UNITED STATES PATENT OFFICE.

FREDERICK M. BECKET, OF NIAGARA FALLS, NEW YORK, ASSIGNOR TO ELECTRO METALLURGICAL COMPANY, A CORPORATION OF WEST VIRGINIA.

PROCESS OF REDUCING METALLIC OXIDS.

No. 906,854. Specification of Letters Patent. Patented Dec. 15, 1908.

Application filed June 19, 1906. Serial No. 322,449.

To all whom it may concern:

Be it known that I, FREDERICK M. BECKET, a subject of the King of Great Britain, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Processes of Reducing Metallic Oxids, of which the following is a specification.

This invention is a process particularly adapted for the production of metals and alloys of low silicon and carbon content, and is more particularly applicable to the metals chromium, tungsten, molybdenum and vanadium and to the alloys of these metals with iron or nickel.

The invention consists in reducing a suitable oxid or oxygen containing compound or mixture of oxids by the simultaneous action of silicon and carbon, used preferably in proportions and under conditions to insure a commercial purity of the product. The conditions necessary for a substantially complete reduction of the metallic oxid or oxids and the production of metals or alloys of low silicon and carbon content are obtainable so far as known only in an electric furnace. Preferably a basic flux is used to combine with the silica derived from the oxidation of the silicon, and any silica present in the charge.

Metallurgists have long been familiar with the reducing action of silicon on certain metallic oxids, such as oxid of iron, and advantage is taken of this chemical reaction in many industries,—for example in the manufacture of steel. In these cases the silicon exists in the form of an alloy, its reducing properties are employed as a means of eliminating it from the finished product rather than as a means of producing further quantities of metal, and the proportion of reducible oxid used for its removal is largely in excess of that theoretically necessary. In the form of silicids, silicon is employed to reduce metallic oxids dissolved in molten metals.

I have found that silicon and carbon, preferably combined as silicid of carbon, may be advantageously employed in the electric furnace as a reducing agent in the production of chromium, molybdenum, tungsten and vanadium, or of the iron or nickel alloys of these metals. When a suitable mixture consisting of silicid of carbon, an oxid of one or more of the above metals, and a basic flux is treated in an electric furnace, the advantages of a continuous and very rapid process may be obtained, and by suitably proportioning the ingredients of the charge the silicon and carbon contents of the reduced metals may be reduced to a fraction of a per cent.

Attempts have been made to produce low carbon metals or alloys of the character above referred to by reduction by carbon in the electric furnace, using in the charge the minimum proportion of carbon necessary to effect the reduction; but in this case the yields have been found to be low and moreover the electrodes have been rapidly consumed. I have discovered, however, that when the reducing action of carbon is supplemented by that of silicon excellent yields may be obtained and the reaction proceeds without undue consumption of the electrodes. I prefer to supply the silicon and carbon in chemical combination as silicid of carbon, SiC. By the use of this compound the production of metals or alloys low in silicon and carbon is more easily and economically attained, probably for the reason that the portions of metal first reduced do not come into contact either with free silicon or with free carbon, and therefore do not absorb the same to any injurious extent.

As a specific example of the process I will describe its application to the manufacture of low carbon and low silicon ferrochromium from chromite. As the chromium in chromite exists as chromium sesquioxid, Cr_2O_3, and practically all the iron as ferrous oxid, FeO, the following reactions take place.

$$Cr_2O_3 + SiC = 2Cr + SiO_2 + CO.$$
$$3FeO + SiC = 3Fe + SiO_2 + CO.$$

A fair commercial grade of chromite contains 52 per cent. Cr_2O_3 and 16 per cent. FeO, and 100 pounds of this ore will therefore require, according to the above reactions, about 16.6 pounds of SiC for complete reduction of the chromium and iron. It is advantageous to use the silicid of carbon in a fairly fine state of subdivision, depending on the scale of the operation. The use of a basic flux, such as lime, is usually advantageous as tending to economy of operation; it is not, however, essential.

Most commercial chromites contain from 8 to 15 per cent. Al_2O_3 and 8 to 15 per cent.

MgO. These materials serve as basic flux for the silica present in the ore and for that produced by oxidation of the silicon, but the proportions are such that to maintain this slag fluid for tapping a higher temperature is necessary than that required for complete reduction of the chromium and iron oxids.

By mixing chromite and silicid of carbon in practically theoretical proportions, together with some basic flux such as lime, and bringing the mixture to a state of fusion in an electric furnace, a very high yield of chromium and iron may be obtained from the ore used and the alloy contains only fractions of a per cent. of carbon and silicon. It is not essential that the proportions be precisely those indicated by theory, because in case a very low silicon content is required in the alloy (less than 0.2 per cent.) the chromite is used in slight excess of such proportions; and in case a low silicon content is not essential the silicid of carbon is used in excess. In the latter case the yield of metal from the ore is slightly higher.

I do not limit myself to any particular type of electric furnace, but I have found it advantageous to carry on the reduction continuously in an electric furnace in which the current passes through a molten bath of a mixture of ore, silicid of carbon and flux, and from which part or all of the metal or slag may be withdrawn as desired, fresh portions of the mixture being added from time to time. To obtain a high yield of the desired metal or alloy and to insure a low silicon content therein I have found it advantageous to feed the mixture to a bath which is maintained at a temperature higher than that necessary to cause some reaction.

The electric furnace operation may be carried out by fusing the ore and flux and then adding thereto the silicid of carbon, or by heating a mixture of ore and silicid of carbon and adding flux to the bath from time to time, should the use of a flux be advantageous.

As the reaction between silicid of carbon and the above mentioned metallic oxids is exothermic, a relatively small amount of electrical energy is required for the reduction. The use of silicid of carbon is highly advantageous in practice as compared with the use of aluminum for several reasons, among which may be mentioned the relatively large weight of metal which is separated per unit weight of the reducing agent; the ease with which silicid of carbon is obtained in a fine state of subdivision whereby a more intimate mixture is secured with its attendant advantages; and also because of the fact that by its use silicious ores, which are relatively inexpensive, may be successfully employed.

Aluminum reduces silicon from the silica invariably present in such ores as chromite, wolframite, etc., and I have found in practice that silicon so reduced, as well as portions of the aluminum used for reduction, alloy with the reduced metal, thereby necessitating either a costly refining process or a costly selection of ores in case a product low in silicon is required. On the other hand, in the use of silicid of carbon as a reducing agent there is no necessity for excluding silicious ores. For this reason I have found special advantages in the reduction of vanadium ores by silicid of carbon.

I claim:—

1. The process of reducing metallic oxids which consists in passing an electric current through a molten bath containing a metallic oxid, and a reducing agent containing silicon and carbon.

2. The process of reducing metallic oxids which consists in passing an electric current through a molten bath containing a metallic oxid and silicid of carbon.

3. The process of reducing metallic oxids which consists in passing an electric current through a molten bath containing a metallic oxid, silicid of carbon and a basic flux.

4. The process of reducing metallic oxids which consists in smelting a charge containing a metallic oxid, silicon and carbon, the silicon and carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids whereby a substantially complete oxidation of the silicon and carbon is secured and a product low in silicon and carbon is obtained.

5. The process of reducing metallic oxids which consists in smelting a charge containing a metallic oxid and silicid of carbon, the silicid of carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids whereby a substantially complete oxidation of the silicon and carbon is secured and a product low in silicon and carbon is obtained.

6. The process of reducing metallic oxids which consists in smelting a charge containing a metallic oxid, silicid of carbon and a basic flux, the silicid of carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids whereby a substantially complete oxidation of the silicon and carbon is secured and a product low in silicon and carbon is obtained.

7. The process of reducing metallic oxids which consists in passing an electric current through a molten bath containing a metallic oxid and silicid of carbon, the silicid of carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids, whereby a product low in silicon and carbon is obtained.

8. The process of reducing metallic oxids which consists in passing an electric current

through a molten bath containing a metallic oxid, silicid of carbon and a basic flux, the silicid of carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids, whereby a product low in silicon and carbon is obtained.

9. The continuous process of reducing metallic oxids which consists in passing an electric current through a molten bath containing a metallic oxid, silicid of carbon and a basic flux, adding fresh portions of the charge and withdrawing the products as desired.

10. The process of reducing oxid of chromium which consists in reacting thereon with a reducing agent containing silicon and carbon.

11. The process of reducing oxid of chromium which consists in reacting thereon with silicid of carbon.

12. The process of reducing oxid of chromium which consists in reacting thereon with silicid of carbon, the silicid of carbon being present in substantially the proportion required to combine with the oxygen of the reducible oxids, whereby a substantially complete oxidation of the silicon and carbon is secured and a product low in silicon and carbon is obtained.

13. The process of reducing oxid of chromium which consists in passing an electric current through molten bath containing oxid of chromium, and a reducing agent containing silicon and carbon.

14. The process of reducing oxid of chromium which consists in passing an electric current through a molten bath containing oxid of chromium and silicid of carbon.

15. The process of reducing oxid of chromium which consists in passing an electric current through a molten bath containing oxid of chromium, silicid of carbon and a basic flux.

16. The process of producing ferrochromium which consists in reacting on chromite with silicid of carbon.

17. The process of producing ferrochromium which consists in reacting on chromite with silicid of carbon in presence of a basic flux.

18. The process of producing ferrochromium which consists in passing an electric current through a molten bath containing chromite and silicid of carbon, the silicid of carbon being present in substantially the proportion required to combine with the reducible oxids, whereby substantially complete oxidation of silicon and carbon is secured and a product low in silicon and carbon is obtained.

19. The continuous process of producing ferrochromium which consists in passing an electric current through a molten bath containing chromite, silicide of carbon and a basic flux, adding fresh portions of the charge and withdrawing the product as desired.

In testimony whereof, I affix my signature in presence of two witnesses.

FREDERICK M. BECKET.

Witnesses:

R. L. MacDonald,

Chas. M. Saxe.