UNITED STATES PATENT OFFICE.

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PROCESS OF MAKING INGOT IRON AND STEEL.

SPECIFICATION forming part of Letters Patent No. 314,506, dated March 24, 1885.

Application filed February 4, 1885. (Specimens.)

To all whom it may concern:

Be it known that we, JAMES P. WITHEROW, HENRY W. OLIVER, Jr., JOHN F. WILCOX, and GEORGE E. TENER, all of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Process of Making Ingot Iron and Steel; and we do hereby declare the following to be a full, clear, and exact description thereof.

Our improved process of manufacturing ingot iron or steel by the pneumatic process, while especially adapted to the manufacture of soft or low carbon steel, may be employed in the production of other grades higher in carbon. It is well known in the art that Bessemer metal or steel containing over .12 per cent. of phosphorus is unfit for most industrial purposes. Consequently when an ore contained more than .06 per cent. of phosphorus, it was not suitable for use in the manufacture of pig metal for use in the Bessemer process as heretofore practiced, unless subjected to the expensive and troublesome basic or other dephosphorizing process. At least four-fifths of the ores in use contain too much phosphorus for making Bessemer pig, and are consequently cheaper than those applicable thereto. Furthermore, there are enormous deposits of iron ore on this continent and elsewhere which have heretofore been considered entirely worthless, owing to the high proportion of such impurities as phosphorus, sulphur, &c., contained therein, which rendered it impossible to produce marketable iron therefrom by any of the processes mentioned or known. By our improved process we are enabled to produce a very superior metal by the use of cheap cold or red short pig-iron made from such ores without dephosphorizing, which metal is applicable to many uses to which Bessemer metal has not been heretofore applied, and is much better for many purposes than wrought-iron, while at the same time it is much cheaper than the latter.

Briefly stated, our invention consists in desiliconizing phosphoric pig-iron in the pneumatic or like process by oxidizing the metal and immediately removing the slag resulting from said oxidation.

Our improved process may be carried on in a stationary converter having one or more tuyeres extending horizontally through its sides at proper intervals, preferably at or about midway of the height of the column of metal in the converter, a cinder-notch about eighteen or twenty inches above the metal-line, and means for supplying a mild blast, say, of six or eight pounds pressure, or otherwise regulating the same as regards heat and pressure.

While we speak of a stationary converter, we do not limit ourselves thereto, because, as is evident to those skilled in the art, our process may be carried on in a tipping converter, ladle, open-hearth or other vessel or furnace having means for tapping off the slag where the metal can be subjected to the desiliconizing and decarbonizing action of a blast of air or like agent, as will be understood.

We will now describe the process as it has been practiced by us in the stationary converting-vessel hereinbefore particularly mentioned. A charge of, for example, say, three thousand four hundred pounds of molten pig metal, containing, say, 1.8 per cent. of silicon and .55 of phosphorus, is put into the converter. As soon as the metal begins to flow into the converter, the blast is gradually turned on until, when the entire charge has been introduced, the maximum pressure, which is from six to eight pounds, is attained. The pressure of the blast is then slowly reduced to about five pounds as the metal becomes more fluid. The effect of the blast on the metal is to oxidize a portion of the same, thereby forming a base with which the silica unites, producing a slag containing the silica, which, being lighter than the metal, rises and is separated therefrom. The action of the blast causes the charge to foam up until in five or six minutes the slag begins to flow out at the cinder-notch, which flow will continue for one or two minutes. When it ceases, the cinder-notch is stopped up with clay, and the blow is continued until the flame drops, which indicates that the carbon has been consumed, a period usually of

five or six minutes. The fluid metal is then tapped off as quickly as possible into a ladle, and, if desired, is recarburized by the addition of a sufficient quantity of ferro-manganese, preferably heated, or other suitable recarburizer. The manganese of the addition has its usual functions. The metal is then poured into the ingot-molds.

The average of a number of analyses of the slag which is run off during the blowing of a charge of the character aforementioned shows that it has the following composition, viz: silica, sixty-two per cent.; oxide of iron, 30.21 per cent; manganese, 7.79 per cent; phosphorus, a trace. This slag is, therefore, essentially a silicate of iron and manganese formed by the oxidation of these elements, and no dephosphorization of the metal takes place in the converter. The phosphorus consequently remains in the metal, and its proportion in the product is about the same as in the charge, owing to a slight loss in conversion.

The average of a number of analyses of the slag from the ladle after the addition of the ferro-manganese shows the following composition, viz: silica, 58.30 per cent.; oxide of iron, 35.84 per cent.; manganese, 5.86 per cent.

We have used in our process common mill iron containing as high as .5 per cent. of phosphorus, and produced steel therefrom containing from .4 to .5 per cent. of phosphorus, which has been utilized for various purposes and shows remarkable physical tests.

The following is a table of the physical tests of a steel containing .54 per cent. of phosphorus made by our process, viz: Tensile strength, seventy thousand to eighty thousand pounds; elastic limit, fifty thousand pounds; elongation, twenty per cent.; reduction of area, thirty-five per cent. Its working qualities are perfect ease of welding, extreme ductility, spreading freely, and absence of tempering properties. It is particularly adapted for use in the manufacture of nail-plate, tacks, spikes, rivets, bolts, chains, shovels, spades, and all kinds of stamping-ware, wire, rails, crow-bars, harrow-teeth, wood-choppers' wedges, picks, mattocks, &c., pipes, tubes, and flues, tin plates and sheets, tank and boiler iron, and all kinds of blacksmithing and merchant iron.

With regard to the working qualities above mentioned, the metal being low in carbon possesses a constant welding property which is not present in other low steels, and when it is made from Bessemer pig containing from .10 to .12 per cent. of phosphorus its welding properties are equal to the best Swedish iron or the finest open-hearth steel.

For welded shovel-blades, which is one of the most thorough welding tests in use, we obtain perfect results with steel made by our process containing .35 per cent. of phosphorus and .12 per cent. of sulphur. For nail-plates we obtain the best results from a moderately cold short pig. The nail-plate we have made from pig-iron containing .5 per cent. of phosphorus is better than that made from the best Bessemer stock, the latter lacking the desirable stiffness which the former possesses. The important features of our process are the treatment of the phosphoric metal as described and the tapping off or otherwise removing the slag containing the silica as soon as it is formed. By this process we obtain a product practically free from oxide of iron and gases which produce piping, and practically free from silicon, and containing about the same percentage of phosphorus as was in the charge. We obtain uniformity of product and a minimum waste of manganese, as there is little or no oxide of iron present in the charge when tapped.

The process is applicable to use with any pig metal, whether containing much or little phosphorus, but, as has been stated, it is particularly advantageous with phosphoritic pig, because it enables it to be used for the production of an improved ingot iron or steel, whereas before this material was unfit for general use without dephosphorization.

When starting with a cold cupola and a fresh converter, we prefer to use about two per cent. of silicon for two or three heats, and then reduce it to 1.6 or 1.7 per cent. or thereabout. This can be done by adding a proper quantity of cast or wrought iron or steel scrap, and if the charge is working too hot the temperature can be reduced by adding such scrap either in the cupola or converter, as the case may be.

When steel is desired, the amount of ferro-manganese or other recarburizer added will of course depend upon the quality of steel desired. For very soft steel about .8 per cent. of "eighty-four per cent." ferro-manganese is ordinarily used.

A large number of analyses demonstrate that the process gives remarkably uniform results. The carbon and silicon are almost completely eliminated, especially the latter, as in no case have we found more than a trace.

No appreciable amount of oxide of iron has been found in the resultant steel, and the satisfactory working of the steel is to a considerable extent attributable to its absence.

We have discovered that the phosphorus may be utilized as a steelifying agent for iron in place of silicon or carbon, which have heretofore been considered essential to the production of steel, and in proportion as the other metalloids are reduced or eliminated. This property of the phosphorus is utilized, so that the necessity of the final additions of carbon and manganese heretofore used in the basic and other oxidizing processes is more or less obviated. If it is desired that the steel should contain these elements as well as the phosphorus, they may be added in quantities to suit the particular grade of metal required, as will be understood. The presence of the phosphorus assists in keeping up the heat of the bath

after the elimination of the silicon and carbon, and also imparts to the resultant product hardness, stiffness, and rigidity, properties of value for many uses in the arts, while it has been found by us that it does not detract from the working or malleable qualities of the metal.

We do not limit ourselves to the use of a stationary converter, but claim the right to use our improved process in any apparatus suitable therefor, as hereinbefore stated.

We do not herein claim the phosphor ingot iron or steel which can be produced by our improved process, as such product forms the subject of a separate application of even date herewith.

What we claim as our invention, and desire to secure by Letters Patent, is—

1. The process of making phosphor steel herein described, which consists in blowing a charge of molten pig metal high in phosphorus, and removing the slag containing the silicon when formed, substantially as and for the purposes described.

2. The process of making phosphor steel herein described, which consists in blowing a charge of molten pig metal high in phosphorus, removing the slag during the earlier period of the blow, and continuing the blow until the carbon is consumed.

In testimony whereof we have hereunto set our hands this 30th day of January, A. D. 1885.

JAMES P. WITHEROW.
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Witnesses:
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