UNITED STATES PATENT OFFICE.

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METHOD OF PRODUCING STEEL METALS.

1,017,807. Specification of Letters Patent. Patented Feb. 20, 1912.

No Drawing. Application filed October 10, 1911. Serial No. 653,784.

To all whom it may concern:

Be it known that I, AUGUSTE J. ROSSI, a citizen of the United States, and a resident of Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Methods of Producing Steel Metals, of which the following is a specification.

My present invention relates to processes for producing steel, and more particularly to the production of a steel of approved tensile strength, without aid, or content of hitherto practiced additions of manganese and silicon.

Hitherto in the manufacture of steel by either the Bessemer, or open hearth, or crucible methods, it has been deemed indispensable to add to the molten metal manganese and silicon for purposes hereinafter mentioned, the fact being that final steel products containing less than certain percentages of manganese, say from 0.4% to 1% or even somewhat more, are regarded as unfit for certain purposes, as for instance rails. This insistence on manganese is based on increase of ductility and tensile strength believed to be imparted by certain proportions of that metal. On the other hand, as is now well understood, excess of manganese produces the contrary effect, and, if excessive, prohibitory brittleness. Proper proportioning of manganese therefore presents an important, and often difficult, problem in actual industrial operations; the effect of manganese on oxid of iron present, and consequently the amount of manganese retained in the final product, varying unaccountably with baths of apparently the same composition as regards constituents other than said oxid. As is well known, manganese is almost invariably added to the metal in the forms of spigel-eisen, or ferro-manganese, according to the proportion of manganese desired in the final steel product. Advantage is taken of this association of iron with the manganese to utilize the alloy, or compound, as a recarburizing agent on account of its carbon constituent. Thus in the treatment by manganese of so-called Bessemer steel, the ferro-manganese, or spiegel-eisen, as the case may be, is usually introduced into the metal in the converter near the end of the blow in such proportions as to supply deficiencies of carbon, and assure in the final product the desired percentage of manganese after allowing for losses due to its reactions with the oxids. On the other hand, the ferro-manganese or spiegel-eisen is sometimes added to the metal in the teeming ladle instead of the converter.

In the production of steel by the open hearth, basic or acid, processes the manganese is likewise, in the forms of spiegel-eisen, or ferro-manganese, added usually to the prepared, or properly carburized, metal in the furnace. In the manufacture of crucible steel the manganese is similarly added to the metal before the same is poured from the crucible. It will thus be observed that according to present practice the carbon constituent of the spiegel-eisen or ferro-manganese is, or not, depended upon for recarburization according to convenience, or method, employed; but that, in all instances, incorporation of manganese as aforesaid is practiced as essential and for the purposes aforesaid. As to silicon, this element is usually introduced in the form of ferro-silicon and substantially similarly to the aforesaid additions of ferro-manganese or spiegel-eisen, the proportions of the silicon being such as to retain in the final steel product from about 0.06% to 0.2% of that element. The effect at present attributed to the silicon thus added is, in part, like that of manganese, reduction of the oxids of iron, and likewise, it has been claimed, a tendency to convert carbon present from the combined into the graphic state.

I have heretofore discovered that steel manufactured as aforesaid by aid of additions of manganese and silicon may be improved by also adding thereto, when melted, titanium in the form of ferro-titanium proportioned to incorporate titanium sufficient to combine with all undesired elements and compounds not previously removed by said manganese or silicon, for which invention Letters Patent of the United States, No. 1,003,805 were granted to me on September 19, 1911. I have also, however, discovered that the aforesaid additions of manganese and silicon, including spiegel-eisen, ferro-manganese and ferro-silicon, may, with

equally good, if not superior, results, be dispensed with entirely, provided sufficient titanium be added, this resulting in production of a novel high grade steel, more economically and readily produced than former steels of corresponding grade containing manganese and silicon.

My present invention may be practiced as follows, viz:—The iron ore employed is first smelted as usual. The resulting iron while molten is next purified to an extent by the usual procedures, that is to say there is removed therefrom many undesired elements and compounds therein contained as by aid of the air blast in the converter of the Bessemer process, or by aid of the oxidizing action of the producer gases of the open hearth accelerated by additions of ore or scrap, or both, or by aid of well known reactions produced in the metal prior to its further treatment in the crucible. Each of these heretofore long practiced methods of purification result, as is well known, in removing from the metal not only undesired elements and compounds but also incidentally substantially all of the manganese, silicon, and more or less, or usually most, of the carbon therein contained. My next step is, as usual, by any of the well known methods now practiced, except by additions of compounds or alloys containing manganese, to recarburize the metal purified as aforesaid, *i. e.* add thereto and incorporate therein while molten carbon sufficient to raise the total carbon content to the desired percentage. The very generally, if not universally, prevailing resort to additions of ferro-manganese or spiegel-eisen for recarburizing the "prepared metal," particularly that produced in the Bessemer converter, is thus avoided by my process.

When the steel is produced by the aid of the Bessemer or pneumatic process, I recarburize, either in the converter or in the intermediate ladle, by any of the well known recarburizing methods other than by ferro-manganese or spiegel-eisen. To the metal thus recarburized so as to contain the required percentage of carbon I add, either in the converter, or preferably in the intermediate ladle, the alloy of iron and titanium in quantity sufficient to incorporate enough titanium to satisfy the affinities therefor of all undesired elements and compounds present. I then pause in the operation a time determined to be sufficient to insure all the reactions possible with the titanium, after which the metal may be poured and cast into ingots as usual. When the ferro-titanium is introduced otherwise than in the converter, I prefer to add it to the metal while pouring. In cases in which the steel is produced by the open hearth, basic or acid, processes the ferro-titanium should be added on pouring the metal into the intermediate ladle and there likewise allowed to rest a time sufficient to insure all the reactions attributable to the titanium. In cases in which the steel is produced by the crucible process so called, the ferro-titanium should likewise be added to the metal as it is poured from the crucible into the intermediate ladle and there also allowed to rest a similar time as aforesaid.

In all the foregoing instances cited of the application of my process, whether to Bessemer, open hearth or crucible steel, it will be observed that my novel steel product is produced entirely without the aid of any of the hitherto practiced additions of manganese or silicon in any form.

Notwithstanding the absence in my final resulting steel product of added manganese and added silicon, it will be found that the tensile strength according to content of carbon will be fully as great as, and in some instances has proved greater than, that characterizing steel produced by the previous methods employing additions of manganese and silicon.

My resulting steel product is therefore distinguishable from those preceding it in the particulars that it will be found by chemical analysis to contain some titanium, if only traces, also approximately say not to exceed 0.2% of manganese, this, or usually less, being the remainder, after reactions, of the manganese incidentally contained in the materials employed. My said final product may also be distinguished as containing approximately say a few hundredths of 1%, or less, of silicon, this being also the remainder, after reactions, of the silicon incidentally contributed by the materials employed, and my said final product is also further distinguishable in that, notwithstanding it may contain only a moderate per cent of carbon, say for example not to exceed 0.5%, its tensile strength is as great, or greater, than though it had contained the heretofore usual percentages of manganese and silicon required for instance in steel used for rails.

My resulting product is thus broadly distinguishable from what has preceded it in the aforesaid particulars of containing some titanium, including traces thereof, much less manganese, much less silicon, if any more than traces, and less carbon than in previous steels of substantially the same or even less tensile strength.

I am aware that it has hitherto been suggested that beneficial results would follow additions to molten steel of aluminum alloyed with titanium, such alloy containing from 0.75 per cent. to 2.50 per cent. of titanium, and added in proportion of from two to four ounces of the alloy per ton of steel. This procedure I do not regard as constituting any part of my present inven-

tion, the proportion of titanium thereby added being altogether too small, *i. e.*

from $\frac{1}{23900}$ of 1% to $\frac{1}{3584}$ of 1%

of titanium, which is less than sufficient, in any case, to combine with and eliminate the undesired elements and compounds present even in the steel referred to, which does not appear to have been exempted from the aforesaid, hitherto deemed indispensable, additions of manganese and silicon for purification or other purposes, my invention being distinguishable from such procedure in that, among other differences, it dispenses with additions of aluminum, manganese and silicon, and to that end employs titanium in quantity sufficient to make up for their absence and impart to the resulting product, with enhanced economy and simplicity of operation, more desirable characteristics.

I am also aware that it has been previously suggested that titanium be added to steel in such large percentages as to justify designation of the resulting product as an "alloyed," or "titanium," "steel," *i. e.* a steel which owes its distinguishing properties chiefly to the presence of a thereto added and therein retained element other than carbon, such as titanium. My present invention is distinguishable from such procedures in that the steels referred to do not appear to have been exempted from the aforesaid hitherto deemed indispensable additions of manganese and silicon, and the amount of titanium added to justify designation of the product as a "titanium steel" is much greater than that employed by my method.

What I claim as new and desire to secure by Letters Patent is the following, viz:—

1. The method of producing steel characterized as containing less than 2% of titanium and less than 0.2% of manganese, which consists in first smelting iron ore, next in removing from the resulting iron while molten undesired elements and compounds together with, incidentally, manganese and carbon, next adding to the molten metal carbon, and finally adding thereto titanium in quantity sufficient to combine with and remove remaining undesired elements and compounds and leave in the resulting product less than 2% of titanium.

2. The method of producing steel characterized as containing less than 2% of titanium and less than 0.2% of manganese, which consists in first smelting iron ore, next in removing from the resulting iron while molten undesired elements and compounds together with, incidentally, manganese and carbon, next adding to the molten metal carbon, next pouring the metal and adding thereto an alloy of iron and titanium, next waiting a period, and, finally, pouring the metal into the mold, the said titanium being proportioned to combine with and remove remaining undesired elements and compounds and leave in the resulting product less than 2% of titanium.

3. The method of producing steel characterized as containing less than 2% of titanium, less than 0.2% of manganese and less than 0.02% of silicon, which consists in first smelting iron ore, next in removing from the resulting iron while molten undesired elements and compounds together with, incidentally, manganese, silicon and carbon, next adding to the molten metal carbon, and finally adding thereto titanium in quantity sufficient to combine with and remove remaining undesired elements and compounds and leave in the resulting product less than 2% of titanium.

4. The method of producing steel characterized as containing less than 2% of titanium, less than 0.2% of manganese and less than 0.02% of silicon, which consists in first smelting iron ore, next in removing from the resulting iron while molten undesired elements and compounds together with, incidentally, manganese, silicon and carbon, next adding to the molten metal carbon, next pouring the metal and adding thereto an alloy of iron and titanium, next waiting a period, and, finally, pouring the metal into the mold, the said titanium being proportioned to combine with and remove remaining undesired elements and compounds and leave in the resulting product less than 2% of titanium.

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Witnesses:
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