Dec. 10, 1929. S. MORSE 1,738,663

ELECTRIC HEATER

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FIG. 1.

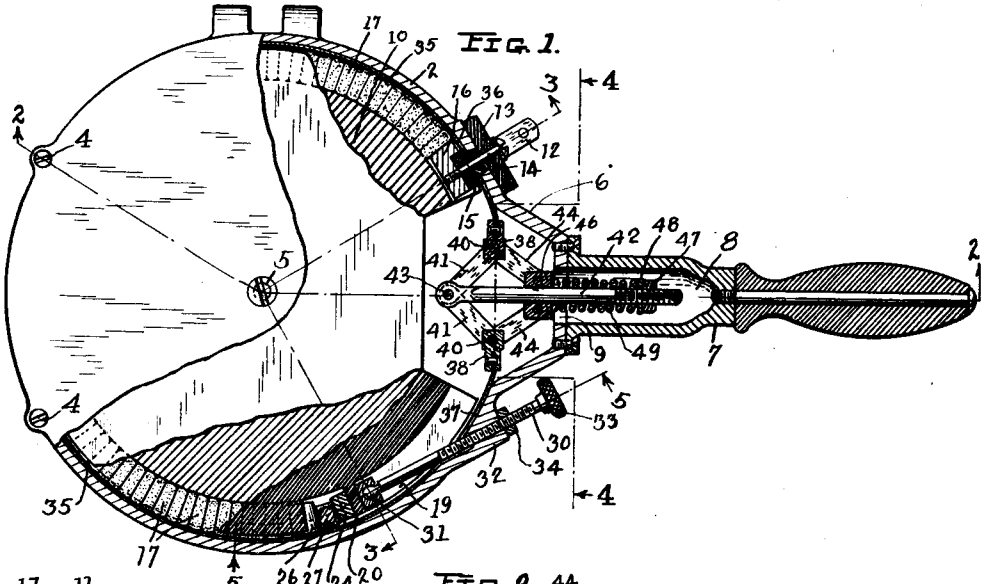


FIG. 2.

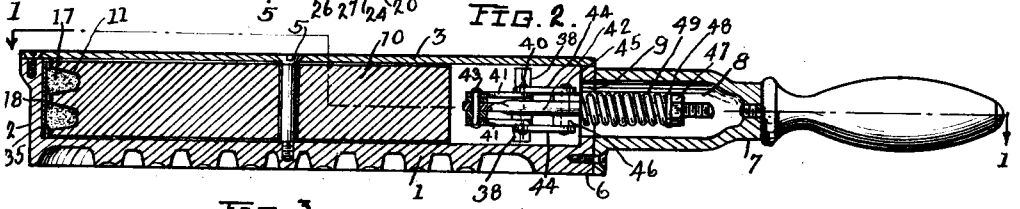


FIG. 3.

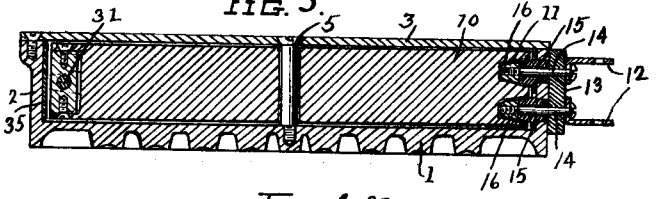


FIG. 4.

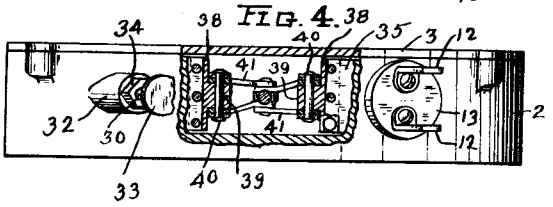


FIG. 6.

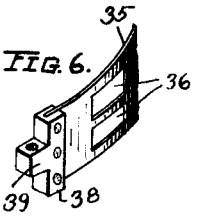


FIG. 7.

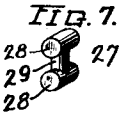
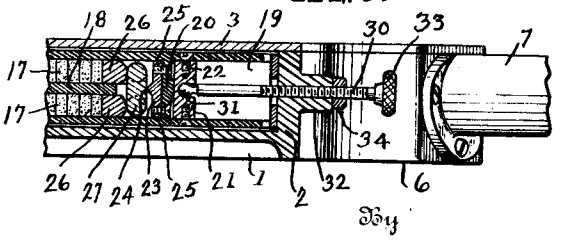


FIG. 5.



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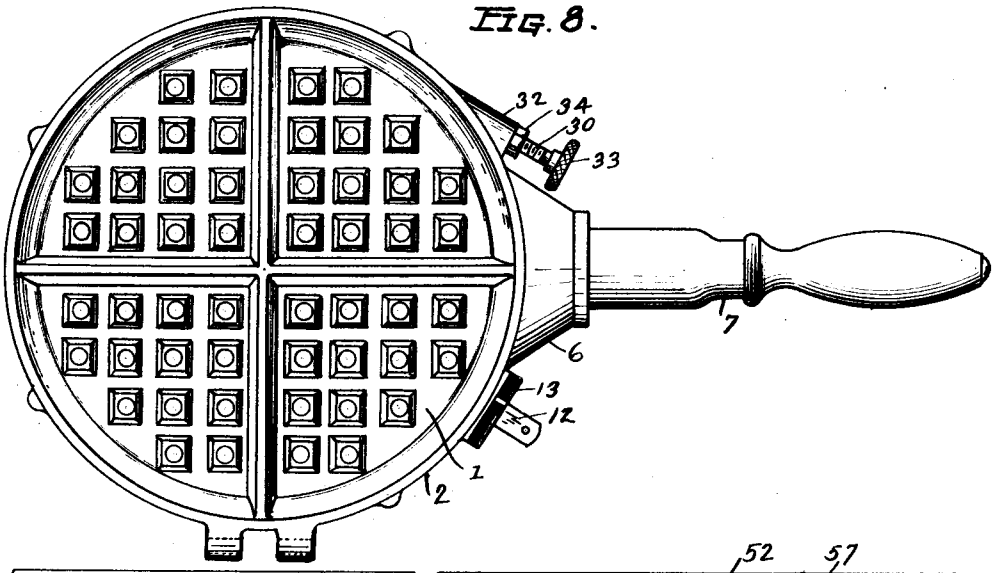
Attorneys

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ELECTRIC HEATER

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FIG. 8.



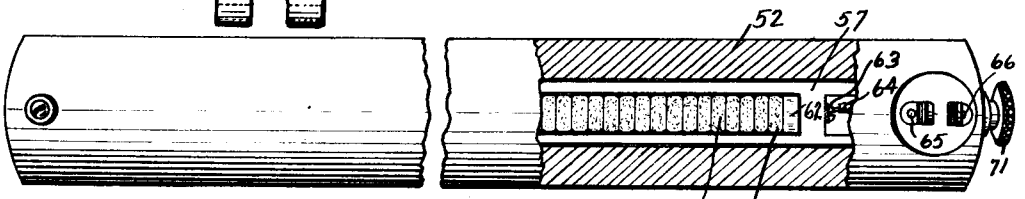


FIG. 9.

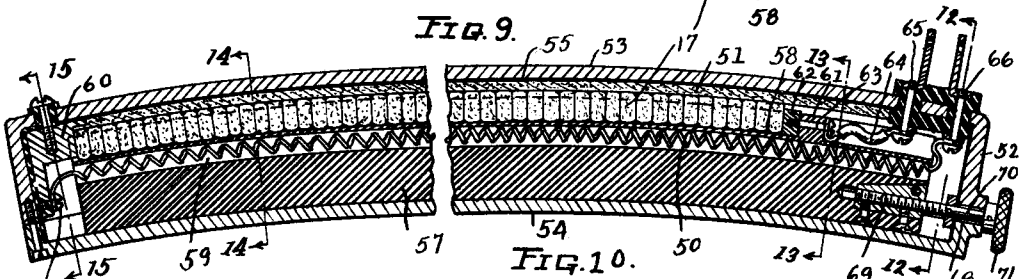


FIG. 11. FIG. 12. FIG. 10.

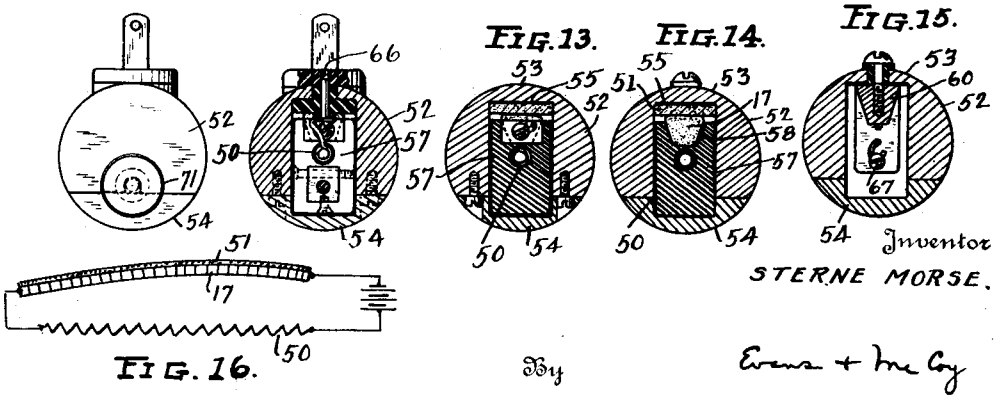


FIG. 16.

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Patented Dec. 10, 1929 1,738,663

UNITED STATES PATENT OFFICE

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ELECTRIC HEATER

Application filed September 24, 1927. Serial No. 222,476.

This device is a specific embodiment of the general principles disclosed in my copending application Serial No. 86,413 filed February 6, 1926, and represents improvements in the devices therein disclosed.

These improvements have for one object the provision of improved means for conducting heat from the heating element to the body of the device.

A further object is a construction such that the resistor blocks will be retained at all times in substantial physical contact with the containing member whether or not pressure is being exerted upon them longitudinally.

A further object is the provision of an adequate type of insulation which is adaptable to non-ferrous containing members such as aluminum, which is mechanically unyielding and substantially incompressible, which may be easily renewed, and which, being laterally flexible, responds to the thermal expansion of the containing member however large it may be.

A further object is the provision of a combined insulation and parallel substantially fixed resistor in connection with the variable resistor.

A further object is the provision of a substantially fixed series resistance and a substantially fixed parallel resistance in order to prevent the device from taking either too large a current from the source of energy supply or too small a current for the satisfactory operation of the device.

A further object is the provision of a substantially fixed parallel resistor in substantial electrical contact with the variable resistor throughout its length in order to equalize the voltage drop throughout the variable resistor.

A further object is the provision of a containing member substantially concavely curved with the resistor lying against the internal curvature of the container in order that the resistor is pressed firmly against the containing member along its entire length by a component of the longitudinal pressure on the resistor, this pressure being therefore substantially proportional to the current flow and insuring an increase of heat conductivity between resistor and containing member with increase of heat produced in the resistor and vice versa.

A further object is the provision of a container consisting of two cooperating members together forming a channel for the resistor, these members being movable with respect to each other along the longitudinal axis of the resistor, and each member carrying a lug or other mechanical means for exerting pressure on the resistor, the resistor being longitudinally compressed by relative motion of the cooperating members so that every part of the resistor is disturbed by such relative motion.

Another object is the provision of means whereby the resistor may be broken up into two or more parts in which the longitudinal pressure is transmitted from part to part throughout the length of the resistor.

A further object is the production of a resistance medium of contacting aligned resistor blocks which operates at a temperature very little higher than the temperature desired in the body to be heated. This is secured by so designing the heating unit that close material contact of the heating element throughout its length with the body which is to be heated is obtained.

A further object is the construction of an electric heater, heating rapidly until a definite temperature is reached.

With the above and other objects in view, the invention may be said to comprehend the electrical heating unit illustrated in the accompanying drawings hereinafter described and particularly set forth in the appended claims, together with such variations and modifications thereof as will be apparent to one skilled in the art to which the invention appertains.

Reference should be had to the accompanying drawings forming a part of this specification in which:

Figure 1 is a plan view of a heating unit in which a portion of the outer casing is broken away and shown in section on the line indicated at 1—1 in Fig. 2.

Fig. 2 is a section taken on the line indicated at 2—2 in Fig. 1.

Fig. 3 is a section taken on the line indicated at 3—3 in Fig. 1.

Fig. 4 is a section taken on the line indicated at 4—4 in Fig. 1.

Fig. 5 is a section taken on the line indicated at 5—5 in Fig. 1.

Fig. 6 is a detail view showing one end of the insulator band.

Fig. 7 is a detail view showing the pressure equalizing member used in connection with the variable resistance.

Fig. 8 is a plan view showing the waffle iron to which the heating device of the present invention is applied.

Fig. 9 is a plan view partially in section showing a heating unit of the immersion type to which the invention is applied.

Fig. 10 is a longitudinal section through the heating unit shown in Fig. 9.

Fig. 11 is an end view of the heating unit.

Fig. 12 is a section taken on the line indicated at 12—12 in Fig. 9.

Fig. 13 is a section taken on the line indicated at 13—13 in Fig. 9.

Fig. 14 is a section taken on the line indicated at 14—14 in Fig. 9.

Fig. 15 is a section taken on the line indicated at 15—15 in Fig. 9.

Fig. 16 is a wiring diagram showing a circuit for the electrical heating element usually applied to either of the modifications herein disclosed but for simplicity, illustrated in detail only in Figs. 9 and 10.

In Figs. 1 to 8 of the accompanying drawings, the invention is illustrated as applied to a waffle iron in which the heat receiving plate 1, formed of a metal having a high coefficient of thermal expansion and which has high heat conductivity, is provided with an upstanding cylindrical heat receiving wall 2, the interior concave face of which closely overlies the electrical heating element which will be hereinafter described. A cover plate 3 is attached to the upstanding wall 2 by means of screws 4 and at its center to the plate by means of a bolt 5, the cover 3 completing the casing within which the heating element is enclosed. The wall 2 has a projecting portion 6 to which a handle is attached, the inner portion of the handle being provided with a recess 8, which communicates through an opening 9 with the interior of the casing for a purpose which will be hereinafter explained.

Mounted within the casing, there is a circular supporting member 10 mounted to turn on the central bolt 5, and which is of a diameter and thickness at the periphery such as to closely approximate the casing, here being composed of insulating material. This disc has a depressed or channeled peripheral portion in which an electrical heating element may be mounted, the heating element receiving portion of the disc being preferably in the form of two parallel circumferential channels 11, their cross sections preferably tapering inwardly from the periphery of the member.

For supplying current to the device, terminal clips 12 are attached to an insulating block 13 secured upon the outer face of the wall 2, preferably adjacent the handle, and the clips and insulating block are secured in place by means of binding screws 14, which extend through apertures in the wall 2 and which are insulated from the wall by means of sleeves 15 of insulating material extending through the apertures, the inner ends of the screws being threaded into metal electrodes 16 which fit into the peripheral channels 11 of the supporting member.

The heating element is in the form of an electrical resistance of the type in which the electrical current is caused to flow through a series of contacting resistor bodies which are electrically conductive and which are held together with a pressure which may be varied to vary the pressure between the individual bodies and to thereby vary the resistance offered to the passage of an electric current. The resistor bodies are preferably in the form of graphite blocks 17 of trapezoidal form which have a sliding fit in the channels of the supporting disc.

In order to vary the pressure on the resistance element, means is provided for imparting a turning movement to the disc 10 and for transmitting an endwise thrust upon the arcuate rows of resistor bodies in the peripheral channels of the disc. The rows of resistor bodies extend from the electrodes 16 around a major portion of the circumference of the disc, the two channels being separated by an intermediate web 18 throughout the portion of the periphery of the disc in which the resistor blocks are placed. The web 18, however, is discontinued in the portion of the disc to the side of the handle 7 opposite that to which the terminals 12 are mounted in order to provide a chamber 19 to accommodate the thrust applying devices by which endwise pressure is exerted upon the resistance element. The supporting member has an integral web 20 extending across the chamber 19 and on the outer side of this web, there is mounted a metal thrust block 21 which is attached by means of screws 22 to the supporting disc 10. Upon the inner side of the web 20 there is a thrust block 23 provided with a knife edge 24, which is attached to the web 20 by screws 25 which are counter sunk into the outer face of the web so that the block 23 is insulated from the block 21. In the adjacent ends of the channels 11 are metal blocks 26 which have flat inner faces engaging the endmost blocks of the resistance element and which have rounded outer faces which are engaged by an equalizing member 27, which is interposed between the thrust block 23 and the blocks 26 in the two channels. The equalizing member 27 particularly shown in Fig. 7

is a metallic member having parallel end portions 28 of cylindrical form and with a transverse connecting portion 29 also of cylindrical form. The cylindrical end portions 28 of the equalizing member bear upon the rounded ends of the blocks 26 and the cylindrical connecting portion 29 is engaged by the knife edge 24 of the thrust block 23. Turning movement is imparted to the supporting member 10 by means of a tangential screw 30, which has a ball and socket connection 31 with the block 21 and which extends through the wall of a casing and has threaded engagement with a boss 32 formed on the wall. The screw 30 has a knurled head 33 at its outer end by means of which it may be turned to shift the disc 10 about its axis to apply pressure through the equalizing member 27 to the two resistance elements or to relieve the pressure on the resistance elements, lock nut 34 being provided on the screw which is engageable with the boss 32 to lock the screw in a position to which it has been adjusted.

The resistor bodies extend from the electrodes 16 to the thrust blocks 26 and the two resistor elements which are insulated from each other by the web 18 are connected in series through one terminal 12 and electrode 16, through the blocks 26 and equalizing member 27 and the other electrode 16 and its terminal.

An important feature of the present invention is the provision of a movable supporting element for the resistance element which has frictional contact with the rows of resistor blocks throughout the length thereof, and which carries the pressure applying lug through which endwise pressure is applied to the resistor bodies. Since the frictional engagement between the supporting member and the individual resistor bodies insures substantial uniformity in the pressure between the bodies throughout the length of each of the resistor elements, it prevents inequalities in pressure on adjustment which would otherwise impair the efficiency of the heating element. The heat receiving plate is formed of a metal which has a high coefficient of thermal expansion as compared with the resistor blocks and coacts with the resistor blocks to automatically limit the temperature to which the blocks may be heated by the electric current passing through them. The end thrust on the blocks has an outward component pressing the row of blocks outwardly against the heat receiving wall so that when the wall expands to a greater diameter, due to the heat supplied thereto from the blocks, the individual blocks will have an outward movement which lessens the pressure between the individual blocks and automatically increases the ohmic resistance and cuts down the current passing through the blocks.

The outward component of the end thrust on the blocks also serves to vary the heat conductivity between the resistance element and heat receiving plate substantially with the variations in the generation of heat in the resistor bodies. When the plate is cold, the end pressure on the resistor bodies is high and the pressure of the resistor bodies against the heat receiving wall is relatively high so that the heat rapidly generated by a large flow of current through the resistor bodies is rapidly transmitted to the plate. As the plate becomes hot the thermal expansion relieves the pressure on the resistor bodies reducing the current and the rate at which heat is generated and lessens the pressure between these bodies and the heat receiving wall so that the heat conductivity between the resistor bodies and wall is also reduced, and a substantially constant difference in temperature is maintained between the resistor bodies and heat receiving wall.

An important feature of the invention is the provision of channels of tapering cross section for the resistor elements and resistor elements of tapered form to fit in these channels. The tapered form of channels tends to cause the blocks to move freely in outward radial direction to maintain contact with the concave retaining wall even when the blocks are loose. The tapering channel also cooperates with the tapered blocks to maintain the individual blocks in proper alignment and in upright position, the tapering form of channel preventing the larger outer ends of the blocks from swinging toward the bottom of the channel.

A further important feature of the invention is the provision of a resistance element of the contacting resistor body type, which consists of two or more parts arranged with different lines of pressure and mechanically connected so that longitudinal pressure may be transmitted from one part to another throughout the length of the resistor, with the result that substantially equal pressure is maintained in all parts of the resistance. This is accomplished by means of equalizing member 27, which serves to balance the pressure between the two rows of resistor blocks, endwise pressure transmitted from the electrode 16 through one row of blocks being transmitted through the rocking equalizing member 27 to the other row of blocks, thus insuring equal compression at all times in both rows.

A further important feature of the present invention is the provision of an insulation suitable for electrically insulating the resistance element from non-ferrous heat receiving containing members such as aluminum or its alloys, the insulating means being of such a nature that it readily transmits the heat from the resistance element to the heat receiving body, that is mechanically unyielding, that it may be easily renewed and that it responds to the thermal expansion of

the containing member. This insulation is preferably in the form of a thin laterally flexible steel band, which is coated on its inner face with a suitable insulating vitreous enamel and which is interposed between the concave face of the heat receiving wall and the outer edges of the resistor blocks. The band 35 extends throughout the major portion of the circumference of the disc 10 and is provided with elongated slots 36 to receive the insulating sleeves 15 and with an elongated slot 37 to receive the adjusting screw 30. The ends of the band are positioned adjacent the portion of the casing to which the handle is attached and are provided with heads 38, which have centrally located projecting lugs 39 which receive pivot pins 40 upon which are pivoted a pair of inner toggle links 41, which are pivoted together and to an outwardly projecting rod 42 by pivot 43. A second pair of toggle links 44 are pivoted on the pins 40 and project outwardly therefrom, the outer ends of these links being connected by pivots 45 to a collar 46, which is slidable upon the rod 42.

The rod 42 projects into the recess 8 of the handle and is threaded to receive a nut 47. Interposed between a washer 48 on the inner side of the nut 47 and the sliding collar 46 there is a coil spring 49 which exerts an inward pressure on the collar 46 and an outward pressure on the nut 47, tending to straighten both pairs of toggle links and spread the adjacent ends of the insulating band. This pressure tends to expand the band and holds the same tightly against the inner face of the heat receiving walls 2. Suitable pressure may be exerted upon the spring 49 by screwing down the nut 47 and this pressure is transmitted at all times to the band so that it will instantly respond to the thermal expansion of the heat receiving wall. The spring 49 being located entirely within the recess 8 of the handle outside the main body of the casing is protected against the heat generated by the resistor element within the casing and from the heat transmitted to the heat receiving plate which has high heat conductivity so that the spring is not injuriously affected by the heat.

The cycle of operative changes which the device goes through and which determine its thermostatic property are briefly as follows:

When the device is cold, the aligned resistor blocks will ordinarily be closely confined by the confining means. The resistance of the device being determined by the pressure between the blocks, being low when this is large, a comparatively large flow of current ensues and much energy is developed in the form of heat. The device therefore heats more rapidly than any known heating element of the same working capacity. For example, a given device designed to operate at 500 watts and set for a temperature of 150° C. may take as much as 4000 watts when cold. This, while a great advantage when the wiring permits, is frequently not desirable when the current supply wires are not fitted to supply so large a current. I often therefore prefer, as diagrammatically illustrated in Fig. 16, to employ a series fixed resistance 50 such as nichrome wire or one of the dispersed conductors later to be described, which has the further advantage that it decreases the effective voltage on the variable device per se. And for the reason that excessively large currents are at no time permitted to pass through the device, it tends to prevent over-regulation or "hunting". The heat developed heats both element and, by conduction, the containing member, but heat transfer being made very good the element remains only a few, and nearly constant, number of degrees hotter than the containing member. Both expand but the containing member expands to a greater degree than the resistor. The initial pressure on this accordingly diminishes, the resistance rises and less heat is developed. At some point, the energy inflow will equal energy outflow and the temperature of the device will remain constant. If conditions change such that a larger withdrawal occurs, the temperature of the device will fall slightly. This causes the containing member to contract faster than the element does, the longitudinal pressure on the blocks being thereby increased and their resistance accordingly decreases with consequent increase of current flow. Heat will be increasingly developed until the increased heat input is equal to the increased output. It may be arranged so that the fall of a degree or two may increase the current flow several times, though for most purposes a sensitiveness of this grade is not desirable.

It is frequently also desirable that the full possibilities of the device as regards current regulation on the minimum side be not used and I consequently often desire to introduce a fixed resistor in parallel with the variable resistor. This may be a wire register of the usual type of nichrome or other resistance material or it may preferably be of a ceramic disperse conductor type such as the resistor 51 illustrated diagrammatically in Fig. 16.

Such a resistor, for example, may be made by mixing clay or other non-conducting binders such as phenolic resins and the like with more or less of materials which are either originally conductors or become so when subjected to heat. Clay, for example, may be mixed with graphite or some form of amorphous carbon, the whole pressed and fired. Or the carbon may be introduced as any carbon containing material such as dextrose or coal tar pitch and the whole compacted by pressure and then fired. In particular, for the purposes of the present invention, I prefer to lay on to a strip or body of enameling

steel an insulation of vitreous enamel and subsequently overlay this with such a composition as is above described, firing the whole to one integral mass. This strip either forms the containing expansible member or is fixed within the expansible member and forms the insulating strip in the modification of the invention above described. The variable resistor is disposed in close contact with this strip as elsewhere described in this specification and such a construction has the important further advantage that the potential gradient is fixed along the length of the conductor to a very large extent, the electric conduction being everywhere free between the fixed resistor and the blocks comprising the variable conductor. No great difference of potential can ever exist between adjacent blocks, no matter how defective the transmission of pressure from block to block may be. In this form of construction, it is desirable that the conduction edges of the blocks adjacent the fixed surface of the fixed resistance be somewhat beveled away so that the contact of each of the adjacent blocks with the fixed resistor be somewhat separated.

In Figs. 9 to 15 of the drawings, there is shown a modification of the invention which in its essentials simply represents a smaller arc of the heating unit shown in Figs. 1 to 8 in which the fixed parallel and series resistance shown diagrammatically in Fig. 16 are employed. The heating unit in this modification is of the immersion type and the heat receiving and confining element is in the form of a longitudinally curved tubular casing 52, which has an internally concave heat receiving wall 53, and a removable wall 54 opposite the wall 53, the removable wall providing means by which the heating unit may be inserted into or removed from the casing. The heat receiving wall 53 has a layer of insulating material 55 upon its inner face, the insulation consisting preferably of a coating of vitreous enamel, and to the insulated inner face of the wall there is secured the parallel resistance 51 above described.

The heating element 57 supporting this modification is of a form to substantially fit within the walls of a casing, its curvature corresponding to that of the casing, the heating element being formed of insulating material as in the modification above described, then having an inwardly tapering channel 58 in its convex face, which is closely adjacent the heat receiving wall.

The length of the heating element supporting member is somewhat less than that of the casing and the supporting member is mounted to slide in the casing beneath the channel 58. The supporting member is provided with a longitudinal aperture 59 through which the series resistance 50 extends. As in the modification first described, the variable resistance consists of a row of the tapered resistor blocks 17, which are pressed together and toward the heat receiving wall as in the modification first described. Within the casing 52 at one end thereof, there is an electrode 60 which is fixed to the casing and insulated therefrom, this electrode having a portion which fits within the end of the channel 58 and engages the endmost block of the resistance element. The supporting member 57 is provided with a lug 61 extending into the channel 58 adjacent the end thereof opposite that in which the electrode 60 engages and attached to the inner face of this lug there is a metal block or electrode 62 which engages the endmost resistor block in the channel so that when the supporting element is moved endwise, pressure is exerted upon the row of resistor blocks. In this modification, as well as in the modification first described, the blocks are maintained in proper alignment and in upright position by their engagement with the tapered channel and uniform pressure is obtained throughout the length of the row of blocks by the frictional engagement of the bodily movable supporting member with the blocks throughout the length of the row. The metal block 62 is connected by means of a binding screw 63 with the lug 61 and with a wire 64, which leads to a terminal post 65 carried by the casing and suitably insulated therefrom. A second terminal post 66 is mounted adjacent post 65 and is connected to the adjacent end of the series resistance 50 which is connected at its opposite end by a screw 67 to the electrode 60, so that current supplied through the terminals 65 and 66 passes through the fixed resistance 51 and variable resistance 17 in parallel and through the fixed series resistance 50.

For adjusting the supporting member 57 in the casing, a screw 68 is provided which is threaded into a metal block 69 secured in one end of the member 57 and which extends through an aperture 70 in the end wall of the casing. The projecting end of the screw is provided with a parallel head 70 by means of which it may be adjusted to move the supporting member in the casing and vary the pressure exerted endwise upon the row of blocks, the aperture 70 being slightly larger than the screw to permit the slight angular movement of the screw, resulting from the movement of the supporting member.

In this modification, as well as the first, the confining and heat receiving member has high heat conductivity and has a high coefficient of thermal expansion. The insulation and the dispersed resistance element interposed between the carbon blocks of the variable resistance and the heat receiving wall readily transmit the heat from the main resistance element to the wall, so that the heat receiving body quickly absorbs heat from the heating element and only a small differ-

ence in temperature is required between the heating element and heat receiving body.

In both modifications, the heat receiving and retaining body, by reason of its high coefficient of thermal expansion, and by reason of the engagement of the heating element along a concave face of the heat receiving body, serves to automatically relieve the pressure between the individual blocks of the variable resistance element, increasing the resistance and cutting down the current so that the temperature to which the resistor blocks may be raised is maintained at all times below the temperature at which the blocks be injuriously affected by the heat. In both modifications, the outward component of the end thrust on the row of blocks composing the resistance element serves to maintain the resistance element at all times in close contact with the heat receiving wall and to maintain effective heat transmitting relation thereto.

Furthermore, it is to be understood that the particular forms of apparatus shown and described, and the particular procedure set forth, are presented for purposes of explanation and illustration and that various modifications of said apparatus and procedure can be made without departing from my invention as defined in the appended claims.

What I claim is:

1. An electrical heating unit comprising a resistance element composed of contacting electrically conductive resistor bodies, confining means electrically insulated from said resistor bodies and disposed in heat receiving relation thereto, said confining means having a coefficient of thermal expansion relatively high as compared to that of said resistor bodies and adjustable pressure applying means engaging one end of the resistance element and having a part in contact with the resistance element throughout the length thereof.

2. An electrical heating unit comprising a resistance element composed of contacting electrically conductive resistor bodies, a casing for said resistance element having a heat receiving wall closely adjacent said resistance element, a support for said resistance element movably mounted in the casing and having a channel to receive said resistance element, a member carried by the casing engaging one end of the resistance element, a member carried by the support engaging the opposite end of the resistance element and means for shifting said member in the casing to apply endwise pressure to the resistance element.

3. In an electrical heating unit, in combination, a substantially curved expansion member, a resistance element composed of a series of aligned resistor blocks disposed closely adjacent said expansion member on the concave side thereof and closely following the concave curvature thereof, said expansion member having a relatively high coefficient of thermal expansion with respect to that of said blocks, said blocks being electrically insulated from said expansion member, a fixed lug secured to said expansion member and abutting said series of blocks at one end thereof, an electrically non-conducting co-operating member arranged to contact with said blocks and movable along the longitudinal axis of the series of resistor blocks, a lug secured to said co-operating member arranged to abut said series of blocks at the other end thereof, means for slidably adjusting said co-operating member relative to said blocks and maintaining said co-operating member in desired adjusted position, said longitudinal pressure being variable with the expansion and contraction of said expansion member due to heat received from said resistor blocks, and means for supplying current to said resistance element to heat said blocks.

4. An electrical heating unit comprising a casing having an internally concave heat receiving wall, a member mounted within the casing having an external convex curvature substantially conforming to the curvature of said wall, said member having a channel in its outer face, a resistance element interposed between said movable member and wall and seated in said channel, said resistance element being composed of contacting electrically conductive resistor bodies, a layer of material having electrical insulating and heat conducting properties interposed between said resistance element and heat receiving wall, a lug fixed with respect to the wall engaging one end of said resistance element, a lug fixed with respect to the movable member engaging the opposite end of the resistance element, and means for moving said member along the wall to vary the pressure between said resistor bodies.

5. An electrical heating unit comprising a casing having an internally concave heat receiving wall of high heat conductivity, a member in the casing having an outer face conforming to the curvature of the heat receiving wall and closely adjacent thereto, said member having an inwardly tapering channel in said outer convex face, a resistance element in said channel composed of a row of contacting resistor bodies of tapered form fitting in said channel, a heat conducting insulation interposed between said resistance element and casing wall, means for applying an endwise pressure to said row of bodies, and means for supplying an electric current to said resistance element.

6. An electrical heating unit comprising a heating unit having a supporting member provided with a convex face, said supporting member having an inwardly tapering channel in its convex face, a resistance ele-

ment composed of contacting electrically conducting resistor bodies of tapering form fitting in said channel, an outer heat receiving casing of high heat conductivity and having a thermal coefficient of expansion relatively high as compared to said resistor bodies, said casing having a concave retaining wall insulated from said bodies and engaging the outer edges thereof, members on the casing and channel engaging opposite ends of said resistance element, means for moving said supporting member in the casing to apply endwise pressure to said resistance element, and means for supplying current to said resistance element.

7. An electrical heating unit comprising, a resistance element composed of contacting electrically conductive resistor bodies arranged in a plurality of separate rows, means for applying endwise pressure simultaneously to said rows of blocks, means for equalizing the pressure exerted on said bodies and for transmitting pressure from one row of bodies to the other, a casing having a heat receiving portion of high heat conductivity closely adjacent said resistance elements and insulated therefrom, and means for supplying current to said resistance element.

8. An electrical heating unit comprising a resistance element composed of contacting electrically conductive resistor bodies arranged in a plurality of separate rows, side by side, a casing having high heat conductivity and a high thermal coefficient of expansion relative to said resistor blocks, said casing having a wall disposed in confining relation closely adjacent said blocks and insulated therefrom, members fixed to the casing engaging the ends of said rows of contacting elements at one end, means for applying pressure to said rows of bodies at the opposite ends thereof, said pressure applying means including means for equalizing the pressure transmitted to said rows of blocks and for transmitting pressure from one row to another, and means for supplying current to said resistance element.

9. An electrical heating unit comprising an internally concave heat receiving element, a resistance element composed of a series of contacting electrically conductive resistor bodies, a laterally flexible insulating member of non-compressible material interposed between the heat receiving element and the resistance element engaging and conforming to the concave wall of the heat receiving element, and means for applying pressure to said resistance element.

10. An electrical heating unit comprising a resistance element composed of a series of contacting electrically conductive resistor bodies, a casing for said resistance element having an internally concave heat receiving wall, a relatively thin transversely flexible insulating member interposed between the resistance element and wall, means for exerting pressure on said insulating member to maintain the same in engagement with the casing wall, and means for applying endwise pressure to said resistance element and for maintaining the same in contact throughout its length with said insulating member.

11. An electrical heating unit comprising a casing having an internally concave heat receiving wall, a resistance element composed of a series of contacting electrically conductive resistor bodies and having longitudinal curvature conforming to the curvature of the wall, a thin transversely flexible expansive insulating band interposed between the resistance element, and heat receiving wall, and means for exerting endwise pressure on said band and on said resistance element to press the band outwardly against said wall and said resistance element outwardly against said band.

12. An electrical heating unit comprising a casing having an internally concave heat receiving wall which has a relatively high temperature coefficient of expansion, a thin transversely flexible expansible electrically insulating and heat conducting band engaging and conforming to said concave wall, means for maintaining a pressure on the ends of said band to maintain the same in engagement with the wall, resistance element composed of contacting electrically conductive resistor bodies along the inner side of said insulating band, and adjustable means for applying endwise pressure to said resistor element to maintain the same in contact with said band.

13. An electrical heating unit comprising a casing having an internally concave heat receiving wall, a member movably mounted within the casing which has an outer face conforming to the curvature of the heat receiving wall and closely adjacent thereto, a plurality of channels extending along said outer face of said member, resistance elements in said channels each composed of a series of contacting resistor blocks, means insulating said resistor elements from said heat receiving wall, lugs fixed to said heat receiving wall and engaging said resistance elements at one end, means for moving said member along said wall, means interposed between said movable member and resistance elements at the end opposite that engaged by the fixed lugs for simultaneously applying endwise pressure to said resistance elements, and means for supplying current to said resistance elements.

14. An electrical heating unit comprising a casing having an internally concave heat receiving wall, a member movably mounted within the casing which has an outer face conforming to the curvature of the heat receiving wall and closely adjacent thereto, a

plurality of channels extending along said outer face of said member, resistance elements in said channels each composed of a series of contacting resistor blocks, means insulating said resistance elements from said heat receiving wall, lugs fixed to said heat receiving wall and engaging said resistance elements at one end, means for moving said member along said wall, means interposed between said movable member and resistance elements at the end opposite that engaged by the fixed lugs for simultaneously applying endwise pressure to said resistance elements, said pressure applying means including means for equalizing the pressure on said resistance elements, and means for supplying current to said resistance elements.

15. An electrical heating unit comprising an internally concave heat receiving element, a relatively thin metal band coated with insulating enamel, engaging the concave wall of the heat receiving element, means connected to the ends of said band to apply endwise pressure thereto to maintain the same in close contact with said wall, a resistance element engaging the inner face of said band and composed of a row of contacting electrically conducting resistor blocks, means for applying endwise pressure to said resistance element, and means for supplying current thereto.

16. An electrical heating unit comprising a resistance element composed of a row of contacting electrically conducting resistor blocks, a support for said element having a convex face provided with a channel in which said element is mounted, a thin insulating band of laterally flexible incompressible material, engaging the outer side of said resistance element, a casing having a heat receiving portion of relatively high temperature coefficient of expansion as compared to said blocks, said heat receiving portion of the casing having a concave wall substantially conforming to and closely adjacent the convex face of said support, means for applying endwise pressure to said resistance element, a spring connected to said band to exert endwise pressure thereon to maintain the same in contact along said heat receiving wall, and means for supplying current to said resistance element.

17. An electrical heating unit comprising a resistance element composed of a row of contacting electrically conducting resistor blocks, a support for said element having a convex face provided with a channel in which said element is mounted, a thin insulating band of laterally flexible incompressible material, engaging the outer side of said resistance element, a casing having a heat receiving portion of relatively high coefficient of thermal expansion as compared to said blocks, said heat receiving portion of the casing having a concave wall substantially conforming to and closely adjacent the convex face of said support, means for applying endwise pressure to said resistance element, a spring connected to said band to exert endwise pressure thereon to maintain the same in contact along said heat receiving wall, said spring being mounted in a position such that it is substantially uneffected by the heat of said resistance element or of said heat receiving body, and means for supplying current to said resistance element.

18. An electrical heating unit comprising a heat receiving body having a cylindrical wall, a supporting member of insulating material fitting within said cylindrical wall and mounted to turn about a central axis, said supporting member having a channel along its circumferential face, a resistance element composed of a row of contacting electrically conducting resistor blocks seated in said channel, a lug fixed to the casing engaging one end of said resistance element, means for moving said supporting member about its axis, means interposed between said supporting member and the opposite end of the resistance element to apply endwise pressure to the resistance element, insulating means interposed between the blocks and said cylindrical wall, and means for supplying current to said resistance element.

19. An electrical heating unit comprising a heat receiving body having a cylindrical wall, a supporting member of insulating material fitting within said cylindrical wall and mounted to turn about a central axis, said supporting member having a channel along its circumferential face, a resistance element composed of a row of contacting electrically conducting resistor blocks seated in said channel, a lug fixed to the casing engaging one end of said resistance element, means for moving said supporting member about its axis, means interposed between said supporting member and the opposite end of the resistance element to apply endwise pressure to the resistance element, a thin insulating band interposed between the resistance element and cylindrical wall, a spring mounted outside said cylindrical wall and connected to the ends of the band to exert an expanding pressure on the band, and means for supplying current to said resistance element.

20. An electrical heating unit including a variable resistance element comprising a row of contacting electrically conducting resistor elements and means for applying endwise pressure to said row of resistor elements, a fixed resistance in parallel with said variable resistance, and a second fixed resistance in series with said variable resistance.

21. An electrical heating unit comprising a variable resistance element comprising a row of contacting electrically conducting resistor elements and means for applying endwise pressure to said row of resistor ele-

ments, a heat receiving body in close proximity to the outer side of said variable resistance, and a resistance element of the dispersed ceramic type connected in parallel with the variable resistance and interposed between said variable resistance and said heat receiving body.

22. An electrical heating unit comprising a variable resistance element comprising a row of contacting electrically conducting resistor elements and means for applying endwise pressure to said row of resistor elements. a heat receiving body in close proximity to the outer side of said variable resistance, a resistance element of the dispersed type connected in parallel with the variable resistance and interposed between said variable resistance and said heat receiving body, and a fixed resistance extending along the inner side of said variable resistance and connected in series therewith.

23. An electrical heating unit comprising a variable resistance element formed of a series of contacting electrically conducting resistor bodies, means for varying the resistance of said element, and a second resistance element arranged in parallel electrical relation with the variable resistance element and electrically connected to certain of the intermediate resistor bodies.

24. An electrical heating unit comprising a variable resistance element formed of a series of contacting electrically conducting resistor bodies, means for varying the resistance of said element, and a second resistance element arranged in parallel electrical relation with the variable resistance element and electrically connected to the variable resistance element at a plurality of points intermediate its ends.

25. An electrical heating unit comprising a resistance element composed of a series of contacting electrically conductive resistor bodies, a casing for said resistance element having a heat receiving wall closely adjacent said resistance element, a support for said resistance element movably mounted in the casing, said resistor bodies being mounted between said casing and said support and held in alinement by one of them, a member carried by the casing engaging one end of the resistance element, a member carried by the support engaging the opposite end of the resistance element, and means for shifting one of said members to apply endwise pressure to the resistance element.

In testimony whereof I affix my signature.

STERNE MORSE.