UNITED STATES PATENT OFFICE.

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METHOD OF REDUCING ORES.

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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 Methods of Reducing Ores, of which the following is a specification.

This invention relates to the production of metals of low-carbon content, and while capable of general use is more particularly intended for the production of such refractory metals as chromium, tungsten, molybdenum and vanadium, and the alloys of these metals with iron and nickel.

The invention contemplates the employment as a reducing agent of boron, or of certain alloys or compounds of boron wherein the boron is in a non-oxidized state and is therefore capable of acting as a reducing agent for oxids or oxidized ores or compounds. As suitable reducing agents, I may mention boron of commercial purity or grade, ferro-boron, and the borids or boron compounds of carbon, calcium or the like. The use of boron in any of these forms presents particular advantages in the production of metals or alloys which are required to be low in carbon and silicon, and more particularly in such cases where the presence of a small proportion of boron is either advantageous or unobjectionable.

As a specific example of the process I will describe its application to the manufacture of low-carbon ferrochromium from chromite. In case the boron is not combined with or used in conjunction with another element capable of acting as a reducing agent, typical reactions may be expressed as follows:

$$Cr_2O_3 + 2B = 2Cr + B_2O_3,$$
$$3FeO + 2B = 3Fe + B_2O_3.$$

In case a carbon borid or carbon-boron compound is employed the proportion of boron is preferably reduced in accordance with the carbon content, the carbon under these conditions serving also as a reducing agent. In similar manner, when commercial boron or ferro-boron containing carbon, silicon or other unoxidized impurities or constituents capable of exerting a reducing action on the components of the ore are used, these impurities are considered in the preparation of the charge. The reducing agent may be used in substantially the proportion required to combine with the oxygen of the charge, or in somewhat smaller or greater proportion, depending upon the character of the product desired and whether boron is a desirable or non-injurious constituent thereof. In cases in which it is desired to produce a product low in boron or free from boron, the ore is preferably employed in excess; on the other hand where boron is unobjectionable or is a desirable constituent of the product, a somewhat higher efficiency of operation may be secured by using a slight excess of the reducing agent, or such excess as may correspond to the desired boron content of the product.

The operation is facilitated by the presence in the charge of a base capable of uniting with the oxid of boron produced. Most commercial chromites contain from 8 to 15 per cent. of alumina and a similar proportion of magnesia, and to the extent of their presence these serve the purpose of a basic flux. In case of ores free from basic constituents, or in case of the deficiency of such constituents a suitable basic flux as lime is added as required, the object being the formation of a slag having a suitable fusing point and a proper degree of fluidity at the working temperature of the furnace. Obviously, an acid flux may be added should the constitution of the charge require it for the production of a proper slag.

In case of the employment of calcium borid, or of calcium-boron compounds or alloys containing free calcium or boron, both the calcium and boron constituents serve as reducing agents and are taken into account in compounding the charge, as in the case of the carbon-boron compounds above referred to. In this case the oxidation of the calcium and boron give rise respectively to basic and acid slag constituents. This presents the advantage that a smaller proportion of flux is required to be added to the charge, with a corresponding reduction in the weight of inert material required to be heated to the reacting temperature.

The reduction is preferably carried out in an electric furnace, and where a fused metallic product low in boron is required, the use of the electric furnace, or of a furnace capable of affording a like high temperature, is probably essential. The electrodes may be of carbon, or of a refractory metal or alloy suitably water-cooled, in accordance with the proportion of carbon permissible in the product. The lining of the furnace should be chosen with reference to the composition of the slag to resist so far as possible its corrosive effect. In case very low percentages of carbon are not required, the furnace may have a hearth or lining of carbon. The operation is preferably substantially continuous in character, the charge materials being supplied as required and the molten products tapped from the furnace. The slags are advantageously utilized for the production of borates, as for example the borates of the alkali metals, or they may be reduced by carbon in a separate operation. In the latter case the boron constituent is recovered, usually in the form of an alloy with the other reducible constituents of the slag, as for example, an alloy of boron with silicon, or with silicon and calcium, often in conjunction with a considerable proportion of the metal, as chromium, etc., originally reduced; in this form the boron may be repeatedly utilized for the reduction.

By the expression "refractory metals" occurring in certain claims, I mean such metals as require the application of heat to the charge to maintain the reacting temperature for their reduction by boron or alloys or compounds of boron with production of a reduced metal free or substantially free from the unoxidized reducing agent, the reaction not being self-propagating in character.

I claim:

1. The method of reducing ores of refractory metals, which consists in smelting a charge containing such ore and boron, while applying heat to the charge and maintaining therein a temperature sufficient to reduce the same.

2. The method of reducing ores of refractory metals and producing alloys thereof with iron, which consists in smelting a charge containing such ore and ferro-boron.

3. The method of reducing ores of refractory metals which consists in electrically smelting a charge containing such ore and boron.

4. The method of reducing oxid ores of refractory metal which consists in electrically smelting a charge containing such oxid ore and boron, the boron being present in substantially the proportion required to combine with the oxygen of the ore, whereby a product low in boron is obtained.

5. The method of reducing ores which consists in smelting a charge containing an ore reducible by boron, boron and a basic flux.

6. The method of reducing oxid ores of refractory metals which consists in smelting a charge containing such oxid ore, boron and a basic flux, the boron being present in substantially the proportion required to combine with the oxygen of the ore, whereby a product low in boron is obtained.

7. The method of reducing ores and producing iron alloys which consists in smelting a charge containing an ore reducible by boron, and ferro-boron.

8. The method which consists in smelting an ore with boron, thereby producing a metal or alloy and a slag containing boron, and smelting such slag to recover boron therefrom.

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

FREDERICK M. BECKET.

Witnesses:

J. N. DEINHARDT,

DEAN BURGESS.