Aug. 25, 1970 H. W. WESTEREN ET AL 3,525,795

ELECTRIC FURNACE AND TUBULAR HEATING ELEMENT FOR USE THEREWITH

Filed April 29, 1968 2 Sheets-Sheet 1

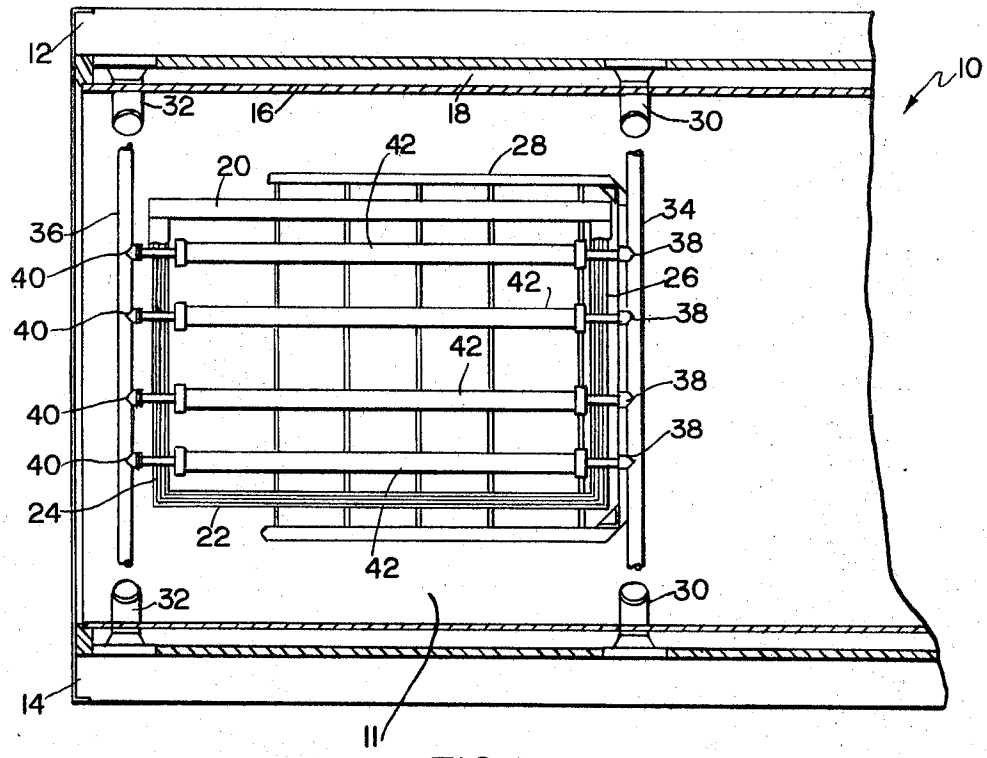


FIG. 1

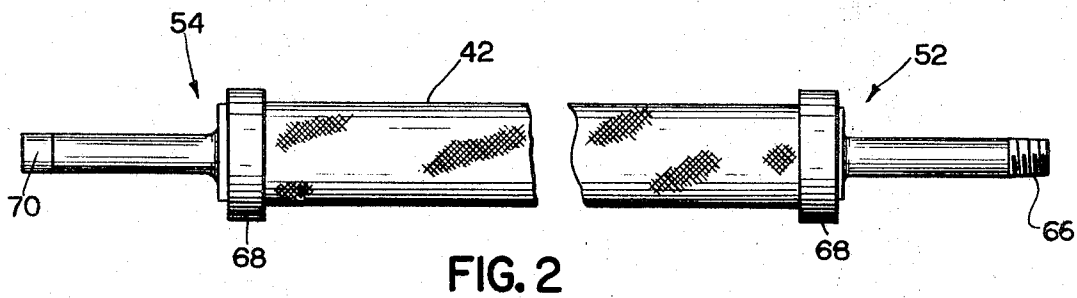


FIG. 2

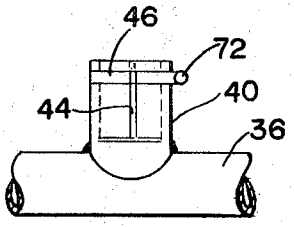


FIG. 3

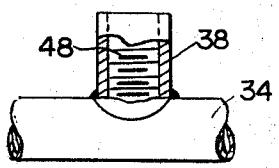


FIG. 4

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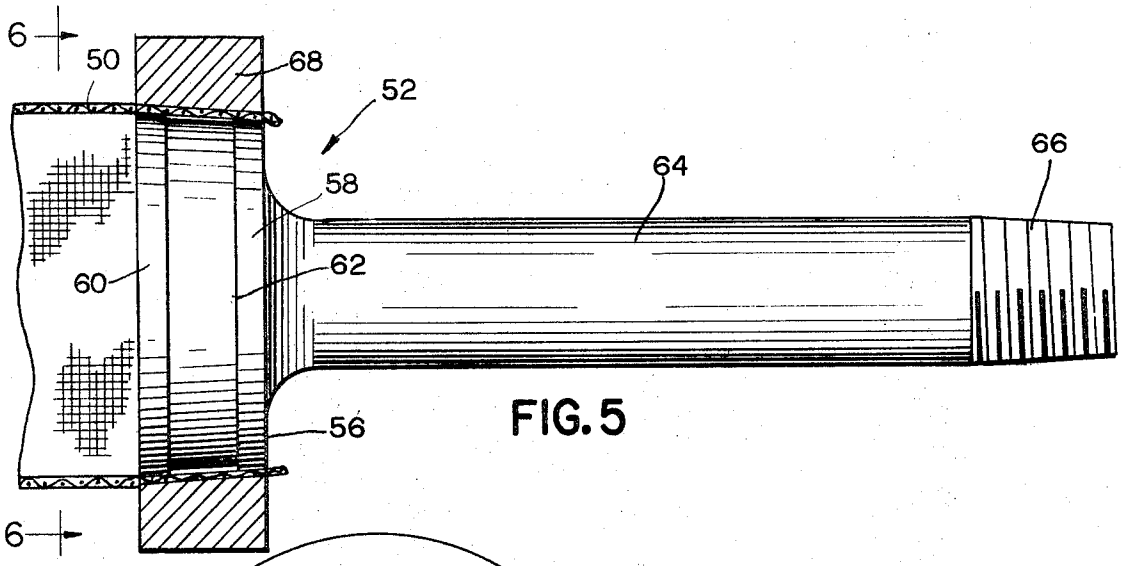


FIG. 5

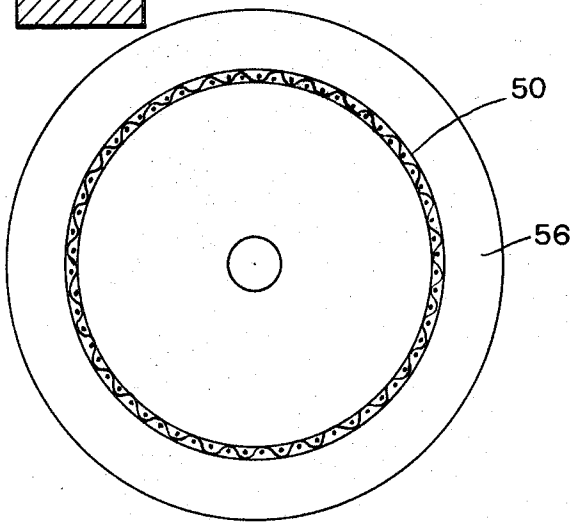


FIG. 6

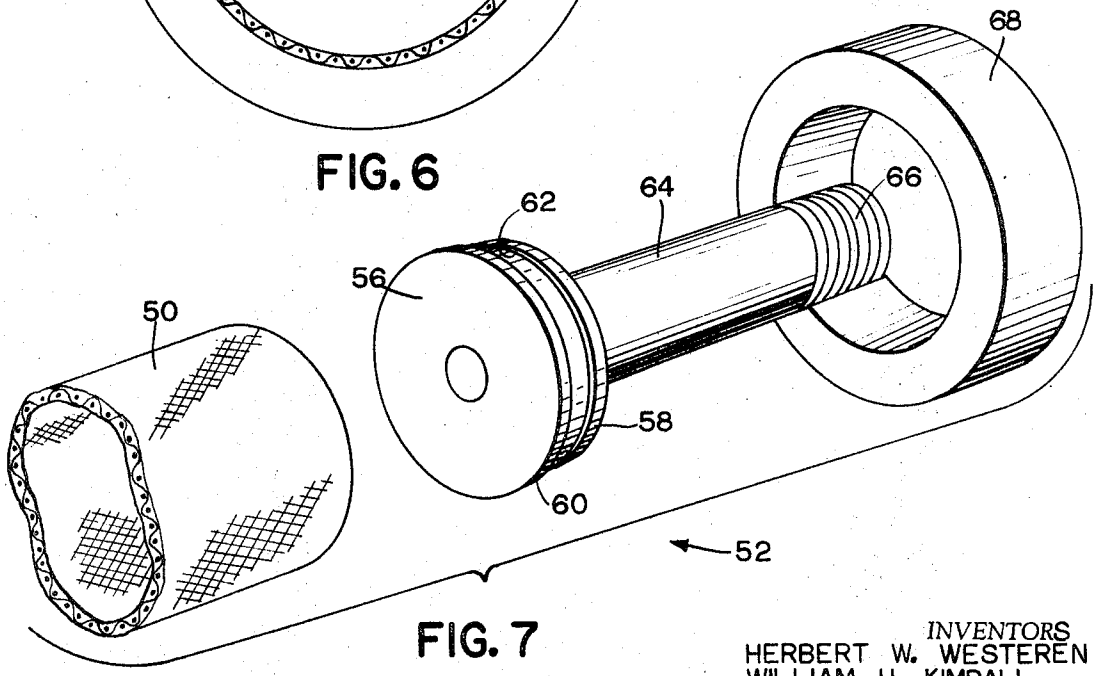


FIG. 7

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United States Patent Office 3,525,795
Patented Aug. 25, 1970

3,525,795

ELECTRIC FURNACE AND TUBULAR HEATING ELEMENT FOR USE THEREWITH

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Filed Apr. 29, 1968, Ser. No. 724,716
Int. Cl. H05b 3/60, 3/66
U.S. Cl. 13—25 10 Claims

ABSTRACT OF THE DISCLOSURE

An electric furnace having a heating chamber in which a heating element is located, the resistance heating element being comprised of a flexible graphite cloth material that has a generally tubular configuration.

BACKGROUND OF THE INVENTION

Electric furnaces known heretofore used in the heat treatment of metallic articles have usually incorporated metallic or ceramic type resistance heating elements in the heating chambers thereof. Although these prior known heating elements were found to be satisfactory for many purposes, they had a tendency to expand unevenly and were therefore somewhat brittle after a period of use. Moreover, the prior known resistance heating element was relatively expensive to operate and required a special terminal construction in the use thereof.

Prior to the instant invention, resistance heating elements formed of a flexible graphite material have been employed in an electric furnace construction as a substitute for the metallic resistance heating element and have been found to be efficient in operation and relatively inexpensive in the fabrication and use thereof. The use of such flexible cloth graphite heating elements is illustrated and described in Pat. No. 3,257,492. Although the graphite cloth heating element as employed in the heating chamber of a furnace construction and described in the aforesaid patent has been found to be efficient in operation and is relatively inexpensive in the use thereof, the manner of application thereof was still limited when incorporated in certain types of high vacuum electric furnaces. It is desirable in vacuum furnaces to limit the number of feed-throughs in the furnace wall, and when it was necessary to increase the temperature requirements in the heating chamber using the prior known graphite heating elements additional terminals were required necessitating additional, special insulated power feed-through in the furnace walls. Such special feed-throughs, that were required to penetrate through a double-wall vacuum vessel, constituted an item of considerable expense.

SUMMARY OF THE INVENTION

The present invention relates to an electric furnace that incorporates a graphite heating element in the heating chamber thereof, and although the invention is not limited to an electric furnace of the vacuum type, it has particular application therewith. Because the furnace as contemplated for use herewith does operate under vacuum, it is desirable to reduce the number of fittings extending through the walls thereof, and in this connection the heating elements as employed in the present invention are connected to spaced terminal bars that extend through the furnace walls, and thus, not only are the number of fittings that extend through the furnace walls reduced, but a concentrated heating area is defined by the arrangement of the heating elements. In the present invention, the heating element as used in the furnace heating chamber is constructed of a flexible graphite cloth material in a tubular configuration and is mounted in place by fitting the

ends thereof over cylindrical portions of rigid graphite terminals. A compression ring envelopes the cloth on the cylindrical portion of the terminal and cooperates therewith to lock the end of the cloth in place. Preferably, the cylindrical portion and the compression ring have a corresponding tapered configuration that provides for maintaining a tight fit as the cloth is captured therebetween. By locating the heating elements between spaced terminal bars in a relatively unflexed position a relatively confined heating area is defined.

Each of the terminals to which a heating element is secured is formed with an elongated portion, these portions being interconnected to the terminal bars that extend through the walls of the vacuum vessel. Thus, the spaced terminal bars have a plurality of the terminals interconnected thereto and act to locate any number of graphite tubular heating elements in parallel spaced relation within the furnace heating chamber. However, regardless of the number of heating elements that are located in the heating chamber, only a limited number of feed-throughs extend through the furnace walls.

Accordingly, it is an object of the present invention to provide an electric furnace having a flexible heating element for use therewith.

Another object of the invention is to provide a vacuum electric furnace in which a plurality of heating elements having a tubular configuration and formed of a flexible graphite cloth material are located in the furnace heating chamber and are interconnected to terminal bars in spaced parallel relation.

Still another object is to provide a flexible heating element for use in an electric furnace that is formed in a tubular configuration and that is secured to a terminal bar at the end thereof by means of an interfitting compression ring and cylindrical portion.

Other objects, features and advantages of the invention will become apparent as the description thereof proceeds when considered in connection with the accompanying illustrative drawings.

DESCRIPTION OF THE DRAWINGS

In the drawings which illustrate the best mode presently contemplated for carrying out the present invention:

FIG. 1 is a horizontal sectional view through the heating chamber of an electric furnace showing in top plan a plurality of heating elements of the present invention that are located in spaced parallel relation and are connected to spaced terminal bars;

FIG. 2 is an elevational view showing a heating element of the present invention as attached to end terminals;

FIG. 3 is an enlarged view of a portion of a terminal bar showing a connection for receiving one of the terminals that is interconnected to the heating element;

FIG. 4 is an enlarged view with parts shown in section of a portion of a terminal bar illustrating another connection for receiving the other terminal that is interconnected to the heating element;

FIG. 5 is an enlarged view of a terminal with parts shown in section and illustrating the interconnection of a tubular heating element therewith;

FIG. 6 is a sectional view taken along lines 6—6 in FIG. 5; and

FIG. 7 is an exploded perspective view of a portion of a tubular heating element and the associated terminal.

DESCRIPTION OF THE INVENTION

Referring now to the drawings and particularly to FIG. 1, a high-vacuum heat treatment furnace of the cold-wall type is illustrated and is generally indicated at 10. The furnace 10 as illustrated in FIG. 1 is broken away so that only the heating chamber indicated at 11 is shown. The remaining portions of the furnace, including the loading

end, the cooling station and a quench area, are not illustrated herein and form no part of the present invention.

Mounted on opposed brackets **12** and **14** is the furnace housing the interior wall of which is indicated at **16**. Spaced from the interior wall **16** is an outer wall **18** that cooperates therewith to define a cooling chamber **18** in which a cooling fluid, such as water, is circulated. Not shown are connections that extend through the walls **16** and **18** and that communicate with a vacuum pump, the vacuum pump being adapted to exacuate the interior of the furnace to a predetermined vacuum for carrying out the heat treatment operation.

Located in the heating chamber **11** of the furnace is an arrangement of laminated graphite insulating sections indicated at **20**, **22**, **24** and **26** and that cooperate to form a confined heating area therebetween. As further illustrated in FIG. 1, a carriage **28** is provided and is movable on tracks (not shown) for transferring a workload between a load and/or cooling station and the heating chamber **11**. The construction of the carriage **28** and the means for carrying out the movement thereof do not form any part of the present invention.

In order to supply the required heat for the heating area, opposed power feed-throughs indicated at **30** and **32** are provided and extend through the housing walls **16** and **18** for communication with a source of current. Spaced tubular bus or terminal bars **34** and **36** extend laterally across the heating chamber **11** exteriorly of the insulating sections and are electrically interconnected to the power feed-throughs **30** and **32**, respectively. Joined to the tubular terminal bar **34** are a plurality of interiorly threaded sleeve connectors **38**, while joined to the tubular terminal bar **36** are a plurality of slotted sleeve connectors **40**. As shown in FIG. 1 each of the sleeve connectors **38** is aligned with a sleeve connector **40** and, as will be described hereinafter, each aligned pair of connectors are adapted to mount a heating element indicated at **42** therebetween. Water is normally circulated through the tubular terminal bars **34** and **36** for maintaining them at an operating temperature, and it is seen that since all of the heating elements **42** are interconnected to the terminal bars **34** and **36**, only four feed-throughs as indicated at **30** and **32** are required for extending through the walls of the furnace housing. Thus it is seen that a number of the heating elements **44** may be concentrated in the heating area to form a confined heating zone, wherein the required temperature may be obtained in the heating area within a minimum period of time and may be maintained thereat with little temperature variation.

As shown in FIG. 3, each of the sleeve connectors **40** is welded to the terminal bar **36** and is slotted as indicated at **44** to form a flexible-type connection. A compression clamp **46** is mounted on each connector **40** and, as will be described, is adapted to clamp a first heating element terminal therein. The connector element **38**, on the other hand, is interiorly threaded, as indicated at **48** and is also welded to its associated terminal bar **34**. A second terminal that is joined to the heating element **42** is received in threaded relation in the connector **38** and cooperates with the first terminal for securing the heating element **42** between the terminal bars **34** and **36**.

Referring now to FIGS. 2, 5, 6 and 7, one of the heating elements **42** is shown in detail and, as illustrated, is formed of a flexible graphite cloth material that is woven and as constructed in accordance with the present invention is arranged in a tubular configuration. The tubular graphite heating element **50** may be woven in the tubular form, or it may be woven in a web, cut and then wrapped in the tubular configuration. With respect to the use of the graphite cloth material as a heating element in web form, reference is made to Pat. No. 3,257,492. In the present invention, as illustrated in FIGS. 5, 6 and 7, the tubular graphite cloth **50** is supported at the ends thereof by terminals generally indicated at **52** and **54**. As will be described, the terminals **52** and **54** are similarly constructed, except that the outer ends thereof are especially formed for being secured to their respective terminal bars **34** and **36**. Referring again to FIGS. 5 and 7, the terminal **52** is shown including a cylindrical portion **56** on which spaced annular lands **58** and **60** are formed. The lands **58** and **60** define a groove **62** therebetween, and, as illustrated in FIG. 5, the peripheral surface of the cylindrical portion **56** as defined by the lands **58** and **60** has a taper that decreases in a direction away from the land **60** and toward the land **58**. Integrally joined to the cylindrical portion **56** is a bar portion **64**, the outer end of which is threaded as indicated at **66**. The threaded end **66** of the bar portion **64** is receivable in threaded relation in the threaded portion **48** of a connector **38**, thereby securing the terminal **52** to the terminal bar **34**. In order to fix the tubular heating element **50** to the terminal **52**, a compression or retaining ring **68** is provided, and has an inner tapered surface that conforms to the taper of the lands **58** and **60**. The diameter of the lands **58** and **60** is dimensioned to receive the tubular cloth **50** therearound and with the cloth mounted on the cylindrical portion **56** as illustrated in FIG. 5, the ring **68** is forced thereover so as to capture the end of the cloth **50** therebetween and the cylindrical portion **56**. By forming the lands **58** and **60** with the groove **62** therebetween, point contact is provided between the lands and the inner surface of the ring **68**, wherein the end of the cloth **50** is firmly locked on the cylindrical portion **56** of the terminal **52**.

The terminal **54** is constructed substantially identical to the terminal **52**, except that the outer end thereof is smooth, as indicated at **70**, rather than being threaded as previously described. The smooth end **70** of the terminal **54** is received within a connector **40** that is joined to the terminal bar **36**, and the compression clamp **46** is then clamped around the sleeve connector **40** by tightening a screw **72**, thereby securely locking the terminal **54** within the connector **40**.

In the assembly of the graphite heating elements **42** between the terminal bars **34** and **35**, the ends of the heating elements are first locked in place on the cylindrical portions of the terminals by the retaining rings **68**. Each terminal **52** is then threadably secured to a connector **38** on the terminal bar **34**. The heating elements **42** are then stretched to their full length so as to be substantially unflexed, and the smooth portions **70** formed on the bar portions **64** of the terminals **54** are inserted within the connectors **40** and clamped in place therein by the compression clamp **46**. The heating elements **42** are thus mounted between the terminal bars **34** and **36** in spaced parallel relation in the heating chamber **11** of the furnace.

The plurality of tubular heating elements **42** as located in the heating chamber area of the furnace provide a concentrated plane of heat within a relatively confined area. Since the heating elements are joined to the opposed terminal bars **34** and **36**, only a limited number of through connections are required for insertion through the furnace walls. The manner of connecting the heating elements **42** to the terminal bars is simple and can be accomplished with a minimum of effort and since the retaining rings **68** define a friction fit around the tubular cloth elements **42** the whole assembly may be dismantled with relative ease. The use of the tapered fit between the compression ring **68** and the cylindrical portion **56** of the terminal insures a tight fit and a good electrical connection between the graphite cloth tubes and the terminals. All of the heating elements and terminals are standardized; and with the exception of the threaded end of one terminal and the smooth end of the other terminal, the parts can be interchanged. The various arrangements of the tubular elements and the variations in the material resistance as defined by the woven graphite cloth offer considerable design flexibility, and the physical configuration of the tubular heating elements is such that high velocity cooling can be carried out in the heating chamber with minimum element attrition.

While there is shown and described herein certain specific structure embodying the invention, it will be manifest to those skilled in the art that various modifications and rearrangements of the parts may be made without departing from the spirit and scope of the underlying inventive concept and that the same is not limited to the particular forms herein shown and described except insofar as indicated by the scope of the appended claims.

What is claimed is:

1. An electric furnace comprising a housing having a heating chamber located therein, a resistance heating element assembly mounted in said heating chamber and including at least one elongated resistance heating element formed of a flexible, graphite cloth material and having a generally tubular configuration, and terminals located at the ends of said tubular heating element and being connected thereto for electrical communication therewith, said terminals being formed of a solid graphite material that has electrical conducting characteristics, the terminals located at the ends of said tubular heating element including a cylindrical portion to which an elongated portion is integrally joined, said cylindrical portion of each terminal being received within an end and the elongated portion projecting outwardly thereof, for junction with a source of current, and a securing ring interfitting over the tubular element on the cylindrical portion of the terminal, wherein said tubular heating element is captured between said cylindrical portion and securing ring.

2. An electric furnace as set forth in claim 1, said cylindrical portion having an annular groove formed therein that defines annular lands, said ring capturing said tubular resistance heating elements therebetween and said lands wherein said lands provide for secure engagement of said ring therewith.

3. An electric furnace as set forth in claim 2, the peripheral surface of said lands having an increasing taper toward said elongated portion, and the inner surface of said ring having a corresponding taper, wherein the interfitting tapered lands and tapered ring effectively capture the tubular element therebetween and provide for a firm mounting of said element on the associated terminal.

4. An electric furnace as set forth in claim 1, the elongated portion of one of said terminals having a threaded end, the elongated portion of the other terminal having a nonthreaded end, said source of current including spaced terminal bars, one of which has a threaded sleeve joined thereto for threadably receiving the threaded end of said one terminal, and the other of said terminal bars having a nonthreaded sleeve for clampingly receiving the nonthreaded end of the other terminal.

5. An electric furnace as set forth in claim 4, each of said spaced terminal bars having a plurality of sleeves joined thereto that are located in aligned relation with sleeves joined to the opposed terminal, and a plurality of the flexible tubular resistance heating elements fixed between said terminal bars in spaced, parallel relation.

6. A resistance heating element for use in an electric furnace, comprising a body portion formed of a flexible, graphite cloth material and having a tubular configuration, and electrical terminals mounted in spaced relation at the ends of said body portion and secured thereto for mounting said tubular body portion in a relatively unflexed position therebetween.

7. A resistance heating element as set forth in claim 6, each of said terminals including a cylindrical portion to which a longitudinal portion is joined, an end of the body portion of said heating element being received over the cylindrical portion, and a securing ring interfitting over said cylindrical portion for capturing the tubular body portion therebetween.

8. A resistance heating element as set forth in claim 7, the peripheral surface of said cylindrical portion being tapered and the inside surface of said ring having a corresponding taper, wherein the tubular body portion is tightly interlocked between said cylindrical portion and ring when they are interfitted with the tubular body portion captured therebetween.

9. An electric furnace comprising a housing having a heating chamber located therein, a resistance heating element assembly mounted in said heating chamber and including at least one elongated resistance heating element having a body portion formed of a flexible, woven graphite cloth material and having a generally tubular configuration, and terminals located at the ends of said tubular heating element and being connected thereto for electrical communication therewith, each of said terminals having a cylindrical portion that receives an end of said tubular heating element and that communicates with a source of current, and clamping means cooperating with the cylindrical portion of each terminal for securing an end of the body portion of each heating element thereon.

10. A resistance heating element for use in an electric furnace, comprising a body portion formed of a flexible, graphite cloth material and having a tubular configuration, and terminals located in spaced relation at the ends of said body portion and secured thereto for mounting said tubular body portion in a relatively unflexed position therebetween, each of said terminals including a cylindrical portion that receives an end of the body portion of said heating element, and clamping means cooperating with the cylindrical portion of each terminal for securing an end of the body portion of said heating element thereon.

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U.S. Cl. X.R.

219—531, 541