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Truman

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[54] **UTILIZATION OF SILICON FINES IN CASTING**

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[51] **Int. Cl.²** **B22D 3/00**

[58] **Field of Search** 423/348, 349, 350; 164/72, 164/80, 138, 97, 55–59, 122; 249/112, 114, 134

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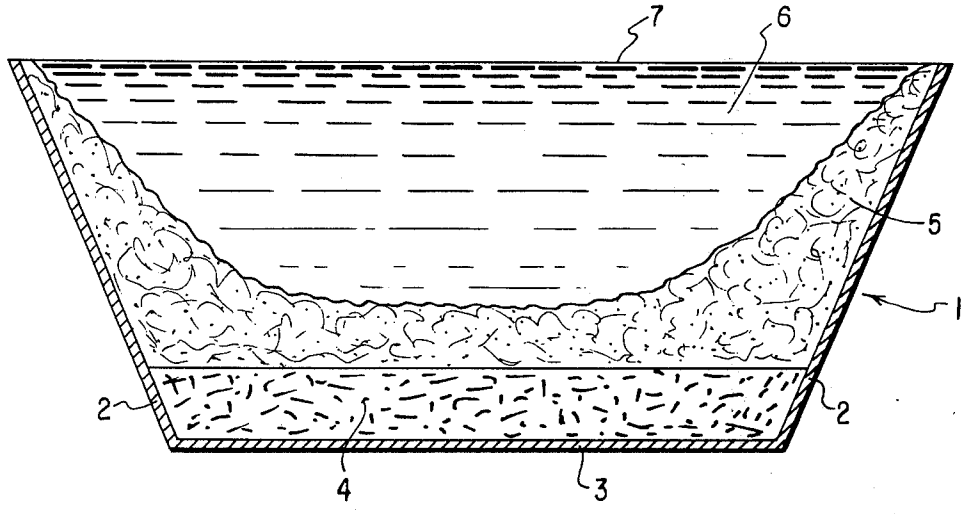
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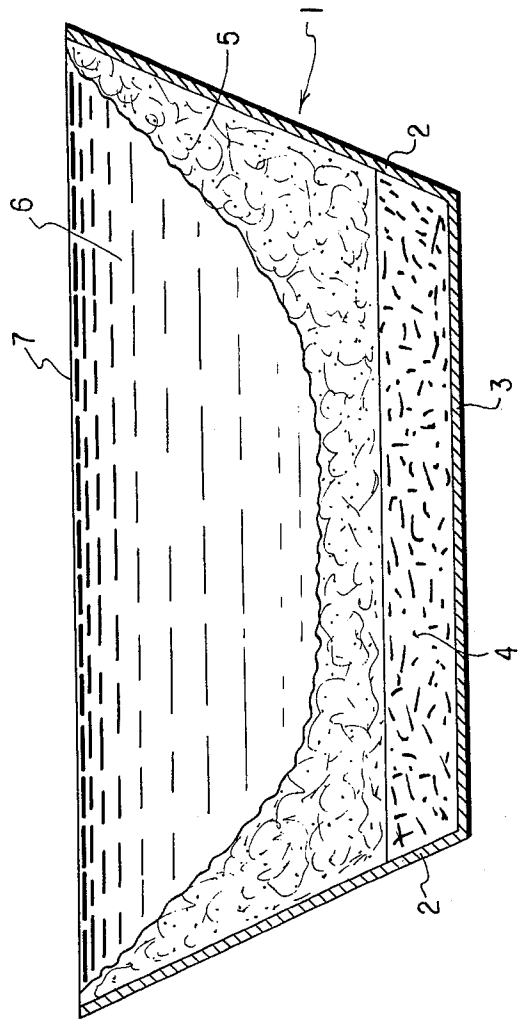
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[57] **ABSTRACT**

A method of casting molten silicon in a mold having a metal shell and an interior carbon lining, wherein the carbon lining of the mold is covered with a layer of granular silicon, and the molten silicon is cast in the mold in contact with said layer.

5 Claims, 1 Drawing Figure




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UTILIZATION OF SILICON FINES IN CASTING

BACKGROUND OF THE INVENTION

Silicon metal is conventionally produced by the carbothermic reduction of silica in electric arc furnaces in accordance with the general reaction:

$$SiO_2 + 2C \rightarrow Si + 2CO$$

As the source of the silica, there may be employed a variety of siliceous minerals, quartz being preferred. The carbon is provided by a suitable carbonaceous reducing agent which is low in iron, preferably petroleum coke.

The silicon metal thus formed is tapped while molten from the furnace into large steel molds in which it is allowed to solidify. The resulting ingot is removed from the mold and broken up into large lumps, ranging in size from about 2 to 6 inches average diameter. These are suitable for various industrial applications, such as, for example, the manufacture of aluminum-silicon die casting alloys, or for further refining to produce semiconductor grades, and the like.

In the course of comminuting the ingot silicon to a lump size desired by industrial users, for example using a jaw crusher, there is produced a substantial amount of silicon metal "fines", comprising small granules, ranging in size principally between about 0.75 and 0.10 inches. These fines are not wanted by silicon users and hence present a disposal problem to the silicon metal producer.

The present invention provides a novel method for the practical and economical utilization of the silicon fines, which at the same time achieves a substantial improvement in the ingot casting technique.

GENERAL DESCRIPTION OF THE INVENTION

In accordance with the present invention, there is provided a novel method for the utilization of silicon fines in the casting of silicon, whereby the properties of the cast silicon are improved and the life of the casting equipment is prolonged.

The mold which is customarily employed for casting molten silicon into ingots and the like as it is tapped from the electric reduction furnace, is fabricated from steel, and has a bottom lining of carbon to protect the steel shell against the intense heat. In normal practice, the silicon as tapped from the furnace at a temperature from about 1600°C to about 1800°C contacts the steel or carbon surface causing alloying of the silicon with iron or carbon. This produces a contamination of the silicon by iron and carbides, and also produces warping and erosion of the steel mold, with consequent shortening of mold life.

In accordance with the present invention, the mold which has a carbon lining in the interior of the metal shell, is packed with the silicon fines or granular silicon in such manner that all of the steel surface and the carbon surface are covered with a suitably thick layer of granular silicon, thus providing a concave pocket into which the molten silicon is tapped from the furnace. Thus the molten silicon is cast in the mold in contact only with the layer of granular silicon fines and does not come into contact with either the mold metal or the carbon lining.

The layer of silicon fines serves as a heat sink for the tapped hot silicon metal, which is at a temperature of about 1600° to 1800°C, by causing the silicon fines,

which melt about 1400°C, to sinter and become an integral part of the formed silicon ingot. However, the temperature at the surface of the silicon fines never becomes hot enough to cause significant attack and alloying of the steel mold. In this way, the purity of the silicon product is protected, and long mold life is assured. The process of the invention produces large dense ingots, and employs molds which are readily prepared.

DETAILED DESCRIPTION OF THE INVENTION

The practice of the invention will be more readily understood by reference to the accompanying drawing, which illustrates a mold suitable for the tapping of metallurgical grade silicon metal, which has been provided with a protective layer of granular silicon fines, in accordance with the invention.

In the drawing, the mold embodiment shown in cross-section comprises a fabricated steel plate shell **1**, having tapering sides **2** and bottom **3** which is provided with a bottom lining of carbon **4** which is of conventional type. The carbon lining **4** is prepared from a cathode paste comprising a mixture of calcined anthracite, metallurgical grade coke, and a coal tar pitch binder, the proportion of binder being about 13% by weight of the paste. The paste is introduced while hot, tamped in place by suitable means, such as a pneumatic tamping device, and the shell and paste are heated in an oven whereby the paste is baked and carbonized to form a hard carbon bottom. Usually the only time this carbon bottom requires replacement is when the hot silicon burns through the carbon and breaks up the bottom when the ingot is removed.

A layer of silicon fines **5** having a concave contour is superimposed on the carbon bottom and covers the interior walls of the mold above the carbon layer, forming a pocket in which the molten silicon is received and cooled to form the ingot **6.**

The silicon fines or granules may be produced from the crushing of silicon ingots, and range in size principally from about 0.75 inch to about 0.10 inch, average diameter. A typical mesh size range of silicon fines may be as follows:

+ .742	inches			0
− .742	"	to	+ .525"	9.51%
− .525	"	to	+ .371"	32.20%
− .371	"	to	+ .250"	25.06%
− .250	"	to	+ .187"	14.94%
− .187	"	to	+ .0937"	15.27%
− .0937	"	to	+ .0787"	1.68%
− .0787	"	to	+ .0331"	.63%
− .0331	"	to	+ .0197	.13%
− .0197	"	to	+ .0083"	.13%
− .0083	"	to	+ .0029"	.26%
− .0029	"	to	dust	.19%

In the mold embodiment illustrated in the drawing, the tapping pan or mold may be made of ¾ inch steel plate and have, for example, the following dimensions:

top length and width 72 to 76 inches
bottom length and width 57 to 60 inches
height of sides 25 to 32 inches.

In a mold having the foregoing dimensions, the depth of the carbon layer will be about 8 inches. The average depth of silicon fines above the carbon layer will also be about 8 inches. Depending upon the coarseness of the silicon fines and their angle of repose, the width of the fines layer against the walls may taper from about 18 inches at the carbon to about 2 inches at the top. More fines can be used, but this reduces the volume of

the ingot metal **6.** If a thinner layer is used, the hot silicon may melt the fines layer and burn into the carbon layer causing difficulty in removing the silicon from the steel shell without damage to the bottom.

EXAMPLE

A mold made of ¾ inch steel plate and having the dimensions top length 76 inches, bottom length 60 inches, height of sides 32 inches, is provided with a bottom layer of cathode paste of the character previously described, to a depth of 8 inches, and the mold is held in an oven at a temperature of 600°F to carbonize and bake the bottom layer. A layer of granular silicon of the character previously described is poured into the mold to form a layer having a depth of 8 inches above the carbon layer, and tapering against the walls from a depth of about 18 inches at the lower end to about 2 inches at the top.

Molten silicon at a temperature of 1700°C. tapped from an electric arc furnace in which it has been formed by reduction of quartz, is allowed to flow into the mold above the silicon fines layer until the mold is filled to level **7,** and the mold and contents are allowed to cool. The resulting ingot is readily removed from the mold, and may be crushed to any desired particle size. The resulting fines are reclaimed and utilized for further mold linings.

What is claimed is:

1. In the art of casting molten silicon in a mold to form an ingot and thereafter crushing the ingot to obtain lumps of silicon, wherein said crushing also produces more finely divided silicon, the method which comprises lining the mold with a layer of the finely divided silicon from previous crushing operations and casting the molten metal in contact with said layer.

2. The method of claim **1,** including casting the molten silicon at a temperature of about 1600°–1800°C. effective to sinter said layer of finely divided silicon.

3. The method of reclaiming finely divided silicon which comprises contacting molten silicon with a layer of the finely divided silicon in a mold at a temperature effective to sinter said layer and recovering an ingot containing silicon from both sources.

4. The method of casting molten silicon in a mold having a metal shell and an interior carbon lining, comprising the steps of covering said carbon lining with a layer of finely divided silicon and casting the molten silicon in contact with said layer.

5. The method of claim **1** in which said finely divided silicon is in the form of granules having an average size between about 0.10 and about 0.75 inch.

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