UNITED STATES PATENT OFFICE.

ALFRED EPHER HUNT, OF PITTSBURG, PENNSYLVANIA.

PROCESS OF MANUFACTURING STEEL.

SPECIFICATION forming part of Letters Patent No. 493,090, dated March 7, 1893.

Application filed February 1, 1892. Serial No. 419,879. (No specimens.)

To all whom it may concern:

Be it known that I, ALFRED EPHER HUNT, of Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in the Process of Manufacturing Steel, of which the following is a full, clear, and exact description.

My invention pertains to the manufacture of steel by the open-hearth, Bessemer, or similar processes, and is intended to afford means by which the steel can be carburized with accuracy to the required degree, and the grade and quality of the steel thus determined. Prior to my invention such recarburization has been done principally by addition to the molten steel of iron alloys containing an excess of carbon, such as spiegeleisen, high-carbon pig, &c., but such method is objectionable, because the alloys employed are often expensive, and because, in order to introduce the required amount of carbon, by means of an alloy of manganese, for instance, it is frequently necessary to introduce with it so much metallic manganese as to impair the value of the steel, while if high-carbon pig be used to carburize the steel, other impurities, such as sulphur, silicon and phosphorus, are apt to pass with it into the molten bath, and to exercise on the product their usual deleterious effects. These objections I avoid by the use of a carburizing agent of solid free carbon, which in the form of charcoal, coke, graphite, anthracite coal, &c., may be obtained cheaply and in a state of sufficient purity. I have discovered that if manganese alloy be added to the bath to free the metal from red shortness, and at about the same time, (and at or near the termination of the refining process) such free carbon be added to the bath and thoroughly intermingled with the same in definite proportions, the percentage of combined carbon in the steel can be raised to any degree desired for commercial results, it can be done with certainty, and a finer, purer, and in many ways better product can be obtained than is possible with prior methods of carburization. To the successful practice of this process, four factors are essentially necessary; first, that the carbon addition should be made at or near the end of the refining operation, either soon before the metal is tapped from the furnace or converter, or after it has been withdrawn therefrom into a ladle, mold or other receiving vessel; second, that the addition of carbon must be accompanied by the addition of an alloy of manganese, or similarly deoxidizing metallic element, which can be introduced before simultaneously with or after the free carbon; third, that the carbon should be added in definite quantity, (which can be determined by a process of calculation stated below,) since if too much or too little is added, or if it is added in uncertain amounts, it is impossible to obtain products of commercial value; and, fourth, that the carbon must be added so as to be intermingled thoroughly with the molten bath, either by agitation, stirring, or in any other manner. If any of the conditions above noted is absent in the conduct of the process, certain results cannot be attained and certainty of product is well recognized as indispensable to the commercial and economic success of any metallurgical operation.

My invention therefore, generally stated, consists in an improvement in the manufacture of steel, in which the metal is first refined in a furnace or converter, so as to bring it to a steely condition, and is then treated with manganese, or its equivalent, and recarburized by the addition and thorough admixture with it of a definite proportion of free carbon (by which I mean solid carbon uncombined chemically with metals) sufficient in amount to raise the carbon content of the steel to a predetermined point.

My invention is of value both in connection with the manufacture of steel in an open-hearth furnace and its manufacture in a Bessemer converter, and the steps of the method as suggested above, may be practiced either before or after the tapping of the metal. I have found it however to be of special value as applied to the open-hearth process, and will describe it in detail as used therein while the metal is still in the furnace; from which description, those skilled in the art will be able not only to use the process in the manner specified, but also to modify its working details so as to render it useful in the variations of its application suggested above.

I wish it to be understood that my invention is not limited in its scope to the manner of operation herein specified particularly, but

that, as stated in the first claim, it is intended to cover broadly the treatment of steel after it has been refined by treating with manganese or its equivalent, and recarburizing by the addition and thorough admixture of a definite proportion of free carbon, however and at what ever period after the refining operation, the same be introduced and mixed.

The preliminary operation of the open-hearth furnace may be conducted in the usual manner, *i. e.*, a bath of pig iron introduced and melted on the hearth may be reduced by means of iron ore; or the bath may be diluted with wrought iron or steel scrap until the excess of silicon and carbon in the pig iron has been oxidized from it; the well-known basic process being employed when it is desired to make use of its properties of dephosphorization.

When the refining operation has been carried on in the usual way and the metal is brought into proper condition for recarburization, I introduce the carbon in definite proportion, and rabble it thoroughly into the bath. This I prefer to do by binding together bundles of charred wood with wrought iron bands, attaching them to rabbles and stirring the bath vigorously therewith; or, if desired, powdered charcoal, coke, anthracite coal, or carbon in other form may be introduced and stirred into the bath. In any case, however, the carbon must be introduced in definite proportion sufficient to raise the percentage of combined carbon in the steel to the point desired. To determine the proper quantity of carbon to be added in this manner, one must know approximately the weight of the bath under treatment, and the proportion of carbon which acts efficiently in carburization. Thus, in treating a bath of say twenty thousand pounds of molten steel, having when refined after the manganese addition and immediately before the time of making the carbon addition, a content of three-tenths of one per cent., of carbon, which is desired to be raised to five-tenths of one per cent., it will be necessary to add an amount of carbon equal to two-tenths of one per cent., of the total weight of the bath, plus the weight of carbon that will be lost in combustion or otherwise without doing useful work in carburizing the steel. This coefficient of loss can be made to be practically constant in any given mode of introducing the solid carbon into the steel. Thus in rabbling into the bath (after the manganese addition and before tapping) sticks of solid wood-charcoal (of hard wood, such as birch, hickory or oak) in the manner above described, the loss amounts to about twenty-five per cent., of the weight of the carbon, but where powdered anthracite coal and powdered coke are rabbled into the bath, the loss is much greater, amounting to about fifty per cent. Therefore, in the example stated above, using stick charcoal as the carburizing agent, two-tenths of one per cent., of twenty thousand pounds equals forty pounds, and to this adding twenty-five per cent., for loss, it follows that fifty pounds of carbon should be added to raise the carbon content of the steel from three-tenths of one per cent. to five-tenths of one per cent.

I claim—

1. In the manufacture of steel, the method which consists in refining the metal, then at or near the end of the refining operation adding to it a deoxidizing agent, and recarburizing the refined metal under treatment by the addition and thorough admixture of a definite proportion of solid free carbon proper to raise the carbon content of the steel to a predetermined point; substantially as and for the purposes described.

2. In the manufacture of steel, the method which consists in refining the metal, adding to it a deoxidizing agent, and recarburizing the refined metal under treatment by the addition and rabbling into it of a definite proportion of solid free carbon proper to raise the carbon content of the steel to a predetermined point; substantially as and for the purposes described.

3. In the manufacture of steel, the method which consists in refining the metal, adding to it a deoxidizing agent, and recarburizing the refined metal under treatment by the addition and rabbling into it while still on the hearth or converter a definite proportion of solid free carbon proper to raise the carbon content of the steel to a predetermined point; substantially as and for the purposes described.

4. In the manufacture of steel, the method which consists in refining the metal, adding to it a deoxidizing agent, and recarburizing the refined metal under treatment by the addition and rabbling into it carbon in the form of sticks in definite proportion; substantially as and for the purposes described.

In testimony whereof I have hereunto set my hand this 30th day of January, A. D. 1892.

ALFRED EPHER HUNT.

Witnesses:
R. H. WHITTLESEY,
THOMAS W. BAKEWELL.