UNITED STATES PATENT OFFICE.

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MANUFACTURE OF OPEN-HEARTH STEEL.

SPECIFICATION forming part of Letters Patent No. 652,226, dated June 19, 1900.

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To all whom it may concern:

Be it known that I, AMBROSE MONELL, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in the Manufacture of Open-Hearth Steel, of which the following is a full, clear, and exact description.

In the process of making open-hearth steel most commonly practiced about fifty per cent. of steel-scrap is used in the mixture introduced into the furnace; but steel-scrap is often difficult to obtain and is expensive, so that its use entails serious disadvantages. The manufacture of open-hearth steel from pig-iron and iron ore without steel-scrap has also been practiced for many years; but it has the objection of requiring a long time to make the heats, thereby seriously diminishing the product of the furnace and causing a furnace of a given capacity to make less steel in a given time than can be made by the ordinary pig-and-scrap process. The ordinary pig-and-ore process, here referred to as carried on in a basic open-hearth furnace, say, of forty-ton capacity, consists in charging about eight thousand pounds of limestone together with about six thousand pounds of iron ore, then introducing about eighty thousand to ninety thousand pounds of pig metal in the form of cold pig, melting down this entire charge, thinning the slag, if necessary, with a flux, such as fluor-spar, and then working out the carbon and impurities by successive additions of ore introduced from time to time, and finally tapping the charge. The phosphorus is not eliminated until the carbon has reached a low point. The average time of the heat is about twelve hours, and taking into consideration the time required for repairs an average of about eleven heats per week is obtained from a furnace, whereas in my process I have already obtained eighteen heats in a week's run without detriment to the furnace.

My invention, which I will now describe, avoids the objections above stated. It enables the manufacturer, if he desires to do so, to dispense with steel-scrap or to greatly reduce the percentage of scrap in his charge, and it enables the process, with the use of pig and ore, to be carried on as rapidly and economically and with as great output per furnace as with charges containing fifty per cent. of scrap.

My process can be carried on with either high or low phosphorus pig, thus having the advantage that it enables me to make high-carbon steel from a relatively high phosphorus pig—that is, a pig containing .5 per cent. of phosphorus or over—whereas in former basic open-hearth practice in making spring-steel too high for recarbonization it has been necessary to start with a low-phosphorus pig-iron, (which is generally more expensive,) because in the ordinary open-hearth process the removal of phosphorus is continuous, being complete only at or near the end of the operation, when the carbon reaches .20 per cent. or under.

The invention also enables me to make from high-phosphorus pig steel of any desired percentage of carbon without recarbonizing.

In the practice of my invention I charge into a basic open-hearth furnace preferably about the usual quantity of limestone which is now employed in a furnace of like capacity with charges of fifty per cent. of pig and scrap and an amount of iron ore or iron oxid preferably equal to about twenty per cent. of the weight of the pig-iron which it is proposed to treat, although the proportion of ore or oxid may be varied according to the percentage of carbon desired in the finished product. These materials are heated until the ore is, say, at a red heat; but while they are still wholly or partly unfused the charge of pig-iron in a molten condition, which may be taken either from a blast-furnace directly, from a mixer, or from a cupola, is poured into the furnace, preferably as rapidly as possible and at as nearly one time as possible. This causes an active reaction and a rapid production of basic slag, and the materials being at a comparatively-low temperature the ore oxidizes the phosphorus, silicon, and manganese in the pig-iron with extreme rapidity and at the same time oxidizes a portion of the carbon. At the end of a period of, say, about one hour, more or less, the phosphorus will have been substantially eliminated from the metal—that is, reduced to .10 per cent. or less (.10 per cent. being the highest percentage of phosphorus ordinarily permissible in commercial steel made by the acid Besse-

mer process) and preferably to about .040 per cent. or less if the original phosphorus content was, say, from .50 to .80 per cent., and practically all of the silicon and manganese will have been removed with the phosphorus and a portion of the carbon will have been oxidized by the ore. The slag formed by the reactions above stated and containing the eliminated phosphorus and silicon is removed from the furnace as it forms and boils up, or, if convenient, it may be removed at a single operation. The removal of slag is finished early in the process—say at the end of an hour from the introduction of the molten metal—and is preferably as complete as possible. In practice it will be desirable to remove about eighty per cent. of the entire body of the slag, leaving the bath of metal nearly uncovered. By these operations the metal is dephosphorized and the phosphorus and silicon bearing slag removed at an early stage of the process, while the metal is still at a relatively-low temperature, which is the condition of temperature most favorable for that purpose, since at the high temperature employed in the latter part of the open-hearth process the phosphorus cannot be removed except partially and incompletely without reducing the carbon to a very low point.

Although the metal is substantially dephosphorized by the operation described above and the phosphorus removed from the furnace when the slag is withdrawn, the decarbonization is not then completed—that is, the carbon is preferably not reduced to less than from one and one-half to two per cent. when the slag is removed. The removal of the slag, however, at an early stage in the removal of carbon leaves the surface of the metal nearly uncovered and in the best condition to be rapidly heated and for its carbon to be promptly oxidized by the flame and by further additions of ore. Throughout the process the flame is preferably of a highly-oxidizing character, the treatment being such as to oxidize the carbon. The slag having been withdrawn, the bath is heated as rapidly as possible to about the temperature required for tapping, and the ore is then added as needed to reduce the carbon. Such ore and the oxidizing action of the flame bring down the carbon with great rapidity, and when it is reduced to the proper point, which may be in five hours, more or less, from the time of removing the slag, the metal is tapped into a ladle and treated in the ordinary way with silicon or manganese, or both. The additions of silicon may be made by adding ferrosilicon or spiegeleisen, and the manganese may be added in the form of ferromanganese. If care is taken to reduce the carbon only to the point desired in the finished steel, and this I deem preferable, it will not be necessary to recarbonize it with coke or anthracite coal, as has been the practice heretofore, although such recarbonization may be performed, if desired. The possibility of thus working my process without causing the decarbonizing below the point desired in the finished product effects a great saving of time and fuel.

The economy which results from my process will be appreciated by the skilled steel-maker. It enables me in the ordinary basic open-hearth furnace equipped to receive the charges of pig-iron in molten condition to make from pig and ore with less fuel as large a tonnage as from pig and scrap, the only change needed in the furnace being to provide convenient means for removing the slag. It makes it unnecessary to work the heat down to a low carbon and then to recarbonize in order to secure a certain removal of phosphorus in the manufacture of high-carbon steel from high-phosphorus pig, because as I practically dephosphorize the metal at the beginning of the operation I am enabled to tap it as soon as the desired carbon-point is reached. In making high-carbon steel this effects a saving of about one hour per heat. I also obtain advantages in the removal of the slag from the furnace during the first stage of the process, since in this way the phosphorus and silicon are taken out of the furnace and the bath is left in the best condition for subsequent heating and decarbonizing.

By practically removing the phosphorus from the pig metal while the carbon is still one and one-half per cent. or more I am enabled without reducing the output to manufacture a low-phosphorus steel of any desired high carbon either from high or low phosphorus pig in the same open-hearth furnace in which the operation is started.

My process also results in economy because of the fact that I can obtain substantially as great weight of steel as the pig metal charged into the furnace, the weight of the eliminated metalloids (carbon, phosphorus, siiicon, &c.) being substantially replaced by iron reduced from the ore.

Within the scope of my invention as defined in the claims the skilled steel-maker can modify the process in various ways, and it can be applied not only to the treatment of high-phosphorus pig, but to pig containing a low percentage of phosphorus, since

I claim—

1. The method herein described of making steel which consists in introducing into a basic open-hearth furnace iron oxid and lime and molten pig-iron, substantially eliminating phosphorus from the iron while the iron is at a comparatively-low temperature; withdrawing, at an early stage in the removal of carbon, the bulk of the slag containing the eliminated phosphorus, and heating the bath of metal and oxidizing the carbon until the carbon has been reduced to the point at which the metal is to be tapped; substantially as described.

2. The method herein described of making steel which consists in introducing into a basic

open-hearth furnace iron oxid and lime and molten pig-iron, substantially eliminating phosphorus from the iron while the iron is at a comparatively-low temperature; withdrawing, at an early stage in the removal of carbon, the bulk of the slag containing the eliminated phosphorus, without withdrawing the metal, then heating the bath of metal and oxidizing the carbon until the carbon has been reduced to the point at which the metal is to be tapped; substantially as described.

3. The method herein described of making steel, which consists in introducing into a basic open-hearth furnace iron oxid and lime, heating the same, then introducing molten pig-iron, substantially eliminating phosphorus from the iron while the iron is at a comparatively-low temperature; and withdrawing, at an early stage in the removal of carbon, the bulk of the slag containing the eliminated phosphorus, heating the bath of metal and oxidizing the carbon until the carbon has been reduced to the point at which the metal is to be tapped; substantially as described.

In testimony whereof I have hereunto set my hand.

AMBROSE MONELL.

Witnesses:
G. I. HOLDSHIP,
G. B. BLEMING.