

UNITED STATES PATENT OFFICE.

A. K. EATON, OF NEW YORK, N. Y.

IMPROVEMENT IN THE PROCESS OF MANUFACTURING MALLEABLE CAST-IRON AND STEEL AND IN THE DEOXIDIZING OF IRON ORE.

Specification forming part of Letters Patent No. **32,621**, dated June 25, 1861.

To all whom it may concern:

Be it known that I, A. K. EATON, of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Decarbonizing Cast-Iron and Deoxidizing Iron Ore; and I do hereby declare that the following is a full and exact description thereof, reference being had to the accompanying drawings, and to the letters of reference marked thereon.

My invention consists in decarbonizing cast-iron by means of carbonic acid, and deoxidizing iron ore by means of the carbonic oxide thus produced.

In fully describing the character and limits of this invention it becomes necessary to allude to Letters Patent previously issued to me for kindred purposes, as they form a part of the history of this improvement. In 1857 Letters Patent were issued to me for the manufacture of malleable-iron castings by packing cast-iron in the oxide or carbonate of zinc and exposing to a high heat. In my preliminary experiments of the previous year, I demonstrated not only the decarbonizing action of oxide of zinc and its carbonate, but also of soda and its carbonate, but failed to recognize the fact that the carbonic acid of these compounds was instrumental in the decarbonization effected, attributing it wholly to the action of the oxides. The use of soda proved objectionable in the malleable-iron process, but afterward proved of essential importance in the decarbonization of cast-iron for the purpose of manufacturing steel, for which application Letters Patent were issued to me during the present year. This process, consisting in its most available modification in the use of a bath of melted carbonate of soda into which plates, bars, or other forms of cast-iron were introduced and exposed to long-continued heat, really involved the decarbonizing action of carbonic acid; but this fact was not recognized at the time, nor was it claimed in the patent. The application of the process subsequently on a larger scale demonstrated that while the simple hydrate of soda would decarbonize cast-iron the carbonate would act with much greater efficiency. This result pointed to carbonic acid

as the probable cause of the discrepancy, and, to leave no doubt with regard to it, experiments were instituted which demonstrated that carbonic acid of itself would decarbonize thoroughly. Indeed, it was proved that carbonic acid is the most efficient available agent for the decarbonization of iron in its solid condition, and that it was only for the purpose of removing impurities, sulphur, phosphorus, and silica that soda was essential in the steel process. The application of this discovery gives me a new and improved method of manufacturing malleable iron and modifies my process for producing steel from cast-iron. I will first describe the principal mode of applying it to the production of malleable-iron castings.

The iron is packed in an iron, fire-clay, or other receptacle, mounted like a gas-retort, for example. The castings should occupy only the hottest portion of the retort. Into the mouth, which is to be kept much cooler than the body of the retort, I introduce the requisite amount of carbonate of lime in the form of chalk, bits of marble, common limestone, or whatever form of said carbonate can be most readily obtained. The retort thus charged and closed at the mouth is exposed to a high heat. It is essential, however, to avoid too great an elevation of temperature at the mouth in order to prevent too rapid an evolution of carbonic acid. This gas, as it is expelled by heat from the carbonate of lime, comes immediately in contact with the highly-heated castings and rapidly removes carbon therefrom. About twenty-five pounds of carbonate of lime should be used to decarbonize one hundred pounds of cast-iron, except when oxide of iron is present with the castings. The retort may be set perpendicularly, if preferred. The limestone may be introduced at intervals in small quantities, if desirable. A small tube connected with the rear end of the retort from which the carbonic oxide can be burned as it issues will enable the operator to note the progress of the decarbonization.

Owing to the tendency of the more delicate castings to become bent by their own pressure upon each other when in a mass and at a heat that renders them soft, it will be necessary to

pack them in some coarsely-powdered substance not injurious to the castings. Crushed limestone itself may be made use of, in which case some decarbonizing effect will be produced by its own carbonic acid; but as the temperature of the iron when at the most advantageous heat is so high as to expel carbonic acid rapidly, that contained in the packing would be only partially available. Oxide of iron—such as is used in the ordinary malleable-iron process as packing—may be used for this purpose with peculiar advantage on account of the reaction that takes place between it and the carbonic oxide produced by the action of the carbonic acid upon the iron. Carbonic oxide readily takes up oxygen from highly-heated oxide of iron, and thereby becomes carbonic acid. Thus in the presence of both cast-iron and oxide of iron, at a high heat, carbonic acid is first decomposed by the carbon of the cast-iron and immediately reproduced twofold by the oxygen of the oxide-of-iron packing, and is again decomposed with double its original decarbonizing effect. The reactions may be thus represented, assuming that the cast-iron acted upon, though not a definite chemical compound, may be represented by Fe_3C : First reaction, $3\text{CO}_2 + 3\text{Fe}_3\text{C} = \begin{cases} 6\text{CO} \\ 24\text{Fe} \end{cases}$; second reaction, $6\text{CO} + 2\text{Fe}_2\text{O}_3 = \begin{cases} 6\text{CO}_2 \\ 4\text{Fe} \end{cases}$ —i. e., three equivalents of carbonic acid (3CO_2) decarbonizing three equivalents of the assumed compound of carbon and iron, ($3\text{Fe}_3\text{C}$), and the result is six equivalents of carbon oxide (6CO) and three equivalents of Fe_3 , or twenty-four equivalents of malleable iron, (24Fe .) By contact with two equivalents of peroxide of iron ($2\text{Fe}_2\text{O}_3$) the six equivalents of carbonic oxide become six of carbonic acid, (6CO_2), and four equivalents of iron (4Fe) are reduced from the oxide. These six equivalents of carbonic acid thus reproduced act, of course, upon twice the amount of cast-iron that the original three decarbonized. Thus the carbonic acid increases in a geometrical ratio as the reactions continue. To simplify the statement, sixty-six pounds of carbonic acid, (3CO_2), acting but once—i. e., upon iron not packed in oxide of iron—would decarbonize six hundred and ninety pounds of cast-iron, ($3\text{Fe}_3\text{C}$); but if brought in contact with one hundred and sixty pounds of peroxide-of-iron packing, ($2\text{Fe}_2\text{O}_3$), one hundred and thirty-two pounds of carbonic acid (6CO_2) would be generated. It will be seen at once that the second action of this carbonic acid will involve the decarbonization of twice the original amount of cast-iron. Hence the importance of peroxide of iron as a means of packing cast-iron when it is to be made malleable by means of carbonic acid. Carbonic acid may be obtained for this purpose from carbonate of lime or other carbonates by chemical decomposi-

tion, but that generated by heat is the most economical.

In accordance with the principle demonstrated by this discovery with regard to the action of carbonic acid, the soda process for the manufacture of steel is modified, as follows: first, by using, instead of the simple carbonate of soda, the bicarbonate; second, by passing through or over the bath of melted soda containing the cast-iron which is being decarbonized a current of free carbonic acid, in order that the soda may be recarbonated as fast as its carbonic acid is decomposed by the cast-iron.

By this method the amount of soda required would be much less than that required by the original process. I make use of common salt in connection with soda to obviate the necessity of so large a bulk of the latter as would otherwise be required.

Another valuable improvement resulting from the use of carbonic acid in decarbonizing cast-iron consists in the ability to produce another valuable product in the act of reproducing carbonic acid—viz., malleable iron directly from the native oxides of iron.

The reduction of iron ores directly to malleable iron has long been a subject of investigation. I believe that nothing has proved so effective as a reducing agent as carbonic oxide; but serious difficulties have arisen in connection with its production and reproduction. The present process for the conversion of cast-iron to malleable iron supplies continually the material for the reduction of the native ores—i. e., carbonic oxide—and the reduction of the ores necessarily involves the return of a double supply of decarbonizing material, (carbonic acid,) as we have seen in the reactions that take place in a retort containing cast-iron packed in peroxide of iron. In the case now under consideration the carbonic acid should first pass over the iron castings, and, having become reduced to carbonic oxide, pass thence into a chamber containing the ore to be reduced. From this chamber it should pass (having become double its original volume of carbonic acid) into a second retort containing cast-iron, and so continue *ad libitum*, producing malleable iron alternately from cast-iron and from the ores. The same series of changes may be connected with the retorts for making steel. A small volume of carbonic acid may thus be made to do an almost unlimited amount of work.

The use of carbonic acid as a decarbonizing agent is not limited to its action upon iron in a solid form. If a current of this gas be forced through melted iron or over its surface, it separates carbon much more rapidly than from solid iron, and thus malleable iron or steel may be produced.

I do not herein claim the use of the alkaline carbonates, so far as they incidentally generate

carbonic acid, in the process above referred to as previously patented by me; but

What I claim, and wish to secure by Letters Patent of the United States, is—

1. The use of carbonic acid for the purpose of removing carbon from cast-iron in the production of malleable iron or steel, substantially as herein specified.

2. The use, in combination with the decarbonizing processes, of the carbonic oxide generated by such processes in the reduction of iron ore, substantially as herein described.

A. K. EATON.

Witnesses:

EDM. F. BROWN,
DANIEL BREED.