UNITED STATES PATENT OFFICE.

FREDERICK J. SLADE, OF TRENTON, NEW JERSEY.

IMPROVEMENT IN THE MANUFACTURE OF STEEL.

Specification forming part of Letters Patent No. **171,183,** dated December 14, 1875; application filed May 10, 1875.

CASE B.

To all whom it may concern:

Be it known that I, FREDERICK J. SLADE, of the city of Trenton, in the county of Mercer and State of New Jersey, have invented a new and useful Improvement in the Art of Manufacturing Steel, and that the following is a description thereof.

Ordinary crude irons, it is well known, are heterogeneous compounds of iron and a comparatively small quantity of numerous other substances; but of all the substances usually found in admixture with iron, and which it has been heretofore one of the purposes of refining and steel-making to eliminate, phosphorus has been regarded by manufacturers of cast-steel as the most pernicious for the purposes of their art, not merely because its effect upon the quality of the steel has been injurious, but also, and chiefly, because of the great tenacity with which it unites with the iron to resist all processes and agents for their separation which have not been found too inconvenient or costly for ordinary use in steel-furnaces. Heretofore, all irons containing a larger average proportion of phosphorus than from fifteen to twenty hundredths of one per cent. of their weight have been deemed unfit for manufacture into homogeneous or cast steel. The great bulk of all the iron produced contains a larger proportion than this of phosphorus; consequently, the iron suitable for steel-making is comparatively scarce and dear.

Finding that I could not practically separate the phosphorus from the iron, I have sought to render its presence useful, and discovered that this could be done by expelling, as far as conveniently practicable, all the other substances, so as to leave the phosphorus in preponderance over any of them, while it unites with the iron to form an alloy or combination which is homogeneous, fusible, malleable, and well adapted to such uses in the arts as require a material having these properties, and which is stronger and more homogeneous than wrought-iron.

My new method of manufacture therefore utilizes phosphorus in making cast-steel in such a manner that cheap phosphoric irons may be employed for conversion into such steel, instead of the more costly irons, containing little phosphorus, heretofore deemed indispensable for that purpose.

I have made this steel conveniently and economically by the Martin process, in a Siemens reverberatory regenerative gas-furnace, in the open hearth of which I have charged the quantity and proportions of crude materials which are usual in the practice of making carbon-steel by means of that process and furnace, such charge consisting of pig-iron, old steel rails, or other steel scrap, and wrought-iron, old iron rails, iron-sponge, or scrap iron or iron ore, or any part of these materials, or of cast or wrought iron or steel, in any convenient form and proportions. The phosphorus combined in the materials of the charge may be in the proportion of from twenty hundredths to fifty hundredths of one per cent. of the weight of the iron, according to the wastage in the process, and the degrees of fusibility, malleability, and ductility required in the finished product.

Practically, the separation of any excess of phosphorus from the charge in the furnace is too difficult to be undertaken; therefore, the aim of the furnace-man must be in all cases to have a slight deficiency of phosphorus in the charge, and to compensate that deficiency by means of carbon, to be left in or added to the charge, as may be convenient, since any excess of carbon can easily be removed at any stage of the process by means of oxidizing or decarbonizing agents. If in any case it should be expedient for any reason, technical or economical, to use silicon, chromium, titanium, or other steel-ifying agent in place of carbon, to compensate the deficiency of phosphorus, then the proper equivalent quantity of the replacing agent selected must be left in or added to the charge. If, however, through inadvertence or otherwise, the phosphorus should be found to be in excess, and the steel too hard, then iron containing less phosphorus must be added to the molten mass until the average proportion of phosphorus shall be sufficiently reduced to make the steel of the softness or temper required. Small quantities of the steel are from to time withdrawn from the bath and tested,

by casting, forging, bending, or otherwise, in order to determine the condition of the charge, and show if anything further, and if so, what, is needed to finish it.

After the materials have been melted together, and the proper proportion of each duly established by testing, a quantity of manganese is then to be added, preferably in the form of ferro-manganese or spiegeleisen. From two to ten per cent. of the weight of the charge of the average spiegeleisen of commerce, or its equivalent of ferro-maganese, will supply the manganese required, the precise quantity needed in each case being determined by the workman in charge of the furnace, by testing specimens or otherwise, as in the ordinary manufacture of carbon-steel by the Martin process.

I have discovered that a maximum of phosphorus can be combined in the steel only when it contains a minimum of carbon; therefore, in order to use the most phosphoric irons which the process admits, I sought, by means of the chemical reactions in the furnace, to eliminate the carbon to the utmost from the charge, but found a practical necessity for leaving a small residue, because, when carbon is reduced to a high degree of attenuation, the reaction of oxidizing agents upon the iron grows so intense and wastes it so rapidly that it becomes expedient at this point to arrest the elimination of the carbon. The steel thus made is soft, malleable, and ductile, but not very fusible when the proportion of phosphorus combined in it is small; but as the proportion of phosphorus is increased the steel is rendered more fusible, and less malleable and ductile.

I deem it unnecessary herein to describe more particularly the manner of working the Martin process, or of constructing and managing the Siemens furnace, or in what manner this steel might be made, with the aid of the explanations herein given, by other known processes of working in other furnaces or apparatus, such particulars being within the ordinary skill of experts in the art of steel-making.

What I claim is—

The process of forming steel by regulating, in an alloy of iron, manganese, and phosphorus, the quantity of carbon, silicon, chromium, or titanium to supplement the steelifying action of the phosphorus already in the steel to the desired extent, substantially as described and set forth.

FRED. J. SLADE.

Witnesses:

R. W. RAYMOND,

P. H. WATSON.