Electrical furnace construction

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This is continuation of application Serial No. 262,686, filed March 4, 1963, now abandoned.

The present invention relates to an electric furnace construction. More particularly, the present invention relates to a furnace construction in which resistance heating elements in the form of a flexible graphite material are employed for obtaining relatively high temperatures and which are maintained throughout the heating cycle of the furnace.

The present invention has particular application in the so-called cold-wall type of vacuum furnace wherein the heating element is positioned within the high vacuum chamber. Prior to the instant invention, electric furnace constructions of the vacuum type employed resistance heating elements that were formed of metallic materials and that were arranged in such a manner as to provide a heating area therebetween. One such type of resistance heating element for vacuum furnaces is illustrated in Reissue Patent No. 25,261.

Although the prior known vacuum type furnace which utilized the metallic resistance heating element has been found satisfactory for many purposes, it has been found that these metallic elements have a tendency to expand unevenly and are somewhat brittle after a period of use and are relatively expensive to operate. The present invention embodies a unique resistance heating element construction wherein the elements themselves are formed of a flexible graphite material. Essentially the graphite material is woven in a cloth construction and is cut to the required size and in accordance with the furnace requirements. The graphite cloth as employed in the furnace construction of the present invention not only makes it possible to use full power when the furnace is initially put into operation, but has the characteristic of being able to maintain high temperatures throughout the heating cycle of the furnace construction. The graphite heating elements, furthermore, are not brittle, have a long life, and thus cost less than the prior known form of heating element.

By utilizing the new form of graphite resistance heating element in the present invention, not only can high furnace temperatures be produced, but the construction of the furnace is also more economical and easier to maintain. The economies in operation are produced because of the reduced cost of satureable core reactors that are utilized to control and maintain the power in the furnace at a desired level. Furthermore, by utilizing the graphite cloth heating elements, the required temperature of the furnace is obtained within a matter of seconds and thereby decreases the time required to bring the furnace up to the required temperature level. Since full power is also employed during the starting period of the furnace, further economies are experienced. The material from which the flexible resistance heating elements are formed is also relatively inexpensive, thereby providing for additional economies in the construction of the furnace embodied herein.

It is therefore an object of the present invention to provide an improved resistance heating element formed of a flexible graphite material that is specifically designed for use and operation in a vacuum type furnace.

Another object of the present invention is to provide a resistance heating element having a maximum heat transmitting surface that is constructed to provide rapid and uniform heating.

Still another object is to provide a plurality of graphite heating elements that are formed of a woven cloth material and that are employed in a vacuum type furnace for producing relatively high temperatures therein.

Still another object is to provide flexible graphite heating elements in a vacuum type furnace which are maintained in proper spaced relation by segment bars at one end thereof and by conductor rings at the other end thereof.

Still another object is to provide an electric furnace of the vacuum type that employs woven graphite cloth as resistance heating elements, the graphite cloth being suspended from terminals that project into the furnace and being electrically interconnected at the lower end thereof by interfitting conductor rings.

Another object is to provide a plurality of segment bars and conductor rings for maintaining a plurality of flexible resistance heating elements in proper spaced relation in an electric furnace construction.

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.

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

FIG. 1 is a vertical section view with parts shown in elevation of the furnace construction embodied herein showing the interrelation of the resistance heating elements positioned in the furnace heating chamber;

FIG. 2 is a sectional view taken along lines 2—2 in FIG. 1;

FIG. 3 is a sectional view taken along lines 3—3 in FIG. 1;

FIG. 4 is a sectional view taken along lines 4—4 in FIG. 2;

FIG. 5 is an enlarged perspective view of one of the segment elements illustrated in FIG. 4;

FIG. 6 is an enlarged perspective view of another of the segment elements illustrated in FIG. 4 and that is adapted to be interfit with the segment element illustrated in FIG. 5;

FIG. 7 is a sectional view taken along lines 7—7 in FIG. 3;

FIG. 8 is a perspective view of the larger conductor ring illustrated in FIG. 7;

FIG. 9 is a perspective view of the smaller conductor ring illustrated in FIG. 7 and that is adapted to be interfit with the ring illustrated in FIG. 8; and

FIG. 10 is an enlarged fragmentary sectional view of the lower portion of the furnace construction showing the sealing means therefor.

Referring now to the drawings and more particularly to FIG. 1, a high vacuum heat treatment furnace of the coldwall type is illustrated and is generally indicated at 10. The heat treatment furnace 10 is electrically heated, as will be described, and may be evacuated to 100 microns and less, being normally operated at approximately 10-4 mm. Hg. As illustrated in FIGS. 1 through 3, the furnace construction 10 includes a housing generally indicated at 12 that is defined by a central cylindrical section 14, a top cover 16 and a bottom section 18. The housing 12 is mounted in a generally vertical position on standards 20, the lowermost ends of which are secured in pedestals 22. Sleeves 24 receive the upper ends of the standards 20 and are in turn fixed to the central section 14 of the housing 12 in some suitable manner. A water jacket 26 envelopes the cylindrical central section 14 and is adapted to receive a cooling liquid therein for maintaining the outer walls of the central section 14 at a temperature level that is safe.
for handling of the apparatus. The water jacket 26 further provides for rapid cooling of the heating chamber within the central cylindrical section 14 when desired.

The top cover 16 is removably mounted on the central cylindrical section 14 of the housing 12 and is defined by a plate 28 to which a dome 30 is secured. The top cover 16 is adapted to be mounted on the central cylindrical section 14 in sealing engagement, and for this purpose an annular flange 32 is joined to the uppermost end of the central section 14 and is provided with an annular slot therein in which an O-ring gasket 34 is positioned.

The plate 28 of the top cover 16 is located in overlying relation on the flange 32 and engages the O-ring gasket 34 to define a seal therewith. Any suitable removable means may be utilized for firmly locating the top cover 16 in position on the annular flange 32. The interior of the top cover 16 is also water cooled, and a water inlet 36 is provided therefor for the introduction of water into the interior of the top cover. A centrally located outlet pipe 38 projects from the dome 30 and provides for continuous circulation of the cooling water within the top cover 16.

The bottom section 18 is formed similarly to the top cover 16 and includes a bottom plate 40 to which a dome 42 is adapted to be secured. As illustrated more clearly in FIG. 10, a bottom annular flange 44 is secured to the outer surface of the lowerrmost end of the central cylindrical section 14 and is formed with an annular groove 46 therein in which an O-ring gasket 48 is received. Secured to the dome 42 in spaced relation therearound are a plurality of brackets 50 that are formed with suitable openings for receiving anchor bolts 52 therein. The lowerrmost ends of the anchor bolts 52 are threaded and are retained in place by means of the brackets 50 by nuts 54. The uppermost ends of the anchor bolts 52 are formed in a hook configuration, the end of the hook being received within a suitable hole or groove formed in the upper surface of the annular flange 44. It is seen that the anchor bolts 52 firmly retain the bottom section 18 in secured relation on the central cylindrical section 14, the plate 20 engaging the O-ring gasket 48 to form a seal therewith.

The bottom section 18 is also cooled by external means, and for this purpose is provided with an inlet opening 56 through which a cooling fluid, such as water, is introduced into the interior of the bottom section. An outlet pipe 58 is secured centrally of the dome 42 and is provided with an opening adjacent the innermost end thereof through which the cooling fluid flows during circulation thereof through the bottom section 18.

As mentioned hereinafter, the interior of the furnace construction 10 is adapted to be evacuated during the heat treatment cycle, and for this purpose the central cylindrical section 14 is provided with an enlarged exhaust port 60 with which a pipe 62 communicates. The pipe 62 is secured directly to the central cylindrical section 14 and is provided with an outer flange 64 for securing to a corresponding flange that is in turn connected to the evacuating equipment.

The heating assembly defines the heart of the invention embodied herein, and, as shown in FIG. 1, is generally indicated at 70 and is located interiorly of the central cylindrical section 14. As will be described, the heating assembly 70 includes a plurality of woven graphite flexible heating elements that are adapted to be suspended in vertical relation to define a heating area. In order to provide the necessary current for producing the required heat in these heating elements, saturable core reactors are employed (not shown) to which terminals indicated at 72 are electrically connected. Since high power output is economically utilized by a three-phase system, three terminals 72 are provided and are located equidistant apart and project through the central cylindrical section 14. In order to accommodate the terminals 72, suitable openings are formed in the central cylindrical section 14, and mounting sleeves 74 are secured to the cylindrical section 14 for receiving the terminals 72 thereon. Suitable flanges 76 and 78 are provided for securement of the sleeves 74 to a terminal assembly. One such terminal assembly is illustrated in the aforementioned patent to Westernen No. Re. 25,261.

As described hereinafter, the heating assembly includes a plurality of heating elements that are formed of a woven graphite material. Referring to FIGS. 1 and 2, the woven graphite heating elements are indicated at 80 and are shown being suspended from the innermost ends of the terminals 72. Since the woven graphite heating elements 80 are flexible in construction, they are retained in suspended relation from the terminals 72 to define a heating area therebetween.

In order to locate the graphite heating elements in suspended relation with respect to the terminals 72 the outer ends of the terminals 72 are reduced and are threaded as indicated at 82 in FIG. 4. Mounted on each of the threaded ends 82 of the terminals 72 is a segment element 84 that is arcuate in configuration and is formed with an interior groove 86. An opening 88 is formed in the segment element 84 through which the reduced end 82 of the terminals 72 projects. As illustrated in FIG. 6, a corresponding segment element 90 is adapted to cooperate with the segment element 84 to define a segment bar for retaining the graphite heating element 80 therebetween. For this purpose, the segment element 90, which is also arcuate in configuration, is formed with a projection 92 that is adapted and provided for interfitting in the groove 86 of the segment element 84. A threaded opening 94 is formed in the segment element 90 for receiving the threaded portion of the reduced end 82 of the terminal 72. In the interfitting of the segment elements 84 and 90, the projection 92 is adapted to extend into the groove 86 but is limited therein by the engagement of surfaces 91 and 93 that are located adjacent the groove 86 and the projection 92, respectively. These surfaces are adapted to compress the heating element 80 therebetween and provide unit contact pressure points that insure proper electrical communication between the terminals 72 and the heating elements. Thus the projection 92 does not in fact seat against the wall defining the groove 86, and since the adjacent surfaces mate to lock the heating element 80 therebetween, the heating element will not pull apart from the secured position thereof.

Moreover, the space provided between the projection 92 and groove 86 insures that the heating element may expand therebetween as required. As more clearly illustrated in FIG. 4, the segment elements 84 and 90 interfit to securely retain a heating element 80 therebetween, the heating element 80 being suspended from the segment bar defined by the segment elements 84 and 90 within the interior of the central cylindrical section 14. Each of the terminals 72 is similarly constructed, and, as illustrated in FIG. 2, the heating elements 80 are disposed in equi-spaced relation to define a heating area therebetween.

The heating elements 80 which define the grid members of the heating unit or assembly 70 are connected at the lowermost ends thereof by a conductor assembly defined by concentric interfitting rings 96 and 98. The ring 96, which is the larger of the concentric rings of the conductor assembly, is formed with an interior groove 100 that defines opposed surfaces 102 and 104. The opposed surfaces 102 and 104 are slightly inclined or tapered and define contact areas that cooperate with a tapered face 105 formed on the outer surface of the ring 98 to locate the lowermost ends of the heating elements 80 therebetween in wedged relation. Since the surface 105 of the inner ring 98 is tapered, the opposed surfaces 102 and 104 of the outer ring 96 are taperingly disposed thereabout to define unitary pressure areas for firmly retaining the heating elements 80 therebetween. In the assembly of the rings 96 and 98, the lowermost ends of the heating element 80 are disposed therebetween, and the rings are then wedged into interfitting relation, the contact areas being defined
by engagement of the surfaces 102 and 104 with the tapered face 106. Since the heating elements 80 are formed of the graphite material, a good electrical connection is defined therebetween and the rings 96 and 98 that form the conductors therefrom. As described above in connection with the segment elements, groove 100 between the contact points provides for expansion of the heating element as required.

It is seen that the woven graphite heating elements 80 that are flexible in construction are suspended from the terminals 72, the conductor ring defined by the concentric rings 96 and 98 locating the lowermost ends of the flexible heating elements 80 in substantially taut relation due to their slight of the conductor ring. The conductor ring is also suspended with the heating elements 80 from the terminals 72 and are located in spaced relation with respect to the bottommost end of the central cylindrical section 14.

As mentioned above, the woven graphite heating elements 80 define a heating area therebetween. In order to insulate this heating area so as to obtain the maximum heat treatment benefit for the work being heat treated within the furnace construction, an insulating material indicated at 108 is also provided and is located in surrounding relation with respect to the heating elements 80. The insulating material is defined by a plurality of layers of graphite felt material, the layers being formed in annular relation to define walls as illustrated in FIG. 1 and further including top and bottom layers that are disposed in laminated form. A plurality of graphite rods 110, as shown in FIGS. 1, 2 and 3, extend upwardly from a lower plate 112 located at the lower end of the central cylindrical section and properly locate the annular layers of insulating graphite material 108. A work pedestal 114 may be located within the heating area defined by the heating elements 80 and projects upwardly from the bottom plate 112.

In the operation of the furnace construction embodied herein, the work to be heat treated is placed on the pedestal 114, and the unit is closed by securing the cover member 16 in place. Current is supplied to the terminals 72, and the woven graphite cloth heating elements are quickly brought to the desired temperature to produce the necessary heat for heat treating the work piece. Since the heating elements 80 are formed of the graphite cloth material, high voltages and low amperages may be obtained, thereby obviating the requirement for heavy transformers, cables and other components that were essential in the prior known furnaces which utilized metal heating elements. Because of the inherent characteristics of the heating elements 80, they may be brought to the required temperature within a matter of seconds. This required temperature may be maintained throughout the heating cycle. Furthermore, the full power required for the operation of the furnace is used when starting the furnace, thereby decreasing the cost of operation thereof. In this connection, saturable core reactors are employed to control the power and maintain the power at a desired level, but the cost of operating such saturable core reactors is considerably reduced. The operating temperatures are maintained uniformly, and extremely high temperatures are obtained by the use of the flexible woven graphite heating elements. Because of the fact that such high temperatures can be obtained and maintained for reasonably long periods of time, various kinds of metals for new purposes and uses may be heat treated in the furnace construction of the present invention.

The graphite heating elements which form the heart of the present invention may be quickly and easily replaced if required and are cut to the desired configuration from a larger bolt of the material. Because of relatively few parts required in the furnace construction, maintenance costs are at a minimum.

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. In a vacuum type electric furnace, a housing defined by a central cylindrical section, a top cover removable mounted on said cylindrical section and a bottom section secured to the lower end of said cylindrical section, a plurality of terminals projecting into said cylindrical section in spaced-apart relation, each of said terminals having a segment member joined thereto that includes interfitting arcuate shaped segment bars, a flexible non-metallic resistance heating element secured between the interfitting arcuate shaped segment bars of each segment member and being suspended therefrom, said heating elements being joined at the lower ends thereof by a conductor element, said conductor element including interfitting rings between which the lower ends of said heating elements are secured, and means mounted in said housing and surrounding said heating elements to define a heating zone, thereby insulating said heating elements and substantially confining the heat generated thereby within said heating zone.

2. In an electric furnace, a housing, a plurality of terminals projecting into said housing in spaced-apart relation, each of said terminals having a segment member joined thereto that includes a pair of interfitting arcuate shaped segment bars, a flexible non-metallic resistance heating element secured between the pairs of interfitting segment bars of each segment member and being freely suspended therefrom, said heating elements defining a heating zone therebetween, a circular conductor assembly fixed to the lowermost ends of said flexible heating elements and being suspended therewith from said segment bars, means located in said housing and surrounding said flexible heating elements for insulating said heating elements, and means in said housing for supporting a work piece in said heating zone for the heat treatment thereof.

3. In an electric furnace as set forth in claim 2, each of said segment members including a pair of interfitting arcuate shaped segment elements, one of said segment elements of each segment member being formed with an opening through which a threaded end of a terminal extends, and the other of said segment elements being formed with a threaded opening for threadably receiving the threaded end of said terminals, the segment member having a pair of segment elements and being locked therebetween by the terminal that joins said pair of segment elements.

4. In an electric furnace as set forth in claim 3, said circular conductor assembly including a pair of concentric interfitting rings between which said flexible heating elements are fixed.

5. In an electric furnace, a housing, means for conducting electrical current into said housing, a plurality of flexible non-metallic resistance heating elements disposed in said housing and suspended from said current conducting means, means for locking said flexible resistance heating elements to said current conducting means so as to define a heating zone between said heating elements, and means interconnecting the lower ends of said flexible heating elements and defining a conductor element therefrom, said conducting means including a plurality of segment members, each of which includes a first segment element having a central longitudinally extending groove formed therein that defines spaced marginal contact surfaces, and a second segment element adapted to be interlocked to said first segment element and including a central longitudinally extending projection that is shaped and proportioned for interfitting in said groove.
6. In an electric furnace, a housing, means for conducting electrical current into said housing, a plurality of flexible non-metallic resistance heating elements disposed in said housing and suspended from said current conducting means, means for locking said flexible resistance heating elements to said current conducting means so as to define a heating zone between said heating elements, and means interconnecting the lower ends of said flexible heating elements and defining a conductor element therefor, said interconnecting means including a pair of interfitting rings between which the lower ends of said flexible heating elements are interlocked, the outer peripheral surface of the smaller of said rings being tapered, the inner peripheral surface of the larger of said rings being formed with a central groove to define opposed projecting portions that are tapered, the projecting portions and said tapered surface cooperating to interlock the lower ends of said flexible heating elements therebetween.

7. In a vacuum type electric furnace, a housing, a plurality of flexible non-metallic resistance heating elements located in said housing, means for mounting said heating elements within said housing so as to provide for uniform resistance throughout said elements, said mounting means including a plurality of terminals that project into said housing in spaced-apart relation and a plurality of segment members, each of which is joined to a terminal, each segment member including a pair of interengaging segment elements between which one of said heating elements is secured in suspended relation, one segment element of each segment member having a groove formed therein that defines adjacent surfaces, said adjacent surfaces being located in opposed relation to surfaces that are formed on the other segment element and cooperating therewith to secure a heating element therebetween, the opposed surfaces of each pair of interengaging segment elements defining unit contact pressure points on the heating element secured therebetween, wherein proper electrical communication between each terminal and its associated heating element is provided, so as to produce the uniform resistance throughout each heating element, a conductor assembly joined to said heating elements at the lower ends thereof, and means for supporting a work piece in said housing.

8. In an electric furnace, a housing, a plurality of flexible non-metallic resistance heating elements located in said housing, means for mounting said heating elements within said housing so as to provide for uniform resistance throughout said elements, said mounting means including a plurality of terminals that project into said housing in spaced-apart relation and a segment member joined to each terminal within said housing, each segment member including a pair of interengaging segment elements, a flexible heating element secured between each pair of interengaging segment elements and being freely suspended therefrom, each segment element of a segment member having adjacent surfaces formed thereon, the adjacent surfaces being located in opposed relation to surfaces formed on the other segment element and cooperating therewith to define unit contact pressure points on the heating element secured therebetween, thereby providing for proper electrical communication between each terminal and the associated heating element, a conductor assembly joined to said heating elements at the lower ends thereof, and means for supporting a work piece in said housing.

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