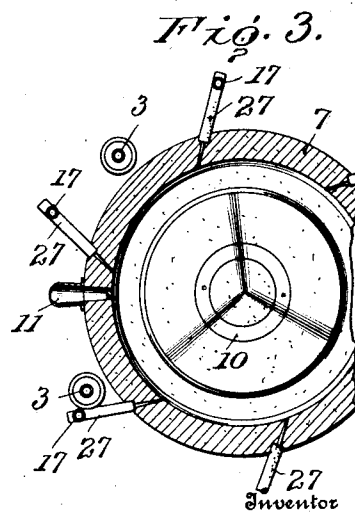
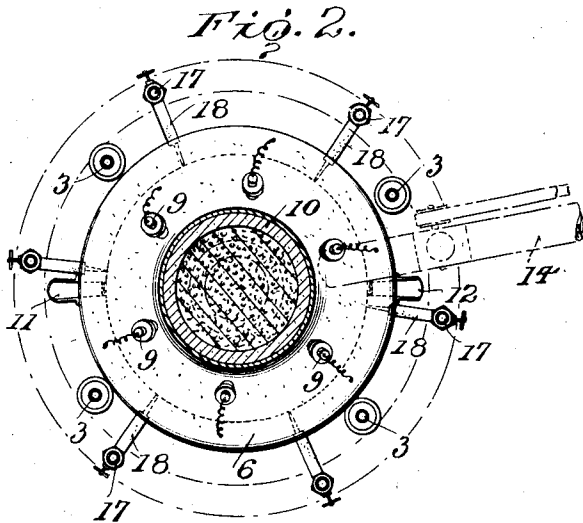
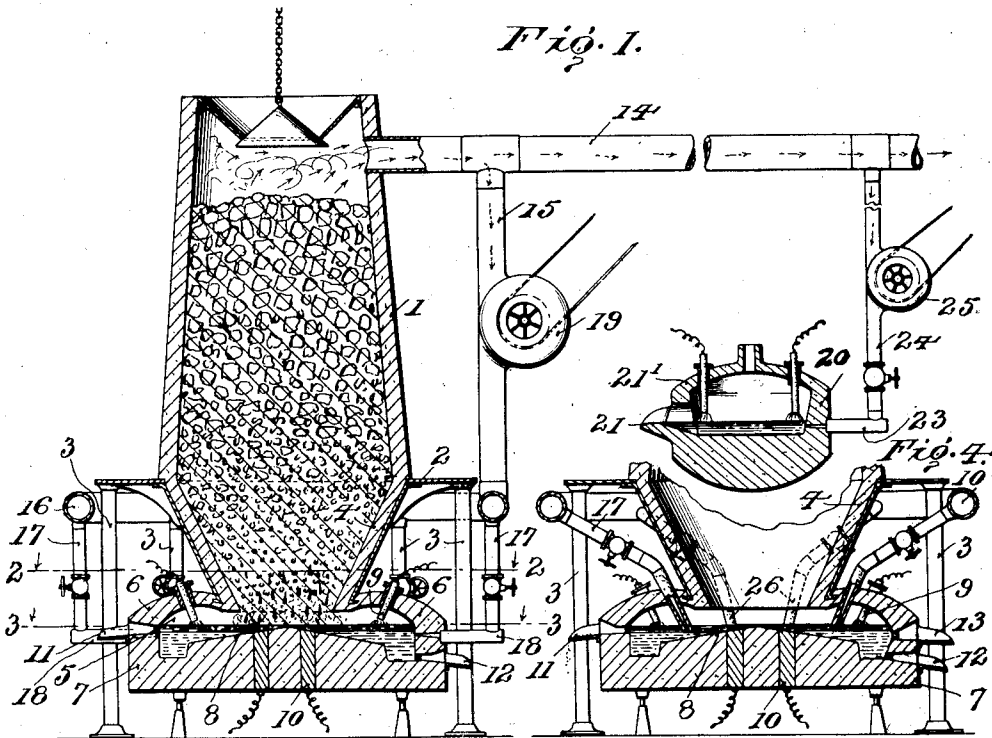


A. E. GREENE.
METHOD OF PRODUCING REFINED METALS AND ALLOYS.
APPLICATION FILED APR. 10, 1908.

1,034,784.

Patented Aug. 6, 1912.



Witnesses

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METHOD OF PRODUCING REFINED METALS AND ALLOYS.

1,034,784.

Specification of Letters Patent.

Patented Aug. 6, 1912.

Application filed April 10, 1908. Serial No. 426,334.

To all whom it may concern:

Be it known that I, ALBERT E. GREENE, of Pueblo, Pueblo county, Colorado, have invented a new and useful Improvement in
5 Methods of Producing Refined Metals and Alloys, which invention is fully set forth in the following specification.

This invention relates to improvements in methods of producing and refining of metals
10 and alloys, particularly to the production of low carbon iron and its alloys.

My invention has for one of its primary objects to eliminate from metals or alloys undesirable elements by a method of selective
15 oxidation in which the metal or alloy, while kept in a molten condition by an electric heating current, is subjected to an oxidizing gas, while controlling the temperature of the molten metal or alloy between desired
20 limits by regulating the supply of electric energy thereto, and thereby effecting selective oxidation of one or more of the undesirable elements in the metal or alloy.

A further object of my invention is to secure oxidizing conditions in a molten bath
25 of metal or alloys containing undesirable elements while maintaining the surface of the bath exposed to a reducing atmosphere or to a protecting slag.

A further object of my invention is to produce alloys from other alloys by the elimination of one or more of the undesired
30 elements of such alloy by means of selective oxidation.

A further object of my invention is to utilize the hot gases escaping from the smelting furnace to effect oxidation in the
35 reduced molten metal and to utilize the resulting reducing gases as a carrier of heat from the heated area about the electrodes to the reducing and fusing zone of the charge, thereby effecting the melting of the reduced
40 metal in a reducing atmosphere.

Another object of my invention is to maintain the metal bath fluid and to facilitate the removal of the acidic elements there-
45 in by use of a basic slag while highly heating the bath by the electric heating current and effecting selective oxidation.

The above objects, together with others, will be more fully explained in the detailed
50 description.

My invention, broadly stated, consists in maintaining the metal or alloy to be refined

in a fluid condition by means of an electric
heating current and controlling the tem- 55
perature of the metal suitable for selective
oxidation of any one or more of its elements
by regulating the supply of electric energy
and subjecting the fluid metal or alloy to 60
the action of a gas capable of giving up
oxygen to oxidize said element or elements,
and capable of producing a reducing gas
above the surface of the metal.

My invention further consists in conduct- 65
ing the reducing gas or gases, which have
been in heat-interchanging relation with the
electrically heated metal, to a body of ore
associated with a solid reducing agent and
flux in an electric smelting furnace, thereby 70
heating the charge, to effect reduction and
melting of the reduced metal, then with-
drawing the hot gases resulting from the
smelting operation and bringing them in
contact with the fluid metal at the base of 75
the furnace to again effect selective oxida-
tion of one or more of said impurities, and
thereby making the reduction and refining
operations continuous.

In operating on iron containing carbon as- 80
sociated with elements such as silicon and
phosphorus, I prefer to use a basic slag, for
the reason that the high temperature of the
electrically heated molten metal is sufficient
to keep a basic slag in fluid condition, and 85
such a slag facilitates the removal of acidic
elements from the metal. It is to be under-
stood, however, that I may use slags that are
not classed as basic. The hot gases may be
introduced into the metal bath from below, 90
or injected into the slag through which the
reduced metal passes into the bath, or in
such other manner as may be deemed desir-
able.

My invention further resides in-features 95
which will be more clearly pointed out in the
detailed description.

For the purpose of illustration, I have
hereinafter specifically described one of the
ways in which I may practise my invention, 100
reference being had to the claims for defin-
ing the limits thereof.

To assist the description, reference is had
to the accompanying drawings, illustrating
suitable apparatus for carrying out my proc- 105
ess, though other apparatus may be em-
ployed, as my process is not confined to use
of this particular apparatus.

Figure 1 is a sectional elevation of an electric smelting furnace and a supplementary refining furnace associated therewith. Fig. 2 is a horizontal sectional view of Fig. 1, taken on the line 2—2. Fig. 3 is a cross-sectional view on the line 3—3 of Fig. 1, showing a slightly different arrangement of the twyers. Fig. 4 is a view of a furnace similar to that of Fig. 1, except that the twyers are shown as entering from above the bath.

Referring to Fig. 1, in which is shown a combined shaft and electric furnace, shaft 1 of the furnace is supported on plates 2 carried by a series of columns 3. Converging downwardly from the bottom of shaft 1 is a bosh having walls 4 of refractory material which may be provided with cooling means, as is common in furnace construction of this kind, or the water-cooling devices may be entirely omitted. Beneath the bosh is an annular refining chamber 5 formed by the lateral projection of the wall 6 of the furnace joining the side walls 7 of the furnace hearth 8. Extending downwardly through the lateral or roof wall are electrodes 9, properly insulated, which may be arranged vertically or inclined as desired, and preferably provided with means for adjustment in a manner well understood.

The hearth of the furnace which is of refractory material is preferably higher at the center inclining toward the outer wall where occurs the deeper portion of the refining chamber 5. The hearth is provided with one or more electrodes 10 centrally located. When one electrode is employed, it is preferably annular. When several are used, they are grouped about the central part of the hearth. In the side wall of the refining chamber is located one or more slag openings 11, at a level slightly below the top of the electrode 10. A metal tapping opening 12 is also provided. The bottom of the hearth at the metal tapping side is made somewhat lower than elsewhere to facilitate draining when the hearth is emptied. A second metal tapping hole 13 appearing in Fig. 4 above the lower opening 12 may be, and preferably is, provided for the removal of metal without completely draining the refining chamber, as is apt to happen when the metal is drawn off at the lowest point. The outer peripheral portion of the hearth thus constitutes an annular conduit, the size of which is so proportioned as to determine to a certain extent the quantity of current carried by the molten metal and slag contained therein.

Near the top of the furnace shaft is located a main draw-off conduit 14 having a down-take pipe 15 which leads to a distributing or bustle pipe 16, which has pipe connections 17 to one or more twyers 18. As shown in Fig. 1, these twyers enter the side walls of the refining chamber, and are shown

as terminating at about the separating line of the metal and slag. Instead, however, the twyers may be located in the top of the smelting chamber as shown in Fig. 4, and open into the slag level or just above the same, or the twyers may be located in the hearth, as shown in Fig. 2. Pipes 17 are provided with gas control valves for the purpose of regulating the flow of gases to the refining chamber, and means, such as a blower 19, are provided, preferably in the down-take pipe, for facilitating the introduction of gases from the stack into the refining chamber.

In connection with the main reducing and refining furnace, I have shown a second electric refining furnace of any well-known type, such as a Heroult tilting furnace, in which the crucible 20 of the furnace is provided with a tapping hole 21, which may also serve for entrance of the metal to be treated, and a cover 21' supporting electrodes 22. The wall of the crucible is provided with an opening for receiving a twyer 23 which, as shown, opens at a level below the lip of the slag spout and is connected with the main 14 by a valved pipe 24, provided with a blower 25.

Any suitable source of electric current may be used, and the heating of the metallic bath thereby be accomplished in any well known manner.

In carrying out my process, I describe its application to the production of refined low carbon iron, but it is to be understood that it is equally applicable to alloys of iron such as ferrosilicon and the like, and to other ores than iron, such as manganese and chromium. The ore, such as iron oxid, carbonate or other iron compound, together with the required portion of carbon and a suitable flux, is introduced into the furnace through the charging bell at the top of the furnace. After the heat of the electric current has established in the refining chamber 5 a bath of metal with a cover of fluid slag, and the temperature of the metal has been raised by passage of the electric heating current through the bath to a temperature suitable for selective oxidation of one or more of the impurities in the iron, such as carbon, as regards silicon or other elements in the iron, the hot furnace gases containing chiefly CO_2 and CO , are withdrawn from the shaft 1 by the blower 19 and introduced in regulated quantity to the molten metal through twyers 18. In the present example, the conditions of temperature in the bath enable the selective oxidation of the carbon in the iron, thereby removing the same from the iron and reducing the CO_2 to CO . The supply of furnace gas to the refining chamber is controlled so as to supply the requisite oxygen to the metal, whereby the resultant gas coming from the reaction con-

stitutes a reducing atmosphere in the refining chamber consisting principally of carbon monoxid in a highly heated state. This reducing atmosphere in the chamber containing the carbon electrodes is effective in protecting them from otherwise rapid oxidation and also in protecting the molten metal. The reducing gas now leaves the highly heated space in the refining chamber and enters the base of the ore charge. Here the reducing gases part with their heat in large measure to the charge, and thereby effect reduction of the ore to metal and fusion of the reduced metal, which, protected by the reducing atmosphere at the entrance to the refining chamber, pass through the slag covering into the pool of molten metal beneath, there to be acted on by the incoming carbon dioxid. The gases leaving the reducing zone contain CO and CO₂, and pass into the upper part of the shaft lowered in temperature to a point below that at which CO₂ reacts with carbon. They are ready now to be withdrawn and returned for use in the refining operation.

In the example given, where iron is the metal reduced and refined, the temperature of the bath is preferably kept above the critical temperature for the selective oxidation of carbon, as regards other elements such as silicon, by means of the heat developed by the electric current. It will be understood that the gaseous mixture is regulated to correspond with the temperature maintained, in order to produce the oxidation of the desired element or elements. In practice I have found that a gaseous mixture in which the oxygen available for oxidizing purposes has a pressure of 92 millimeters of mercury will, when the bath is maintained at a temperature of 1892° C., eliminate the carbon to a trace. With a gaseous mixture in which the pressure of the oxygen available for oxidizing purposes had an oxygen pressure of 80 millimeters of mercury, and where the bath was maintained at a temperature of 1725° C., the carbon was reduced to less than .06 per cent. Likewise, by suitably varying the oxygen constituent of the gaseous mixture, the selective action of the gas on carbon can be accomplished at correspondingly varying temperatures. I may employ, however, other selective temperatures such as that at which silicon will be eliminated first. If it is desired to simultaneously remove one of the acidic elements in the iron, such as silicon, I may, and preferably, do employ a basic slag which forms at the high temperature of the refining chamber a readily fusible cover for the molten iron, and thereby enables the removal of the silicon.

Instead of conducting the refining operation wholly in the main furnace, the metal may be treated in a separate electric furnace for removal of all or a part of the impuri-

ties. For this purpose the metal, after partial refining in the main furnace, or metal which has not been refined at all, is introduced into the second furnace, where the CO and CO₂ gases from the stack are caused to act on the molten metal in regulated quantity to effect an oxidizing condition in the bath and a reducing atmosphere above the bath, while the temperature desired for any particular reaction is obtained by regulating the electric heating current. By use of this process, the iron may be reduced in carbon while retaining the silicon, or the silicon may be partly or wholly removed retaining the carbon, or both elements may be removed successively or at one operation. In a similar way, other elements in the iron may be removed. The use of high temperatures not only permits of selective oxidation of the elements which it is desired to be removed one or more at a time, but enables the decarburized metal to be kept in a fluid condition which facilitates its removal from the furnaces. They also insure in a large measure the absence of occluded gases, such as oxygen, which have an injurious action on the metal.

The proportion of the carbon to the charge of ore is preferably so regulated that practically no free carbon appears in the electrically heated zone. If it were otherwise, much of the oxygen of the CO₂ intended for oxidizing elements of impurity in the metal would go to the free incandescent carbon, necessitating a larger supply of gases to pass through the refining chamber, and requiring more electric energy to be expended in maintaining the temperature therein.

Instead of introducing the CO₂ gases into the body of the metal, they may be introduced into the slag through which the drops of metal pass, or the gas may be introduced into the refining chamber between the electrodes and the base of the charge. This is made possible in my process by reason of the fact that I provide for the absence of free carbon in the vicinity of the electrically heated zone.

Care should be taken to keep the carbon electrodes out of contact with the decarburized metal or finished product both because of the contamination of the product and because of the evil effects of short circuiting. I prefer to keep the ends of the electrodes above the slag layer and in arcing distance therefrom. The temperature of the bath is regulated by the supply of electric energy thereto in any effective manner, such means not being shown, as it forms no part of my present invention.

The CO₂ gas used for refining may be derived from other sources, such as from a lime kiln, and its content in CO₂ may be varied to suit particular conditions.

My process enables the continuous and direct production of refined iron or other metals from their ores in a single operation by use of heat derived from electric energy and without the use of combustion with air or other gas, except such as may occur by use of CO and CO₂ reacting with the ore with a minimum loss of metal.

Fig. 4 shows a sectional detail of the lower part of an electric refining furnace similar to that of Fig. 1, except that the twyers 26 are located in the top of the refining chamber and terminate about on a level with the lip of the slag outlet 11 near the entrance to the annular refining chamber. With this arrangement, the pool of metal is less disturbed, the oxidation of undesirable elements taking place mainly while the metal flows into the bath.

Instead of locating the twyers in the roof of the refining chamber as in Fig. 4 or radially as in Fig. 1, the twyers 27 may be disposed tangentially as shown in Fig. 3, whereby a circulation of the bath is effected which facilitates contact of the gases with the molten metal.

Instead of conducting the selective oxidation of the undesirable elements in the molten metal in presence of a slag which is capable of retaining the element or elements to be eliminated, such slag may be omitted.

The terms "high-carbon" and "low-carbon" as used herein are relative terms and are not intended to specify any particular percentage of carbon.

What is claimed is:—

1. A continuous process of reducing ores and refining metals and alloys, consisting in withdrawing hot gases containing carbon dioxid from an ore-smelting furnace, passing said gases in regulated quantity into contact with fluid metal maintained at a suitably high temperature by electrically generated heat to effect in said metal selective oxidation, and passing the resulting heated reducing gases into contact with the ore in said furnace, thereby reducing the ore and melting the reduced metal to replenish the metal bath.

2. A continuous process of reducing ores and refining metals and alloys, consisting in withdrawing hot gases containing carbon dioxid from an ore-smelting furnace, passing said gases in a suitably regulated quantity into contact with a bath of molten metal and slag through which an electric heating current is passed to effect selective oxidation in said molten metal, and passing the resulting heated reducing gases into contact with the ore charge in said furnace, thereby reducing the ore and melting the reduced metal to replenish the metal bath.

3. A process of reducing ores and refining metals and alloys, consisting in establishing a molten bath consisting of metal and a

slag cover for the same, passing through said bath an electrical heating current to raise the temperature of the metal to a point for selective oxidation, subjecting the heated metal to a gas containing oxygen in suitably regulated quantities to effect said oxidation, and subjecting a body of ore, reducing agent and flux to the resulting heated reducing gases to reduce the ore and raise the temperature of the reduced metal.

4. A process of reducing ores and refining metals and alloys, consisting in establishing a molten bath consisting of metal and a slag cover for the same, passing through said bath an electric heating current to raise the temperature of the metal to a point for selective oxidation, subjecting the heated metal to a gas containing carbon dioxid in quantities suitable for effecting such selective oxidation, but unsuitable at the selected temperature for effecting a like action upon the element or elements which it is desired to retain unoxidized, and subjecting a body of ore, reducing agent and flux to the resulting heated reducing gas to reduce the same and melt the resulting metal.

5. A process of reducing ores and refining metals and alloys, consisting in providing a molten bath containing a metal and a slag cover for the same, heating said metal to raise its temperature to a point for selective oxidation, passing in contact with the same a gas containing oxygen in regulated quantities suitable at the temperature selected to effect said oxidation but unsuitable for a like action upon the element or elements which it is desired to retain unoxidized, and subjecting a body of ore, reducing agent and flux to the resulting heated reducing gas to reduce the ore and melt the reduced metal.

6. A process of reducing ores and refining metals and alloys, consisting in establishing a molten bath of metal, applying heat thereto to raise its temperature to a point for selective oxidation, subjecting said heated metal to a gas containing oxygen in suitably regulated quantities to effect selective oxidation but in quantities unsuitable for a like action upon the element or elements which it is desired to retain unoxidized, smelting a body of ore with the resulting heated reducing gas, and returning a portion of the hot gases from the smelting operation to the metal to be refined.

7. A process of producing low carbon metals or alloys, consisting in feeding a charge of ore flux and reducing agent into a smelting furnace having a refining chamber at its base, maintaining a bath of metal in said refining chamber and regulating the temperature of the bath within desired limits by controlling the passage through of an electric current, withdrawing the gases from the smelting furnace, and

passing the same through said bath to de-
carbonize the metal, and then passing the
resulting reducing gas into the ore charge
to reduce the ore and melt the reduced
5 metal.

8. A process of producing low carbon
metals or alloys, consisting in smelting an
ore charge in a furnace, withdrawing the
gases from the top of the furnace and intro-
10 ducing said gases into a bath of metal and

slag maintained within desired tempera-
tures by controlling the passage of electric
current therethrough.

In testimony whereof I have signed this
specification in the presence of two sub- 15
scribing witnesses.

ALBERT E. GREENE.

Witnesses:

W. B. KERRAM,

FREDERICK A. HOLTON.