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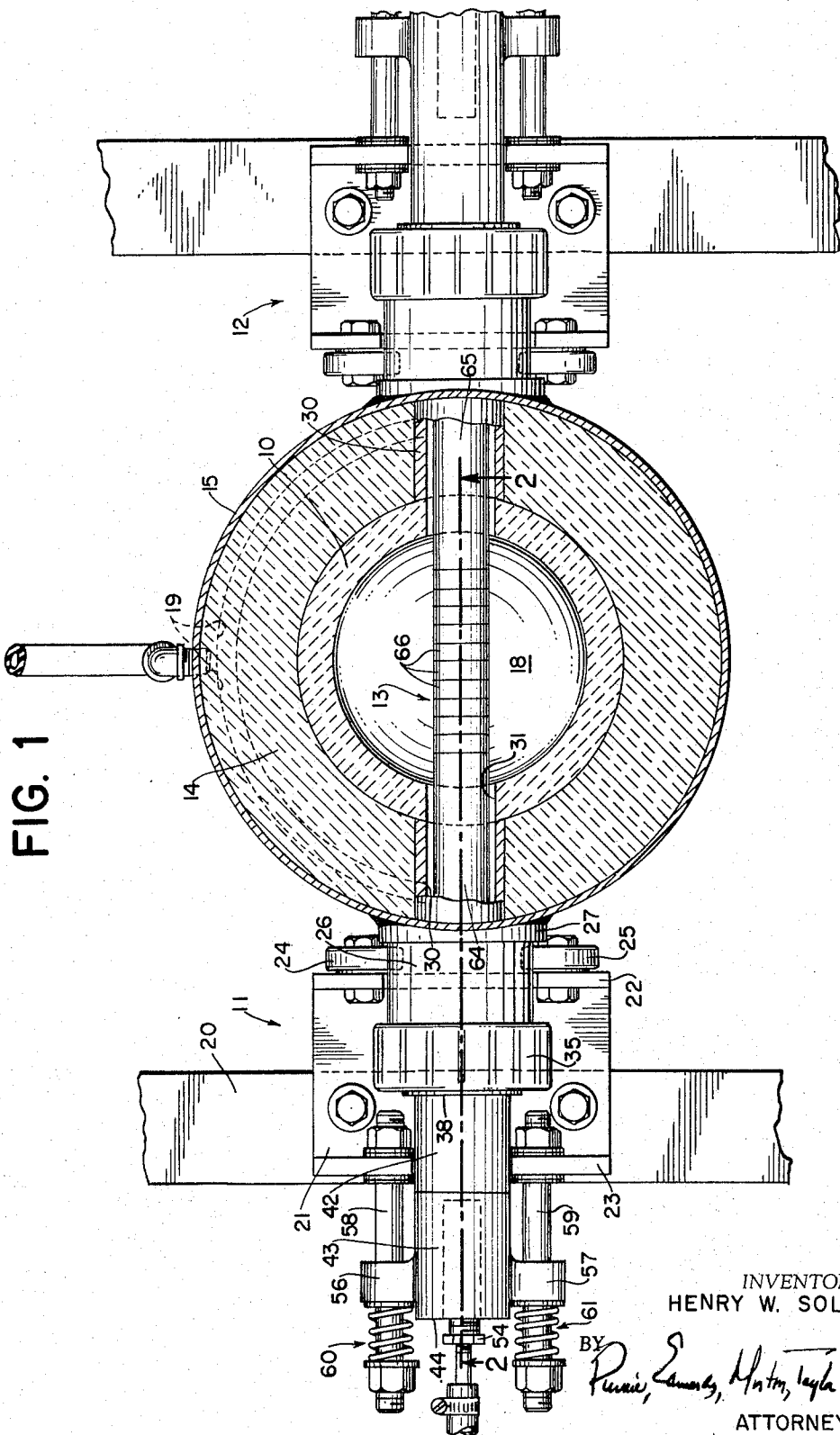
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3,371,142

RESISTANCE MELTING FURNACE

Filed Dec. 4, 1964

3 Sheets-Sheet 1



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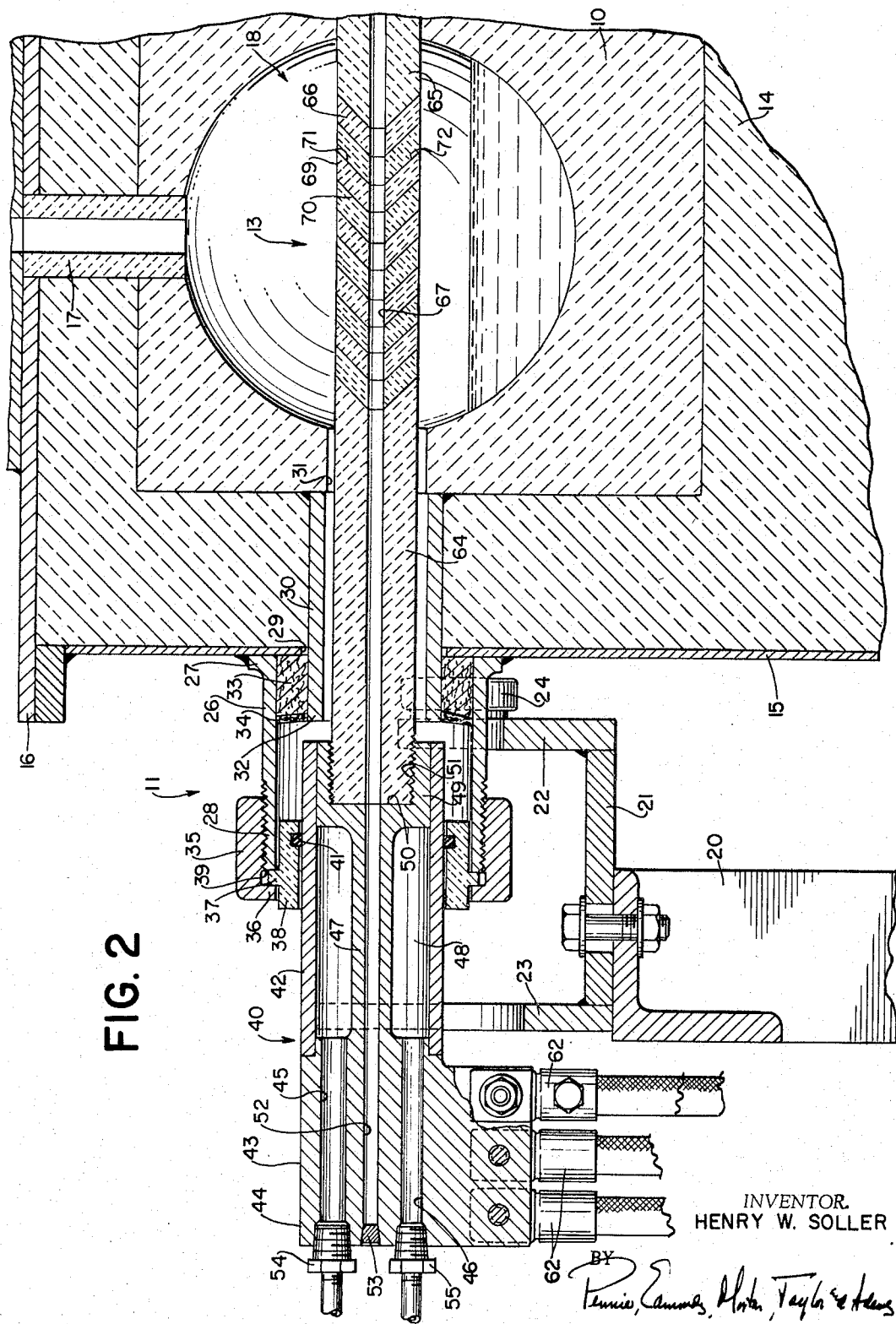
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FIG. 3

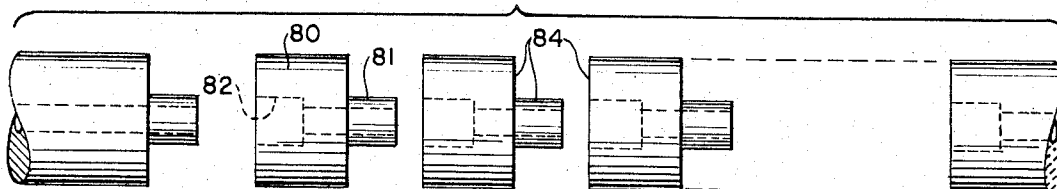


FIG. 4

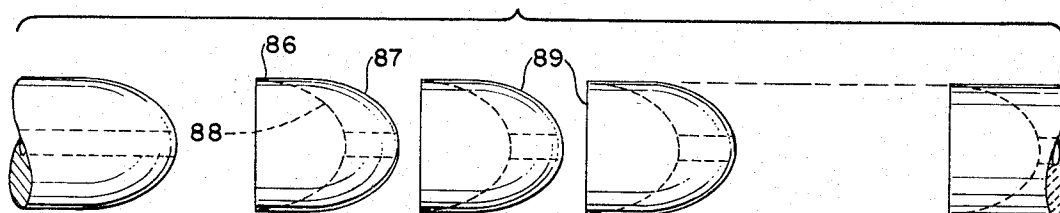
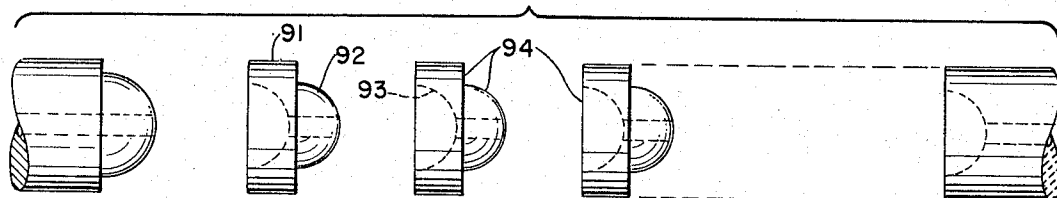


FIG. 5



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RESISTANCE MELTING FURNACE

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This invention relates to a resistance melting furnace and more particularly it relates to such a furnace having a resistance heating element constructed of a plurality of portions which provide increased internal resistance in the heating element and corresponding blockage of thermal conduction therealong.

Among conducting materials, carbon, particularly graphite, has unsurpassed high temperature refractory properties and is the material generally selected for the heating element in resistance melting furnaces. The advantages of carbon are seriously hampered in this use by its poor natural resistivity, and for a resistance furnace containing a carbon electrode to work effectively, high amperages and very low voltages were required. For this reason, in designing furnaces for relatively large melts, in the order of 10 or more pounds, attempts have heretofore been made to increase the resistance of the carbon heating element by lengthening the element or reducing its cross section. But in lengthening the heating element the conversion of electrical energy to heat is spread along a relatively large area and the melting efficiency realized is not proportional to the increase in resistance; and by reducing the cross section of the element, it is rendered more fragile and combustible and has a shortened useful life. It is the purpose of this invention to provide a resistance melting furnace with a carbon heating element which gives optimum performance. This is achieved by a novel carbon heating element construction which increases the internal resistance and effectively blocks thermal conduction along the heating element so as to give greater heat radiation and more effective and efficient melting within the furnace.

Broadly stated, I provide a carbon heating element for use in combination with a resistance melting furnace of the type having a suitable crucible for melting. The resistance heating element is comprised of two end portions which extend into the crucible from opposite sides thereof, and a plurality of intermediate portions supported between the end portions to form an elongated heating element which is suspended within the crucible. The heating element has adjacent portions joined together in matching surface-to-surface contact and a plurality of contact resistance interfaces defined between adjoining surfaces of the portions and positioned within the heating element along a portion thereof located within the crucible to provide increased internal resistance in the heating element and corresponding blockage of thermal conduction therealong.

By providing a plurality of contacting interfaces within the heating element, there is an increase in resistance within the element. This contact resistance provides, of course, great heat liberation and higher operating temperature ranges. Also, this internal contact resistance increases the electrical resistance of the element so as to add to the natural resistivity of the carbon, and this permits reduction in amperages, current carrying conductors and transformer capacity, as well as a rise in the applied voltage so as to maintain the same kw. output with smaller components such as conductors and switches. In addition to these advantages which naturally flow from the novel structure, the element can be shortened to concentrate the conversion of electrical energy to heat to a very small crucible area, and the section of the element can be increased to render it structurally stronger and

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increase its radiating surface area so as to increase its useful life.

A preferred embodiment of the invention is described hereinbelow with reference to the drawings wherein:

FIG. 1 is a plan view partly in section and partly broken away of the resistance melting furnace of the invention;

FIG. 2 is a section of the apparatus taken substantially along the lines 2-2 of FIG. 1;

FIG. 3 is a fragmentary side elevation of a first embodiment of a heating element configuration showing the portions of the element separated;

FIG. 4 is a fragmentary side elevation of a second embodiment of a heating element configuration showing portions of the element separated; and

FIG. 5 is a fragmentary side elevation of a third embodiment of a heating element configuration showing portions of the element separated.

The basic structure of a resistance melting furnace in which the heating element is used is shown in FIGS. 1 and 2 and consists of a cylindrical refractory crucible 10 which is mounted on support assemblies 11 and 12 for rotation about a horizontal axis and has a graphite resistance heating element 13 extending through the crucible in alignment with the axis of rotation. A heat insulating material 14 substantially encapsulates the crucible 10 and an outer metal shell 15 which surrounds the heat insulating material and is closed at its bottom portion and has a top metal plate 16 completing the outer casing. This crucible assembly, which has a generally standard construction, also includes an inlet conduit 17 which opens into the crucible 10 from the top plate 16 and serves as the inlet and outlet conduit of material and melt to and from the crucible melting zone 18. In FIG. 1 an inlet 19 is also indicated which leads into crucible 10 and then divides into two tubes which lead into the trunnions through sleeves 30 into the melting zone to provide a source of protective gas, such as argon, nitrogen, carbon monoxide or any other gas which is non-reactive with the heating element or the metal being melted.

The support assemblies 11 and 12 are positioned at diametrically opposed sides of the crucible which can be identical in construction so that the heating element can be inserted from either side or they can differ somewhat in detail to permit the heating element 13 to be inserted from only one side of the crucible 10. Thus, a description of support assembly 11 through which the heating element is insertable will serve also as a description of support assembly 12. The support assembly 11 through which the heating element is inserted into the crucible is comprised of an upright support 20 on which is fixed a mounting bracket 21 that has upright first and second plates 22 and 23 which are spaced laterally substantially along the axis of rotation of the crucible. The first plate 22 has a pair of ball bearings 24 and 25 mounted thereon which extend to a position between the first bracket plate 22 and the outer shell 15. The ball bearings are spaced so that a trunnion 26 which is comprised of a metal cylinder is fixed to the metal shell and extends outwardly therefrom can ride on the bearings for rotation of the crucible thereon. As shown one end portion 27 is secured to the outer shell 15 and the other end portion 28 is threaded.

An opening 29 is provided in the outer shell 15 of smaller dimensions than the diameter of the trunnion 26, and the end portion 27 of the cylindrical member is fixed to the outer shell about the opening. Extending through the opening 29 and the heat insulating material 14 is a cylindrical refractory sleeve 30 which opens in alignment with a smaller opening 31 in the crucible 10. One end portion 32 of the sleeve 30 extends outwardly beyond the outer shell 15 and is positioned in concentric spaced rela-

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tionship with the cylindrical trunnion 26. An asbestos wicking 33 is positioned between the sleeve 30 and the trunnion 26 and is held therebetween by a cement deposit 34 which will hold at temperatures up to 3000° F.

Threaded on the threaded end portion 28 of the trunnion 26 is a collar 35. The collar 35 has an inwardly extending flange portion 36 which holds an annular raised portion 37 of a bearing 38 between the flange portion 36 and the endmost edge 39 of the cylindrical member. The bearing 38, which is preferably made of a suitable insulating material such as transite bonded asbestos or the like, is thereby in fixed relationship with the crucible assembly and its inner cylindrical surface is slightly spaced from the outer cylindrical surface of a heating element support assembly 40, and an O-ring 41, which is positioned in bearing 38 is in contact with the cylindrical surface of the support assembly, and allows for rotation of the furnace and furnishes an effective seal of the crucible interior to the outer atmosphere.

Basically the heating element support and electrode assembly 40 consists of a first cylindrical member 42 and a second member 43 which is partially inserted into the cylindrical member. The second member 43 has an outer end portion 44 which is substantially solid except for an inlet 45 and outlet 46 conduit and a small axial bore 52, an intermediate portion 47 which is of substantially reduced diameter and defines an annular chamber 48 with the cylindrical member, and an inner end portion 49 which has substantially the same outside diameter as the inside diameter of the cylindrical member 42 and is fixed in the cylindrical member. The inner end portion 49 is substantially a cylindrical member as there is a recess 50 which opens toward the crucible and has its inner walls 51 threaded or tapered to receive an end portion of the heating element. The second member can also have an axial bore 52 extending completely therethrough and in its operating position would have a plug 53 closing it off.

The inlet 45 and outlet conduits 46 which extend through the end portion 44 open into the annular chamber 48 have hose and hose fittings 54 and 55 attached to the opposite outer end to connect the conduits to a source of water and a suitable discharge connection so that water can be circulated therethrough. It is to be noted that the water chamber 48 is advantageously positioned adjacent the juncture between the bearing and O-ring so as to reduce the heat effect at this point and preserve the relative free rotational relationship therebetween.

As shown in FIG. 1, the outer end portion 44 of the second member of the heating element support and electrode assembly has laterally extending guide sleeve portions 56 and 57 which extend outwardly in diametrically opposed directions. Positioned within the sleeves 56 and 57 are rods 58 and 59 which are attached at one end to, but electrically insulated from, the second plate 23 of the mounting bracket and have a nut, flange and spring assembly 60 and 61 positioned between the end of each rod opposite to that which is attached to the bracket plate and their respective sleeve so that the entire heating element support assembly is spring biased in a linear direction toward the crucible.

Also attached to outer end portion 44 are a plurality of electric cables 62 which connect the heating element support and electrode assembly to a suitable electric source to provide electric power to the heating element 13.

The graphite heating element 13 consists of two cylindrical end portions 64 and 65 extending into the crucible from opposite sides thereof along the axis of rotation and a plurality of intermediate portions 66 which are supported between the end portions to form an elongated heating element. The cross-sectional area of the intermediate portions is the same as that of the end portions 64 and 65 and the intermediate portions 66 are supported and suspended between the end portions solely by axial

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pressure exerted by the spring biased mounting arrangement and their configuration so as to form an elongated heating element of substantially uniform cross-sectional area suspended within the crucible. The end and intermediate portions collectively have an axial bore 67 extending axially therethrough which is in alignment with the bore 52 in the heating element support assembly. This bore arrangement is advantageous as an aid in inserting the heating element into the crucible.

As shown in FIG. 2, the end portions and intermediate portions are shaped so that they nestle together to form a substantially continuous element. The intermediate portions can have many different shapes, but those shown in FIGS. 2, 3, 4 and 5 provide particularly good results. Since the intermediate portions are shaped to fit one into the other, they each have a male end extending from one end of the intermediate portion and a female recess formed into the end opposite from the male end. Thus, in FIG. 2, the intermediate portion has a generally cylindrical shaped first section 69 with a frusto-conical shaped male end 70 and a similar frusto-conical shaped female recess 71. This permits a plurality of intermediate portions to be joined in matching surface-to-surface contact since the male ends and female recesses will fit together so closely and form a generally cylindrical element since the cylindrical section 69 of the portions define the outer surface of the portions when the portions are joined. When the portions are joined in surface-to-surface contact, these also form a contact resistance interface 72 between the portions which greatly improves the inherent inadequate resistivity of the graphite. Thus, it is desirable to provide a surface area interface between adjacent intermediate portions which is preferably greater than the cross-sectional area of the heating element. Each contact interface provides its own contact resistance and by increasing the number of interfaces of the intermediate portions, the over-all electrical resistance is increased. By providing a plurality of intermediate portions and joining them in matching surface-to-surface contact as shown, a plurality of contact resistance interfaces are provided along the length of the heating element. It has been found that not only is increased electrical resistance effected by the plural interfaces, but they also serve as effective heat barriers, and in blocking thermal conduction along the heating element thermal radiation is forced from the intermediate portions into the crucible to greatly improve its heating effect. A final advantage of configuring the intermediate portions so that they connect in a male-to-female connection is that they are self-suspending and require no external supporting member to maintain their integral and substantially continuous construction.

Other configurations of intermediate portions are shown in FIGS. 3-5. They each have end portions which are configured similar to receive the intermediate portions in a connection which gives the continuous structure needed. In FIG. 3 the intermediate portion has a first section 80 of substantially cylindrical configuration, a male end 81 which is cylindrical in shape but of a smaller or stepped diameter than the cylindrical section 80, and a cylindrical female recess 82 formed into the intermediate portion from the end opposite the end from which the male end 81 extends. This permits similar connection as described above and defines an interface 84 which has greater area than that of the general cross-sectional area of the intermediate portion.

In FIG. 4 an intermediate portion is shown which has section 86 of generally cylindrical shape, a rounded male end 87, and a female recess 88 formed into the end of the intermediate portion opposite the end from which the rounded male end extends to define an interface 89 of greater area than the general cross-sectional area of the intermediate portion.

In FIG. 5 an intermediate portion is shown which has a first section 91 of generally cylindrical shape, a rounded axially extending male end section 92 of a smaller out-

side diameter than the first section 91, and a female recess 93 formed into the end of the intermediate portion opposite to the end from which the male end extends to define an interface 94 of greater area than the general cross-sectional area of the intermediate portion.

It is to be noted that the intermediate portions and the end portions of the heating elements all had an axial bore extending therethrough; and the heating element support has its axial bore 52 in alignment with the bore in the intermediate portion. This was provided in this arrangement to facilitate assembling the heating element by sliding the end and intermediate portions in contact with each other on a mandrel which fits through the bore, positioning the portions together to form the heating element, inserting the heating element within the furnace until the elements are maintained axially compressed by the spring and nut arrangement, and then withdrawing the mandrel and inserting the plugs into the bore.

Although the furnace particularly described has been in relation to a furnace for melting metals, the basic heating elements can be used in other types of furnaces as well and these are also considered to be within the scope of the invention.

I claim:

1. In a resistance melting furnace having a crucible for melting which is mounted for rotation about a horizontal axis, the improvement in a carbon resistance heating element in combination therewith comprising two end portions extending into the crucible from opposite sides thereof, a plurality of separate intermediate portions supported between said end portions to form an elongated heating element suspended horizontally across and within said crucible, said intermediate portions having adjacent end portions joined together in matching surface-to-surface contact to provide resistance heating without arcing therebetween, and a plurality of contact resistance interfaces defined between adjoining surfaces of such end portions and positioned within the heating element along a portion thereof located within the crucible to provide internal thermal and electrical resistances in the heating element greater than those of a similar shaped element constructed in one piece.

2. In a resistance melting furnace according to claim 1 said heating element characterized by said intermediate portions being supported and suspended between the end portions solely by axial pressure and means in said furnace for axially compressing said portions.

3. In a resistance melting furnace according to claim 1 said heating element characterized by said intermediate

portions being of substantially the same cross-sectional area as that of said end portions to form an elongated heating element of substantially uniform cross-sectional area.

4. In a resistance melting furnace according to claim 1 said heating element characterized by the adjoining surfaces of the respective portions having surface areas not less than their cross-sectional area.

5. In a resistance melting furnace according to claim 1 said heating element characterized by the adjoining surfaces of the respective portions having surface areas greater than their cross-sectional area.

6. In a resistance melting furnace according to claim 5 said heating element characterized by said portions having substantially conically-shaped axial extensions and recesses formed to permit said matching surface-to-surface contact.

7. In a resistance melting furnace according to claim 5 said heating element characterized by said portions having substantially cylindrical-shaped axial extensions and recesses formed to permit said matching surface-to-surface contact.

8. In a resistance melting furnace according to claim 5 said heating element characterized by said portions having substantially rounded axial extensions and recesses formed to permit said matching surface-to-surface contact.

9. In a resistance melting furnace according to claim 1 said heating element characterized by being graphite.

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