July 26, 1966 C. A. S. HILL 3,263,015

HEATING ELEMENTS FOR HIGH VACUUM FURNACES

Filed Nov. 7, 1963

FIG. 1

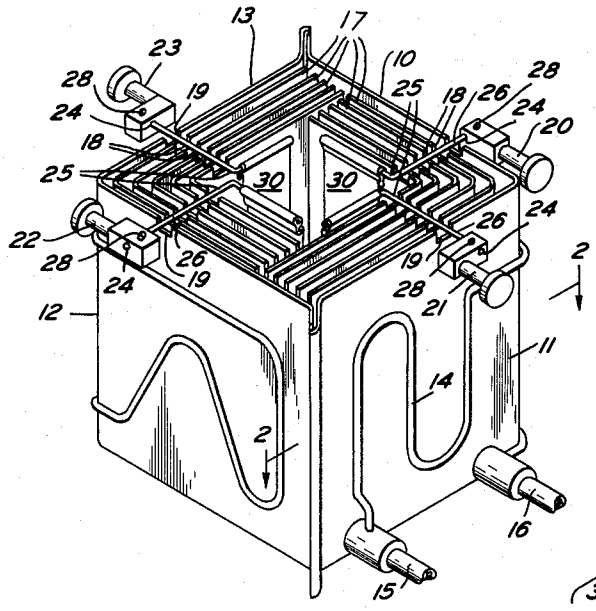


FIG. 5

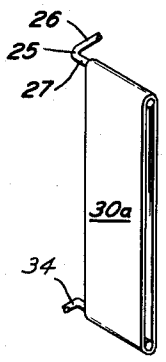


FIG. 3

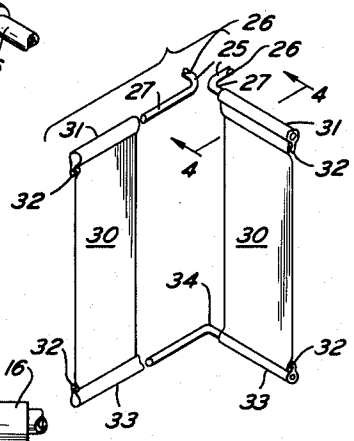


FIG. 2

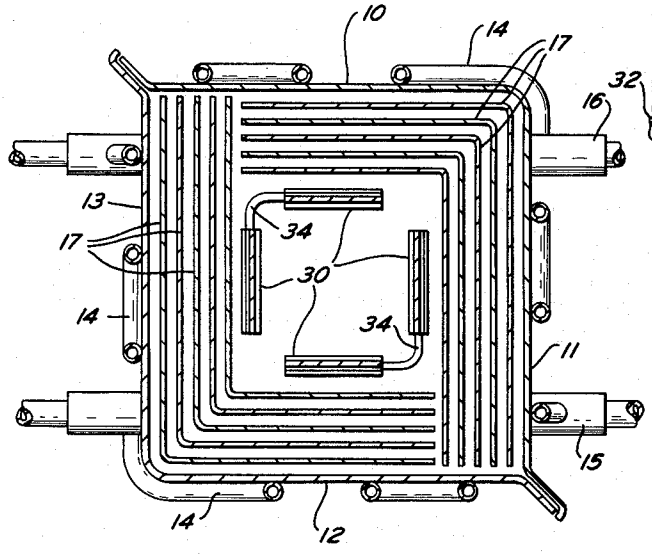
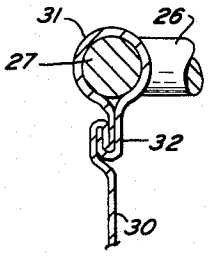


FIG. 4



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HEATING ELEMENTS FOR HIGH VACUUM FURNACES

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This invention relates to resistance heating elements for high vacuum furnaces.

The necessity for heating and melting high temperature refractory metals, and specifically zirconium, columbium, tantalum, molybdenum, tungsten, titanium, rhenium, and alloys thereof, which require heating in a vacuum not only for degassing the metal but to prevent undesired reaction, requires the use of vacuum furnaces.

Serious temperature limitations have been imposed by actual operating conditions on most of the heating elements heretofore available.

In my prior application Serial No. 202,616, filed June 14, 1962, now Patent No. 3,155,758, there is shown an improved heating element with which higher furnace operating temperatures are made available than heretofore. The heating element there shown has limitations, particularly in that it is not as well suited as is desired for electrode materials which are difficult to weld.

The heating element of the present invention has added advantages over those heretofore available.

It is the principal object of the present invention to provide a resistance heating element for vacuum furnaces which is of simple construction and which will permit attaining higher temperatures than heretofore, which will have a longer useful life and which will be free from other difficulties heretofore encountered in this field.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces, which accommodates the elevated temperatures with negligible distortion, which has an improved uniform current input distribution for energization, and which has other improved qualities in use.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces which is simple in construction, sturdy, and free from difficulties in use.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces which permits the use, in an effective manner, of materials which are difficult to weld.

It is a further object of the present invention to provide an improved heating element for vacuum furnaces which is freely suspended so as to permit rapid replacement or interchange of heating elements.

It is a further object of the present invention to provide resistance heating elements for vacuum furnaces which can be readily interchanged so as to substitute one kind of resistance material for another thereby increasing the versatility of the furnace.

It is a further object of the present invention to provide an improved heating element for vacuum furnaces which permits of the use of a wide range of thickness of heating element, including very thin elements, with reduction of power cost and cost of furnace components.

It is a further object of the present invention to provide an improved mounting for heating elements of vacuum furnaces which is exceedingly simple and avoids the necessity for welding or fusion joining of margins of the element.

It is a further object of the present invention to provide an improved heating element for vacuum furnaces in which the length of the element can be selected to match the power supply with elements of different resistivity.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces which is supported in a manner which decreases the likelihood of failure.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces which is supported in a pendant relation in an improved manner.

It is a further object of the present invention to provide a resistance heating element for vacuum furnaces which can be used in furnaces for tension testing at high temperatures and for other purposes.

Other objects and advantageous features of the invention will be apparent from the description and claims.

The nature and characteristic features of the invention will be more readily understood from the following description taken in connection with the accompanying drawings forming part thereof, in which:

FIGURE 1 is a view in perspective of a portion of a vacuum furnace having the heating element of the invention mounted therein;

FIG. 2 is a horizontal sectional view taken approximately on the line **2—2** of FIG. 1;

FIG. 3 is a fragmentary perspective view of the heating element partially assembled;

FIG. 4 is an enlarged fragmentary sectional view taken approximately on the line **4—4** of FIG. 3; and

FIG. 5 is a fragmentary perspective view of a modified form a free suspended heating element in accordance with the invention.

It should, of course, be understood that the description and drawings herein are illustrative merely and that various modifications and changes can be made in the structure disclosed without departing from the spirit of the invention.

Like numerals refer to like parts throughout the several views.

Referring now more particularly to FIGS. 1 to 4 of the drawings, the furnace and its vacuum equipment have been omitted and only the heating element and its associated structure are illustrated. As there shown, an outer water cooled heat sink is provided which comprises opposite pairs of vertical metallic side walls **10**, **11**, **12** and **13**, preferably in connected contiguous pairs for outward swinging so that access can be had to the interior. The walls **10**, **11**, **12** and **13** can be supported in any desired outer furnace enclosure (not shown) and preferably have liquid cooling pipes **14** mounted thereon with cooling liquid supply and delivery pipes **15** and **16**.

Within the interior of the pairs of walls **10**, **11**, **12** and **13**, spaced metallic shields **17** can be provided having notches **18** at their upper margins aligned with corresponding notches **19** in the side walls **10**, **11**, **12** and **13**.

Electrodes **20**, **21**, **22** and **23** are provided, are supported in any desired manner, are preferably liquid cooled, and have sockets **24** for the reception of horizontal heating element mounting rods **25**. The mounting rods **25** are of L-shape with holding arm portions **26** and inner element supporting arm portions **27**. The holding arm portions **26** of the rods **25** can be clamped at their outer ends in the electrodes **20**, **21**, **22** and **23**, respectively, and held in any desired manner, such as by set screws **28**. The holding arm portions **26** extend inwardly through the notches **19** and **18**, and the arm portions **27**, preferably disposed in the same horizontal plane with the portions **26** and with each other, have the heating elements **30** freely pendant therefrom.

The rods **25** can be of any desired electric conductive material capable of functioning at the elevated temperatures in the furnace, and can be of the same metal as the heating elements **30** or of different metals.

The heating elements **30** can be of nickel, molybdenum, columbium, tantalum, tungsten, tantalum-tungsten alloys such as 90% tantalum and 10% tungsten, tungsten-rhenium alloys, rhenium, osmium, iridium, or alloys including binary or ternary alloys of these metals, it is also intended for some purposes to employ conductive nonmetals, so long as these have the desired temperature resistant qualities in use and the desired resistivity.

The heating elements **30** are preferably of material in sheet form, and of the desired thickness in accordance with the heating qualities desired. For example, sheet metal of thickness down to about one half a thousandth of an inch may be employed.

The use of relatively thin sheet material permits of using less power for heating as well as lesser qualities of high cost per pound material for the heating elements.

The heating elements **30** are supported by the arm portions **27** and in pendant relation thereto and at their upper ends, as shown in detail in FIG. 4, can have elongated cylindrical sections **31** with seams **32** therealong, such as are employed on sheet metal containers, to retain the cylindrical sections **31** at elevated temperatures.

The heating elements **30**, at the bottoms thereof, can have similar cylindrical sections **33** for the reception of L-shaped horizontally disposed connector rods **34** of any suitable material, and preferably the same as that employed for the rods **25**.

In the form of the invention shown in FIG. 5, the heating elements **30***a* are shown as sleeves, pendant from the rod portions **27**, and with the connector rods **34** supported thereby as before.

In use, the electrodes **20** and **21** can be connected in one phase of the source of electric energy and the electrodes **22** and **23** can be connected to the same phase or to another phase.

The electric energy supplied through the pairs of electrodes **20**, **21**, **22**, and **23**, and through the rods **25**, and by the connection through the rods **34** is effective for resistance heating of the heating elements **30** or **30***a* the heating action being available in the space enclosed by the elements **30** or **30***a*.

As the heating of the heating elements **30** or **30***a* occurs, with expansion due to temperature increase, the heating elements **30** or **30***a* are relatively free from restraint, horizontally considered, and likewise are free from vertical restraint.

The manner of suspension of the heating elements **30** and **30***a* on the rods **25** and with the lower connector rods **34** loosely mounted therein permits of quick interchange of heating elements so that a heating element of one composition can be substituted for that of another composition, or cross section, with the substituted element, if of different resistivity, of a length to match the power supply, if desired.

Operating temperatures up to 3000° C. can be accomplished by selection of suitable length of the heating element. The direct heat transfer from the heating elements **30** and **30***a* to the rods **25** is reduced because of the small cross sectional area of the rods **25** for heat transfer.

The construction of heating elements heretofore described have a uniformity of current distribution with improved resistance heating action. Further, by reason of the uniformity of heating, they have a substantially uniform temperature profile. Freedom from distortion both upon heating and cooling is accordingly attained.

I claim:

1. A resistance heating device for vacuum furnaces comprising

electrodes,

a matched pair of upper horizontal supporting rods respectively connected to said electrodes,

a matched pair of resistance heating elements in sheet form extending downwardly from said upper supporting rods,

a common lower horizontal connecting rod engaging the lower ends of said pair of elements,

said elements each having a curved upper end portion and a curved lower end portion extending respectively around the upper and lower rods.

2. A resistance heating device as defined in claim **1** in which said heating elements are freely slidable along said upper rods for insertion and removal thereof.

3. A resistance heating device as defined in claim **2** in which said lower connecting rod is freely slidable along the lower ends of said elements.

4. A resistance heating device as defined in claim **1** in which said curved end portion is a cylindrical sleeve.

5. A resistance heating device as defined in claim **1** in which the heating elements are each sleeve shaped.

6. A resistance heating device as defined in claim **1** in which

said upper and lower end portions are cylindrical, and

said heating elements each has a central section of a single thickness of material with seams at the top and bottom thereof connecting said central section with said upper and lower end portions.

7. A resistance heating device for vacuum furnaces comprising

a plurality of electrodes,

a plurality of matched pairs of upper horizontal supporting rods respectively connected to said electrodes,

matched pairs of resistance heating elements for each of said pairs of supporting rods,

said heating elements being in sheet form and extending downwardly from said upper supporting rods,

said heating elements each having a curved upper and a curved lower end portion and said upper end portions being in slidable engagement with said supporting rod,

a common lower horizontal connecting rod of L-shape for each matched pair of heating elements engaging the lower ends of said pair of elements,

said connecting rods being in slidable engagement with said lower ends.

8. A resistance heating device as defined in claim **7** in which

said heating elements each has a central section of a single thickness of material with seams at the top and bottom thereof connecting said central section with said upper and lower end portions.

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