example I

A mixture of ingredients in powder form in the following proportions by weight was employed:

	Per cent
A mixture of nickel and chromium (of which 20 per cent was nickel and 80 per cent was chromium)	90
Blue frit enamel	5
Kaolin (in colloidal form)	2
Chromic acid	3

After thoroughly mixing said ingredients in a suitable manner the mixture was placed in a humidifier and allowed to remain there for forty-eight hours. We then deposited two grams of the humidified powder mixture into each of a plurality of die cavities, into each of which a set of the tubular metal parts 40 and 41 had previously been properly positioned. The parts of the molding dies were then heated to 400 degrees F., and then operated to effect application of a pressure of 10,000 pounds per square inch to the powder mixture.

The articles consisting of the molded bodies (42) and the respective sets of tubular metal members 40 and 41 united thereby were then removed from the molding cavities and sintered at

7

a temperature of 1800 degrees F. in air. The terminal members 53 and 54 were then attached to the respective tubular members 40 and 41 in the manner aforescribed. Upon testing one of the units the same was found to have a resistance value of .000576 ohm. Such unit was then assembled with respect to a thermally responsive device like that shown in Fig. 3, and upon subsection of the circuit containing the same to a current of 80 amperes, the tripping time was found to be 5.22 minutes (under a condition of 40 degrees C. ambient temperature). Under the same ambient temperature condition, upon subsection of the circuit to a current of 78 amperes, the tripping time was found to be 7.15 minutes. Under said ambient temperature condition when the circuit was subjected to a current of 77 amperes the thermal overload would not trip during a period of 30 minutes. Therefore, assuming that said device would require a current of at least 77.5 amperes to effect tripping thereof, the rating of the unit would be: 77.5 times 1.05, equals 81.4. The device when subjected to an overload of 1000 per cent for a number of times performed satisfactorily.

Example II

A mixture of ingredients in powder form in the following proportions by weight was employed:

	Per cent
Iron	33
Carborundum	47
Kaolin	10
Sodium silicate	10

After mixing and molding the powdered ingredients and sintering the molded articles in the manner set forth in Example I, except that 3 grams of the powdered mixture were employed for each article, one of the same, tested for an example, was found to have a resistance value of .017 ohm. The tripping current for said unit was found to be 30 amperes, and the same withstood a number of 1000 per cent overloads very well. This sample was also subjected to the four times fusing 5000 ampere short circuit test. The fuse burned out, and no fire hazard whatsoever resulted from operation of this resistance heater unit. On the contrary, the resistance element was found to remain almost at room temperature. Such a result would, of course, not be possible with a wire coil heater of like or similar operating character or rating.

Example III

A mixture of ingredients in powder form in the following proportions by weight was employed:

	Per cent
Iron	35
Carborundum	45
Kaolin	10
Blue frit	10

The ingredients were mixed and molded in the manner set forth in Example I. However, we here employed two and one-half grams of the molding mixture for each unit. After the molding operation the units were dipped in a blue frit solution. After drying at a temperature below 212 degrees F. the units were placed upon a "Transite" board and deposited in a furnace. The temperature was caused to rise slowly from room temperature to 1200 degrees F., which temperature was attained at the end of a period of two hours.

8

The units were then baked at 1200 degrees F. for about one hour. The temperature was then raised to 1500 degrees F., whereupon the blue frit fused. The supply of heat to the furnace was then discontinued, and the units were removed after the blue frit enamel had hardened. One of the completed units, having a measured resistance value of 2.89 ohms, was tested as follows in conjunction with a conventional overload device (such as that shown in Figs. 1, 2 and 3), with a resultant slight variation in resistance value:

	Amperes	Resistance, Ohms
15 Tripped three times at rated current	2.0	2.89
Tripped three times at current of	3.0	2.92
Tripped three times at current of	3.5	2.90
Tripped three times at current of	4.0	2.93
Tripped three times at current of	5.0	2.92
Tripped three times at current of	7.0	2.92
20 Tripped three times at current of	10.0	2.92
Tripped three times at current of	15.0	2.94
Tripped three times at current of	20.0	2.99

The resistance was measured at the end of each three tripping operations, and it will be noted that the resistance variation amounted to only 0.1 ohm throughout the entire range of currents to which the unit was subjected.

Example IV

A mixture of ingredients in powder form in the following proportions by weight was employed:

	Percent
Iron	38
Carborundum	42
Kaolin	20

Said ingredients were mixed and molded in the manner set forth in Example I, and the molded articles were then sintered at a temperature of 1700 degrees F. in an atmosphere of hydrogen. Such units when sintered were found to have a resistance value of .011 ohm, and a rated current of 20 amperes. During testing the units withstood currents up to 200 amperes without change in the value of their resistance. The units had a good appearance or finish, and especially good mechanical strength.

Example V

A mixture of ingredients in powder form in the following proportions by weight was employed:

	Percent
55 Iron	35
Carborundum	45
Kaolin	20

Said ingredients were mixed, molded and heat sintered in the manner set forth in Example IV. The units were enameled with a low melting point frit. Units produced from the materials and in the manner above set forth were found to have a resistance value of approximately .06 ohm.

Although we have herein specifically mentioned a molding pressure of 10,000 pounds per square inch, it is to be understood that the molding pressure employed may be varied throughout a very wide range, according to the physical characteristics of the particular ingredients of the resistance composition employed and/or the particular characteristics desired in the final article. For example, we have in some cases employed molding pressures as high as twenty-five tons per square inch.

Also while we have herein set forth only certain examples of methods by which the articles herein contemplated may be produced, it is to be understood that innumerable other combinations and proportions of ingredients, and the steps of treating the same, may be employed; but in all cases the advantage of non-fusibility of the resistance element under excessive overload conditions will be attained, as well as other advantages hereinabove set forth.

We claim:

1. In a device of the character described, in combination, an outer tubular metal member, an inner tubular metal member arranged in concentric relationship thereto, and an integral mass of molded powder composition resistance material interposed between said members and rigidly and permanently attached thereto throughout the inner periphery of the outer tubular member and throughout the outer periphery of the inner tubular member, said resistance material comprising essentially a conducting material and a non-conducting material in predetermined proportions, and said resistance material being characterized by its ability to withstand extremely high overload currents passing therethrough without fusing.

2. In a device of the character described, in combination, an outer tubular metal member of circular form in transverse cross section, an inner tubular metal member of circular form in transverse cross section arranged in concentric relationship thereto, an integral mass of molded powder composition resistance material interposed between said members and rigidly and permanently attached thereto throughout the inner and outer peripheries thereof respectively, said resistance material comprising essentially a conducting material and a non-conducting material in predetermined proportions, said resistance material being characterized by its ability to withstand without fusing overload currents which are extremely high with respect to the normal current rating of the device, and a pair of metal terminal members rigidly and permanently attached to the respective tubular members and acting as a support for the device as a whole.

3. A resistance heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members, said members being rigidly and permanently mechanically and electrically connected with each other by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, and said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body.

4. A resistance heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members, said members being rigidly and permanently mechanically and electrically connected with each other by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body, and a pair of punched and stamped sheet metal terminal members rigidly and permanently mechanically and electrically connected to the respective tubular members to afford

mechanical support and electrical connections for the unit as a whole.

5. A resistance heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body, said conducting material consisting of one or more substances of the group composed of iron, nickel, chromium, tungsten, silver, titanium, carbon and Carborundum, and said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin.

6. A resistance heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body, said conducting material consisting of one or more metals of the group composed of iron, nickel, chromium, tungsten, silver and titanium, and said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin.

7. A heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, a portion of said non-conducting material being composed of a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, and said conducting and non-conducting materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said body.

8. A heat sintered heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said mixture having incorporated therein a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, said molded mixture when subjected to a predetermined heat sintering treatment being adapted to provide a predetermined value of resistance of said body, and a pair of punched and stamped sheet metal terminal members rigidly and permanently mechanically and electrically connected to the respective tubular members to afford me-

11

chanical support and electrical connections for the unit as a whole.

9. A heat sintered resistance heater unit for thermal overload devices, comprising a pair of outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said conducting material consisting of one or more substances of the group composed of iron, nickel, chromium, tungsten, silver, titanium, carbon and Carborundum, said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin, said mixture having incorporated therein a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, and the ingredients of said mixture being so proportioned relatively to each other as to provide a predetermined value of resistance of the molded body after a predetermined heat sintering treatment thereof.

10. A heat sintered resistance heater unit for thermal overload devices, comprising a pair of outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said conducting material consisting of one or more metals of the group composed of iron, nickel, chromium, tungsten, silver and titanium, said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin, said mixture having incorporated therein a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, and the ingredients of said mixture being so proportioned as to provide a predetermined value of resistance of the molded body after a predetermined degree of heat sintering treatment thereof.

11. A heat sintered resistance heater unit for thermal overload devices, comprising a pair of outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said conducting material consisting of one or more metals of the group composed of iron, nickel, chromium, tungsten, silver and titanium, said non-conducting material consisting of one or more substance of the group composed of bentonite and kaolin, said mixture having incorporated therein a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, the ingredients of said mixture being so proportioned as to provide a predetermined value of resistance of the molded body after a predetermined degree of heat sintering treatment thereof, and the exposed surfaces of said molded body having a coating of blue frit applied thereon and rigidly united therewith, as an incident to said heat sintering treatment, said coating acting

12

to completely seal said body from contact with the atmosphere.

12. A heat sintered heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members of circular form in transverse cross section, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said materials consisting of 33 per cent by weight of iron, 47 per cent of Carborundum, 10 per cent of kaolin, and 10 per cent of sodium silicate, said molded body being characterized by a resistance value of 2214 ohms when sintered at 1800 degrees F. for a period of fifteen minutes and the same being further characterized by a resistance value of 19.8 ohms when sintered at the aforementioned temperature for a period of ninety minutes.

13. A resistance heater unit for thermal overload devices, comprising a pair of concentric outer and inner tubular metal members, said members being rigidly and permanently mechanically and electrically connected with each other solely by an integral annular body composed of a mixture of conducting and non-conducting materials in powder form molded under relatively high pressure in situ therebetween, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body when heat sintered at a predetermined relatively high temperature for a predetermined length of time, and said molded body being characterized by a variation in its resistance value substantially inversely proportional to an increase in the length of the sintering treatment at said temperature.

14. The method of making a resistance heater unit for a thermal overload device, which comprises rigidly and permanently mechanically and electrically connecting a pair of outer and inner tubular metal members solely by molding under relatively heavy pressure in situ therebetween an integral annular body composed of a mixture of conducting and non-conducting materials in powder form, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body.

15. The method of making a resistance heater unit for a thermal overload device, which comprises rigidly and permanently mechanically and electrically connecting a pair of outer and inner tubular metal members solely by molding under relatively heavy pressure in situ therebetween an integral annular body composed of a mixture of conducting and non-conducting materials in powder form, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body, and thereafter rigidly and permanently mechanically and electrically connecting to the respective tubular members a pair of punched and stamped sheet metal terminal members to afford mechanical support and electrical connections for the unit as a whole.

16. The method of making a resistance heater unit for thermal overload devices, which comprises rigidly and permanently mechanically and electrically connecting a pair of outer and inner tubular metal members solely by molding in situ therebetween under a pressure of at least ten thousand pounds per square inch an integral an-

13
 annular body composed of a mixture of conducting and non-conducting materials in powder form, said conducting material consisting of one or more substances of the group composed of iron, nickel, chromium, tungsten, silver, titanium, carbon and Carborundum, and said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body.

17. The method of making a resistance heater unit for thermal overload devices, which comprises rigidly and permanently mechanically and electrically connecting a pair of outer and inner tubular metal members solely by molding in situ therebetween under a pressure of at least ten thousand pounds per square inch an integral annular body composed of a mixture of conducting and non-conducting materials in powder form, said conducting material consisting of one or more metals of the group composed of iron, nickel, chromium, tungsten, silver and titanium, said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin, said materials being so proportioned relatively to each other as to afford a predetermined value of resistance of said molded body, and then subjecting said molded body to a heat sintering treatment at a predetermined relatively high temperature for a predetermined period of time to effect a predetermined variation in said resistance value.

18. The method of making a resistance heater unit for thermal overload devices, which comprises rigidly and permanently mechanically and electrically connecting a pair of outer and inner tubular metal members of circular form in transverse cross section solely by molding in situ there-

between under a pressure of approximately ten thousand pounds per square inch an annular integral body composed of a mixture of predetermined proportions of conducting and non-conducting materials in powder form, said mixture having incorporated therein a binding agent selected from the group consisting of sodium silicate, chromic acid and magnesium oxychloride, said conducting material consisting of one or more metals of the group composed of iron, nickel, chromium, tungsten, silver and titanium, said non-conducting material consisting of one or more substances of the group composed of bentonite and kaolin, subjecting said molded mixture to sintering at a predetermined temperature for a predetermined period of time to provide a predetermined value of resistance of said body, and thereafter rigidly and permanently mechanically and electrically connecting to the respective tubular members a pair of punched and stamped sheet metal terminal members to afford mechanical and electrical connections for the unit as a whole.

LESTER D. DRUGMAND.
 EDWIN W. SEEGER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
686,245	Bachmann et al.	Nov. 12, 1901
1,086,726	Opsahl	Feb. 10, 1914
1,105,070	Gage	July 28, 1914
1,669,642	Andrews	May 15, 1928
1,927,894	Krause	Sept. 26, 1933
2,022,657	Durham	Dec. 3, 1935

Certificate of Correction

Patent No. 2,479,914

August 23, 1949

LESTER D. DRUGMAND ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 9, line 65, for "elctrically" read *electrically*; column 14, lines 2 and 3, for "annular integral" read *integral annular*; same column, list of references cited, after line 36, insert the following:

1,763,268 Slepian June 10, 1930

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of February, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
 Assistant Commissioner of Patents.