

UNITED STATES PATENT OFFICE.

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TO THE CARBORUNDUM COMPANY, OF NIAGARA FALLS, NEW YORK, A CORPORATION OF PENNSYLVANIA.

MANUFACTURE OF SILICON.

1,061,256.

Specification of Letters Patent.

Patented May 13, 1913.

No Drawing.

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To all whom it may concern:

Be it known that we, THOMAS B. ALLEN and FRANK J. TONE, residents of Niagara Falls, in the county of Niagara and State of New York, have invented a new and useful Improvement in the Manufacture of Silicon, of which the following is a full, clear, and exact description.

Our invention relates particularly to the manufacture of silicon, its alloys and compounds, in a new and efficient manner; though our process is applicable to electrical treatment of other ores where there is a large or considerable loss due to volatilization.

In the regular manufacture of silicon, its alloys and compounds, it has been found that there is a very considerable waste of material and electrical energy due to the poor recovery of silicon from the furnace charge. The reaction zone of the furnace producing this substance has a positive pressure of considerable magnitude and consequently if the furnace charge is of such a nature that the escape of a large volume of carbon monoxid gas takes place along a few paths, the large volume of carbon monoxid gas carries with it a considerable proportion of the vapors of silicon, silicon monoxid and silicon dioxid. These vapors on coming in contact with the air are transformed into silicon dioxid. In using an electric furnace of the arc type for the manufacture of silicon it is found that the necessary free movement of the electrodes causes a path of weakness in the furnace charge and allows the ready escape of gases along this parting line or path. As the furnace mixture is in general quite compact, there is no easy path of egress for the gases except along the electrodes and consequently the carbon monoxid gas formed by reduction escapes almost entirely along these paths. Such paths, therefore, become very highly heated, thus further reducing the possibility of condensation of the silicious vapors. Consequently there is a great loss of material and electrical energy.

In manufacturing silicon; and by the term "silicon" as hereafter used, we intend to include also its alloys and compounds, it has been found that better results are obtained where the silicious material and reducing agent are both in a fine state of division and are intimately mixed. This in-

creases the efficiency of the furnace. We have also found that by briqueting an intimate mixture of finely divided carbonaceous and silicious materials, and then subjecting this briqueted mixture to electrically developed heat in an electric furnace, we can obtain a greatly increased efficiency in furnace practice and also materially decrease the loss of silica from the furnace charge, and the silicon monoxid and silicon, after the reduction has started to take place.

We will now describe in detail a preferred method of carrying out our invention for the production of metallic silicon.

We take 70 parts by weight of pure silica sand and 30 parts by weight of petroleum coke, the materials being preferably in a fine state of division, for example, 12 mesh and finer. These materials are then mixed with about 7 per cent. by weight of hard pitch, which serves as the binder for the briquets. The mixture is then passed through a heater of any well known type and then placed in a hot mixer so that the pitch softens and is thoroughly mixed with the furnace charge. This hot mixture is then fed into a briqueting machine of any well known type and is formed into briquets. The briquets are discharged from the machine and are then preferably cooled, for example, by spraying with water and are then transported to the furnace. Different shapes of briquets may be obtained by changing the shape of the die used in the briqueting machine, but we have found that the spherical shape gives the greatest amount of interstitial space and consequently is best adapted for our purpose. We prefer to use briquets $1\frac{1}{2}$ " in diameter. The briquets thus obtained may be charged into any desirable type of furnace; and for this purpose we prefer to use a furnace of the arc type such as shown in United States Patent No. 921183, granted on May 11, 1909, to Frank J. Tone (one of the inventors herein). This furnace is operated in the usual manner and owing to the briqueting of the finely divided materials, we find that the efficiency of the furnace is greatly increased and the loss of material reduced, by reason of the discharge of carbon monoxid quite uniformly throughout the entire mass of the charge. Instead of discharging the carbon monoxid gas along

the line of the electrode with little condensation of the silicon containing vapors carried along thereby, the carbon monoxid and the silicon containing vapors are discharged through the entire mass and the silicon vapors are condensed in the cooler portions. Owing to the more diffused escape of the carbon monoxid gas, there is also a more diffused heating of the furnace, and consequently a more efficient pre-heating effect from the carbon monoxid gas.

Instead of using a charge of silica and carbon, we may employ a charge of silicon carbide and silica, or a charge of siloxicon and silica.

The method above described of disposing the briqueted charge so that it will act as a condensing medium for the volatile reduction products may be applied with advantage to the reduction of many other ores where there is a considerable loss by volatilization; for instance to the reduction of the ores of aluminum, boron and manganese, and other changes may be made in the materials employed and in the steps of the process without departing from our invention.

We claim:

1. In the manufacture of silicon, the step consisting in subjecting briquets containing silicious and carbonaceous material to the direct heat of an electric arc.

2. In the manufacture of silicon, the step consisting in briqueting a finely divided mixture of silicious and carbonaceous material and subjecting the briquets to the direct heat of an electric arc.

3. In the manufacture of silicon, the method consisting of subjecting a briqueted mixture of finely divided silicious and carbonaceous materials to the direct heat of an electric arc.

bonaceous materials to the direct heat of an electric arc.

4. In the manufacture of silicon, the steps consisting in briqueting a mixture of silicious ore and carbon, charging the same into the reaction zone of an electric furnace, subjecting it to the direct heat of an electric arc, and causing the outgoing gases to permeate and pre-heat the charge.

5. In the manufacture of silicon, the steps consisting of charging an electric furnace with a briqueted mixture and disposing said charge so that on subjecting it to electrically developed heat it will act as a condensing medium for the volatile reduction products carried by the outgoing gases.

6. In a process employing electrically developed heat, the step consisting of electrically heating a briqueted mixture and using said briqueted charge as a condensing medium for volatile reduction products.

7. In the reduction of materials subject to large losses by volatilization, the method consisting in charging an electric furnace with a briqueted mixture thereof, disposing said charge so that it will act as a condensing medium for the volatile products carried by the outgoing gases, and subjecting said charge to electrically developed heat.

In testimony whereof, we have hereunto set our hands.

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