Oct. 9, 1962 C. A. S. HILL 3,057,936

ELECTRICAL HEATING DEVICE

Filed May 13, 1959 2 Sheets-Sheet 1

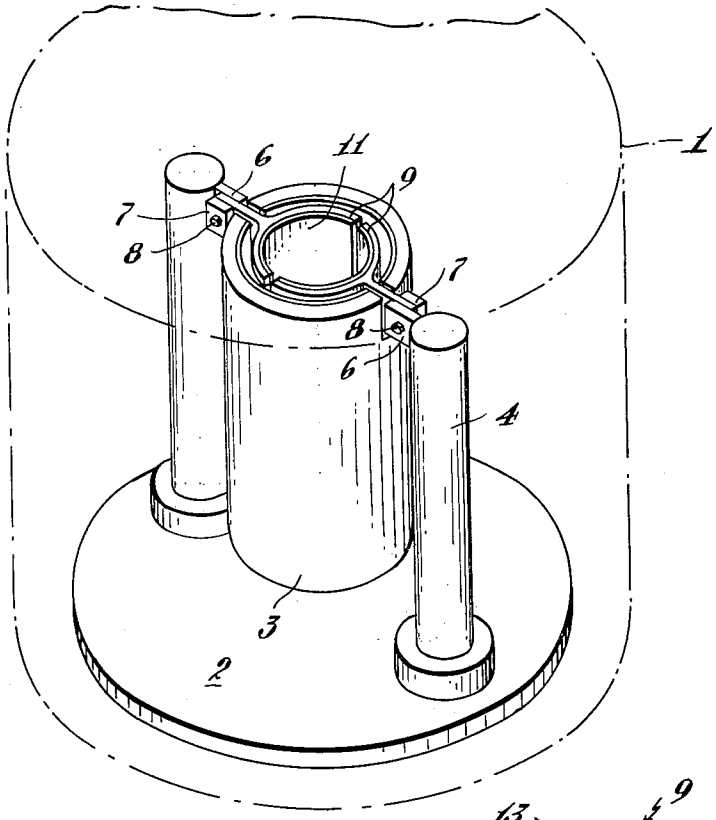


Fig. 1

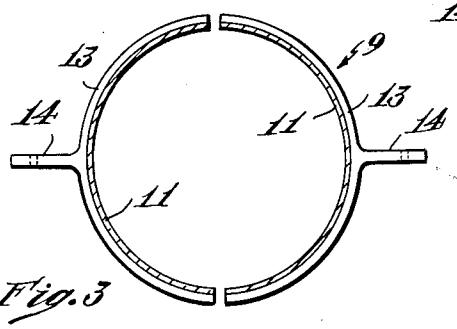


Fig. 3

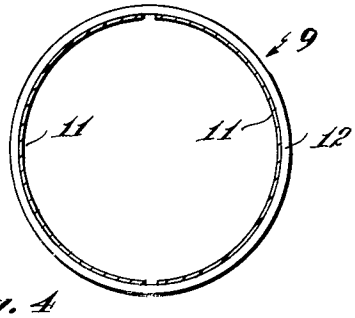


Fig. 4

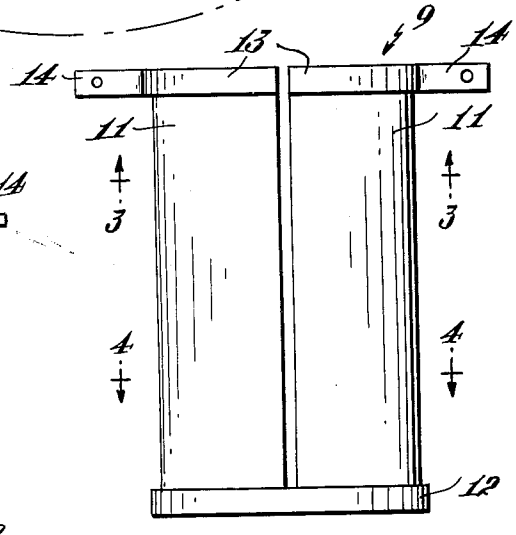


Fig. 2

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Oct. 9, 1962 C. A. S. HILL 3,057,936

ELECTRICAL HEATING DEVICE

Filed May 13, 1959 2 Sheets-Sheet 2

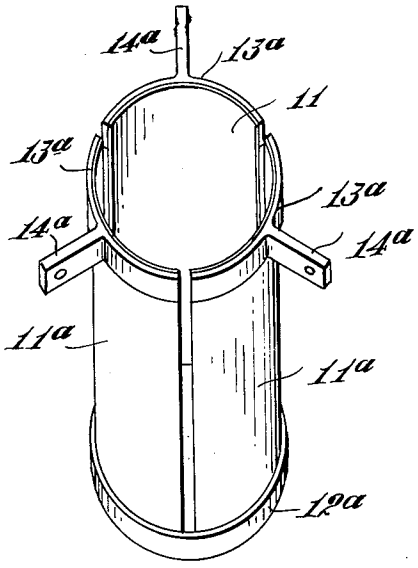


Fig. 5

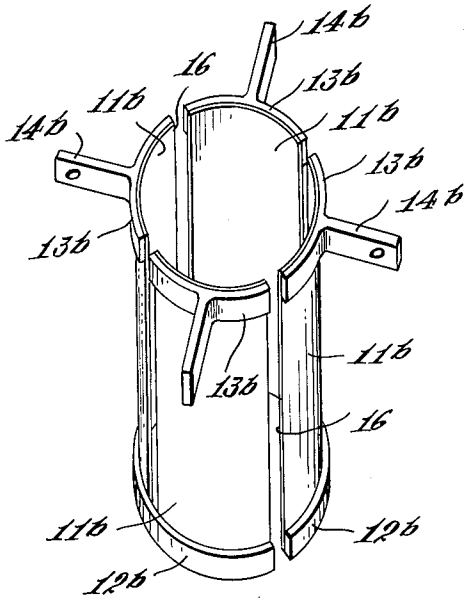


Fig. 6

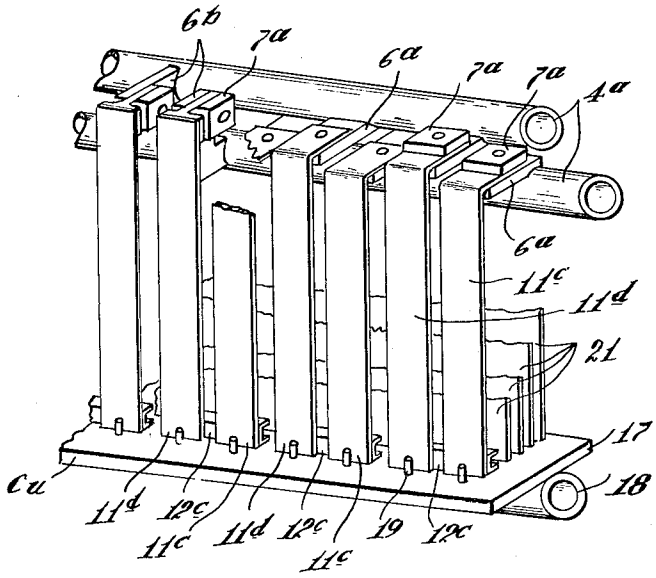


Fig. 7

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ELECTRICAL HEATING DEVICE

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1 Claim. (Cl. 13—25)

This invention relates to electrical resistance heating elements and particularly high temperature elements such as those operated at 1000° to 3000° C. in vacuum furnaces.

In such a high temperature furnace, it has been customary to clamp a length of curved or straight metal sheet between two terminals, current then being supplied to the sheet through the terminals. When such elements carry current in the order of several hundred kilowatts the desired high temperatures are produced. Such elements, however, expand under the high temperatures and at the same time soften so that the expansion stresses cause the element to sag and distort, and within a short time become so cracked or distorted as to destroy their efficiency and usefulness.

Accordingly, it is an object of the present invention to provide a heating element or device which compensates for expansion stresses of prior arrangements, which is capable of enduring higher temperatures over a markedly longer useful life, and which operates with a great increase in thermal efficiency.

According to the invention, a heating element comprises at least two members of resistance heating sheet material, each member having vertical edges, conductive support means connected to the upper end of each member, and means electrically connecting the lower ends of respective members, said connection holding said vertical edges spaced apart and bridging the space between the lower ends of respective vertical edges, whereby when said members are suspended by said electrodes they may soften and elongate without substantial distortion when heated by electrical current supplied through said support means.

The element may be disposed with two or more component members enclosing a hot zone or extending along one side of the zone.

For the purpose of illustration, typical embodiments of the invention are shown in the accompanying drawings in which:

FIG. 1 is an isometric view of a furnace employing one form of heating element;

FIG. 2 is an elevation of the heating element in FIG. 1;

FIG. 3 is a section on line 3—3 of FIG. 2;

FIG. 4 is a section on line 4—4 of FIG. 2; and

FIGS. 5 to 7 are isometric views of other related forms of heating elements.

As shown in FIG. 1, a high temperature furnace comprises a housing 1 indicated generally by broken lines. Within the housing is a base 2 on which is mounted heating apparatus including a water-cooled jacket or shell 3 and a pair of electrical terminal posts 4, also water-cooled. Water is supplied through the base 2 to the jacket 3 and posts 4 in a manner not essential to description of the present invention. On the terminal posts 4 are welded lugs 6 to which clamping blocks 7 are secured by bolts 8.

The new form of heating element 9 shown in FIGS. 1 to 4 is adapted to be clamped to the terminal lugs 6. The element comprises two semi-tubular sheets 11 of refractory metal approximately 0.005 inch thick. Tantalum, molybdenum, tungsten and niobium are particularly well suited for resistance heating at various high temperatures in the range of 1000° to 3000° C. without melting. These heating element metals are generally used only when the housing in FIGURE 1 is evacuated to a high vacuum. It is possible for some of these metals to be heated in inert gases as well as in high vacuum. At the bottom edge of the two half-tube sheets, a ring 12 of like refractory metal is welded to the sheets so as to hold the vertical edges of the tubes spaced apart. By way of example only, if the sheets are six inches long, and curved on a 1½ inch radius, the ring may be ⅜ of an inch wide and 0.10 inch in thickness. The spacing of the vertical edges may be ⅛ of an inch.

To the top of each half-tube sheet is welded a semicircular strap 13 having an integral ear 14 perforated to receive the clamping bolt 8. Typically the strap is ½ inch in width and 0.10 inch in thickness.

In use, the ears 14 of the element are clamped to the lugs of the terminal posts so that the sheets are suspended within the jacket 3. The screws 8 pass through the ears and secure the blocks 7 tightly to make good electrical contact between the ears and the lugs 6, and so as to rigidly and positively position the straps in a horizontal position without placing any stress on the sheets 11. The terminal posts 4 are of sufficient height to hold the lower end of the sheets far enough above the base 2 that upon expansion, they will not come in contact with the base. The supporting straps 13 are thick and rigid compared to the sheets so that even if the sheets are heated to softening point they will only elongate and will not be subject to mechanical stress which would warp, compress, buckle or wrinkle them.

It is possible to suspend the sheets by the straps and still provide an electrical path through the sheets because the bottom ring 12 electrically connects the lower ends of the sheets. Furthermore, the bottom ring 12 is quite rigid relative to the sheets even at high operating temperatures. The ring, cooperating with the upper supports, holds the edges of the sheets spaced apart and parallel while permitting them to elongate when heated.

Thus when current is supplied through the terminal posts 4, it is conducted by one supporting strap to the supported sheet, thence down through substantially the whole of the sheet, across the connecting ring and up the other sheet to its supporting strap. By resistance heating, the sheets raise the cylindrical zone inside them to a temperature dependent on the current supplied. The element whose dimensions are specified by way of example above, i.e., enclosing a zone 3 inches in diameter and 6 inches long, can heat the zone as high as 2700° C., and can operate over a long period at 2200° C. with a marked reduction in power and distortion as compared with previously known elements.

The same structural features and advantages are present in elements having three or more resistive sheets or panels. For example, in FIG. 5 are shown three refractory sheets 11*a* having their vertical edges spaced, as previously explained, by rigid supporting straps 13*a* and a bottom ring 12*a*. The ears 14*a* of the respective straps 13*a* are clamped to three terminal posts to which three-phase alternating current is supplied.

The heating element of FIG. 6 comprises four sheets or panels 11*b* connected in pairs by half rings 12*b*. Each panel is supported by a strap 13*b* having an ear 14*b*. The ears are adapted to be clamped in terminal posts which are mounted in pairs movable relative to each other. Each pair of sheets and its connecting half ring is electrically and mechanically separated from the other pair at vertical edges 16, so that the pairs of sheets may be moved apart horizontally, for example, when it is desired to cool the hot zone quickly.

In FIG. 7 is shown a planar arrayed heating element formed according to the invention. Such an array may form one side of a rectangular or other polygonal hot zone. Current is supplied through tubular terminals 4*a* to which are welded horizontal lugs 6*a*. Clamping blocks

7a secure the upper ends of refractory sheets or panels 11c and 11d to the lugs 6a. Alternatively, vertical lugs 6b may be provided and T-shaped electrodes 14c welded to the panels may be clamped to the lugs 6b by blocks 7a. Each pair of sheets 11c and 11d is joined at the lower end by a rigid connecting channel which holds the lower ends spaced and electrically connects them.

Spaced below the panels is a guide bar 17 of copper, for example, which is water-cooled by a tube 18. Mounted on the guide bar are guide pins 19, preferably of a refractory metal such as tungsten, which serve to steady the hanging resistance panels 11c and 11d. Although guide pins 19 make contact with the panels, the contact is of very high resistance compared to the electrical path through the panels and connecting channel. Furthermore, the guide bar is electrically isolated from the power supply providing heating current, and since the portions of the panels making contact with the pins are substantially at the same potential, there is little tendency for current loss through the pins. The pins therefore guide the downward and upward movement of the panels during heating and cooling without opposing the movement of or applying stress to the hanging panels.

Behind the heating panels are a series of refractory metal heat shields which reflect heat from the back of the heating panels and provide a stepwise descending heat gradient away from the hot zone in front of the panels. Similar tubular shields are preferably used between the tubular element 9 of FIG. 1 and the cooling shell 3. The tubular terminals 4a, the shields 21 and the guide bar 17 may be supported in position in various ways, so well known in the art as not to require illustration.

With each of the heating elements described above, it is possible to produce very high temperatures, e.g. 2000° to 3000° C. during an operative life as much as

three to four times as long as previous elements. The elements have increased heating efficiency which affords a reduction of power of as much as 40% of that needed to produce comparable heating with prior elements. Buckling wrinkling and similar types of distortion are markedly reduced so that a more uniform heat may be maintained throughout the hot zone.

It should be understood that the foregoing description is for the purpose of illustration only, and that the invention includes all modifications and equivalents falling within the scope of the appended claim.

I claim:

An electrical heating device comprising four or more flat members of resistance heating sheet material, each member having a vertical edge, conductive support means connected to the upper end of each member, at least two terminals at different electrical potentials, alternate support means being connected to one and the other of said terminals, and, for each adjacent pair of members connected to respective terminals, means for electrically connecting the lower ends of said adjacent pair of members, said connecting means holding said vertical edges spaced apart and bridging the space between the lower ends of respective members of a pair with adjacent members of adjacent pairs lying in the same plane, whereby each pair of members may be suspended by said conductive support means and may soften and elongate without distortion and independently of other pairs when heated by electrical current supplied through said support means.

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