

# UNITED STATES PATENT OFFICE.

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## MANUFACTURE OF IRON AND STEEL.

SPECIFICATION forming part of Letters Patent No. 245,084, dated August 2, 1881.

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*To all whom it may concern:*

Be it known that I, HUGH McDONALD, of Allegheny, county of Allegheny, State of Pennsylvania, have invented or discovered a new and useful Improvement in the Manufacture of Iron and Steel; and I do hereby declare the following to be a full, clear, concise, and exact description thereof.

My invention relates chiefly to the manufacture of wrought or metallic iron from pig or molten cast iron in the condition in which it ordinarily comes from the blast-furnace, whereby I am enabled to dispense with all or the greater part of the labor, time, and expense of puddling or boiling; and this I accomplish by what may be stated, in general terms, to be a combination of three steps or processes. One step is that in which a portion or charge of molten cast-iron is converted into a material which, if solidified, would be malleable. In working this step the Bessemer or Siemens-Martin or other known process or mode of operation adapted to give the result indicated may be employed. Another step, which, for convenience, I call the "second," is that in which a portion or charge of iron ore is roasted or converted into iron-sponge, and is used in a pulverized or finely-comminuted and highly-heated state. This step may be worked by the use of any of the known processes of roasting or reducing iron ore, (without melting,) including therein what are known as "iron-sponge processes." The remaining or third step is a process of mixing the two charges so as to form a solid mass, somewhat as the same feature forms a part of the Ellershausen process. These three steps or processes I combine and adapt to each other and to the end to be accomplished in such manner that by their conjoint action I secure an ingot or body of solid metal capable of being worked, when at the proper temperature, directly into "muck-bar," so called, or into a quality of iron of such character and condition that the working of it may be continued in the manner of working common malleable-iron ingots, billets, blooms, piles, &c.

Heretofore in the working of the Bessemer and Siemens-Martin processes it has not, so far as I am aware, been found practicable, at

least in a commercial sense, to produce a product which could fairly be called "wrought-iron," or which so nearly resembled wrought-iron as to be capable of being welded in ordinary forging operations; and though the terms "Bessemer iron" and "ingot-iron" have in some cases been applied to such product, it has been done, as I understand, chiefly to distinguish them from steel on the one hand, some of the usual qualities of which they do not possess, and from ordinary wrought or metallic iron on the other hand, in comparison with which they also lack some useful properties, and among others the welding capacity.

The roasting and iron-sponge processes and the Ellershausen process have all been worked more or less, and in some cases and for some purposes with comparatively good results; but they have not proved to be of such character as to supersede or take the place of the old and well-known puddling or boiling process in the general manufacture of wrought-iron. They have not been found to be as economical as was anticipated, and other objections and difficulties have been met with which it would be difficult to explain intelligibly except to a practical iron-worker, and even then the terms ordinarily employed have many of them a local meaning, and would not be readily understood in other localities; but such objections and difficulties are practically well known to those skilled in those branches of the art.

Now, in my present invention I employ the well-known Siemens-Martin or Bessemer steel process in order to purify and decarbonize or reduce a portion of the material I employ; and for the purposes of my present invention I thus (or by other known process) treat the molten iron so long or to such extent or in such manner that the resultant product, if allowed to solidify, would be malleable. I also, for another portion of the material, take pulverized iron ore and roast it or convert it into iron sponge and pulverize it, and while at a high heat mix it with the Siemens-Martin or Bessemer product above described, somewhat in the manner provided for in the Ellershausen process, so as to produce an ingot either then in the condition of wrought-iron or with its



constituent elements so united or intermixed that on further treatment in the reheating-furnace, and without remelting and boiling or puddling, it will come substantially to the condition of wrought or metallic iron, and be ready to be worked, in the ordinary manner, into blooms, billets, or muck-bar, or into a product so nearly akin thereto as to be capable of being further worked in substantially a like manner.

The iron ore referred to may be pulverized to a powder or left partly or wholly in small grains or lumps; but it should be so fine that practically it will all be subjected to the same action or effect while under treatment. This material I treat by any of the known roasting or iron-sponge processes, with or without the mixture therewith of carbonaceous matter, such as coke or charcoal or other deoxidizing or purifying or enriching agent, using for the purpose a high heat, but being careful that it shall not be melted or fluxed, nor come into a glutinous or adhesive state, such as will cause the grains, lumps, or particles to stick to each other. The manner of this treatment in other respects depends somewhat on the quality of the molten material employed, and on the extent to which on such material the converting or reducing process is carried, and on the quality of product desired. Thus, if the molten product, when ready to be poured from the converter or tapped from the open hearth, still contains too much carbon, the ore is to be treated under such conditions or to such extent as will not so completely deoxidize it as to render it unfit to act as a decarbonizing agent to the desired degree when it is mixed with the molten product, as presently to be explained, and it should also contain or carry with it such amount or percentage of oxide or oxidizing elements as may be necessary for "nourishing" the cast material of the ingot on being reheated, so that the latter will not work too "dry," as it is sometimes called; but the manner of securing in or with the ore at the time of the mixing the presence of such oxidizing agent is not material to the present invention. Any suitable material having or capable of evolving or generating oxygen when introduced in a heated condition into the molten fluid product may be employed, and may either be mixed with the ore (being first pulverized, broken up, or finely comminuted) and treated in like manner, or may be separately heated, provided only the treatment be not such as to drive off the oxygen, the presence of which is desired, and be not such as to cause the same to pass into a pasty, glutinous, or adhesive condition. Subject to these conditions, the ore, with or without other material, may be treated in any of the ways known to the art, as in an open hearth under a reverberatory heat, or in a muffle or retort or close or open chamber, either fixed in position or revolving, such elements of the operation and the manner of working them and of the ma-

terial therein being otherwise well known in the art; but, instead of ore, iron-sponge may be used, pulverized or broken up to about the degree of fineness indicated, and, its chemical composition being known, either accurately or approximately, it may be heated and treated as indicated with reference to the ore, and with or without the mixture of other ingredients, as already set forth. Also, iron filings and turnings may be substituted and heated and treated in like manner, as also iron shot or granulated cast-iron, such is made by pouring the molten iron from a height in small streams through the air or into water, and oxides or carbons may be mixed therewith in the preparation of the same in the manner described. Also, tap, forge, or mill cinder containing a considerable percentage of iron may be used in like manner and for the like purposes; or, still further, ore, cinder, iron-sponge, iron turnings or filings, and iron shot, or any two or more of them, may be mixed together and treated and heated in the manner described; and a high temperature, not exceeding that indicated, should exist in the material thus used at the time of the mixing with the molten product, as presently to be described.

The other part of the material which I use may be treated by the air-blast in a Bessemer or other like converter, in the manner substantially as known or practiced in the Bessemer steel process, except that the duration and force of the air-blast, as also the material (if any) to be charged into the molten iron in the converter during or at the end of the blowing operation, may be varied at pleasure with reference to securing any desired character or quality of product in a fluid state, and suitable for mixing with the heated solid pulverized materials hereinbefore indicated, or some of them, and such as will, when so mixed, make the kind or quality of ingot already described; or, subject to like limitations, such molten cast-iron may be treated in the Siemens-Martin or other open-hearth furnace, or by other known process, provided only that whatever process or treatment be used such material shall thereby be brought to such condition that if allowed to solidify it would make a malleable product, and also provided that, after treatment and when ready to be poured out of the converter or tapped from the open hearth or other place of treatment, it shall still be sufficiently fluid to run readily into and fill the molds.

A skilled workman, understanding the kinds or qualities of material he has to deal with in each branch of the process thus far described and the kind or character of ingot he desires to make, can, without serious difficulty, proportion such materials with reference to each other and the capacities of each, so that the mixture shall give the ingot or iron required. But while I have described the solid material as being in a heated state when prepared for the mixing, I do not deem it necessary in all cases that it be so heated, since useful results



may follow its use at its ordinary temperature, especially if it be very rich in iron; but I believe the best results will be secured by heating it as described, and, as a convenient term for including all such solid materials as I have named and others of like character, I designate them as a "metal or metallic alloy," and I use this term in this sense in the claim hereunto annexed. The heated molten material being then in a fluid state and the solid pulverized material being, by preference, in a heated state, as already described, the two are run together and simultaneously into an ingot-mold or other suitable mold or receptacle, substantially as described in the Ellershausen patent, No. 84,053, November 17, 1868, so that they will unite in a solid body or ingot as fast as they are mixed, or at least become so far set or solidified that they will not separate to any appreciable extent in consequence of being of different specific gravity; but care must be taken in running them in that the ore or other solid material shall be distributed uniformly, or practically so, through all parts of the ingot or solid mass thus formed, so that on the reheating of such ingot or mass the action and reaction of its constituent elements on each other will be practically uniform in degree as well as the same in kind, as a result of which the product will be homogeneous, or practically so, throughout. The operator will also exercise his usual skill in proportioning the two kinds of material so run together according to their qualities, or according to the reactionary power which each is adapted to exercise on the other, and with reference to the quality of product desired. In this way I carry the converting or reducing operation beyond the stage or degree which either the Bessemer or Siemens-Martin operations are adapted to give with certainty and safety, for in such operations, as the material is brought to, or nearly to, the condition of wrought-iron, it becomes thick and viscous, in which condition it is liable to set before it can be poured out or tapped off, and, being set, it can only be removed by tearing down the furnace or destroying the converter. Hence it is not deemed safe in such operations to treat the material down to any such low grade as will give a weldable iron when solidified; and while this is the main object of my invention, the same process which I have described may be used with advantage in making a non-weldable iron, or what is usually termed "ingot-iron," of a low grade, or sometimes "homogeneous iron," or even a low grade of steel.

In such use the skilled workman will follow the known rules or practices of the art in varying the variable elements of the process with reference to getting the product desired. As, for example, he will carry the converting or reducing operations to a less extent, or will remove less of the oxygen from the ore while roasting it, or will vary the proportions of the mixture.

Under the term "ingot," as herein used, I include solid masses or solidified bodies of the mixture, made as described, whether the mixture is made in a mold or otherwise.

While I have described what I believe to be the best mode of working my invention, it will also be practicable to employ very rich ores in their raw or unroasted or untreated condition, (if properly pulverized or broken up;) and even ores less rich in iron may be pulverized and mixed with iron turnings or filings, or with iron shot, or crushed cast-iron or scale or cinder, so as to be considerably enriched thereby, and be used in lieu of the solid part of the charge hereinbefore described in the making of some qualities or kinds of malleable product. Hence, in stating, as I have done, that the ore must be treated, I do not mean to limit myself absolutely thereto, but only to indicate that such treatment will uniformly give the best results, or be the most practicable for general purposes; but at the same time it will be within my invention to use any suitable ore or mixture of ore with other ingredients as an element in the process described.

It is not essential that all the specified steps, parts, or features of the invention thus described be worked or carried on at the same time, by which I mean contemporaneously or in immediate succession, nor at one and the same place. For example, after what I have described as the converting or reducing process has been applied fully or in part to the molten material, the same may be run off and allowed to solidify in any suitable form, and afterward remelted or fluxed and further reduced or converted, if need be, till it comes or is brought to the condition or state described; and the first part of this work—that is, the complete or partial reduction or conversion—may be done at one place or furnace or by one party, and such metal so treated, being sold or delivered to another party, may, by remelting or fluxing and by the use of the further steps, as described, be worked in substantial accordance with the present invention. Also, the process, instead of starting with pig or cast iron, may start with any previously reduced or converted iron, or even with wrought-iron or steel in any known form capable of being melted, fused, or fluxed in a suitable furnace, hearth, chamber, converter, or other receptacle, so that, being decarbonized or recarbonized, wholly or in part, or being otherwise treated, it shall thereby be brought to the specified fluid condition in which, if solid, it would be malleable. From this point or stage the process will be, in any event, substantially as above set forth. Hence it will be understood that in the present process it is not material how the treated, reduced, or converted metal is secured or produced, provided only that it be in or be brought to a fluid state or condition in which, if solid, it would be malleable, and that it also possess at



the same time such degree of fluidity that it may readily and safely be run off, as above set forth.

I claim herein as my invention—

5 The process of making iron or steel ingots capable under the application of heat of ready conversion into wrought-iron or steel by first bringing the metal to a fluid condition, in which, if solid, it would be malleable, and while  
10 in that condition and still fluid running it off

and mixing with it a pulverized metal or metallic alloy or mixture thereof, substantially as set forth.

In testimony whereof I have hereunto set my hand.

HUGH McDONALD.

Witnesses:

R. H. WHITTLESEY,  
GEORGE H. CHRISTY.