UNITED STATES PATENT OFFICE.

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MANUFACTURE OF STEEL.

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To all whom it may concern:

Be it known that we, HERBERT H. WEAVER, residing in Upper Yoder township, and GEORGE E. THACKRAY, residing in the borough of Westmont, in the county of Cambria and State of Pennsylvania, citizens of the United States, have invented certain new and useful Improvements in the Manufacture of Steel; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

For the manufacture of steel by the Bessemer or pneumatic processes molten pig-iron is used, and in order to produce the best results the composition of this with respect to the contained metalloids should be within reasonable limits of variations, and the tendency of the present time is to require steel for rails and similar articles with less phosphorus than the previously customary content of one-tenth of one per cent., and to best adapt the material for good rolling and use the steel should also be low in sulfur.

To produce pig-iron that will make steel containing less than one-tenth of one per cent. of phosphorus requires iron ores of preferably high contents in iron—say from fifty to sixty per cent. of metallic iron—and with phosphorus correspondingly about .035 to .045 per cent. in the ore. As practically none of the phosphorus of the ore is eliminated in the blast-furnace and as the pig-iron will also absorb in the process of smelting a certain amount of phosphorus from the limestone or other flux and from the coke or fuel, very low percentages of phosphorus have been heretofore required in the ores in order to produce the results desired.

Although many millions of tons of ores are mined and used every year in the United States, it is becoming more difficult to obtain what are known as "Bessemer" ores—that is, those which will produce pig-iron that will produce steel by the ordinary Bessemer or pneumatic process with phosphorus below one-tenth of one per cent.—but our improved process enables us to use non-Bessemer ores or to improve the quality of steel made from Bessemer ores. It is also necessary to limit the sulfur content of the steel to aid in rolling the same to smooth surface and for other reasons, and as little or none of this element is eliminated in the Bessemer process this again requires that the pig-iron shall contain a comparatively small percentage of this constituent. Further than this, it is well known that in the operation of a blast-furnace varying conditions of the furnace itself, the atmosphere, and, notwithstanding all the care displayed, the variations in the quality of the ores, fluxes, and fuels will result in making pig-iron of varying composition with respect to its contained metalloids, and particularly with regard to the silicon and sulfur contents. In the conduct of the Bessemer process it is also necessary that the silicon content shall be kept as low and uniform as possible within the requirements in order to avoid loss in slag, &c., and to maintain the regularity of the operation, for the reasons that too much silicon will make a hot heat and too little will not produce enough heat to render the blow fluid and homogeneous.

With a knowledge of these difficulties we have devised a process for improving the manufacture of steel, and particularly that made by the acid Bessemer or pneumatic process, which consists, essentially, of taking comparatively irregular metal from a blast-furnace or a series of blast-furnaces and introducing it into a large receiver capable of containing approximately one or more hundred tons of molten metal, this receiver being either with or without extraneous source of heat, dependent upon the condition desired. In other words, this receiver may be a large semicylindrical, rectangular, or other shaped vessel of suitable size, preferably lined with fire-brick and provided with a cover, an opening at one side or the top thereof for the introduction of molten pig-iron, a spout arranged at a suitable level for withdrawing metal therefrom, and means for tilting or otherwise discharging the molten metal from the receiver as required. If the operation performed therein is speedy and continuous, this receiver may work very well without the aid of any extra heat from gas, oil, coal, or other fuel; but in order to provide for stoppage or contingencies and to keep the slag or metal liquid we may furnish the receiver with heating apparatus of any suitable character.

In addition to the receiver we employ an open-hearth refining-furnace, preferably gas-fired, which may either have a stationary, revolving, or tipping hearth, as may be found expedient or necessary, one of the prime conditions of this refining-furnace being that it shall be provided with a basic lining of character such as to aid in eliminating phosphorus, sulfur, and silicon from molten pig-iron introduced therein, and the lining of this refining-furnace may be either of lime, dolomite, magnesite, iron ore, iron oxids, or similar materials fused and fritted in place or previously baked and set in position as may be best. In addition to this apparatus we use the ordinary blast-furnace and Bessemer converter and the necessary auxiliaries to the conduct of a process of this character.

In operating our refining-furnace the largest portion or almost all of the silicon will be eliminated from the metal, and under best conditions we can also eliminate from eighty to almost one hundred per cent. of the phosphorus and at the same time a reasonable portion of the sulfur. In doing this the basic lining of the refining-furnace may be sufficient to accomplish the purifying, or we may use basic additions therein, such as limestone, lime, dolomite, iron ores, &c. During or prior to the transfer of the refined metal from the refining-furnace to the receiver we preferably remove the slag therefrom by decanting, skimming, allowing it to separate by a dam, by overflowing a ladle or other vessel, or in any other way that may be convenient or expedient. The slag from the refining-furnace is thus prevented from going into the receiver with the refined metal, the purpose of this being to obviate the possibility of the impurities, particularly the phosphorus, from being transmitted from the slag to the refined or to the mixed metal.

Having thus briefly described the general nature of the process and the preferred apparatus for conducting same, we will now briefly describe the process itself.

Molten pig-iron from one or more blast-furnaces is introduced into the receiver before mentioned, and by means of diffusion or agitation, or both, therein this pig-iron becomes much more uniform in its non-metallic constituents—such as silicon, sulfur, phosphorus, &c.—than the successive portions which have been introduced. While this is being done the refining-furnace is supplied with pig-iron either the same as that placed in the receiver or it may be either higher or lower in its non-metallic constituents. Basic additions, if necessary, may be made to the charge in the refining-furnace. After the elimination of a large part of the silicon, most of the phosphorus, and a considerable portion of the sulfur in the refining-furnace the purified metal therefrom is separated from its slag and said purified metal is charged into the receiver aforesaid, whereupon the blast-furnace metal is diluted with the purer refined metal, the silicon, phosphorus, and sulfur of the resultant mixture being materially lower than that of the blast-furnace metal alone.

In charging the receiver with blast-furnace metal or refined metal we may either fill or partially fill the receiver with a proper admixture of these two metals in order to produce the composition desired and then withdraw from it successive portions sufficient for a Bessemer blow until the receiver is emptied, or we may introduce blast-furnace metal and refined metal therein more or less continuously, keeping at all times a quantity of metal in the receiver and withdrawing the required portions for a Bessemer blow therefrom at intervals as desired. By carefully regulating the quantities and proportions of the refined metal and blast-furnace metal, with due respect to their impurities or non-metallic constituents, we can produce a mixed iron having a substantially or approximately uniform content of silicon and lower content of phosphorus and sulfur than in the average of blast-furnace metal.

Another and particular advantage of our process is that it enables us to use blast-furnace metal for charging direct into the receiver, if necessary, which contains a higher percentage of silicon than is customary or ordinarily necessary in Bessemer practice.

The manufacture of comparatively high silicon iron in a blast-furnace is an easier and more economical process than to attempt to make low-silicon iron, for the reason that as the silicon decreases in the blast-furnace iron the sulfur correspondingly increases, due to the required low temperature in smelting and other causes. On account of the fact that our refining-furnace produces a refined iron which is both low in silicon and other metalloids, this enables us to use higher silicons in the blast-furnace metals charged into the receiver, the resultant mixture being what is desired and proper. This process includes, therefore, the mixing of irregular blast-furnace metals to render them uniform or with unabrupt changes in their composition from time to time, and in addition to that the lowering of the silicon, sulfur, and phosphorus by the further admixture of refined metal from the refining-furnace aforesaid. We are thus enabled to produce a substantially uniform metal of best quality for use in the Bessemer converter which will produce better and more regular results than heretofore accomplished and furnish a steel with lower phosphorus, sulfur, &c., than could be had by using the blast-furnace metal, either direct or from a receiver.

Although for the purposes of explanation certain figures, sizes, quantities, and analyses are herein stated, we of course do not limit

ourselves to these figures, as they are merely given as examples in elucidation of the objects and purposes of our invention, nor do we confine ourselves to any specific apparatus in carrying out the same.

Having thus described our invention, what we claim, and desire to secure to Letters Patent, is—

1. The process of making steel which consists of placing successive portions of molten iron from one or more furnaces into a receiver, then introducing refined metal from a basic refining-furnace therein, said refined metal containing less metalloids than the furnace metal, allowing the various portions to diffuse and become more uniform in their composition and then bessemerizing, in an acid-lined converter, the resultant metal.

2. The process of making steel which consists of introducing into a receiver successive portions of molten iron from one or more furnaces, which portions are of varying composition, then purifying a portion of somewhat similar metal in a refining-furnace and there removing considerable percentages of the metalloids, including silicon, sulfur, phosphorus, &c., therefrom, then adding said refined metal to the metal in the receiver and making a substantially uniform mixture prior to further treatment in an acid-lined Bessemer converter.

3. The process of making steel which consists of introducing in a receiver successive portions of molten iron from one or more furnaces, which portions are of varying composition, purifying a portion of somewhat similar metal in a basic refining-furnace and there removing considerable percentages of its contained metalloids, separating the refined metal from the slag produced in the purifying operation, introducing the refined metal into the receiver and making a substantially uniform mixture prior to treatment in an acid-lined Bessemer converter.

4. The steps prior to the bessemerizing of molten iron in an acid-lined converter which consists of introducing a number or portions of molten iron from one of more furnaces into a receiver, which portions are of varying composition with regard to their contained metalloids, purifying portions of molten pig-iron in a refining-furnace and there removing considerable percentages of silicon, sulfur, phosphorus, &c., therefrom, introducing said refined metal into the receiver aforesaid and mixing or diffusing the same with the combined portions of the furnace metal and then withdrawing portions of the resultant metal for bessemerizing as aforesaid, maintaining during the operations a considerable quantity of mixed metals in the receiver.

5. The steps prior to the bessemerizing of molten iron in an acid-lined converter which consists of introducing a number of portions of molten iron from one or more furnaces into a receiver, which portions are of varying composition with regard to their contained metalloids, purifying portions of molten pig-iron in a basic refining-furnace and there removing considerable percentages of silicon, sulfur, phosphorus, &c., therefrom, introducing said refined metal into the receiver aforesaid and mixing or diffusing the same with the combined portions of the furnace metal and then withdrawing portions of the resultant metal for bessemerizing as aforesaid.

6. The process of making a mixture of various portions of molten iron direct from the blast-furnace, which are of varying compositions as regards their non-metallic constituents, introducing therein refined iron which has been purified in a basic-lined refining-furnace, removing the slag from said refined metal before mixing it with the blast-furnace metal and then making Bessemer steel in an acid-lined converter from the resultant mixture.

7. The process of making steel which consists of introducing into a receiver various portions of metal direct from a blast-furnace which portions are of varying composition, mixing the metal in said receiver with refined molten metal which has been purified in a basic-lined open-hearth furnace and the slag removed therefrom and then making said mixture into Bessemer steel in an acid-lined converter.

In testimony whereof we hereto affix our signatures in the presence of two witnesses.

HERBERT H. WEAVER.
GEORGE E. THACKRAY.

Witnesses:
E. M. LONGSHORE,
A. E. WEIMER.