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RADIANT HEATER HAVING FORMED FILAMENTS

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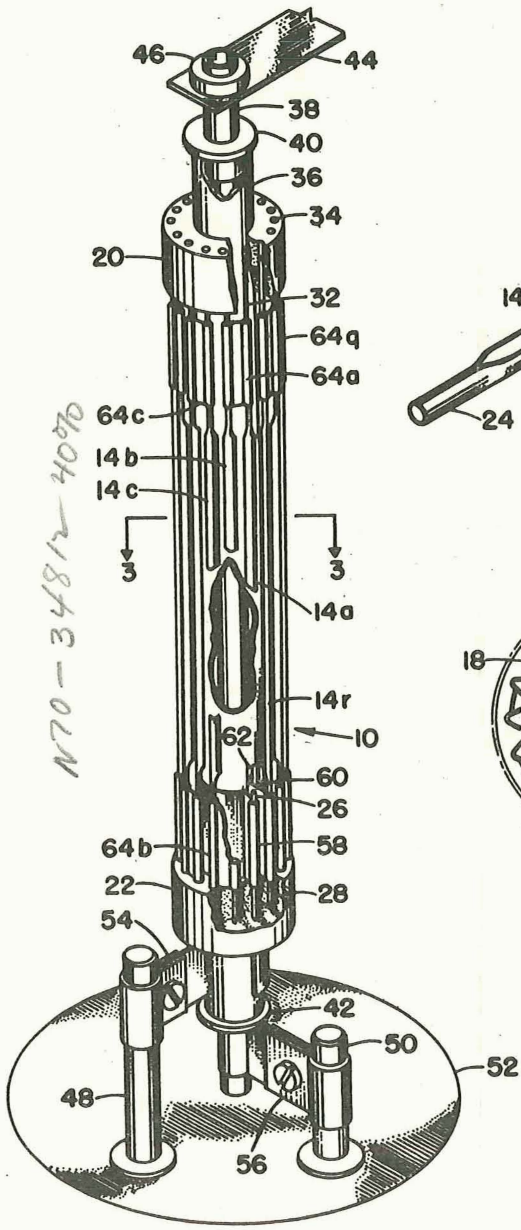

FIG. 1

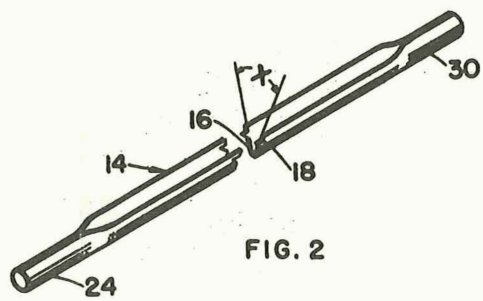

FIG. 2

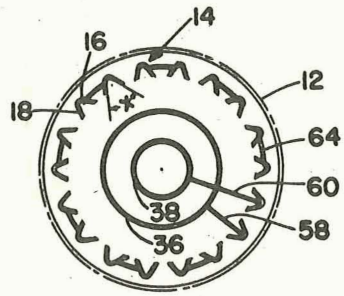

FIG. 3

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RADIANT HEATER HAVING FORMED FILAMENTS

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The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention is concerned with a high-temperature heating device, and more particularly, with a refractory metal radiant heater suitable for operation in a vacuum. The heater of the present invention uses moderate currents and voltages from an alternating current source or a direct current source.

High temperatures in the range between 2200° K. and 2800° K. have been attained over surfaces of several hundred square centimeters using either resistance or high frequency induction heating. Radiant heating with refractory metal resistance elements, such as molybdenum or tungsten wire or ribbon, has been proposed for use in small scale high-vacuum applications such as thermionic devices. To increase the scale to the kilowatt range, however, it is necessary to bring the resistive elements into intimate contact with refractory supports. Because of the resulting gaseous products at high temperatures, this type of heating has not been satisfactory for many vacuum applications.

Some resistance heaters are constructed of refractory metal tubes appropriately slotted to lengthen the electrical path. Such heaters have very low electrical impedance and, therefore, require as much as several thousand amperes to operate at the kilowatt level. Also, the high current demand of resistance and induction heaters requires bulky water-cooled leads and expensive power supplies.

To eliminate the need for cumbersome equipment and to facilitate the construction of appropriate vacuum enclosures, it has been proposed to use high impedance radiant heaters which have applications in a wide range of activity from metallurgical to thermionic studies. With the imposition of the criteria that such devices be self-supporting in the hot zone and that they have small cross-sectioned elements, certain structural problems are posed where large areas are to be heated. Because in many research areas it is desirable to operate heaters with direct current to avoid alternating current pickup in objects being studied, high impedance devices are needed to reduce current demand at kilowatt inputs to values below one hundred amperes.

It is, therefore, an object of the present invention to provide an improved high-temperature heater element for electronic devices and vacuum furnaces which has a low current demand together with a minimum amount of distortion and temperature sag.

Another object of the invention is to provide an improved radiant heater for electronic devices, such as plasma diode thermionic convertors, which may be useful in a variety of high temperature vacuum devices having a large radiation area.

A further object of the invention is to provide a high-temperature heating device which cancels its induced magnetic field and eliminates heavy leads, supports, and accompanying cooling requirements.

A still further object of the invention is to provide a self-supporting high temperature heater in which all ceramic and other high vapor pressure components are maintained outside the hot zone.

Other objects and advantages of the invention will become apparent from the specification which follows and from the drawing in which like numerals are used throughout to identify like parts.

In the drawing:

FIG. 1 is a perspective view with parts broken away of a heating device constructed in accordance with the invention;

FIG. 2 is an enlarged perspective view showing the detailed construction of a typical filament utilized in the heating device illustrated in FIG. 1; and

FIG. 3 is an enlarged sectional view taken along the line 3—3 in FIG. 1.

In order to achieve the aforementioned objects, there is provided a high-temperature heating device for use in a vacuum which has a plurality of refractory metal strips for forming parallel filaments that are arranged in a generally circular array. Each of the filaments is curved about its major centerline to a dihedral angle for structural stability, and the strips are connected to form a series circuit by connecting opposite ends of each of the strips to alternately adjacent strips to effect magnetic flux cancellation as an electric current is passed through the circuit.

Referring now to the drawing, there is shown in FIG. 1 a heating device **10** constructed in accordance with the present invention which is utilized to heat a thermionic device, such as tubular cathode **12** shown in FIG. 3. This thermionic device may also be an anode. The heating device **10** utilizes a plurality of formed filaments **14** of a refractory metal, such as tantalum, tungsten, or molybdenum. As best seen in FIGS. 2 and 3, each of the formed filaments **14** comprises an elongated strip that is transversely curved about its major centerline to a dihedral angle so that each filament has a pair of angularly disposed surfaces **16** and **18** extending longitudinally along opposite sides of the centerline. Very good results have been obtained when the angle X is approximately 60° because the heat emitted from the surfaces **16** and **18** is directed outward toward the cathode **12** and the filaments **14** are self-supporting in the hottest portions of the heater **10**.

The filaments **14** are arranged in a generally circular array of a pair of annular spacing members in the form of rings **20** and **22** of a ceramic material, such as magnesium silicate or alumina. As best seen in FIG. 3, the vertices of the dihedral angles may be considered to represent regularly spaced elements on an imaginary cylinder containing the heater. This is accomplished by crimping the extreme lower portion **24** of each filament **14** as shown in FIG. 2 about a bottom support rod **26** which protrudes upwardly from a blind hole **28** in the ring **22** as shown in FIG. 1 and crimping the extreme upper portion **30** about a top support rod **32** that is received in a through hole **34** in the ring **20**. The holes **28** and **34** are slightly larger than the support rods **26** and **32**, respectively, to provide optimum clearance for unrestricted expansion and contraction of the support rods. The heater **10** can expand uniformly as a unit, and in the process the upper ring **20** slides loosely along a tube **36** which it encircles. An important feature of the invention is that both of the rings **20** and **22** which support the filaments **14** are located outside the central hot zone of the heater **10**.

The tube **36** extends along the central portion of the circular array of filaments **14** and through the rings **20** and **22** as shown in FIG. 1. The tube **36** is of an electrically conducting refractory metal, such as tantalum, tungsten, or molybdenum, and this tube serves not only as a heat reflector, but also as an electrical lead.

A hollow cylinder **38** which is likewise of an electrically conducting refractory metal has an outer diameter substantially smaller than the inner diameter of the tube 36 as shown in FIG. 3, and the cylinder 38 extends through the tube 36. The elongated cylinder 38 is maintained out of electrical contact with the tubular conductor 36 by a pair of ceramic insulators 40 and 42 as shown in FIG. 1. The elongated cylinder 38 forms a basic support for the heater 10 and is rigidly secured to a cantilever support 44 with an insulating member 46. The cantilever support 44 is rigidly mounted in a conventional manner in the system, and the mounting of this member forms no part of the present invention.

Power is supplied to the tubular conductors 36 and 38 from leads 48 and 50, respectively, which extend through a base 52 for the heater 10. The lead 48 is connected to the tubular conductor 36 by an electrically conducting bracket 54 that is secured to this conductor immediately below the ring 22 as shown in FIG. 1. Likewise, a similar bracket 56 is connected to the mating cylindrical conductor 38 immediately below the insulator 42.

The tubular conductor 36 is placed in electrical contact with one of the formed filaments 14 by an electrically conducting bar 58 as shown in FIGS. 1 and 3. Likewise, an adjacent filament 14 is placed in electrical communication with the inner cylindrical conductor 38 by a similar bar 60 which extends through a slot 62 in the tubular conductor 36.

A series circuit is formed between the bars 58 and 60 by electrically connecting opposite ends of each of the filaments 14 to alternately adjacent filaments with connectors 64 so that the current in adjacent filaments is flowing in opposite directions to effect a magnetic flux cancellation. More particularly, the current flows from the lead 48 through the bracket 54 to the tubular conductor 36, whereupon it flows to the filament *14a* through the bar 58. The current flows upward through the filament *14a* to the connector *64a*, then downward through the filament *14b* to the connector *64b*, and upward through the filament *14c* to connector *64c*. The circuit continues in this manner until the current flows through connector *64q* to the filament *14r* and then to the cylindrical conductor 38 through the bar 60, where it passes to the lead 50 through the bracket 56. A feature of the invention is that tight fits between the above-mentioned parts are not required because imperfect electrical contact is immediately remedied by self-welding caused by hot spots arising upon the application of the current.

A typical heater 10 having a length of six inches and a diameter of one inch was constructed in accordance with the invention. Each filament 14 was formed from a strip of tantalum four inches long, 3/16 inches wide, and ten mills thick, and this strip was bent about its major centerline to a dihedral angle of sixty degrees. At the strip ends, ½ inch segments 24 and 30 were made tubular to provide a snug fit over forty mill diameter support rods 26 and 32. The conductors 36 and 38 consisted of two coaxial tubes having a thickness of ten mills. The outer tube 36 had a ½ inch outside diameter and the inside tube 38 had a ¼ inch outside diameter.

This heater was operated under an average pressure of 5×10^{-5} mm. Hg at various temperatures above 2000° K. on a current of fifty-six amperes from a twenty kva. autotransformer. It is contemplated that a seventy-five volt generator would be adequate for a direct current operation. The flux density was measured at a ⅛ inch radial distance from the aforementioned imaginary cylinder and was found to be two gauss at approximately fifty amperes as compared to a reference of seventeen gauss along a straight wire.

While the preferred embodiment of the invention has been illustrated and described, it is contemplated that various structural modifications may be made without departing from the spirit of the invention or the scope of the subjoined claims. For example, an alternate mode of operation is contemplated which consists of applying a sufficiently high potential to the member 12 that is being heated so as to induce electron bombardment.

What is claimed is:

1. A high temperature heating device comprising
   a plurality of transversely curved strips of refractory metal for forming elongated filaments to conduct an electric current,
   a pair of annular members for supporting said strips parallel to one another in a generally circular array,
   a first spaced supports carried by one of said annular members,
   second spaced supports carried by the other of said annular members,
   means for securing one of said first supports to each of said strips at one end thereof,
   means for securing one of said second supports to the opposite end of said strip,
   a tubular conductor extending along the central portion of said circular array through said annular members to form a heat reflector,
   an elongated conductor extending through said tubular conductor,
   means for insulating said elongated conductor from said tubular conductor,
   means for supporting said elongated conductor in a substantially rigid position,
   means for supplying electric power to said conductors, and means for connecting said strips to said conductors in series.

2. A high temperature heating device as in claim 1, including spaced ceramic annular members having holes for receiving said first and second spaced supports, each of said holes having an inside diameter greater than the outside diameter of its corresponding support.

3. A high temperature heating device as in claim 2, including spaced magnesium silicate members for receiving said supports, said members being located on opposite sides of a centrally disposed hot zone in said heating device.

4. A high temperature heating device as in claim 2, including spaced alumina members for receiving said supports, said members being located on opposite sides of a centrally disposed hot zone in said heating device.

5. A high temperature heating device as in claim 1, wherein one of said annular members is located above the other annular member, and said curved strips extend vertically between said members.

References Cited in the file of this patent

UNITED STATES PATENTS

1,954,203	Gurtler	Apr. 10, 1934
2,057,931	Stupakoff	Oct. 20, 1936
2,553,875	Shaw	May 22, 1951
2,596,327	Cox et al.	May 13, 1952
2,662,990	Kohl	Dec. 15, 1953
2,727,177	Dailey et al.	Dec. 13, 1955
2,747,074	Finch	May 22, 1956
2,748,310	Agule	May 29, 1956