J. R. BILLINGS.

ART OF MAKING IRON AND STEEL.

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1,073,587. Patented Sept. 23, 1913.

Fig. 1.

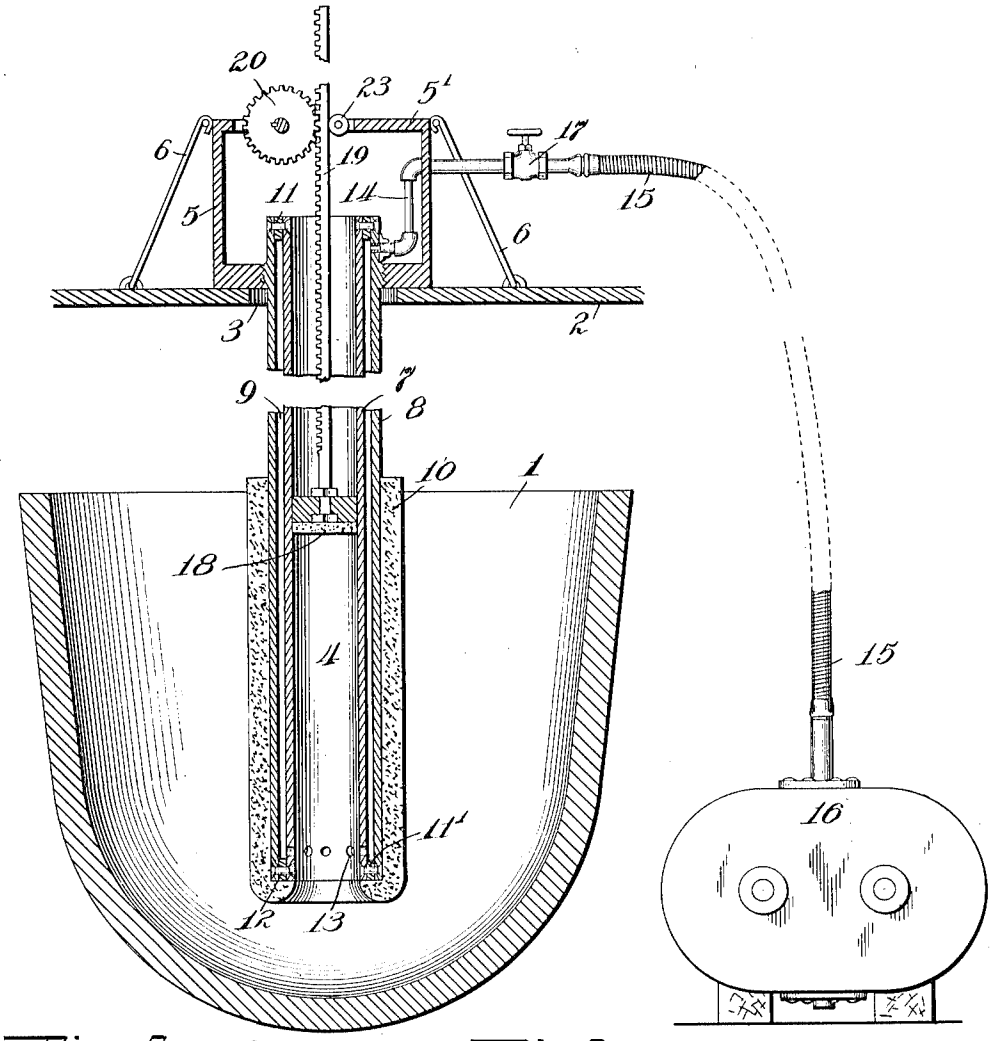


Fig. 2.

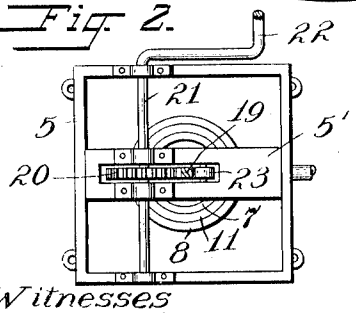
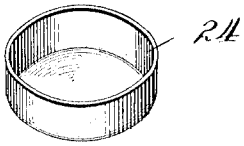


Fig. 3.



Witnesses
Milton Lenoir
Emile Rose.

Inventor,
James R. Billings,
By Albert G. Davis
Attorney.

UNITED STATES PATENT OFFICE.

JAMES R. BILLINGS, OF BIRMINGHAM, ALABAMA, ASSIGNOR TO BILLINGS PROCESS COMPANY, OF BIRMINGHAM, ALABAMA, A CORPORATION OF WEST VIRGINIA.

ART OF MAKING IRON AND STEEL.

1,073,587. Specification of Letters Patent. Patented Sept. 23, 1913.

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To all whom it may concern:

Be it known that I, JAMES R. BILLINGS, a citizen of the United States, residing at Birmingham, in the county of Jefferson and State of Alabama, have invented certain new and useful Improvements in the Art of Making Iron and Steel, of which the following is a specification.

This invention relates to an improvement in the art or process of making iron and steel, and relates more specifically to a process of treating the metal while in molten condition and then casting it, whereby it is given peculiar characteristics and at the same time rendered uniform or practically uniform so far as each particular batch treated is concerned.

Among the principal objects of the invention are to produce from ordinary and the lower grades of iron a metal possessing many, if not most, of the valuable characteristics of steel, and which metal I term a high carbon steel, to provide a process which may be conveniently, rapidly and economically carried out without the necessity of elaborate or expensive apparatus; to provide a process which enables the above referred to metal to be produced without putting it through a preliminary refining treatment, such as has heretofore been deemed essential to the production of steel; to provide a process whereby a metal may be produced having many of the characteristics of steel while at the same time it contains what would under ordinary practice be deemed relatively large quantities of the so-called debasing elements, thereby dispensing with the necessity of eliminating such debasing elements, and to a corresponding extent securing a larger yield from a given quantity of iron; to provide a process which is capable of being very exactly controlled and regulated during the critical step of treating the material; to provide a process which insures the production of a metal admirably suited to direct casting, so that strong and perfect castings may be made from the metal direct from a blast furnace immediately following its treatment in accordance with my improved process; to provide a process which insures the production of an iron or semi-steel which has the characteristic of being peculiarly soft and tough, and which is therefore especially suitable for making castings which require machining or tooling to finish parts thereof; to provide a process which is capable of being varied and controlled to produce definite desired results from varying kinds and qualities of metal; to provide a process which admits of sampling and determining the character of the batch to be treated before subjecting it to the special treatment and therefore enables the latter to be varied to best suit the particular batch from which the sample was taken; and in general to provide an improved process of the character referred to.

To the above ends the invention consists in the matters hereinafter described, and more particularly pointed out in the appended claims.

As is well understood in this art, iron produced by the smelting of iron ores is almost invariably first made into pigs or ingots and subsequently re-melted when required for the various uses in the art; one important, and perhaps the chief, reason for this practice being the uncertainty of securing direct from the blast furnace a metal which will produce strong and perfect castings. In the making of pig iron from the blast furnace, it is also well understood that several grades of iron will usually be produced from each tap-out; the different grades and different characteristics of each grade being due to conditions largely beyond the control of the operator under the practice heretofore obtaining. For example, under ordinary methods now employed, it is practically impossible to make all of the iron from a given tap-out of a blast furnace so nearly of one grade as to enable it to be made into castings direct without incurring a high percentage of loss in poor castings. Obviously the ability to produce a practically uniform quality or grade of iron at will is a most important desideratum, and this becomes of increased importance if that grade or quality be a very desirable one.

In the making of steel by the so-called direct processes, it has heretofore, so far as I am aware, always been deemed necessary to first subject the molten iron to a refining process, to remove the greater proportions of the so-called debasing impurities and to decarburize the metal; the decarburizing being usually continued until the remaining content of carbon is very low and the neces-

sary amount afterwards added by introducing a metal having a known content of carbon. Sometimes, however, the decarburizing treatment is arrested at that stage which, as near as can be determined, will leave about the proper content in the metal. So far as I am aware, however, it has never been known, or deemed to be practical, to make from ordinary iron a metal which is in fact a high carbon steel without first specially treating the metal to eliminate or reduce the debasing impurities. My invention or discovery makes this possible.

Describing this process in general terms, I first provide a batch of molten iron, which may be provided either by smelting ore in a blast furnace or in any other suitable manner, or by re-melting iron in a suitable cupola or furnace, and having thus provided the molten metal, if it is not already in a suitable vessel I transfer it to a suitable vessel, as for example a ladle, and then subject it to that particular step of my improved treatment which largely determines its character. This step consists in subjecting the molten metal to the action resulting from the introduction thereto of a charge of carbon or carbonaceous fuel, introduced in such manner and under such conditions as to insure a rapid combustion or oxidizing action distributed with approximate uniformity throughout the entire mass, whereby there is immediately brought about a thorough commingling of the molten metal with the carbon or carbonaceous material, a resulting generation of intense heat and consequent raising of temperature of the molten iron to a relatively high degree, and the production within the mass of iron of large quantities of carbon dioxid.

In practice I find that the necessary rapid charging of the molten mass with carbon or carbonaceous fuel, and the obtaining of the desired thorough combustion or oxidation to insure the production within the mass of relatively large quantities of carbon dioxid, may be best secured by introducing the carbon in the form of pulverized charcoal, coke, coal or graphite, downwardly against the ferrostatic pressure of the molten iron, and in such manner that it will be discharged or set free and distributed throughout the lower portions of the mass, while at the same time I introduce controlled and limited quantities of air to augment the supply of oxygen. The air should also be so introduced as to be disseminated throughout the mass of metal, and to this end I find it most convenient to introduce the air under pressure through a downwardly extending pipe arranged to discharge near the bottom of the vessel. The treatment should be of comparatively short duration, and the object aimed at is not to carburize the iron or add to its total content of carbon, but rather to produce within the mass of metal the intense heat incident to the oxidation of the fuel into carbon dioxid, and to produce within the metal the dioxid, which is a most important factor in securing the desired result. Promptly after the charge of carbonaceous material has been introduced in the manner described, and as soon as the temperature of the metal has been raised to a high degree thereby, the introduction of the carbonaceous fuel is arrested, as well also as the introduction of oxygen, and immediately, and while the metal is heavily charged or impregnated with the resultant carbon dioxid, I pour it into the molds, which may be either molds for forming pigs or ingots, or molds for forming castings of mechanical parts. I have obtained the best results by using metal molds, which, before receiving the molten metal, have been warmed to a moderate temperature, say from 150 to 200 degrees Fahrenheit, so that while the castings were not chilled and thereby hardened they were nevertheless cooled with considerable rapidity. The metal molds should also be protected with a wash or coating, such as graphite or the like, to prevent the molten metal from sticking to the molds.

While from the nature of the subject it is difficult or impossible to say exactly what reactions and changes take place during the treatment hereinbefore described, and which produce the characteristic results achieved by my process, yet I believe the following is in general a substantially correct explanation: Molten iron, when tapped from the blast furnace, or when melted in a cupola or other ordinary melting device, holds a large proportion of its carbon in the carbonic oxid state and is ordinarily of a temperature of from 2000 degrees Fahrenheit to possibly 2500 degrees Fahrenheit. Upon the rapid introduction of the charge of free carbon, accompanied by a sufficient supply of oxygen, as described, the resulting oxidation greatly increases the heat and converts the carbonic oxid present into carbon dioxid or carbonic acid gas, and this latter, by the subsequent prompt pouring and rapid cooling of the metal, is largely retained in the metal and imparts thereto the peculiar characteristics to the metal.

I have demonstrated that an iron containing a total carbon content of 3.50, silicon 2., sulfur .15, phosphorus 1.25, and manganese .35, may by my process be made into what I term a high carbon steel, showing the curved fracture, uniform gray luster, and taking the nitric acid test, and polishing and working like steel. Such a metal, of course, would be considered a comparatively low grade of steel yet nevertheless a steel. With basic iron having an analysis of 3.25 total carbon, 1.00 silicon, .05 sulfur, .5 phosphorus and 1.00 manganese, I produce a fairly good

casting steel having a tensile strength above 30,000 pounds per square inch. I have further demonstrated that taking the metal as it is tapped out from a given blast furnace, and treating the several tap-outs in accordance with my process, I can so uniform the product that for ordinary foundry practice it will all pass as of one grade. By this I do not mean to be understood as saying that the iron thus treated will all be of the same chemical analysis, but what I do mean is that the iron so produced will all be practically uniform in its working qualities, and this metal while not exactly like any of the grades of metal which are commonly known nevertheless has such characteristics that it has been pronounced as of very high grade.

Inasmuch as it is generally conceded by the best authorities that lack of uniformity in the product from a given blast furnace, or given tap-out, is due to changes in temperature and conditions largely beyond the control of the operator and not so much to the chemical composition of the metal, it will be seen that the results secured by my process are of great importance, because I am able to take the molten metal as it comes from the blast furnace and so subject it to controlled conditions as to secure practical uniformity.

Another and important characteristic of the metal produced in accordance with my process is this: When the metal is re-melted in the foundry or cupola it comes down or melts in a condition much hotter and more fluid than the usual irons with the result that perfect castings can be made with less care, and under more adverse conditions, than when using the usual crude pig irons or mixtures.

The process may perhaps be more exactly described and better understood by a description thereof as carried out in conjunction with one form of suitable apparatus used for subjecting it to what I term the converting step.

In the accompanying drawings—Figure 1 is an axial sectional view of a ladle and suitable apparatus for introducing air and a metalloid; an ordinary blower forming a part of this apparatus being shown in side elevation; Fig. 2 is a plan view of the introducing mechanism pertaining to the ladle and shown in Fig. 1; Fig. 3 is a perspective of a sheet metal cap used for closing the lower end of the introducing tube temporarily.

In this apparatus, 1 designates the ladle, which may be of any usual and suitable type, 2 a platform constructed to extend above the ladle and provided with an aperture 3 through which the introducing tube may be inserted, 4 the introducing tube as a whole, and 5 a supporting frame, conveniently taking the form of a box, through the lower end of which the introducing tube extends and to which it is rigidly united, by screw threads as shown.

The frame 5 is detachably held in place on the platform by means of a set of hook-links 6; the arrangement being such that when a charge of metal is to be treated, after it has been placed in the ladle, the introducing tube is lowered through the platform and into the molten mass, and the frame 5 then locked to the platform by the hook-links.

The introducing tube comprises an inner metal tube 7, an outer concentric metal tube 8 spaced away from the inner tube so as to form an annular air passage 9 therebetween, and an outer refractory covering 10 which covers so much of the tube as is liable to be inserted in the molten metal. The upper and lower ends of the annular space 9 are closed by space rings 11, 11′, through which may be extended the rivets 12 which secure the inner and outer tubes together. A circumferential series of outlet openings 13 afford communication between the lower end of the annular space 9 and the interior of the inner tube. With the upper end of the same space communicates an inlet pipe 14 which is connected by means of a flexible pipe or hose 15 with any suitable source of air or oxidizing blast under pressure. An ordinary positive blower 16 is shown. The blast is controlled by means of an ordinary turncock or valve 17 which is so constructed that the blast may be both turned on and off and graduated.

Within the inner tube is arranged to reciprocate an ejector plunger 18, the stem 19 of which is in the form of a rack which extends upwardly through the frame 5 and meshes with a spur-gear 20. Gear 20 is mounted on a crank-shaft 21 journaled to extend transversely through the frame and conveniently operated manually by means of a crank-handle 22. A roller 23 journaled in a cross frame strip 5′ just back of the rack 19 holds the latter in mesh with the gear. A tin or sheet iron cap 24 is provided, which is constructed to fit tightly upon the lower end of the introducing tube and serves to hold the charge of carbon within the tube after it has been placed therein.

The process as carried out with the foregoing apparatus is substantially as follows: A suitable batch of metal having been charged into the ladle, and the requisite amount of pulverulent charcoal, graphite, or other comminuted carbonaceous metalloid placed in the delivery end of the introducing tube, and confined therein by placing the cap 24 upon the end of the tube, the latter is lowered through the platform into the metal and the frame made fast. As soon as the lower end of the tube is fairly within the molten metal the cap 24 will be melted off, thus exposing the metalloid to the action of

the molten metal. The operators will now commence to force the ejector plunger down gradually and at the same time introduce a regulated quantity of air by opening the turncock 17 to the desired extent. It will be obvious that the carbon and the supply of oxygen will be thus introduced simultaneously, under perfect control and in regulated proportions as to each. When properly manipulated, the resultant reaction will effect an almost perfect combustion of the carbon so introduced, and conversion of the latter into carbon dioxid. The incident generation of gases, ebullition and ferrostatic pressure of the molten mass effects a very thorough dispersion and dissemination of the carbon and gases evolved therefrom throughout the entire contents of the ladle. Moreover, the circulation of the molten mass induced by the very considerable increase in temperature and ebullition will also aid in bringing about a most thorough and uniform treatment of all parts of the mass.

It is to be understood that the treatment should be carried out under the eye and control of the operator, who will be able to determine the moment the charge of metalloid has been exhausted by the action and appearance of the metal. If necessary or desirable a second charge of carbon may be introduced by simply withdrawing the plunger, placing the carbon in a tube and again forcing down the plunger to expel the same. However, in practice a measured charge is used which is made to conform to the quantity of metal to be treated and the necessity of repeated charges thus avoided. As soon as the treatment has been completed the introducing tube with its connected frame and parts is lifted out of the ladle and the metal immediately poured either to form pigs or ingots, or mechanical castings, as the case may be.

I claim as my invention:

1. The improvement in the art of making iron which consists in first obtaining the metal in a molten mass, confining the mass in a suitable receptacle, then while so confined, rapidly but under regulable control, introducing and thoroughly dispersing through all parts of the mass carbon or carbonaceous fuel and simultaneously effecting the generation of carbon dioxid and heat by concurrently introducing and dispersing through the mass under regulable control oxygen under a pressure not greatly in excess of the ferrostatic pressure and in quantities limited to conform approximately to the amount necessary to effect substantially complete combustion of the carbon or fuel so introduced.

2. The improvement in the art of making iron which consists in first obtaining the metal in a molten mass, confining the mass in a suitable receptacle, then while so confined, rapidly but under regulable control, positively forcing downwardly into the molten iron against the upwardly directed ferrostatic pressure thereof a quantity of comminuted carbon and allowing regulated portions of the carbon to escape and rise freely through the molten iron, and simultaneously forcing into said batch of molten metal against the ferrostatic pressure and not greatly in excess thereof and under regulable control air in quantities conforming approximately to the amount necessary to effect substantially complete combustion of the carbon and the production of maximum quantities of carbon dioxid, and then promptly and while the mass is heavily charged with said carbon dioxid converting the iron into castings.

3. The improvement in the art of treating iron, which consists in first obtaining the iron in a molten mass and confined in mass condition in a suitable receptacle, then treating the mass to simultaneously raise the temperature thereof and impregnate the same with carbon dioxid, by disseminating throughout the charge finely divided carbonaceous material and oxygen, in proportions to produce and maintain during the reaction treatment quantities of carbon dioxid in the mass in excess of that which the direct chemical reaction demands, the quantities of oxygen introduced being restricted so as to avoid pronouncedly oxidizing the iron during such treatment.

4. The improvement in the art of making iron and steel, which consists in diffusing throughout the iron, under controlled conditions, with accompanying limited quantities of oxygen, and while the iron is fully molten, material which produces in the presence of the iron and oxygen an exothermic reaction and provides quantities of carbon dioxid in the mass in excess of that which the direct chemical reaction demands, and maintaining said treatment and the molten metal and carbon dioxid in intimate combining relations until the iron has been pronouncedly modified thereby.

JAMES R. BILLINGS.

Witnesses:
ALBERT H. GRAVES,
EMILIE ROSE.