No. 754,262. Patented March 8, 1904.

UNITED STATES PATENT OFFICE.

FREDERICK C. WEBER, OF CHICAGO, ILLINOIS.

PROCESS OF CLEANSING AND IMPROVING THE QUALITY OF IRON OR STEEL.

SPECIFICATION forming part of Letters Patent No. 754,262, dated March 8, 1904.

Application filed March 27, 1902. Serial No. 100,310. (No specimens.)

To all whom it may concern:

Be it known that I, FREDERICK C. WEBER, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented or discovered a certain new and useful Improvement in the Art or Process of Cleansing and Improving the Quality of Iron or Steel, of which the following is a specification.

The discovery or invention relates to a process by which iron or steel will be cleansed of impurities and its quality improved, rendering the metal better adapted for the various purposes and uses to which it may be applied.

The object of the invention is the attainment and assurance of more positive and certain results as to the improved nature of the finished product than has hitherto been attained from attempts heretofore made to accomplish the result; and the invention consists in the addition to iron or steel when in a molten state of binary metallic borids and alloys of iron with the basic metal of the particular borids used for producing a chemical reaction and a chemical change, whereby the impurities will be eliminated and the basic metals of the borids and of the alloys united with the iron or steel and otherwise, as hereinafter more fully described, and pointed out in the claims.

It is well known that commercial iron and steel are contaminated to a greater or less extent with impurities, some of which should be removed and the character of others of which changed in order to improve the quality of the iron or steel, and the present invention attains the removal of some of the impurities and changes the character of others by the cleansing process constituting the essential feature of the invention, and in the application of the process of the invention it is necessary to understand the composition and properties of the metal before proceeding with the treatment to cleanse and improve the metal. As oxid of iron and free oxygen are always present in pig-iron and steel and as these metals when in a molten state are true solvents governed by the physical laws which apply to all solvents these conditions are utilized in bringing about the needed chemical changes. The oxid of iron and free oxygen always present in molten metal react with nascent boron produced by chemical reaction. This result of chemical reaction with the process of the present invention is obtained by the use of the binary borids and alloys of iron with the basic metal of the particular borids used—as, for instance, binary borid like ferroborid and another alloy or combination like ferrotitanium will give the same combination as ferrotitanium-borid, which is a true ternary molecule and best adapted for the cleansing and purifying purposes.

After testing the metals for determining the impurities contained therein—such as baryta, silica, magnesia, alumina, and other earths or foreign substances or other matter—it will then be possible to make the combination of the binary metallic borid and the alloy of iron with the basic metal of the particular borid and introduce the same into the molten metal for cleansing and bringing about the desired modification or change required. The alloy of iron of the particular borid used can be titanium, uranium, tungsten, nickel, chromium, vanadium, and others, which possess the requisite properties to be imparted to the iron or steel when they form the basic metals or radicals of the binary metallic borids employed or the binary compounds employed.

The binary metallic borids employed may be obtained by any suitable process, and the metals to be treated are melted, and the binary metallic borid and the alloy of iron of the particular borid employed are added to the molten metal in such quantity as may be indicated by the composition and character of the metal and the uses and purposes to which it is to be applied. After the binary metallic borids and the alloys of iron with the basic metal of the particular borids employed are introduced into the molten metal the boron becomes nascent and decomposes the reducible oxids and combines with the free oxygen and forms boric anhydrid, which will combine with the impurities and by chemical reaction cause the impurities to form a thin liquid slag or scum, which can be readily removed, and at the same time a chemical change takes place by which the basic metals of the metal-

lic borids and the alloys of iron with the basic metal of the particular borids employed are made to unite with the iron or steel under treatment, changing the nature of the iron or steel accordingly. These results are attained by the solvent properties of the molten iron or steel, which acting as a solvent for the binary metallic borids and the alloys of iron of the particular borids employed causes chemical action to occur from which the desired results are obtained.

The modifying influence of a combination of alloying metals can be practically and successfully employed in the production of iron and steel under the process of the present invention. If the cleansing of the metal is attained by the use of, as an illustration, boromanganese or chromium borid, the addition to the metal after it is cleansed of a combination of alloying metals—such as chromium and tungsten and chromium and manganese in the form of chromium-manganese, chromium-tungsten, or tungsten-manganese—will result in carrying into the metals the characteristics of the alloys to the benefit, advantage, and improvement of the final or finished product. The treatment of the metals requires in some cases a larger quantity of the basic metal of the metallic borids employed and in some cases also the addition of some other metal, and these requirements if indicated can be met by the exercise of judgment, so as to bring about the best results according to the varying conditions by adding the desired metal in the form of an iron alloy of the particular borids employed; but in all cases the boron must be depended upon for reacting chemically upon the contained oxygen and oxid and impurities and have the basic metals in such binary metallic borids or the added basic metal of the alloys at the same time acted upon by the molten iron or steel, the chemical properties of which are brought into action.

It will be understood that in the use of the binary metallic borids and alloys of iron with the basic metal of the particular borid employed one reaction of the molten metal serves to remove the impurities, and in addition the modifying effects of the third element in the shape of an alloy of iron is transmitted to the metal acted upon. The nascent atoms produced enter into combination with the mass of molten metal and act to eliminate the impurities of the metal by the boron thus introduced, and the desired properties for the metal can be obtained through the alloy of iron with the basic metal of the particular borid to the extent that the addition of the third metal can produce a metal of the properties desired.

The calculation for determining how much metallic borids for cleansing molten metal to add to the metal must start first by ascertaining how much free oxygen is contained in the molten metal, which free oxygen is to be eliminated as boron trioxid. Next, how much oxygen is present in the oxids reducible by boron must be ascertained, which oxygen likewise is also to be eliminated as boron-trioxid, so that the addition to the metal in chemical proportions of the metallic borids employed will eliminate the boron trioxid from the two sources named. The boron trioxid produced will combine with the oxids not reducible by nascent boron and form borates, which borates in turn will flux out the non-reducible oxids, which are magnesia and alumina, while the reducible oxids are iron and manganese. The nitrogen present in the molten metal will also be eliminated as titanium-nitrid, and in order to eliminate the nitrogen a determination for nitrogen must be made of the to-be-treated metal. Any excess of titanium will alloy with the mass of the iron or steel; but the boron must not be added in excess to any extent, as an excess of nascent boron over that required will attack iron carbids, thus rendering it necessary to determine the amount of free oxygen and employ the metallic borids or boron in chemically-equivalent proportions correspondingly, as the boron attacking the iron carbids will form B_2C_2, which is objectionable.

The borates formed as above noted can be depended upon to rid molten iron or steel of the non-reducible oxids contained in the iron or steel, together with the slags, as borates makes one of the best fluxes known, dissolving considerably more than their own weight of oxids, slags, and silicates. Having cleansed the molten metal of its nitrogen and free oxygen by the use of metallic borids in chemically-equivalent proportions, together with the reducible oxids and the slags, the cleansed metal is in the best possible condition for changing its character by adding modifying alloys or combining the basic metallic borid used. For instance, using a combination of ferrotitanium, ferroboron, and ferromanganese in making manganese steel the ferrotitan and ferroboron will cleanse, and the ferromanganese will alloy with the steel, making any percentage combination desired by adding the required amount of manganese. Using ferrotitanium boron and ferromanganese, as manganese-titanium boron, or boron-manganese, ferroboron and ferromanganese, will also make the resultant a manganese steel. The combination required can be ascertained absolutely accurate stoechiometrically for the cleansing of the metal and can be modified as may be requisite. These series of combinations can be made to produce all of the recently-formed alloy steels, and in each case absolutely correct results can be calculated to form any kind of metal required which can be produced by the materials employed. Thus the tensile strength of steel-wire and wire-rods can be increased by using titanium, the ductility of boiler-plate

and tin-plate can be increased by adding vanadium, armor-plate can be made by adding nickel, chrome-steel can be made by adding wolfram, and so on by adding the requisite modifying alloy for the production of the metal desired.

It is not to be understood that the adding of metallic borids in chemical proportions to impurities contained in the molten metal is such chemical proportions as will make chemically-pure iron or steel, but that such addition is to be one that will remove the impurities so fully as that the cleansed metal will no longer have the qualities appertaining to the uncleansed and non-improved metal, but will have the new qualities brought about by the cleansing action and the modified quality of the added metal or metalloid. The modifying influence of the combination of alloying metal can be practically and successfully employed in the production of iron and steel under the process of the present invention if the cleansing of the metal is attained by the use of, as an illustration, boron-manganese or chromium-borid, and the addition to the metal after it is cleansed of a combination of alloying metals—such as chromium and tungsten and chromium and manganese in the form of chromium-manganese, chromium-tungsten, or tungsten-manganese—will result in carrying into the metals the characteristics of the alloys to the benefit, advantage, and improvement of the final or finished product.

It will be further understood that the decomposed binary borids and a titanium alloy—that is, a metal with titanium—as, for instance, one of iron or manganese in combination—will cleanse the iron or steel of its contained oxygen and nitrogen and that the boron-trioxid formed as a result of ridding the iron and steel of the oxygen and nitrogen will further act and combine with the slags and irreducible oxids and produce a liquid slag-scum which will rise to the surface of the molten metal, leaving the metal clear of its impurities. This employment of binary borids and a titanium alloy constitutes the essential and important step of the process of this invention.

What I regard as new, and desire to secure by Letters Patent, is—

1. The herein-described process of cleansing of oxygen slags, and occluded nitrogen and improving the quality of iron and steel in one operation, which consists in adding to the to-be-treated molten metal soluble binary metallic borids decomposable in solution under heat furnishing nascent atoms for cleansing the metal, and introducing into the metal when in a molten state alloys of iron with the basic metal of the particular borid used, substantially as described.

2. The herein-described process of cleansing of oxygen slags, and occluded gases and improving the quality of iron and steel in one operation, which consists in melting the same and adding thereto when in a molten state soluble binary metallic borids decomposable in solution under heat furnishing nascent atoms for cleansing the metal, and modifying alloys of iron, whereby impurities will be eliminated by chemical reaction and the radical metals of the borids and of the alloys will be united with the iron or steel, substantially as described.

3. The herein-described process of cleansing of residual oxygen slags, and occluded nitrogen and improving the quality of iron and steel in one operation, which consists in melting the same and adding thereto when in a molten state soluble binary metallic borids decomposable in solution under heat furnishing nascent atoms for cleansing the metal and metallic alloys, whereby impurities will be eliminated by chemical reaction and the radical metals of the crystalline borids and alloys will be united with the iron and steel, substantially as described.

4. The herein-described process of cleansing and improving the quality of iron and steel, which consists in adding to the to-be-treated metal soluble binary metallic borids alone in chemically-equivalent proportions with the contained impurities to be removed from any given metal, the borids being decomposable in solution under heat furnishing nascent atoms for cleansing the metal, whereby the impurities will be eliminated by chemical reaction, substantially as described.

5. The herein-described process of cleansing of residual oxygen slags, and occluded nitrogen and improving the quality of iron and steel in one operation, which consists in melting the same and adding thereto, when in a molten state, soluble binary metallic borids decomposable in solution under heat, furnishing nascent atoms for cleansing the metal, and a titanium alloy whereby impurities and occluded nitrogen will be eliminated by chemical reaction, and the radical metals of the crystalline borids and titanium alloy will be united with the iron or steel, substantially as described.

FREDERICK C. WEBER.

Witnesses:
THOMAS A. BANNING,
OSCAR W. BOND.