UNITED STATES PATENT OFFICE.

JACOB REESE, OF PITTSBURG, PENNSYLVANIA.

IMPROVEMENT IN PROCESSES OF DEPHOSPHORIZING IRON AND STEEL.

Specification forming part of Letters Patent No. **219,519**, dated September 9, 1879; application filed May 31, 1879.

To all whom it may concern:

Be it known that I, JACOB REESE, of Pittsburg, county of Allegheny, State of Pennsylvania, have invented a new and useful Improvement in the Metallurgy of Iron and Steel; and I do hereby declare that the following is a full, clear, and exact description thereof.

The object of this improvement is the dephosphorization of the metal in the course of its manufacture.

The enabling cause which I employ to produce the elimination of phosphorus from the metal is lime or oxide of calcium.

Heretofore, in the treatment of iron and steel various agents have been employed, such as would best act upon the different bases associated with the metal, and in this way lime, silica, alumina, iron-scale, oxide of manganese, &c., have been introduced into the molten metal in a solid condition, and in a powdered state by means of a blast; but in all cases, so far as I am aware, the agents have been introduced while there was a considerable portion of either silicon or carbon, or both, present in the molten metal.

Iron and steel cannot be readily or rapidly dephosphorized until the silicon is removed.

The first part of my invention therefore relates to the time and manner of employing the agent; and consists in injecting the lime or carbonate of lime in a finely-divided state into the molten metal at that stage of the process when decarburization and desiliconization shall have been practically effected and the molten metal is freed from interfering bases, so that the lime may be brought into immediate and intimate contact with the molten metal, whereby dephosphorization will be expedited, and an excess of lime, which might produce a condition of the metal resembling red-shortness, can be avoided; but when the metal is in this desiliconized and decarburized condition most favorable to its dephosphorization, it is also in a condition to be readily oxidized, which is a disadvantage in so far as the more thorough the dephosphorization is made by continuing the process the greater will be the oxidation of the metal and loss therefrom. Therefore the second part of my invention relates to the protection of the metal from oxidation while the process of dephosphorization is continued to the practically complete elimination of phosphorus; and it consists in injecting into the decarburized and desiliconized molten metal which is being dephosphorized by means of finely-divided lime, injected by means of a blast at the same time therewith, finely-divided oxide of iron, either separately or mixed with the lime used for dephosphorization, so that the finely-divided oxide of iron will supply an element which will prevent the oxidation of the bath without interrupting or retarding the process of dephosphorization.

On the 11th day of September, 1866, Letters Patent of the United States were granted to me for the use of "lime or oxide of calcium as a lining for reducers or furnaces wherein ores or metals are reduced or refined." On the 18th day of June, 1867, Letters Patent of the United States were granted to me for "the use of a covering of metallic oxides for protecting metals from the influence of carbon, substantially as described." On the 24th day of July, 1875, Letters Patent of the United States were granted to me for the injection of oxide of iron and other substance into the molten metal in the converter by means of the blast; and as one of the objects of each of the patents cited was the elimination of phosphorus and sulphur, I have cited them so as to more fully show the importance of dephosphorizing iron and steel, and to show that this invention is supplementary to and an improvement on said inventions, as therein set forth.

A great majority of the ores of iron are impregnated with phosphorus. The limestone and coal or coke with which the ores are smelted often contain phosphorus. From these causes it is estimated that ninety per cent. of all the pig metal manufactured in Great Britain and seventy-five per cent. of all the production of pig metal of the United States contains phosphorus to an extent unfitting it for the manufacture of steel. From this fact metal sufficiently low in phosphorus to be suitable for steel is now known as "Bessemer pig," and, owing to its scarcity and the necessary care required in its manufacture, commands from four dollars to six dollars per ton above the metals high in phosphorus. Hence it becomes a matter of great importance to eliminate phosphorus, so as to enable the manufac-

turer to produce a good quality of steel from pig metal high in phosphorus.

Phosphorus appears to be the most difficult to eliminate from iron of all foreign substances combined with it. It appears almost impossible to oxidize phosphorus in the presence of any considerable quantity of an acid substance; but when molten metal containing phosphorus is surrounded by a basic lining and a basic bath, and washed by a basic injection, the phosphorus becomes oxidized and passes from the metal into the slag as phosphoric acid. I find lime or the oxide of calcium the most suitable basic material for a lining, owing to its cheapness and its ability to withstand the heat and the chemical action of the metal or slag.

I shall now describe the means by which I introduce the lime as practiced in the different processes of manufacture of iron and steel.

In the manufacture of pig metal I inject lime of a finely-powdered state (both as an oxide and as a carbonate) into the hearth of the blast-furnace through the ordinary tuyeres, or through auxiliary tuyeres, by means of the blast, as more fully explained in Letters Patent No. 193,551.

The lime may be blown in a pure state, or may be admitted with oxide of iron. In the latter case the iron will be reduced, the oxygen will unite with the phosphorus, forming phosphoric acid, and thus the iron produced will be relieved to a great degree of phosphorus.

In blowing carbonate of lime into the blast-furnace by this process the carbon in chemical union with the lime will have a tendency to enter the metal and carbonize it to a higher degree than it would otherwise contain.

In the application of my improvement to the manufacture of steel by the Bessemer process, I line the converter with limestone cut into suitable blocks, (magnesian limestone preferred.) This stone lining may then be coated with slaked lime or lime moistened with petroleum; or the whole lining may be made of lime moistened with petroleum until it assumes a stiff plastic condition. The shell of the converter being washed with a thin solution of lime, the plaster is then placed in and rammed down hard, so as to produce a solid coating or lining. Asphaltum may also be used in place of oil.

After lining the converter it should be thoroughly dried, which may be done by placing coal, coke, or other fuel into it and blowing it with a moderate blast for half an hour, and then blowing up to a melting temperature. At this point a charge of about five hundred pounds of iron ore admixed with a like amount of lime should be thrown into the mouth of the converter. This mixture immediately liquefies, and is blown against the sides of the converter and forms a glaze. The temperature is now raised, and as the lining dries and cracks by contraction the cracks are filled up by the glazing, and thus the lining becomes solid. When the metal is charged into the converter and the blow has commenced the metal wears a portion of the lime lining down, which becomes incorporated in the slag. The metal washing against the lime sides and being blown through the slag, a portion of the phosphorus unites with the lime and is abstracted from the metal; but to more fully secure the advantages of lime I inject a portion of lime as an oxide or a carbonate into the metal by means of the blast.

The lime may be blown in separately, or it may be admixed with other oxides and injected, as described in Letters Patent No. 193,551.

When the metal has been blown a sufficient length of time to eliminate the carbon and silicon, if the blow is continued the metal will be wasted by oxidation. To prevent this and more fully to dephosphorize the metal, I continue the blow, after the silicon and carbon are burned out, about three or four minutes, and admix oxide of iron or a carbonate of iron with the lime or carbonate of lime, which will protect the metal from oxidation and more fully dephosphorize it. At this juncture (where the silicon and carbon have been eliminated) a carbonaceous solid liquid or vapor may also be introduced by use of the blast, which will keep up the temperature and aid the dephosphorization of the metal.

Care should be taken not to blow more lime into the metal than required to eliminate the phosphorus, as an excess will have a tendency to dry the metal, producing phenomena similar to red-shortness in metal.

In the application of my improvement to the manufacture of ingot iron or steel by what is known to the trade as the "open-hearth process," I line the working or metal chamber with a lime lining, prepared as before described in reference to the converter, and impart an oxide bath as a covering to protect the metal from the effect of carbon, and as an agent in decarbonizing and cleaning the metal of its impurities. To this oxide bath I add twenty-five per cent. (more or less) of lime or oxide of calcium, and if the open hearth is provided with an adjustable or movable bottom or metal chamber, through which air or vapor blast is blown into the metal, then, in that case, I inject lime or oxide of calcium into the metal by means of the blast, as more fully described in my Patent No. 193,551. In the latter case I inject iron ore into the metal for the purpose of decarbonizing it and cleaning it.

The ore and lime may be mixed, or they may be used separately.

In case where the lime is injected into the metal by means of the blast, the lime lining may be omitted, as the limed oxide bath and the injecting the lime will be all sufficient.

When the bath of metal in the open hearth is highly impregnated with phosphorus it may be necessary to tap off the oxide bath and renew it with a pure oxide and fresh lime, as the oxide bath, when fully saturated, will not absorb additional phosphorus.

The enabling element producing the de-

phosphorization of the metal in that process herein described is calcium. It may be administered in the condition of limestone, magnesian limestone being preferable, care being had that the limestone be low in silicon and phosphorus, and as pure in all respects as possible, with the exception of magnesia, which is not objectionable.

The calcium may be used as an oxide, (lime,) or admixed in any manner, the result being in proportion to its purity and proper proportion administered.

I do not claim the use of lime or oxide of calcium as a lining for reducers or furnaces wherein iron ores or metals are decomposed or refined; nor do I claim the use of an oxide bath to protect the metal being refined from the influence of carbon; nor do I claim, broadly, the injecting oxide of iron into the molten metal by means of the blast; but

What I do claim as my invention, and desire to secure Letters Patent for, is—

1. The process of dephosphorizing iron and steel, which consists in injecting, after the metal has been decarbonized and desiliconized, finely-divided lime or carbonate of lime into and throughout the metal while the same is in a molten state, whereby the lime is brought into immediate contact with the particles composing the molten mass, and the operation of dephosphorization is expedited, substantially as and for the purpose specified.

2. In dephosphorizing iron and steel, the process of protecting the molten metal from oxidation after the carbon and silicon have been removed, which consists in injecting, by means of a blast, finely-divided lime or carbonate of lime and finely-divided oxide of iron into the molten metal, to be disseminated throughout the same, the lime to dephosphorize and the oxide of iron to prevent oxidation, substantially as and for the purpose specified.

JACOB REESE.

Witnesses:

A. C. JOHNSTON,

WALTER REESE.