ABSTRACT OF THE DISCLOSURE

High-temperature electric furnace includes at least one molybdenum silicide heater element having two mounting terminals and having a glow portion forming a number of sequential meander loops between the terminals, the heater element being mounted in the furnace with the loops suspended from the terminals so as to have the bights of the loops alternately at top and bottom locations, ceramic structure supporting the glow portion between the terminals, and spacer means of molybdenum silicide interposed between the ceramic structure and the glow portion.

My invention relates to high-temperature electric furnaces with heater elements of molybdenum silicide. Such elements consist of molybdenum and silicon in a composition which, as a rule, corresponds fairly accurately as only approximately to the formula MoSi₂ and, in most cases, also contains additions, for example oxidic substances.

Heretofore, such molybdenum silicide heater elements have been given a shape similar to U-, W- and θ- (omega) configurations. It has been found preferable to mount U- and θ-shaped elements in vertically suspended or upright positions within the furnaces, particularly in tubular furnaces, chamber furnaces, hood-type and tunnel-type furnaces, for producing furnace temperatures up to about 1650° C. The U- and θ-shaped elements have also been mounted in prone positions for producing heat in flat-type furnaces. It has been found that virtually only the freely suspended and freely radiating U-shaped molybdenum silicide elements are suitable for producing high temperatures of up to 1650° C. for a sufficiently long useful life in continuous or discontinuous furnace operation, such as for many thousand hours and several hundred on-off switching operations. The reason for the outstanding results of the U-shaped molybdenum silicide heater elements is the fact that, due to their freely radiating installation, they do not enter into any reactions with the furnace ceramic materials. Attempts to operate furnaces discontinuously or at different temperatures, with U-type or W-type heater elements supported on ceramic material have failed. This is because molybdenum silicide heater elements become coated with an SiO₂-containing layer of glass when exposed to an oxidizing atmosphere and will then adhere during operation to the oxidic or silicatic support. As a result, the heater element is subjected to mechanical stresses due to temperature variations, and this results in fissures in the glow portion of the element since the molybdenum silicide heating conductor has a thermal coefficient of expansion different from that of the furnace ceramic.

Such discouraging results of tests and the unfavorable experience gained in practice have caused the furnace builders and users to employ virtually exclusively molybdenum silicide heating conductors of U-type in suspended position, independently of the type of furnace.

Furthermore, despite the excellent high-temperature resistance, burn-off resistance, and relative absence of aging, the use of molybdenum silicide heater elements, so far, has been very limited because the U-shaped elements are relatively expensive, the cost-determining factor being particularly constituted by the heavy terminals of these elements.

It is an object of my invention to minimize or eliminate the above-mentioned difficulties.

To this end and in accordance with my invention, a furnace is equipped with at least one molybdenum silicide heater element whose active glow portion is constituted by a number of sequential meander loops extending between the two terminals, the heater element being mounted in the furnace with the loops suspended from the terminals so that the bights of the loops are alternately located at the top and at the bottom respectively.

According to another feature of my invention, the loops of the multi-loop element are supported by at least one ceramic structure preferably located in one of the top bights or several such bights of the glow portion.

The above-mentioned and further objects, advantages and features of my invention, said features being set forth with particularity in the claims annexed hereto, will be apparent from and will be mentioned in the following with reference to the accompanying drawings in which:

FIG. 1 shows a front view of a multi-loop molybdenum silicide heater element employed according to the invention;

FIG. 2 shows in section an electric furnace equipped with a plurality of U-type heater elements according to the prior art;

FIG. 3 shows a furnace in section equipped with multi-loop heater elements in accordance with the invention;

FIG. 4 shows a fragment of the furnace of FIG. 3 in perspective view.

The heater element of molybdenum silicide shown in FIG. 1 comprises a sequential number of meander loops I between only two terminals T. This heater element may be looked upon as being electrically or thermally equivalent to a multiplicity of U-type heater elements but has only two terminals for all of the loops. This solves the problem of reducing the cost as well as the space requirements posed by the large number of terminals required when an electric furnace is equipped with U-type heater elements.

The two terminals T of the heater element shown in FIG. 1 thus serve for supplying current to a relatively large number of loops rather than for supplying current to but a single loop as is the case with U-shaped elements.

As mentioned, such a multi-loop or meander-type molybdenum silicide heater element is suspended in the furnace 5 with the aid of ceramic supports which are preferably mounted on the furnace wall 4 on which they are readily exchangeable or adjustable. The provision of such supports affords the desired reliability of operation.

To prevent detrimental reaction with the ceramic materials despite the slight size of the engaging area at the individual supporting localities, it has been found preferable to provide at each individual supporting locality between the multi-loop glow portion and the support, an intermediate member or plurality of such intermediate members consisting of a material of the same kind as the glow portion and consequently likewise formed of molybdenum silicide material. Preferably two or more such intermediate members are provided at each individual supporting locality. The intermediate members are especially designed as rollers having a diameter equal to that of the glow portion at the locality of engagement with the roller. This has the result that the particular arcuate loop portion of the heater element is supported at only two or three point-shaped localities by means of material of the same kind so that no reaction with the ceramic material
The advantages of the invention are best apparent from the comparison between the known mounting of U-elements shown in Figs. 2 with a furnace equipped with multiloop elements according to the invention as shown in Fig. 3. The known U-shaped heater elements in Fig. 2 are denoted by 12. One of the multi-loop molybdenum silicide heater elements according to the invention is denoted by 11 in Fig. 3. The ceramic supports are denoted by 2 and the intermediate roller members of MoSi by 3.

The comparative illustrations in Figs. 2 and 3 exhibit essentially the following three advantages of the invention:

1. Depending upon the number of arcuate loops in each individual heater element, one-half up to ½ of the otherwise necessary terminals are eliminated thus greatly reducing the cost.

2. The reduced number of the current supply terminals affords improving the insulation of the furnace roof structure.

3. The uniform distance between the heating sections of the heater elements (Fig. 3) secures a higher degree of temperature constancy in the furnace.

Referring to Figs. 3 and 4, the ceramic supporting structure 2 preferably consists of a bar displaceably slotted into a matching opening 2' of the furnace wall 4 and freely protruding therefrom so that, in the event a bar breaks off, the remaining portion can be shoved forward to again assume the required supporting duty, the rollers 3 on each bar being given an axial length greater than the diameter of the glow portion 1' so that, when the bar 2 with the rollers 3 is shifted into supporting position, the roller seated on the bar remains effective to engage the glow portion.

The invention is especially well suitable for furnaces of relatively large size, for example tunnel furnaces and glass melting furnaces. However, the invention is likewise applicable for furnaces of smaller size, particularly also for transportable furnaces. For example, the multiloop heater elements according to the invention are advantageously applicable in such smaller furnace units as are employed in industrial as well as in laboratory applications.