June 5, 1956 F. L. DIETERICH 2,749,424

ELECTRICAL HEATING APPARATUS

Filed March 5, 1954 2 Sheets-Sheet 1

Fig. 1

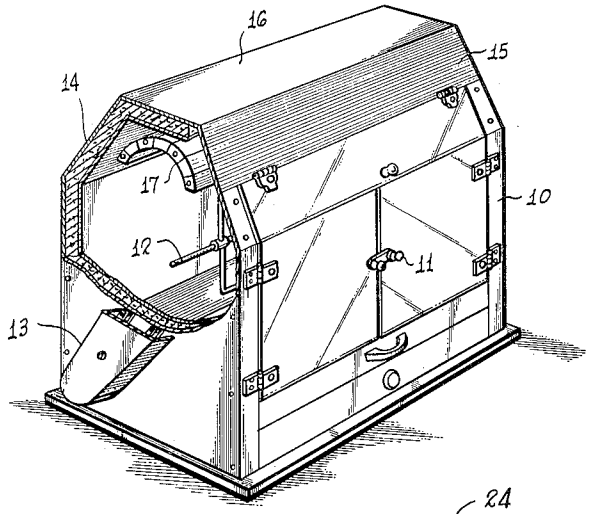


Fig. 3

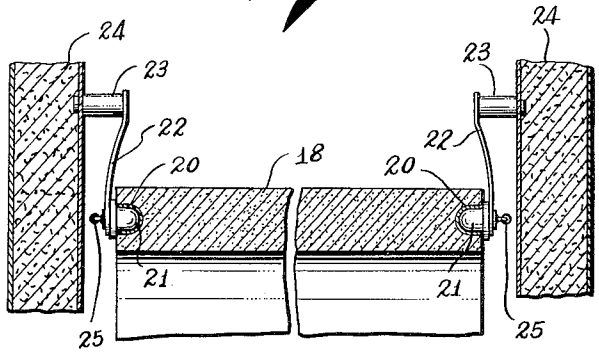
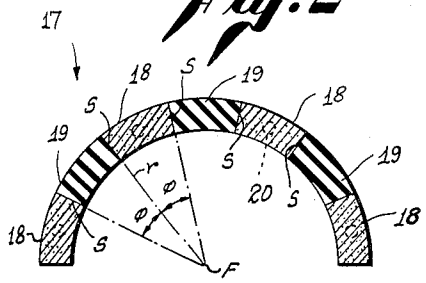


Fig. 2



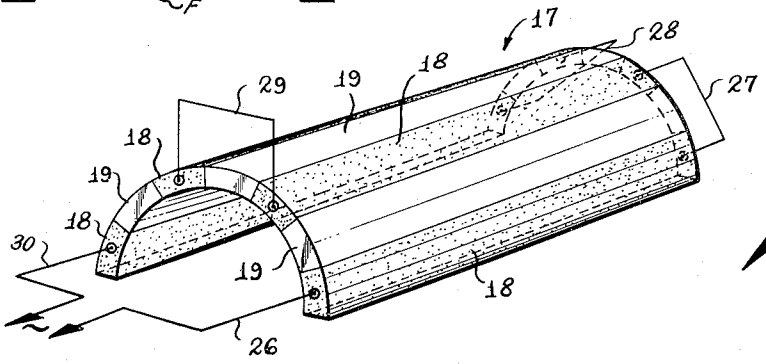


Fig. 4

INVENTOR.
FRANCIS L. DIETERICH
BY Fulwider Mattingly & Babcock
Attorneys

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Fig. 5

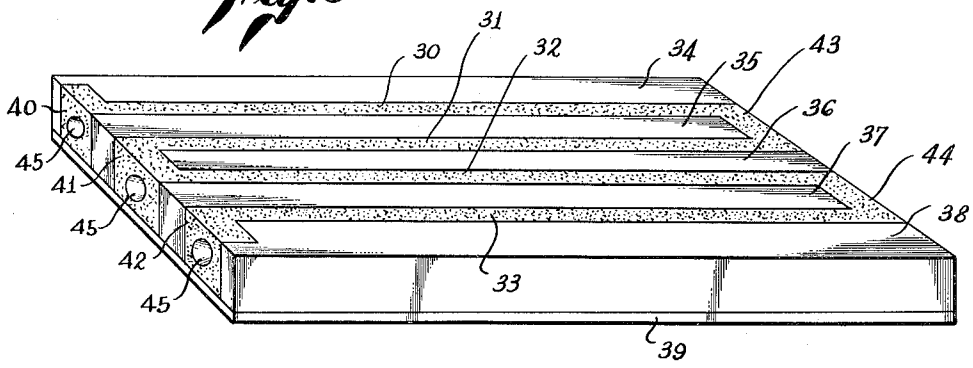
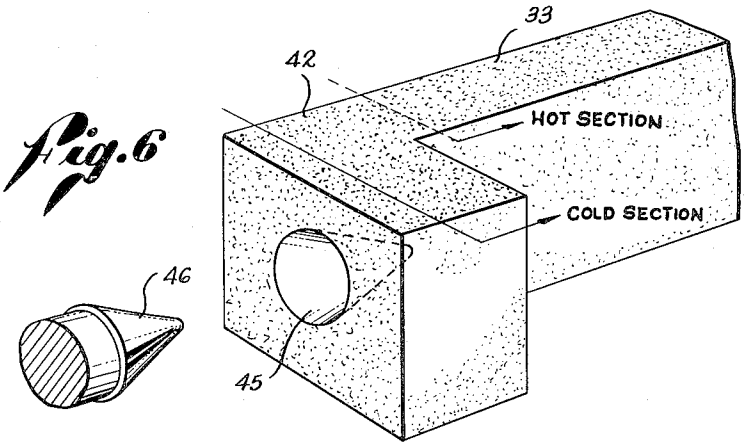


Fig. 6



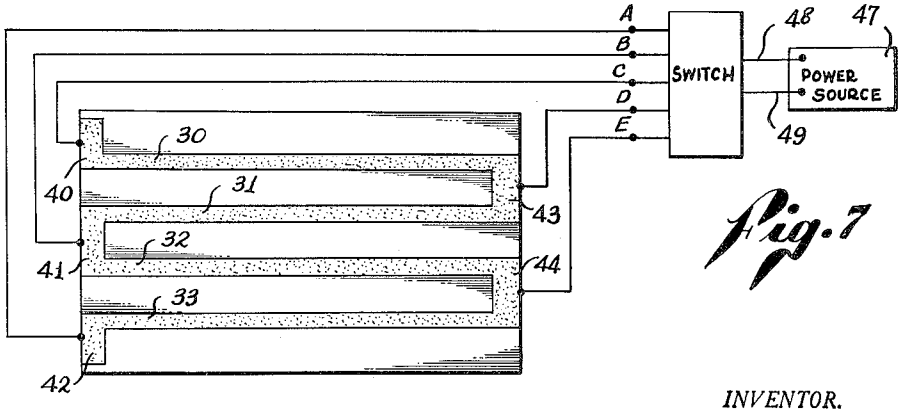


Fig. 7

INVENTOR.
FRANCIS L. DIETERICH
BY Gulwider Mattingly & Babcock
Attorneys

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ELECTRICAL HEATING APPARATUS

Francis L. Dieterich, Culver City, Calif.

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16 Claims. (Cl. 219—35)

This invention relates generally to electrical heating apparatus and more particularly to apparatus of the type employing semi-conductive elements made up of silicon carbide crystals for electrical resistance heating.

Transforming electrical energy into heat energy by passing electric current through resistance elements is well known. One form of element in which the efficiency of this energy transfer is high, takes the form of a rod or bar made up of recrystallized silicon carbide crystals or grains. Such elements find wide use in high temperature electric furnaces and will operate successfully up to 2700° F. The initial resistance and thus heat produced by a given bar or rod depends upon the "mix," the grain size of the silicon carbide crystals, the type of grain and method of recrystallization, the cross-sectional area, and the length of the bar. Therefore, in the initial manufacture of the bars the heat radiation can be substantially adjusted to a desired value by varying the above-noted parameters. Once the bar has been cured, however, its heat producing characteristic is substantially fixed for a given applied voltage.

In supporting bars of the above type, resilient mountings are employed to accommodate expansion and contraction. Electrical connections to the ends of the bar are effected through springs or cup-like elements urged into contact with a layer or coating of conductive material, such as aluminum, sprayed over these ends. In order to keep the high surface temperature of the hot portion of the bar from direct contact with the conductive coating or layer, a short section of a special silicon carbide mixture of high electrical conductivity, usually impregnated with silicon, is secured to each end of the bar. Because of their relatively low resistance, these end sections will not heat appreciably and are known as "cold" ends. With bars in which the heat producing characteristic is substantially fixed, it is generally necessary to employ "cold" ends to effect reliable electrical connections.

Aside from the above noted characteristics, the bars presently available are relatively fragile. They cannot be repaired once broken, and there is no salvage value.

It is a primary object of the present invention to provide a vastly improved electrical heating apparatus incorporating silicon carbide, semi-conductive, heat-producing elements in a form in which the radiated heat-producing characteristic may be adjusted over a substantial range.

Another object in this connection is to provide a composite heating apparatus in which the net radiated heat may also be adjusted prior to final manufacture of the apparatus without the necessity of varying the grain size, cross-sectional area, or length of the elements incorporated in the composite block.

A related object is to provide a heating apparatus in which the use of "cold" ends for effecting reliable electrical connections may be avoided.

Another object is to provide a heating apparatus of the above type which is structurally strong as compared to prior heating elements.

Still another important object is to provide a composite heating apparatus which is shaped in such a manner as to provide both a relatively increased radiating surface and a surface of such configuration as to focus the radiated heat.

Another object of the invention is to provide a heating apparatus in combination with a rotisserie in which the radiated heat is substantially controlled and focused or directed so as to be concentrated in the area of the rotisserie spit.

These and further objects and advantages of the present invention are attained by providing an electrical heating apparatus made up of parallel strips or elements of heat producing, semi-conductive material incorporating silicon carbide crystals, alternated with electrically insulating strips. These strips are sintered together to form an integral composite block, the net amount of heat produced being controlled in part by the relative thickness of the insulative and semi-conductive strips, respectively.

The insulative strips and the conducting strips are essentially of the same composition, the only difference being the existence of small amounts of clay in the mix, and/or the omission from the mix of small metallics or carbon in the insulative strips. This slight difference results in a vast difference in the electrical resistance properties of the conducting and insulative strips, but has negligible effect on their other physical properties, such as heat coefficient of expansion and heat conductivity. Thus, the strips may be formed into an integral composite block without fear of the block cracking or warping due to the differences of thermal expansion in the strips.

Inasmuch as the strips are in intimate contact with each other, conduction of the heat through the entire body or block insures a substantially uniform heat radiation from the surfaces of the block. Thus, the operating temperature of the individual semi-conductive strips may be modified and controlled by the thickness of the insulative strips in contact therewith and the heat conducting properties of such strips.

The composite block may be shaped to provide various curved surfaces and thus take advantage of the large radiating surface to direct a particular heat radiation pattern. A preferred shape takes the form of a semi-cylindrical configuration and the invention will be described with respect to such a concave surface. Other surface shapes may, of course, be used.

In a preferred form of the electrical heating apparatus, the opposite end portions of the heating elements are provided with electrical conducting coatings or contacts and cooperating conductors, serving to connect the semi-conductive elements in series with a source of electrical energy. The manner of connecting the elements together, however, may be revised to provide further control over the net radiated heat. Because of the semi-cylindrical construction of the entire block, the radiated heat from the inner concave surface will be focused along the center line corresponding to the center of the radius of curvature.

The feature of controlled heat and focusing of the heat radiation is especially advantageous when the heating apparatus of the present invention is employed in combination with a rotisserie. In such a combination the points of maximum heat concentration are positioned to correspond with the surface of the food supported on the spit. With this arrangement, the maximum heat will be concentrated on the food and radiation to the sides of the rotisserie substantially reduced. Further, there is a desired range of heat most efficient for the purpose at hand. This range for efficient heat radiation purposes is in the infra-red or near infra-red band. With the feature of controlled heating of the integral block

in accordance with the present invention, this desired range can be easily effected.

A better understanding of the invention will be had by referring to the accompanying drawings, in which:

Figure 1 is a cutaway perspective view of a rotisserie employing the electrical heating apparatus of the present invention;

Figure 2 is a transverse cross-section of the heating apparatus illustrating the alternate layer construction;

Figure 3 is a longitudinal cross-section of one of the heating elements illustrating one form of electrical contact and supporting means;

Figure 4 is a general perspective view of the heating apparatus showing schematically one means of electrically connecting the various heating elements together to a source of electrical energy.

Figure 5 is a perspective view of another form of heating apparatus in accordance with the invention;

Figure 6 is an enlarged perspective view of a portion of the apparatus shown in Figure 5; and

Figure 7 is a reduced plan view of the apparatus shown in Figure 5.

Referring to Figure 1, there is shown a rotisserie 10 of generally rectangular shape provided with access means in the form of doors 11. Within the rotisserie there is mounted a spit 12 adapted to be rotated by means of a drive chain within a housing 13. The upper or roof portion of the rotisserie comprises sloping walls 14 and 15 connected by a flat section 16 to provide a generally concave cover. The electrical heating apparatus for the rotisserie indicated at 17 is disposed within this concave roof portion and is shaped and positioned to radiate heat in the direction of the spit as will become clear as the description proceeds.

Referring now to Figures 2, 3, and 4, the heating apparatus 17 comprises a plurality of semi-conductive heat producing element 18 in the form of elongated bars each having a transverse cross-section in the shape of a truncated sector. Disposed between adjacent elements 18 there are provided similarly shaped elongated members 19 of insulative non-heat-producing material. The composite structure forms an integral block of substantially semi-cylindrical shape to provide a concave radiating surface having a radius of curvature (r) as shown. Heat radiated from this concave surface accordingly will be generally concentrated along a focus line (f) which in Figure 2 extends normally from the plane of the drawing. The surface of the meat or other food to be cooked on the spit 12, will pass through the focus line (f) of maximum heat concentration as the spit 12 rotates.

Referring particularly to Figure 2, it will be seen that the truncated sector cross-sectional shape of each element 18 provides a larger radiating surface for a given amount of material than would result in the case of a circular or square rod. Further, because of the concave inner surface resulting from the truncated portion of the sector, the heat radiation is focused as described above. The insulative members 19 are shaped in a similar manner, but the sector angle θ, while shown to be the same as the elements 18 in Figure 2, may be varied more or less to effectively vary the spacing between the heat-producing elements and thus vary the heat produced per unit area of the entire composite block.

The engaged surfaces between the elements 18 and the insulative members 19 are designated (s) in Figure 2 and permit heat transfer by conduction from the heated elements 18 to the insulated members 19. The total heating is therefore distributed substantially uniformly over the entire block.

This uniform heat distribution is an important feature of the invention since it permits the surface heat produced per unit area to be less than would be the case if no insulative layers of material were employed. In other words, the insulative members 19 will also radiate heat which otherwise would normally be radiated from the

semi-conductive elements. Accordingly, the semi-conductive elements are somewhat cooler than normal and electrical contacts at their end portions may be effected without having to employ "cold" ends.

Figure 3 shows one method of mounting the composite block for electrical connection and for accommodating any construction or expansion due to cooling and heating of the apparatus.

As shown in Figure 3, opposite end portions of the elements 18 are provided with dimples or depressions 20 which may be sprayed with a suitable conductor such as aluminum. Within these dimples are adapted to fit cups 21 of conducting material secured to resilient springs 22, in turn fixed to insulated mounting projections 23, fixed to opposite walls 24 of the rotisserie. Electrical energy may be supplied to opposite ends of the elements 18 through terminals 25 electrically connected to the cups 21. The resilient nature of the springs 22 will accommodate the above-referred to contraction and expansion of the heating element, these springs 22 being normally biased to urge the cups 21 into the corresponding dimples 20.

A preferred arrangement of electrical connections to the various elements 18 is shown in Figure 4. A lead 26 from a suitable power source is connected to one end of a first element 18 as shown. The far end of this element is bridged by an electrical conducting means 27 with the adjacent end of the next element. A second adjacent pair of far ends of elements 18 is similarly bridged by an electrical conducting means 28. One element of each pair has its near end portion bridged to the other by electrical conducting means 29 whereby the four elongated elements 18 of Figure 4 are connected in series. The near end connection of the last element to the power source is effected by conductor 30.

In operation, current is applied to the conductors 26 and 30, respectively, to pass through the various bars in series following the circuit described in Figure 4. This current will be partially transformed, through the resistance characteristics of the heating elements 18, into heat energy, which energy will be conducted into the insulated members 19, the tendency being for the entire composited block to acquire a substantially uniform temperature. As pointed out above, varying the thickness or truncated sector angle θ of either the insulative members 19 or the heat producing element 18, enables the quantity of heat radiated per unit area to be adjusted. Further, however, in view of the multiple circuits employed, it is possible by re-arrangement of the bridging conducting means 27 and 28 and the power leads 26 and 30, to utilize only one or a part of the elements 18, and to connect the elements 18 in series, parallel, or series-parallel, thus providing great flexibility of control.

The provision of insulative members 19 disposed alternately between the heat producing elements 18 to form a composite structure increases considerably the over-all structural strength of the heating apparatus, inasmuch as the insulative members 19 can be constructed themselves to be structurally strong, whereas the dimensions of the heat producing elements 18 are necessarily limited by the heat producing qualities desired.

In Figure 5 there is shown another form of composite heating block employing relatively thin semi-conductive elements. In this instance the block is substantially flat rather than concave, it being understood that any desired shaping of the block may be provided prior to sintering the various elements and members together. As shown in Figure 5, the composite block comprises a series of semi-conductive elongated heat producing elements 30, 31, 32, and 33, alternately disposed between insulative members 34, 35, 36, 37, and 38. A backing plate 39 of insulative material may be sintered to the composite body for increasing the uniformity of heat radiated per unit area at any point on the surface of the block.

As shown in Figure 5, the near ends of the semi-con-

ductive strips are expanded into block shapes **40, 41,** and **42,** respectively. Similarly, the far ends of the strips terminate in enlarged blocks **43** and **44.** These blocks include contact making cup-shaped recesses **45** and are of identically the same material as the semi-conductive strips, but have relatively large cross-sectional areas and are accordingly not subject to high heating during operation, as will be explained more fully below. It will be noted that the center semi-conductive strips **31** and **32** are electrically connected together by the block **41,** while the far ends of these strips are connected to the outermost strips by blocks **43** and **44.** These conductive blocks accordingly serve the same function as the bridging conductors **27, 28,** and **29** shown in Figure 4.

The enlarged blocks **40, 41, 42, 43,** and **44** also serve an important additional function as will now be explained in connection with Figure 6. Since the action of these blocks is identical, description of one will suffice for all.

As previously mentioned, the enlarged block **42** is made of identically the same material as the strip **33,** and therefore has the same resistance per unit cross-sectional area. Since the cross-sectional area of the block **42** is substantially greater than the cross-sectional area of the strip **33,** however, the heating of block **42** due to passage of current will be considerably less than the heating of the strip **33.** In other words, taken as whole members, the resistance of block **42** is considerably less than the resistance of strip **33.** Thus, this block will be relatively cold with respect to strip **33.**

The electrical connection to the strip **33** is effected through the block **42** by a suitable contact **46** being received in the cup **45.** The contact and cup are of relatively large dimensions whereby a large contact area is effected. As the block constitutes a relatively cold end, any damage to these contacts through excessive heating is accordingly avoided. The blocks **40, 41,** and the blocks **43** and **44** at the far end of the composite structure, similarly provide relatively cold ends for similar cup contacts.

Enlarged end blocks, such as illustrated in Figures 5 and 6, are useful where the semi-conductive strips **33** are relatively narrow to provide the contact making cold ends for the composite block, the small cross-sectional area of these strips resulting in their reaching a fairly high temperature in the hot section. The insulated backing plate **39** aids considerably in distributing the high heat from the relatively thin semi-conductive strips over the entire composite block.

Referring now to Figure 7, there is shown schematically terminal wires designed A, B, C, D, and E from the ends of the semi-conductive strips **30, 31, 32** and **33.** The terminal wires A and C connect to blocks **40** and **42** while the wires B, D, and E connect to the bridging blocks **41, 43** and **44,** respectively. Also shown in Figure 7 is a source of electrical power **47** having two output power leads **48** and **49.** With this arrangement, there are available various combinations in which the power terminals **48** and **49** may be connected to the various terminals A through E for providing different heats from the composite block. These various connections may be readily effected by means of any type of switch. A few examples of such connections follow.

Connecting conductors A to C directly to terminals **48** and **49,** respectively, results in a low heat because of the series connections of the strips **30, 31, 32,** and **33.** This connection is the same as that indicated in the Figure 4 embodiment. For the highest heat, each of the strips is connected in parallel. This connection may be accomplished by shorting the conductors A, B, and C together and connecting them to the terminal **48,** and then shorting conductors D and E together and connecting them to terminal **49.** Such connection places the strips **30, 31, 32,** and **33** all in shunt. For an intermediate heat, the terminals A and C may be shorted together and connected to the power terminal **48** and the conductor E connected to the power terminal **49.** This arrangement places the strip **33** in parallel and the remaining strips **30, 31,** and **32** in series.

Other combinations of connections will occur to those skilled in the art; the above examples are given merely to illustrate how the net radiated heat may be easily varied by a simple switching operation.

It will be appreciated from the above description that the present invention provides an electrical heating apparatus in which the quantity of heat radiated may not only be easily controlled but which is structurally strong and may be shaped in any desired manner to provide various heat radiation patterns.

Further, the provision of enlarged blocks forming integral portions of the semi-conductive strips solves the problem of excessive heating at the terminal connections, since the larger cross-sectional areas of these blocks result in less heating at these points due to the generally lower resistance.

Various modifications incorporating the principles of the present invention will occur to those skilled in the art. The apparatus is therefore not to be thought of as limited to the specific embodiments chosen for illustrative purposes.

I claim:

1. An electrical heating apparatus comprising: a plurality of elements made of semi-conducting heat-producing material arranged in side-by-side substantially parallel relationship with members made of insulating non-heat-producing material disposed between adjacent elements, said elements and members constituting integral block; and electrical conducting means at opposite end portions of said elements for passing a current therethrough, whereby heat is conducted to said members and heat radiation is effected from both said elements and members.

2. The subject matter of claim 1, in which said integral block is concave whereby said heat radiation is focused.

3. An electrical heating apparatus comprising: a plurality of elongated semi-conducting heat-producing elements arranged in side-by-side, substantially parallel relationship; insulative members respectively disposed between adjacent heat-producing elements to form with said elements an integral block; electrical conducting contact means at opposite end portions of each of said elements; electrical conducting means bridging the adjacent contact means of a first pair of said elements at one end of said block; electrical conducting means bridging the adjacent contact means of a second pair of said elements at said one end of the block adjacent the first pair; and electrical conducting means bridging the contact means at an opposite end of an element in said one pair with the contact means at an opposite end of an element in the second pair, whereby all of said elements are connected in series.

4. An apparatus according to claim 3, in which said integral block is of semi-cylindrical configuration to provide a focused heat radiation.

5. In a barbecue rotisserie including an insulated housing having spit means mounted within the housing, an electrical heating apparatus for concentrating heat radiation substantially in the area of said spit, comprising: an elongated substantially semi-cylindrically shaped integral block made up of elements of heat producing semi-conductive material, and co-extensive alternate members of insulative non-heat-producing material; electrical contact means at opposite end portions of said elements; and electrical conducting means cooperating with said contact means to supply electric current to each of said elements, the center of the radius of curvature of said block being positioned substantially in the area of said spit.

6. In a barbecue rotisserie including an insulated housing having spit means mounted within the housing, an electrical heating apparatus for concentrating heat radiation substantially in the area of said spit, comprising: an elongated substantially semi-cylindrically shaped in-

tegral block made up of elements of heat producing semi-conductive material, and alternate members of insulative non-heat-producing material, each of said elements having cup-like depressions in each end thereof; a metallic coating on the surface of each of said depressions bonded to said elements and in electrical contact therewith; an electrical contact member for each of said depressions, each of said contact members having a portion corresponding in shape to the shape of said depressions and receivable within said depressions to make electrical contact with said coatings; and a flat supporting spring for each of said contact members, one end of said spring being secured to said contact member, and the other end of said spring being secured to said housing, said springs normally urging said contact members into pressure engagement with said coatings and serving also to support said block within said housing.

7. An electrical heating apparatus comprising: a plurality of elongated semi-conducting heat producing elements arranged in side-by-side, substantially parallel relationship; insulative members respectively disposed between adjacent heat-producing elements to form an integral block of semi-cylindrical configuration, each of said elements having cup-like depressions in each end thereof; a metallic coating on the surface of each of said depressions bonded to said elements and in electrical contact therewith; an electrical contact member for each of said depressions, each of said contact members having a portion corresponding in shape to the shape of said depressions and receivable within said depressions to make electrical contact with said coating; a flat supporting spring for each of said contact members normally urging said contact members into pressure engagement with said coatings; electrical conducting means bridging the adjacent contact members of a first pair of said elements at one end of said block; electrical conducting means bridging the adjacent contact members of a second pair of said elements at said one end of the block adjacent the first pair; and electrical conducting means bridging the contact member at an opposite end of an element in said one pair with the contact member at an opposite end of an element in the second pair, whereby all of said elements are connected in series.

8. An electrical heating apparatus comprising: an elongated element of semi-conductive heat-producing material; and contact means at the opposite ends of said element for passing electric current through said element, said opposite ends having an increased cross-sectional area relative to intermediate portions of said element whereby said ends are relatively colder than said intermediate portions.

9. An electrical heating apparatus according to claim 8, including at least one elongated member of insulating material disposed adjacent said element and in intimate contact therewith to form with said element a composite integral block, heat from said element being conducted to said member whereby heat is radiated from both said element and member.

10. An electrical apparatus according to claim 9, in which said integral block is shaped to provide a concave surface whereby said heat radiation is focused.

11. An electrical heating apparatus comprising: a plurality of elongated elements of given electrical resistance disposed in substantially parallel side-by-side relation; a plurality of elongated members of resistance greater than said given resistance, alternately disposed between said elements and forming with said elements an integral block, the ends of said elements having an increased cross-sectional area relative to their intermediate portions; and electrical contact means at said ends for passing current through said elements, heat produced by said current in said elements being conducted to said members whereby said integral block radiates heat substantially uniformly.

12. An apparatus according to claim 11, including a backing plate of resistance greater than the resistance of said elements, secured to said integral block.

13. An electrical heating apparatus comprising: a plurality of elements made of semi-conducting, heat-producing material arranged in side-by-side substantially parallel relationship with members made of insulating non-heat-producing material disposed between adjacent elements, said elements and said members having substantially equal cross sectional areas, said elements and members constituting an integral block, whereby heat is conducted from said elements to said members and heat radiation is effected from both said elements and members.

14. In a barbeque rotisserie including an insulated housing having spit means mounted within the housing, an electrical heating apparatus for concentrating heat radiation substantially in the area of said spit, comprising: an elongated substantially semi-cylindrically shaped integral block made up of elements of heat producing semi-conductive material, and alternate members of insulative non-heat-producing material, each of said elements having cup-like depressions in each end thereof; an electrical contact member for each of said depressions, each of said contact members having a portion corresponding in shape to the shape of said depressions and receivable within said depressions to make electrical contact with said elements; and a supporting spring for each of said contact members, one end of said spring being secured to said contact member, and the other end of said spring being secured to said housing, said springs normally urging said contact members into pressure engagement with said elements and serving also to support said block within said housing.

15. An electrical heating apparatus comprising: an elongated element of semi-conductive heat-producing material adapted to be heated by the passage of an electric current through said element, the ends of said element having an increased cross-sectional area relative to intermediate portions of said element, whereby said ends are relatively colder than said intermediate portions.

16. An electrical heating apparatus comprising: a plurality of elongated elements of given electrical resistance disposed in substantially parallel side-by-side relation and adapted to be heated by the passage of an electric current; a plurality of elongated members of resistance greater than said given resistance, alternately disposed between said elements and forming with said elements and integral block, the ends of said elements having an increased cross sectional area relative to their intermediate portions, whereby said ends are relative colder than said intermediate portions, heat produced by said current in said elements being conducted to said members whereby said integral block radiates heat substantially uniformly.

References Cited in the file of this patent

UNITED STATES PATENTS

1,490,207	Colby	Apr. 15, 1924
1,533,224	Colby	Apr. 14, 1925
1,897,004	Heyroth	Feb. 7, 1933
2,195,251	Kimball	Mar. 26, 1940
2,245,220	Nelson	June 10, 1941

FOREIGN PATENTS

116,016	Switzerland	May 12, 1924