

UNITED STATES PATENT OFFICE.

JULIUS BAUR, OF NEW YORK, N. Y.

IMPROVEMENT IN THE MANUFACTURE OF STEEL.

Specification forming part of Letters Patent No. **99,624**, dated February 8, 1870.

To all whom it may concern:

Be it known that I, JULIUS BAUR, of the State, county, and city of New York, have invented certain new and useful Improvements in the Manufacture of Steel; and I hereby declare that the following is a full, clear, and exact description thereof.

The nature of these improvements consists, first, in a method, hereinafter to be described, of making steel in crucibles, or any other suitable furnace or vessel, by alloying or combining metallic chromium with metallic iron or other steel-making material in such manner that chromium in a metallic state shall be present in the finished product to impart valuable properties thereto; and, second, in making steel in crucibles or otherwise, as stated, by so alloying or combining the metallic chromium with the metallic iron or steel-making material that the finished product shall derive its requisite steely properties from the metallic chromium present in it, and not from carbon or carbonaceous matter.

Letters Patent of the United States have heretofore been granted to me for processes for the manufacture of steel, whereby metallic chromium is caused to be combined with the iron designed to be converted into steel, and the improvements hereinafter described relate to a modification of these inventions.

By my previous processes I have contemplated forming, prior to the actual conversion of the iron into steel, what I have termed a "compound," consisting of chromium reduced from the ore to the metallic state, united in suitable proportions with metallic iron, and adapted to be readily combined in the ordinary crucible with the iron designed to be converted to steel. This method of procedure, it will be seen, involves the reduction of the chrome ore either in the crucible, the blast-furnace, or in some other suitable apparatus, and afterward the combination of the product thus obtained with iron, to make the steel. Such a process will, as since the introduction of my previous invention has become well known, make the very highest quality of steel; but I can, if desired, dispense with the twofold operation above mentioned, and the process now to be described consists in so doing. In order to effect this I employ chrome ore or oxide of chrome, and I so arrange the reduc-

tion thereof, or, as it may properly be termed, in view of the present invention, the combination of the chromium with the steel-making iron, that the operation of reduction of the ore to the metallic state shall include or be simultaneously attended by the combination of the chromium in the metallic form with the iron employed for conversion to steel; and by this means I dispense with one entire step of my previous processes, while I make a product which is quite as rapidly, easily, and cheaply obtained as the chromium steel heretofore produced by my inventions, and is of equally excellent character, possessing great tenacity and toughness, and having practically almost perfect uniformity.

In practicing these improvements, I have secured successful results by taking, to every fifty pounds or thereabout, or in that proportion, of the iron designed for steel—say, three pounds of chrome ore, as it usually comes, and one pound of carbon or carbonaceous matter in any suitable form—and melting the whole together at one operation in a crucible, in the ordinary steel-melting furnace, in the manner commonly followed in making crucible steel. The melting may, however, if preferred, be performed in a suitable gas-furnace or in any other convenient apparatus.

The above mixture will produce a most excellent quality of what is termed "high steel;" and if I desire to make a steel of a lower grade, I employ, with the above-stated productions of iron and chrome ore, twelve ounces or thereabout of the carbon or carbonaceous matter, and proceed as described; or, for steel of a still lower grade, I may diminish the carbon or carbonaceous matter to eight ounces or thereabout, proceeding in other respects as already set forth.

The product thus made will, when run into ingots in the usual way, be found to be a pure, fine, uniform metal, possessing all the excellent characteristics of my chromium steel, as heretofore manufactured; and it will be observed that it is produced at a single operation by what may be termed a simultaneous reduction and combination with the steel-making iron of the chrome, which is the foundation of the metal, in lieu of the twofold procedure of first forming a chromium compound at one melting, and then uniting that com-

pound with steel-making iron at a second melting.

In respect, however, of the second branch of these improvements, in which the metallic chromium in the finished product is, as has been stated, employed instead of carbon, to impart the requisite steely properties to the metal, I wish it to be understood that, although I contemplate the employment of carbonaceous matter, as stated, I do not do it in order to secure for the product any effect from such carbon; nor does the process operate in any such way or secure any such effect. The carbon is used merely to accomplish the reduction of the chrome ore to metallic chromium, and that is the sole function which it performs in the operation. Therefore, when the proportion of the carbon or carbonaceous matter is varied, as above stated, in making steel of the different grades which have been mentioned, it must be understood that it is only done because it is the reducing-agent for the chromium; and, consequently, since the greater or less proportion of alloying chromium which exists in the metallic form, in combination with the iron in the finished product, is the only thing in the second part of my process which determines the degree of hardness of the steel and its character or grade, the carbon must, or preferably should be, increased or diminished according as the proportion of chrome ore mixed with the iron to be converted into steel is increased or diminished; for the more chrome ore thus mixed the more carbon will be required to reduce the chromium to the metallic form, in order that it may alloy with the iron, and the less chrome ore the less carbon.

Hence, in the three examples hereinbefore given, although the proportion of chrome ore is made the same in all, the theory upon which the examples proceed is that only so much of the chrome ore, as stated in the examples, as will be reduced by the proportion of carbonaceous matter, also stated in each example respectively, will be converted into the metallic form, and enter into an alloy with the iron to make the finished steel. Thus, in the first example, where one pound (sixteen ounces) of carbon is mentioned, substantially the entire three pounds of chrome ore given in the example will be reduced to the metallic state by this carbon, thereby imparting to the finished steel the qualities mentioned under that example. In the second example, there being but twelve ounces of the reducing-agent employed, something less than the whole three pounds of chrome ore will be reduced, thus producing the modification of the product stated for that example; and in the third example, the eight ounces of carbon will reduce still less of the three pounds of chrome ore, thereby causing a still further modification of the product.

If desired, however, the following examples and method of procedure may be adopted:

For a high steel, suitable, for instance, for

turning-tools and similar uses, take to every one hundred pounds of proper steel-making iron, such as Peru or Danemora iron, three pounds of chrome ore and as much carbon or carbonaceous matter as may be required, according to the quality of the latter, to reduce this amount of chrome ore to the metallic state, proceeding in all other respects as above directed.

For a lower grade of steel, adapted to taps, dies, &c., take to every one hundred pounds of the steel-making iron of proper quality one pound of chrome ore and sufficient carbon to reduce the latter to the metallic form, proceeding otherwise as before.

For any other grades or variations desired in the product between these two examples, take to the one hundred pounds of iron any suitable amount of chrome ore between the one pound and the three pounds of the examples, according to the character of product required by the operator, and employ with it such amount of carbon as will suffice to reduce to the metallic state the quantity of chrome ore so selected.

In many cases, as, for instance, when "Bessemer scrap," or iron which contains a larger than ordinary percentage of carbon or "blister steel," is employed for conversion into steel by my process, the carbon thus existing in the same will be found sufficient in quantity to reduce the chrome ore to the metallic state without the addition of any more carbon for that purpose. In these cases, which in practice will readily be distinguished by the operator, the use of such additional carbon may, therefore, be dispensed with.

From the foregoing remarks it will be seen that the carbon used as described in this specification need not, and, so far as respects the second part of my improvements, does not, in any way influence or determine the character or qualities of the steel when finished; and when finished it does not possess the qualities of carbon steel as distinguished from the chromium steel manufactured by my previous inventions, but it has only the well-known characteristics of such chromium steel. It will therefore be seen that it is the chromium, and the chromium alone, which imparts to it its distinctive features and determines its character.

Steel made of these processes is far superior to other steel, and my practical experience with them has tended to convince me that this is due to the less affinity which oxygen has for chromium than it has for carbon.

From this it follows that the unavoidable exposure, more or less, to the atmosphere, to which, in all processes, the steel-making materials are always subjected during the manufacture, must necessarily cause much less chromium, if that be used, to be removed or affected, so as to lead to injury or lack of uniformity in the product, than it will carbon if carbon be used. Hence the maker of steel by the ordinary methods is frequently unable to

judge what percentage of carbon will be found in the finished metal, because he cannot know what proportion of that which he puts into his crucibles or other vessels will be carried off by the oxygen of the atmosphere during the melting. This appears to be an important cause of the want of uniformity so frequently observed in steel made in the usual way. But my chromium processes are practically wholly unaffected by oxygen, and therefore secure the most perfect uniformity and certainty of product.

I may remark that in carrying out these inventions I prefer to employ the chrome ore in the form of small grains—say, about the size of ordinary writing-sand—and the carbon in the form of pure hard charcoal, reduced to grains of about the size of barley.

I do not find it necessary to use any flux; but any suitable one may be employed, if desired.

I wish it, however, to be understood that I do not limit myself to the specific proportions of steel-making iron, chrome ore, and carbon or carbonaceous matter, above referred to, as these may be varied without departing from my inventions, and the foregoing examples are given only as those mixtures and variations which I have found preferable.

I am aware that chromium has been alloyed with iron merely for scientific or laboratory experiment; and I am also aware of the English letters which have been granted to Robert Mushet, in which he has spoken of the use of chrome ore or oxide of chromium with other substances in making steel. But "limited, accurate, and specific rules of practical application" for accomplishing what is herein described have never before been made known; and my inventions are clearly distinguishable from anything which preceded them in this, that it has not heretofore been supposed that steel, or, as perhaps it should be termed, a substitute for steel, could be made in a practical way, and for practical and valuable use in the arts, by alloying metallic chromium with metallic iron; nor has it been known that by so doing this no carbon, or substantially no more than existed in the material before it was converted into steel, shall be present in the finished product, the properties required in steel, and recognized as constituting the difference between steel and iron, and for the imparting or production of which carbon (usu-

ally with other substances, such as manganese, &c.) has hitherto been supposed to be essential, can be given to the product solely and entirely by the alloy in it of the metallic chromium without the employment, in any degree whatever, of carbon or any kind of carbonaceous matter to effect the finished metal. Hence, no process in which chrome ore or oxide of chrome operates, either designedly or not, only as a flux, is here claimed or is regarded by me as possessing importance.

It is essential to my inventions that the chromium in a metallic state should alloy or combine with the steel-making iron or material in a metallic state and be present in the finished metal, and the product of my processes is such an alloy or combination of metallic chromium and metallic iron, and the presence of the metallic chromium in it may be demonstrated by proper tests.

In the product of the second branch of my process I am to have no carbon or carbonaceous matter whatever, and in practice there is none in it except only the insignificant amount which existed in the bar-iron or other steel-making material before it was converted into the steel or alloy mentioned. Furthermore, when in practicing this part of my process use is made of new crucibles or "pots," or crucibles containing carbon, which may be imparted to the steel-making materials during the operation of melting, I make allowance for this carbon, and employ so much the less for the reduction of the chrome ore. But

Having thus made known my improvements, what I claim as new, and desire to secure by Letters Patent, is—

1. The above-described process of making steel by combining or alloying metallic chromium with metallic iron, so that the metallic chromium shall be present in the finished product, substantially as set forth.

2. The foregoing process of making steel, or what may be termed a substitute for steel, by combining or alloying metallic chromium with metallic iron in such a manner that the metallic chromium shall be present in the finished product, and shall be the only agent which imparts to such product the qualities of steel, substantially as described.

JULIUS BAUR.

Witnesses:

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