

UNITED STATES PATENT OFFICE.

REGINALD H. BULLEY, OF SYRACUSE, NEW YORK, ASSIGNOR TO HALCOMB STEEL COMPANY, OF SYRACUSE, NEW YORK, A CORPORATION OF NEW YORK.

PROCESS FOR PURIFYING STEEL.

955,378.

Specification of Letters Patent.

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No Drawing.

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To all whom it may concern:

Be it known that I, REGINALD H. BULLEY, citizen of the United States, residing at Syracuse, in the county of Onondaga and State of New York, have invented a new and useful Process for Purifying Steel, of which the following is a specification.

My invention is a new process for manipulating steel in a basic open hearth furnace, whereby a metal can be obtained of great purity and with as high a percentage of carbon as may be desired.

It consists essentially in pouring out the entire contents of the furnace; particularly all the slag, receiving said contents into a ladle, depositing carbon in the furnace to produce the desired degree of carburizing, and then teeming back into the furnace the molten metal, care being taken to prevent the return of any of the slag. New slag making materials may then be added where necessary further to purify the metal.

By this process a continuous bath of metal is maintained in the furnace, which is both kept at the lowest point in phosphorus and sulfur, and recarburized to any desired extent. The great difficulties and disadvantages of the old processes are overcome or avoided: particularly, the danger of the metal getting into a superoxidized condition, with the attendant waste and difficulty of working; the tendency of the phosphorus to return from the slag into the metal; the difficulty of introducing carbon or carbon compounds (carburizing materials) through the slag.

This process is particularly valuable where an open hearth furnace is used in connection with an electric furnace; a continuous bath may be maintained in the open hearth furnace and the electric furnace supplied at frequent intervals with comparatively small amounts of molten metal, (of high carbon if desired). The open hearth furnace is essentially an oxidizing furnace, where it is difficult to maintain a bath containing a high degree of carbon for any length of time and there is danger of the metal getting into what is known as the superoxidized condition. In that condition the carbon is, practically, entirely removed and an excess of oxygen is present; while a metal very low in phosphorus can be obtained in that superoxidized condition (for

transfer to an electric furnace), yet there are certain serious objections thereto. The superoxidized metal becomes of a creamy, semi-viscous consistency, so that it is difficult to work and very difficult to teem out of the bottom of the ladle, by means of the usual stopper and nozzle, which is desirable to avoid the return of any slag; there is considerable loss occasioned by a portion of the metal adhering to the sides of the ladle. Another serious objection to the use of metal in this condition in the open hearth furnace is the great loss, for a considerable portion of the metal oxidizes and passes into the slag. Also when the metal in the open hearth furnace has reached this superoxidized condition it is very difficult, by the ordinary process, to recarburize the bath.

Heretofore it has been proposed to produce high grade steel by superoxidizing to remove the phosphorus, but this I believe to be impractical, on account of the aforesaid disadvantages necessarily attendant on superoxidizing; furthermore I am not aware that any practical means for recarburizing the metal has been suggested.

My process consists of pouring the entire contents of the furnace into a ladle and for this purpose a furnace of the tilting type is preferable. Care should be taken to drain the furnace as completely as possible from all the slag. Some of the slag may overflow from the ladle into the slag pit. A sufficient quantity of carbon to produce the desired degree of carburization is then thrown on the bottom of the furnace. For this purpose anthracite coal, coke, charcoal or any other form of carbon, which can be procured sufficiently free from phosphorus and sulfur, may be used. The molten metal in the ladle is then teemed back into the furnace by means of the ordinary nozzle and stopper, care being taken to close the nozzle before any of the slag runs through. This molten metal, coming into direct contact with the carbon in the bath of the furnace, unites with it readily, and a very high degree of carburization can thus be obtained. It is essential to withdraw all the slag from the furnace and to return none of it. New slag making materials such as limestone or calcined lime, fluor-spar and iron ore or roll scale, can then be added, which will form a

pure slag particularly free from phosphorus. If the metal be carburized to a point considerably above the desired degree of carburization, iron ore, or oxid of iron in some other form, can be added to reduce the carbon to the desired point. This produces a boiling action in the bath, which greatly facilitates the removal of the remaining phosphorus into a new slag. This operation can be repeated from time to time whenever it is found necessary, and it is thus easy to maintain a bath of a high degree of carbon and great freedom from sulfur and phosphorus. In transferring this metal to the electric furnace it can readily be teemed out of a ladle by the use of the stopper and nozzle in the ordinary way, and by taking over in the ladle a greater quantity than is needed and stopping the teeming operation when the desired quantity is in the electric furnace, no slag will be introduced into the electric furnace. This is very important, because, if any slag is introduced into the electric furnace, any phosphorus in said slag will pass into the metal in that furnace. The excess steel remaining in the ladle can then be returned to the open hearth furnace and the loss of metal in the operation is very slight.

By maintaining a bath in the open hearth furnace at a high degree of carburization the loss of metal in the furnace due to oxidation can be kept very low, and the high degree of loss due to superoxidization can be avoided.

My process is simple, economical and very convenient; it has the above stated important advantages; it is practiced in connection with a single open hearth furnace; it overcomes the aforesaid disadvantages and difficulties. To further explain this—if a portion of the metal is removed in the ladle to an electric furnace and a quantity of pig metal equal to the amount so removed be added to the bath in the open hearth furnace, it will be found very difficult to raise the percentage of carbon in the bath, should the metal have become low in carbon, even though the pig metal contains a considerable quantity of carbon. It is in fact, difficult or impossible to get carbon either free, or in combination of metals, through the slag on top of the metal in sufficient quantity to raise the percentage of carbon in the bath to any great extent, as aforesaid, if it has once become very low in carbon.

In the purification of iron or steel in the basic open hearth furnace most of the phosphorus and much of the sulfur passes into the slag. But the phosphorus, more particularly, has a tendency to return into the metal from various causes that can not always be controlled. If the slag could be completely removed and a new slag or slag forming materials free from phosphorus added, then the return of phosphorus from the original slag

would be prevented and additional amounts of phosphorus and sulfur could be removed from the metal in the bath. But this removal of the slag is so difficult as to be practically impossible. It has been attempted in open hearth furnaces by tilting the furnace back and allowing the slag to flow out of a special slag notch in the back doors; this is assisted by raking the slag toward the notch with iron rakes. All the slag however cannot be removed by this method and it will be found also that the slag so raked out will take with it a considerable quantity of metal. The work is exceedingly laborious and the men using the rakes are exposed to the extreme heat of the furnace; it is difficult to get them to perform the operation to the practical limit and it will be found that not more than 50 to 75% of the slag can be so removed. By my process there are none of these difficulties; the slag is completely removed to the last drop that can be drained out of the furnace; the metal is returned without appreciable loss and the men are not exposed to the heat and have no arduous work to perform. In addition, the combination of the metal with the free carbon, when returned to the furnace, produces some heat to make up for the loss occasioned by its transfer to the ladle and back again, so that the temperature of the bath in the furnace is easily maintained.

Having thus described my invention what I claim as new and desire to secure by Letters Patent, is:—

1. The herein described process for carburizing iron or steel in an open hearth furnace consisting in first melting the metal in the furnace, then pouring the entire contents of the furnace into a ladle, then throwing carbon into the bottom of the furnace and teeming the metal from the ladle back into the furnace on top of the carbon.

2. The herein described process for simultaneously recarburizing iron or steel in an open hearth furnace, purifying the metal, and maintaining the purity by complete removal of the slag, which consists in first melting the metal in the furnace, then drawing out the contents of the furnace, including all the slag, receiving all the molten metal including more or less slag in the ladle, throwing carbon onto the bottom of the furnace, and teeming the metal back into the furnace from the ladle, without permitting the return of any of the slag.

3. The process for converting cast iron-scrap, or the like into high grade steel, which consists in first melting the metal in an open hearth furnace without superoxidizing, then removing the contents of the furnace, particularly all the slag, into a ladle, depositing carbon in the furnace, teeming the molten metal back into the furnace but retaining all the slag in the ladle, then transfer-

ring the required amounts of the molten metal to an electric furnace and there transforming it into the desired product.

4. The herein described process for carburizing iron or steel in an open hearth furnace, consisting in first refining in the furnace, then pouring the contents of the furnace into a ladle, then throwing carbon into the bottom of the furnace, teeming the molten metal into the furnace, while retaining

the slag in the ladle, and then adding to the furnace suitable slag making materials free from phosphorus and sulfur.

In testimony whereof I have signed my name to this specification in the presence of 15 two subscribing witnesses.

REGINALD H. BULLEY.

Witnesses:

EDWARD KENT,
L. SCHLOSSER.