UNITED STATES PATENT OFFICE.

JACOB REESE, OF PITTSBURG, ASSIGNOR TO THE BESSEMER STEEL COMPANY, (LIMITED,) OF PHILADELPHIA, PENNSYLVANIA.

PROCESS OF MANUFACTURING IRON AND STEEL.

SPECIFICATION forming part of Letters Patent No. 401,903, dated April 23, 1889.

Application filed June 27, 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 Process of Manufacturing Ingot Iron and Steel; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention consists in an improved process for the manufacture of malleable iron and cast-steel by the following method: Molten cast-iron is conveyed into and subjected to the decarburizing and desiliconizing action of a Bessemer converter. The metal is then conveyed, while in a molten condition, into an open hearth, and therein dephosphorized, recarburized, and further refined while kept in the molten state by the use of other fuel than that contained in the metal.

The objects of the invention are, first, to secure the rapid and efficient action of the Bessemer process in decarburizing and desiliconizing the metal without its disadvantages by keeping the metal in a fluid state without oxidation while being dephosphorized, recarburized, and further refined, as is incidental to the employment of separate fuel for keeping the metal in a molten condition for that purpose, as fully set forth in Letters Patent No. 65,830, dated June 18, 1867, and now practiced in the open-hearth process; second, to secure a decarburized and desiliconized metal in a molten condition previous to the refining in the open hearth, so that the metal may be dephosphorized and refined quickly, as it is impossible to dephosphorize iron in the presence of any considerable quantity of silicon, and at present, owing to the fact that several hours are consumed by removing the silicon in the open hearth, considerable silicon and earthy impurities are absorbed by the molten metal from the lining, sides, and roof of the furnace during the treatment; third, to render the dephosphorizing and cleansing action of the bath steady, constant, uniform, and efficient by first decarburizing and desiliconizing the metal, as above stated, whereby the process is not only expedited, but the bath remains of a basic nature, as the metal has previously been desiliconized, and the quick treatment of the metal greatly reduces the amount of silicon which may impregnate the bath from the lining of the furnace; fourth, to produce a more uniform and a finer quality of steel, freer from impurities, than has been heretofore produced either by the Bessemer or open-hearth process.

I shall now refer more particularly to the state of the art previous to this invention.

By the Bessemer process the cast-iron is converted into cast-steel as follows: Molten metal is run into the converter and a blast of atmospheric air is forced through the metal until it is decarburized and desiliconized to a minimum. The metal is then deoxidized and is carburized to the proper degree by a charge of carbide of iron or spiegeleisen. After this operation has been performed the ebullition soon ceases, and as the blast is discontinued there is no means of keeping the metal in a fluid condition, and the loss of caloric by radiation is very great, so that it must be emptied immediately from the converter. This process decarburizes and desiliconizes the metal more rapidly and efficiently than any other known to the art of metallurgy, but on account of the sudden stoppage above mentioned is not adapted to dephosphorizing and further refining the metal, and in practical tests I have found its product lacked uniformity and other desirable qualities. I therefore conceived that the defect of this process was due to the sudden stoppage above mentioned, preventing the attainment of the desired qualities in the metal, because there was not sufficient time after the silicon had been removed to eliminate the phosphorus and to allow the carbide to be thoroughly diffused throughout the metal, so that the carbon could come into chemical union, as in the crucible process, and not form a mere mechanical union, as is apt to be the case where separate fuel is not employed to keep the metal fluid, as in the Bessemer process. Keeping this idea in view, I made certain experiments which resulted in the process of refining iron, steel, and other metals set forth in Letters Patent No. 65,830, dated June 18, 1867, the object of said Letters Patent being, first, to keep the metal in a fluid condition after the carbon had been removed, so that the carbon of the carbide should have sufficient time to form a chemical and not a mere mechanical union with the metal; second, to keep up

the heat for the further refining of the metal; third, to prevent loss by oxidation, which takes place in the Bessemer process; fourth, refining the metal with an oxide or basic bath and protecting it from the influence of carbon from the fuel.

By the use of the process just referred to steel of very desirable qualities and of different grades may be readily made from cast-iron; but in quantity and cost of production it ranks below the Bessemer, so that it will readily be seen that each process has some peculiar advantages and peculiar defects. Now, the object of this invention is to consolidate the advantages of both processes and to leave the defects out by combining part of the Bessemer with part of the open-hearth process.

The advantages arising from this combination will be readily understood from the following:

First. Phosphorus cannot be eliminated until after the silicon has been removed. The time required by the Bessemer process for the decarburizing and desiliconizing is from fifteen to twenty minutes. The time required in the open hearth for that purpose is five to eight hours.

Second. On account of the sudden stoppage of the Bessemer process it is not adapted to remove phosphorus, or for the further refining of the metal, whereas in the open hearth the metal is kept fluid by the use of separate fuel, so that sufficient time is had for dephosphorizing, treating, and further refining the metal, and for the carbon to unite chemically with the metal.

Third. By desiliconizing the metal in the Bessemer converter previous to its treatment in the open hearth the bath in the latter is enabled to retain its basic character constantly during the treatment, and as the treatment in the open hearth is accelerated the metal will not become so heavily impregnated with silicon and earthy impurities from the lining, walls, and roof of the furnace.

In order to obtain all the advantages of the last-mentioned process, and also the advantages in point of time and amount of production which are incidental to the use of the Bessemer process, I make use of the method hereinafter described.

I shall now describe my invention fully, so that others skilled in the art to which it appertains may utilize the same.

In the practice of the combined process which I now claim I cause cast-iron to flow from the blast or other furnace into a converter, and by the use of air-blast blown therein the carbon and silicon are oxidized to a desired minimum. The molten metal is then conducted into an open hearth, which has been previously heated and properly prepared. The metal is then covered with a basic bath of metal oxides, which may include lime or the oxide of calcium. The metal is then recharged with carbon, such as spiegeleisen or ferro-manganese, as may be found best suitable to the quality of steel to be made. The manganese in the carbide will cleanse the metal of any oxide intervening between its particles. The heat should be kept up so as to retain the metal in a highly-fluid state, and thus give sufficient time for the carbon to form an intimate chemical combination with the iron. The time occupied in refining a heat of twenty tons in the open hearth by this process will not exceed one hour, and for many purposes may be done in thirty (30) minutes.

During the process of refining the metal samples should be withdrawn in a ladle and tested. When the tests are satisfactory, the metal should be run out into the ladle and thence into molds, as usually practiced.

The furnace is kept at a uniform temperature and recharged with fresh metal as soon as a bath is run into the ladle.

The carbide may be added to the metal before it is poured out of the converter if the thorough dephosphorization of the metal is not an object desired; but I prefer to add it to the bath in the open hearth.

When a Bessemer plant consists of two ten-ton converters, one heat of each converter made at the same time and run into the open hearth will serve to charge it with eighteen or twenty tons. The next heats of the converters may be treated as usual for Bessemer metal and run into ingots, and by the time the third heats are ready the open-hearth charge will have been refined and emptied into the ladle. Thus every alternate heat will be Bessemer and the other open-hearth steel; or, if desired to produce all open-hearth steel, then in that case I provide two open-hearth furnaces and charge them alternately.

By this process I am enabled to decarbonize and desiliconize the metal in the Bessemer converters, and dephosphorize and further refine it in the open hearth. I use the oxide bath in the open hearth in order to protect the metal from being oxidized by the action of the atmosphere or any free oxygen or carbonic acid which may pass over the metal from the fuel-chamber, and to protect it from the influence of any carbon which may pass over it. The oxide bath not only protects the metal as above described, but it dephosphorizes and also cleanses the metal of its earthy and metallic impurities which may remain in it after it has passed through the converter.

Should the metal being worked contain phosphorus to amount to over one-tenth of one per cent., I prefer to line the metal chamber of the open hearth with lime. I prefer to blow lime into the converter with the blast and also impregnate the oxide bath of the open hearth with lime. The effect of the lime and the oxide of iron or either of them is to remove the phosphorus and other earthy or metallic impurities from the metal, thus enabling the metallurgist to produce a fine pure grade of steel or ingot-iron from crude cast-iron.

The advantages of this invention are:

First. The production of a better quality of cast-steel than can now be produced from the Bessemer process, owing to the abrupt stoppage of the process, and better than can be produced by the open hearth, owing to the fact that the metal is retained in the furnace so long that the metal takes up silicon from the sand and bricks of which the furnace is composed, while in my process the metal is exposed to these elements so short a time as to not injure it to any appreciable degree.

Second. The advantages of the open hearth are secured with a largely-increased production and economy.

Third. By the use of this process the bath of the open hearth remains of a pure basic character during the treatment of the metal, and consequently its cleansing and dephosphorizing action is rendered constant, uniform, and efficient.

I do not claim the lime lining or the use of the oxide bath, as I have previously obtained Letters Patent therefor; nor do I claim impregnating the oxide bath with lime, nor blowing lime into the converter through the blast, as I have previously applied for Letters Patent therefor; nor do I claim recarburizing the metal in the open hearth with a carbide of iron, as it is set forth in Letters Patent No. 65,830 and is now a common practice; but

What I do claim, and desire to secure by Letters Patent, is—

1. The process herein described for dephosphorizing in the manufacture of ingot iron and steel, which consists in decarburizing and desiliconizing the metal in a Bessemer converter and immediately conveying it into an open hearth for the purpose of keeping it in a fluid state by the use of other fuel than that contained in the metal, and therein dephosphorizing it by the action of a basic bath and recarburizing and deoxidizing by the use of a manganesic carbide of iron, and further refining it by the action of the basic bath, substantially as herein set forth.

2. In the manufacture of ingot iron and steel, the process herein described, which consists in decarburizing and desiliconizing the metal in a Bessemer converter, and then transferring it while in a molten condition to a converting-furnace, and therein maintaining its fluid condition by means of heat obtained by the use of fuel extraneous to the metal, and subjecting it the action of a basic bath, substantially as hereinbefore described.

3. In the manufacture of ingot iron and steel, the process of first decarburizing and desiliconizing the metal in a Bessemer converter, then running the molten metal into an open hearth having a calcareous lining, and then exposing it under the influence of additional heat obtained by the use of extraneous fuel to the action of a basic bath for the purpose of dephosphorizing the metal, substantially as hereinbefore described.

4. In the manufacture of ingot iron and steel, the process hereinbefore described of first desiliconizing the metal in a Bessemer converter, then transferring the molten metal to a converting-furnace, and exposing it therein to the action of basic reagents under the influence of additional heat for the purpose of dephosphorizing it, substantially as described.

JACOB REESE.

Witnesses:
A. C. JOHNSTON,
WALTER REESE.