

May 27, 1958

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2,836,638

ELECTRIC RESISTANCE MELTING FURNACES

Filed May 21, 1956

3 Sheets-Sheet 1

FIG. 1

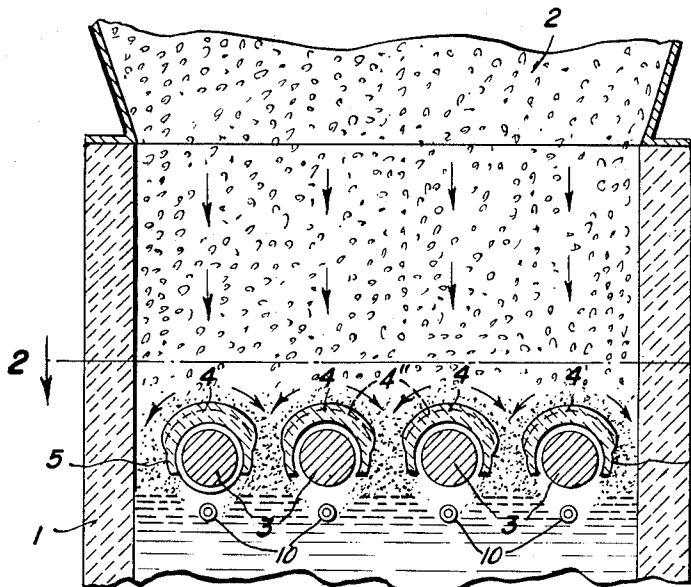


FIG. 3

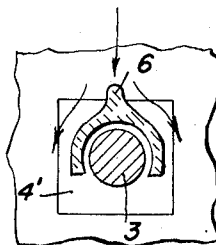


FIG. 4

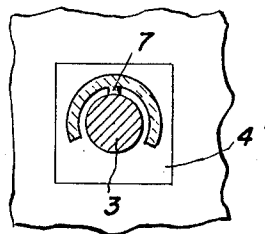


FIG. 2

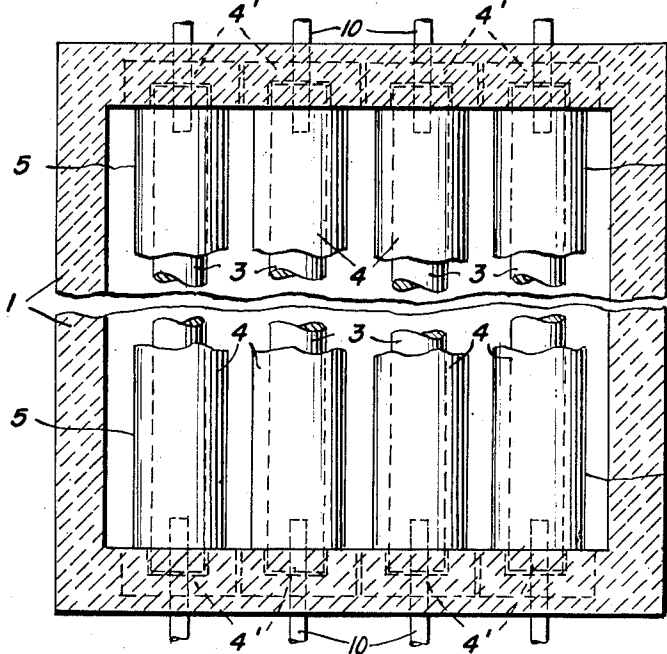
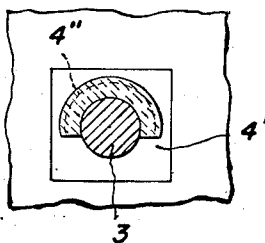


FIG. 5



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FIG. 6

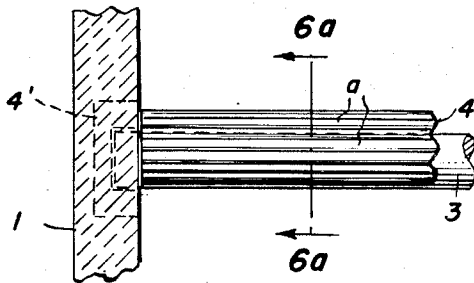


FIG. 6a

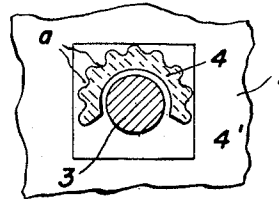


FIG. 7

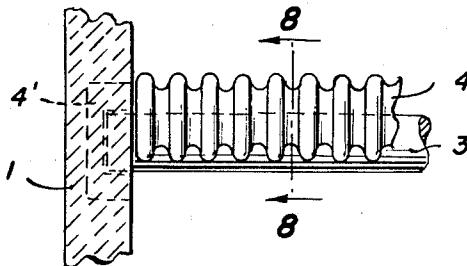


FIG. 8

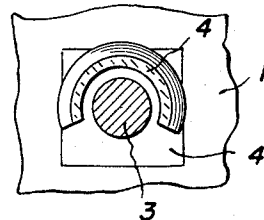


FIG. 9

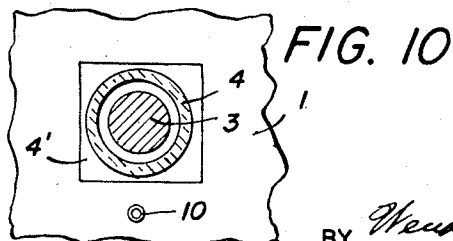
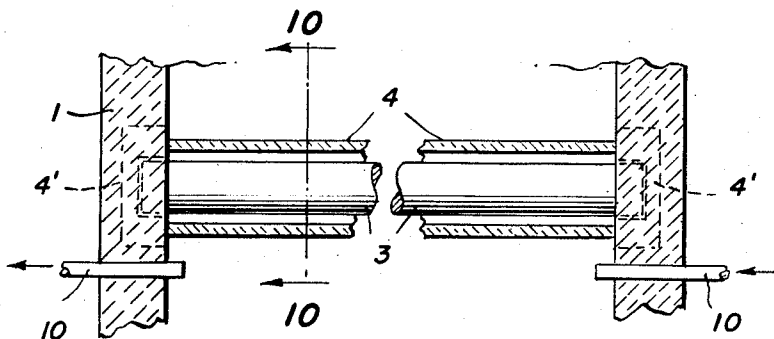


FIG. 10

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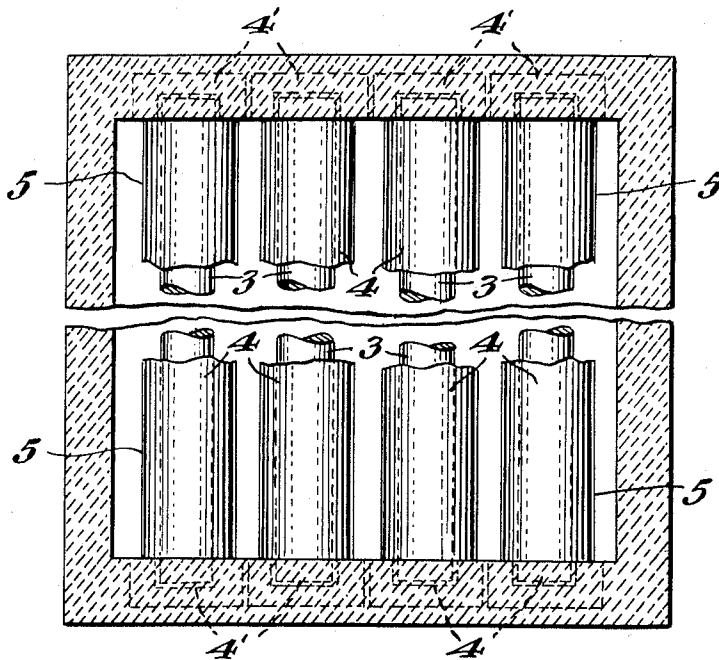
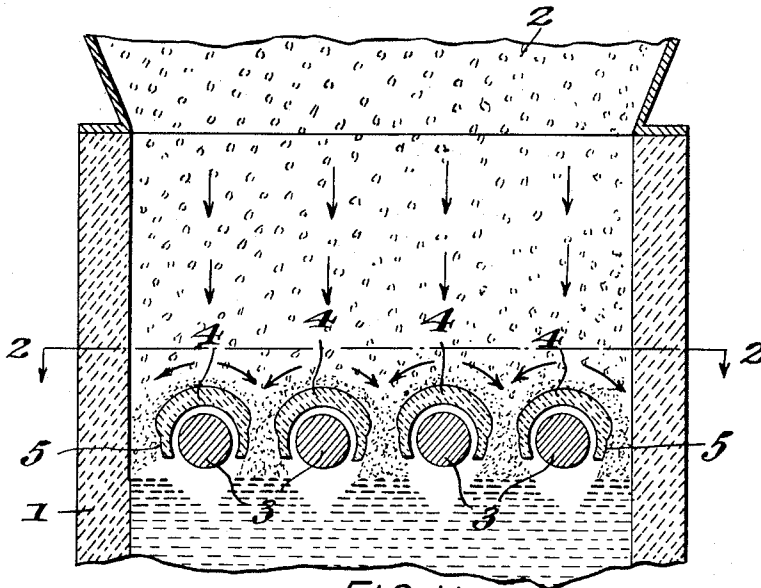
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ELECTRIC RESISTANCE MELTING FURNACES

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ELECTRIC RESISTANCE MELTING FURNACES

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Application May 21, 1956, Serial No. 586,142

9 Claims. (Cl. 13—33)

This invention relates to electric resistance melting furnaces of the type in which the material to be melted flows downwardly between generally horizontal spaced electrically-heated melting rods. The invention is particularly although not exclusively applicable to electric resistance furnaces for the melting of quartz sand into fused quartz.

In such furnaces it has been found that the heating rods which are normally made of graphite are subject to very great wear, so that after an operating period which generally amounts to only a few hours they have to be replaced. The resultant interruption of the melting process makes it impossible to produce large blocks of material, especially those of great length, or even to maintain continuous operation.

The objects of the present invention is to increase the life of the heating rods and thus to make possible the prolonged operation of the furnace.

According to the present invention each heating rod is screened from direct contact with the material being melted by an individual cover which extends over the whole of its length but conducts none or no substantial part of the heating current, the material being melted flowing downwardly between adjacent covers.

It was observed that during the process of melting quartz sand in furnaces of the type specified, a layer of silicon carbide forms in the surface layer of each graphite heating rod. This layer of silicon carbide is wholly or partly torn off on coming into contact with the melt. The fresh graphite surface layer thus exposed once again forms a surface layer of silicon carbide, which in turn is torn off by the melt. The continual repetition of the forming and tearing off of surface layers of silicon carbide from the graphite heating rods effects in a very short time a marked decrease in the cross-section of the rods, to a point at which the rods are overloaded by the passage of the current and current interruption occurs, with arc formation. The failure of one heating rod out of several rods connected in series is sufficient to interrupt the entire melting process. As such failures occur after only a brief operating period, large uniform melt blocks can not be produced, as the melting time needed for their production is not available.

By means of the present invention in which the rods are screened from contact with the material being melted, the repeated formation and tearing off of layers of silicon carbide is avoided and the premature destruction of the heating rods due to this cause is prevented. The working life of the heating rods is lengthened, enabling larger uniform blocks of melt, and blocks of greater length, to be produced, and also enabling a continuous melting process to be performed.

The screening of the heating rods may be carried out in various ways. For example, each rod may be completely enclosed in a tubular cover in which the rod is inserted, with an annular space left between the rod and the cover. In such case, the protecting tube would

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not carry electric current but would be mounted suitably at its ends on the electrode blocks which feed the rod.

The cross-section of each tube may be of any suitable form which will allow a good flow of the melt mass, for example circular, oval or egg-shaped. The tube may be provided with circumferential external ridges and grooves along its length to increase the heating area, and may be provided with a longitudinal external rib projecting upwardly and lying along the whole length of the tube at its highest part, which will also give the tube greater resistance to bending.

In another arrangement of the invention however, each cover comprises a protective cap or roof which overlies the upper side of its associated electrode only, and deflects the descending melt down through the spaces between the heating rods, thus preventing the melt from coming into contact with the heating rods themselves.

The covers may either be spaced radially from the surfaces of their associated heating rods, or they may lie in contact with those surfaces. The covers should be made of a highly refractory non-metallic material which is also highly heat conductive. For example highly refractive oxides such as zirconium oxide may be used, or nitrides, for example titanium nitride or zirconium nitride, or borides, for example titanium boride or zirconium boride, or carbides, for example silicon carbide itself. The covers can even be made of graphite. It is true that if made of graphite the covers will become coated with a layer of silicon carbide, but as the covers do not carry the heating current and consequently do not reach the very high surface temperature which is produced by the heating current in the rods themselves, the silicon carbide layer of the covers will remain firm and will not be torn off by the passage of the melt, and no sputtering of the silicon carbide layer will take place. The silicon carbide layer forms a protective coating which will lengthen the life of the covers. A similar protective coating or layer of silicon carbide or of other suitable material may also be applied to the covers before they are built into the furnace, even if the covers are of material other than graphite.

The construction of the covers as protective caps for the heating rods has the advantage that a considerable proportion of the heat radiated from the heating tubes is not intercepted by the covers but impinges directly on the material being melted. The upper surfaces of each cover may be straight or curved, and may be formed with an external longitudinal rib protruding upwardly from the uppermost portion and extending along its whole length. In longitudinal section the covers may be of undular form, or may be provided with transverse external ribs, to increase the heating area.

Preferably each of the cap-like covers is provided with skirts along its longitudinal edges which extend downwardly one on either side of the associated heating rod, the skirts being spaced laterally from the heating rod to prevent descending molten material coming into contact with the surface of the rod itself. The skirts may be formed with indentations along their lower edges, so that the formation of bridges in the melt material between the skirts of adjacent covers will be reduced or avoided.

If the covers are made of material whose electrical conductivity is about the same as or is greater than that of the heating rods themselves, the covers must be so insulated from the rods that the passage of any substantial amount of electric current through the covers will be avoided. In cases where the covers have a substantially poorer electrical conductivity than the rods, however, for example if the covers are of silicon carbide and the heating rods are of graphite, the covers may then touch the rods and may even be welded to them.

In this case the covers will not participate in the passage of the current to more than a small extent, as the current will always tend to concentrate in the better conductor. Consequently there will be no excessive destruction of the covers in this case.

If the covers are so disposed that they are radially separated from their associated heating rods, a space free from melt will always remain around the heating rods underneath the covers on account of the high viscosity of the melt. Even in cases where the covers lie directly on the heating rods, melt-free spaces will form beneath the rods. In all these hollow spaces gases or vapours such as CO, Si, SiO and SiO₂ will collect during the melting process, and these should preferably be withdrawn. For this purpose a suitable gas under pressure, for example an inert gas such as nitrogen, may be introduced at one end of each heating rod into the hollow space associated with the rod, and the gases collected in the space can be expelled or sucked out completely at the other end of the heating-rod. By these means undesirable gas occlusions in the melt mass are avoided and the mass may be kept free from bubbles.

The screening of the heating rods of electric resistance melting furnaces, in accordance with the invention, may be employed in connection with various kinds of different heating rods, and for the melting of various different substances where it is desirable to protect the heating rods from coming into contact with the melt flux or where the discharge of the resultant gases is necessary.

Presently-preferred specific exemplary embodiments of the invention will now be described by way of example with reference to the accompanying drawings, which comprises a diagrammatic cross-sectional view of an electric resistant melting furnace for the melting of quartz sand into fused quartz, as well as detailed views of alternative constructions.

On the accompanying sheets of drawing,

Fig. 1 is a diagrammatic sectional view through a part of an electric resistance melting furnace according to the invention;

Fig. 2 is a top plan view corresponding to Fig. 1;

Fig. 3 is a sectional view through a detail showing a modified form of protective cap;

Fig. 4 is a similar view showing another alternative detail;

Fig. 5 is a similar view showing still another alternative arrangement;

Fig. 6 is a fragmentary side elevational view showing another modified form of cap;

Fig. 6a is a sectional view taken along line 6a—6a of Fig. 6;

Fig. 7 is a side elevational view showing still another modification;

Fig. 8 is a sectional view taken along line 8—8 of Fig. 7;

Fig. 9 is a diagrammatic view of a detail according to still another modification;

Fig. 10 is a sectional view taken along line 10—10 of Fig. 9.

Fig. 11 is a diagrammatic sectional view through a part of an electric resistance melting furnace contemplated by the instant invention; and

Fig. 12 is a top plan view corresponding to Fig. 11.

In the embodiment illustrated in Figs. 1 and 2 of the drawing, the melting shaft 1 of the furnace, which is preferably rectangular and the walls of which are of refractory material (e. g. brickwork or the like), is illustrated in section taken through its longer dimension, and is provided with a conventional charging hopper, shown diagrammatically at 2, and with a number of graphite heating rods 3 which are arranged transversely to the shaft in a single horizontal plane. The quartz sand descends in a steady stream from the hopper 2 and passes through the gaps between the heating rods 3 by which it

is melted, the molten quartz material descending between the heating rods while fresh sand descends from above, and the melting operation being continuous.

As shown in Fig. 1, there is a melt-free angular space beneath each heating rod 3, and this is flushed with flushing gas as hereinbefore and hereinafter set forth.

Each heating rod 3 is provided with a cover in the form of a protective cap 4 of e. g. zirconium oxide, by which it is screened from direct contact with the melting material, and particularly from the melt itself. The protective cap overlies the whole length of the heating rod and is slightly spaced from its upper surface.

External layer 4' represents a pre-formed layer of silicon carbide provided on cap 4.

A bearing block 4' is mounted in the refractory wall of the furnace at each end of each heating rod 3, and the ends of the latter are journaled in said blocks, as shown.

To eliminate gases which may collect beneath each cap-and-rod assembly, conduits 10 may be provided for introducing an inert gas such as nitrogen into the space beneath each assembly, and for exhausting such gas. The gas supply and exhausting means are per se conventional. Such means may be employed with any of the modifications shown in Figs. 3 to 8 as well as in that shown in Figs. 9 and 10 in which it is further illustrated.

Each protective cap is provided with skirts 5 which extend downwardly on either side of the heating rod sufficiently far to ensure that the melt cannot come into contact with the sides or under surface of the heating rod.

The cross-section of each protective cap may be provided with straight upper sides inclined at a little under 45° to the horizontal; see Fig. 3. In the embodiment illustrated a stiffening rib extending longitudinally along the upper surface of the cap may be provided as indicated at 6, in Fig. 3.

Fig. 4 shows a further configuration of cap 4, spaced from rod 3. The inner surface of the cap is provided with any desired number of spacer ribs or projections 7, which are integral with and of the same material as cap 4. This arrangement is adapted to the situation where cap and rod are made of similar or essentially similar material. It will be understood that spacers 7 are provided in every case where the cap 4 is spaced from the rod 3.

Fig. 5 illustrates the cap 4 as in direct contact with rod 3. In this embodiment, external layer 4' represents a pre-formed layer of silicon carbide provided on cap 4, as hereinbefore described.

Figs. 6 and 6a show a further modification of cap in elevation and section, respectively. Longitudinal ribs a extend externally along the cap. In the embodiment according to Figs. 7 and 8, the caps are transversely ribbed on the exterior.

Figs. 9 and 10 illustrate the situation where the cap 4 extends entirely around rod 3. To eliminate gases which may collect beneath each cap-and-rod assembly, conduits 10 may be provided for introducing an inert gas such as nitrogen into the space beneath each assembly, and for exhausting such gas (see left-hand conduit 10 in Fig. 9). The gas supply and exhausting means are per se conventional.

In the embodiment illustrated in Figs. 11 and 12 of the drawing, the melting shaft 1 of the furnace, which is preferably rectangular and the walls of which are of refractory material (e. g. brickwork or the like), is illustrated in section taken through its longer dimension, and is provided with a conventional charging hopper, shown diagrammatically at 2, and with a number of graphite heating rods 3 which are arranged transversely to the shaft in a single horizontal plane. The quartz sand descends in a steady stream from the hopper 2 and passes through the gaps between the heating rods 3 by which it is melted, the molten quartz material descending be-

tween the heating rods while fresh sand descends from above, and the melting operation being continuous.

As shown in Fig. 11, there is a melt-free angular space beneath each heating rod 3, and this is flushed with flushing gas as hereinbefore set forth.

Each heating rod 3 is provided with a cover in the form of a protective cap 4 of e. g. zirconium oxide, by which it is screened from direct contact with the melting material, and particularly from the melt itself. The protective cap overlies the whole length of the heating rod and is slightly spaced from its upper surface.

A bearing block 4' is mounted in the refractory wall of the furnace at each end of each heating rod 3 and the ends of the latter are journaled in said blocks, as shown.

Each protective cap is provided with skirts 5 which extend downwardly on either side of the heating rod sufficiently far to ensure that the melt cannot come into contact with the sides or under surface of the heating rod.

Naturally the modifications shown in Figs. 3 to 10 may be substituted for the corresponding elements of Figs. 11 and 12.

It is to be understood that any of the modifications illustrated in Figs. 3, 4 and 6 to 10 may be provided with an external layer similar to 4'' shown in Figs. 1 and 5.

The electrical connections for rods 3 are not shown, these also being of per se conventional construction.

As previously indicated, the drawing is diagrammatic in character. It will be understood that the device may be assembled in any suitable or convenient manner. Thus, for example, the caps may be slid onto their respective heating rods from the ends; moreover, one wall of the furnace at an end of the rods may be removable to facilitate assembly, or if desired a portion of one or both walls may be made removable for this purpose.

Having thus disclosed the invention, what is claimed is:

1. An electrically heated melting furnace for the continuous conversion of quartz sand into fused quartz comprising a plurality of heating rods arranged in spaced relationship, means for supplying quartz sand to said furnace at a point above said rods whereby the quartz sand continuously passes by gravity downwardly between said rods and is heated thereby and converted into fused quartz which may be continuously withdrawn from the bottom of the furnace, and an individual cover for screening each heating rod from direct contact with material being melted and with molten material, said cover extending over the entire length of the rod and being sub-

stantially throughout in spaced relationship with respect to said rod, said cover being downwardly open so that substantially the entire surface of the heating rod is exposed, whereby maximum heat transmission from said

rod may be effected, each said cover being provided with means for insuring that its respective heating rod is maintained out of contact with the fused quartz therebeneath.

2. The relationship of parts according to claim 1, wherein said last named means comprises a downwardly-extending skirt portion on each cover on each side of said heating rod, whereby a zone is provided beneath each heating rod which is free from quartz sand and fused quartz.

3. A furnace as claimed in claim 1, wherein each cover is provided with a longitudinally extending reinforcing rib along the upper surface thereof.

4. A furnace as claimed in claim 1 wherein the upper surface of each cover is undulated.

5. A furnace as claimed in claim 1, wherein the cover is made of graphite.

6. A furnace as claimed in claim 1, wherein the cover is made of silicon carbide.

7. A furnace as claimed in claim 1, wherein the cover is made from a highly refractory non-metallic material of good heat conductivity selected from the group consisting of oxides, nitride and borides of zirconium and titanium.

8. The relationship of parts according to claim 1, wherein said last named means comprises a downwardly-extending skirt portion on each cover on each side of said heating rod, whereby a zone is provided beneath each heating rod which is free from quartz sand and fused quartz, and means for introducing gas at one end of heating rod into the said melt-free zone and for withdrawing gas at the other end of the rod.

9. A furnace according to claim 1, in which each cover is provided with a protective outer layer of material especially resistant to the mechanical and chemical action of the melted material.

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