UNITED STATES PATENT OFFICE.

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PROCESS OF CONVERTING CAST-IRON INTO IRON OR STEEL.

No. 807,026. Specification of Letters Patent. Patented Dec. 12, 1905.

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To all whom it may concern:

Be it known that I, PAUL LOUIS TOUSSAINT HÉROULT, a citizen of the Republic of France, residing at La Praz, Savoie, France, have invented certain new and useful Improvements in Processes for Converting Cast-Iron into Iron or Steel, of which the following is a specification.

In previous patents there have been described processes and apparatus for the manufacture of iron and steel in an electric furnace from cast-iron, scrap-iron, ores, and the like. In these processes all the operations—such as refining, purification, reduction, carburization, the addition of metals or alloys, &c., which are concerned in obtaining the desired product—are conducted in an electric crucible or furnace. According to the present invention "high-grade" or "crucible" steel, by which I mean steel of a high degree of purity and generally, but not necessarily, of a high-carbon content—such, for example, as is generally used for the making of the special steels containing manganese, nickel, &c., hereinafter referred to—is made from cast-iron or the like by first refining it by oxidation in the usual or any suitable manner and then transforming it in the electric furnace into the desired product. The first apparatus may be a converter of the Bessemer kind or an oxidizing-furnace of any kind. To facilitate this explanation, it may be assumed that a basic-lined Bessemer converter is to be used analogous to those usually employed for dephosphorizing. Side by side are arranged the converter and the electric furnace, the latter being, for example, of the oscillating kind already described in a previous patent, (No. 707,776, dated August 26, 1902.)

The first part of the operations which is conducted in the converter consists in treating the molten cast-iron of the first or second fusion containing more or less carbon, silicon, manganese, sulfur, phosphorus, &c., so as to refine it by oxidation according to the usual method. This oxidation operation is stopped at a point suitable for the succeeding operations—for example, when the content of the molten metal in carbon has been reduced to between 0.02 and 0.05 per cent. When phosphoric pig is being treated, the oxidation is pushed further—namely, until the phosphorus has been practically completely oxidized and has passed into the basic slag formed by the addition of basic material, such as is usually added in the basic process. The slag formed is then removed nearly completely by tilting the converter. The metal thus more or less refined or more or less partially oxidized and remaining in the converter, instead of being further treated by addition of carburizing materials or materials more or less rich in manganese, silicon, &c., in the converter itself, as is customary in making Bessemer steel, is poured either directly from the first apparatus into the electric crucible or into a steel ladle or another like apparatus, and thence into the electric crucible, the metal being all the time fluid. The pouring should be effected in such a manner that the liquid metal runs into the electric crucible from the lower part of the vessel which contains it in order that the last portions of slag containing impurities floating upon the metal may be retained in the vessel at the end of the pouring. The liquid metal is introduced into the crucible while the latter is still hot, having either been heated for the purpose or from the preceding operation, and the electric current is passed so as to raise the temperature to the desired degree. The mass, which generally contains more or less oxygen or oxid of iron, is kept in a state of fusion by the heat of the electric arc which supplies the necessary calories. It is now treated under the desired conditions for obtaining steel of the desired quality. For example, there is introduced into the crucible carbon in the form of carburite (see French Patent No. 320,682, dated April 25, 1902) in order to deoxidize completely the metal and to produce the degree of carburization proper to the quality of steel desired. Equally well there may be added at a suitable moment alloys or metals—such as ferromanganese, ferronickel, ferrochrome, or chromium, nickel, tungsten, molybdenum, vanadium, &c.—if it is desired to obtain a steel containing such metals.

This process permits of heating metal previously superoxidized in a Bessemer converter or the like without exposure to flame or a blast of air (and consequent oxidation) to a higher temperature (1,900° centigrade, as compared with 1,700° centigrade) and with a regularity and consequent accurate control of composition which cannot be obtained in

any other way. The effect of heating (due chiefly to the increased chemical activity of the carbon) in the electric furnance as compared with a Bessemer converter is illustrated in the following table, which shows for a given percentage of carbon the minimum content of oxygen which may be obtained with the Bessemer converter and the electric furnace, respectively, (presuming an absence of manganese and silicon and the highest temperatures obtainable in the two apparatus:)

	Bessemer.	Electric.
C=0.05 or less	O=0.75	O=0.30
C=0.10	O=0.50	O=0 01
C=0.20	O=0.30	O=0.00
C=1.60	O=0.01	O=0.00

In the Bessemer and open-hearth processes it is impossible to carry the oxidation sufficiently far to completely eliminate the impurities initially present without leaving a considerable quantity of oxygen, which is well known as a most hurtful element, a metal entirely free from impurities being necessarily so superoxidized as to be practically or nearly useless according to the previously-employed methods of deoxidation, (such as treatment in the Siemens furnace or in the crucible.) Such a superoxidized metal, however, is perfectly utilizable in the second stage of my process. For example, the following table illustrates the percentage of impurities in good basic Bessemer steel and in a product of my process:

	Bessemer.	Heroult.
Carbon	0.10	0.005 (to any desired maximum.)
Silicon	0.01	0.000 (to any desired maximum.)
Manganese	0.50	0.000 (to any desired maximum.)
Phosphorus	0.07	0.005
Sulfur	0.07	0.005

By reason of the absolute control which can be had of the electric furnace and the avoidance of the necessity of introducing manganese or spiegel for deoxidizing the carbon or other content of the steel may be determined with greater accuracy than heretofore. A steel of extra hardness or extra softness may be made with equal certainty.

Owing to the separation of the foregoing operations into two phases in order to conduct the process which forms the subject-matter of this application for the manufacture of iron and steel in an electric furnace, not only is one able more completely to control the reactions involved, but also one may effect a considerable economy of time and labor. In fact, while the direct transformation of cast-iron into steel, including the purification, occupies more than five to six hours in the electric furnace the duration of the two treatments in the actual process—that is to say, successively in the Bessemer converter and the electric furnace—may be reduced to one-half that named. More particularly it may be noted that the operation in the Bessemer converter being stopped after the oxidation takes less time than usual. Besides, the operation of conversion in the electric furnace is abbreviated, because the electrical energy is no longer required to effect the decarburization and the purification. Moreover, if several electric crucibles or furnaces are to be worked at the same time each must be furnished with the electrical energy necessary for the first phase of the operation, while the new method has the advantage that it is possible to feed several such electrical apparatus by a single Bessemer converter, so that the yield produced by an installation is industrially much more considerable. To this end it is useful in practice to arrange a Bessemer converter so that it may serve several electric crucibles or furnaces and in such a manner as to facilitate rapid transference of metal. With a single operation in the converter it is possible to feed four or six electric furnaces, and even more, according to the respective capacities of the converter and the electric furnace. Finally it may be added that by this process the carburization is effected in a more satisfactory manner and more surely in the electric furnace, especially when the materials worked are phosphoric, since it is easy to remove the phosphoric slag completely during the transference of the metal from the Bessemer converter to the electric furnace.

The superoxidation referred to is especially of importance when phosphoric pig is being treated in order to completely oxidize the phosphorus as stated above. In the ordinary Bessemer process, for example, the oxidation is carried on until the flame disappears or is said to "drop." Substantially the whole of the carbon has then been oxidized, and the continuation of the process beyond this point constitutes a superoxidation which distinguishes the present process as applied to phosphoric pig.

The term "cast-iron," as herein used, refers not only to the original product of the blast-furnace, but to any other metal or mixture (usually containing carbon and more or less silicon, manganese, sulfur, and phosphorus) requiring substantially the same operations to convert it into iron or steel. The iron or steel product is one of exceptional purity, which purity forms the principal feature of advantage in the process.

I claim as my invention—

1. A process for converting cast-iron or the like into high-grade or "crucible" steel, which consists in first treating the metal in a Bessemer converter, then transferring it to an electric furnace in which it is finally treated to deoxidize and carburize it, substantially as described.

2. A process for converting cast-iron or the like into high-grade or "crucible" steel, which

consists in first refining it by oxidation, and then transforming it in an electric furnace into the desired product.

3. A process for converting cast-iron or the like into high-grade or "crucible" steel, which consists in first refining it by oxidation, and then removing the slag and transferring the remainder to an electric furnace and there deoxidizing and transforming it into the desired product.

4. A process for converting cast-iron into iron or steel, which consists in first refining it by oxidation until any phosphorus contained has been practically completely oxidized, and then deoxidizing and transforming it in an electric furnace into the desired product.

5. A process for converting cast-iron or the like into iron or steel of exceptional purity, which consists in first oxidizing it, continuing the oxidation until the mass is superoxidized beyond the point at which substantially all the carbon has been oxidized, and then transforming it in an electric furnace into the desired product.

6. A process of converting cast-iron or the like into high-grade or "crucible" steel, which consists in first refining it by oxidation beyond the point to which oxidation is ordinarily carried in the Bessemer process and until the content of harmful ingredients is sufficiently reduced for the manufacture of such steel, and then deoxidizing and transforming it into steel of the desired composition in the electric furnace.

7. A process for converting cast-iron or the like into high-grade or "crucible" steel, which consists in first refining it by oxidation beyond the point to which oxidation is ordinarily carried in the Bessemer process and until the content of harmful ingredients is sufficiently reduced for the manufacture of such steel, and then oxidizing and transforming it into steel of the desired composition under the application of the heat of an electric arc.

8. A process for converting cast-iron or the like into iron or steel, which consists in first refining it by oxidation until any phosphorus present has been practically completely oxidized, and then deoxidizing and transforming it into iron or steel of the desired composition under the application of the heat of an electric arc.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

PAUL LOUIS TOUSSAINT HÉROULT.

Witnesses:

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