

United States Patent Office.

JACOB REESE, OF PITTSBURG, PENNSYLVANIA.

Letters Patent No. 65,830, dated June 18, 1867.

IMPROVED PROCESS OF REFINING IRON, STEEL, AND OTHER METALS.

The Schedule referred to in these Letters Patent and making part of the same.

TO ALL WHOM IT MAY CONCERN:

Be it known that I, JACOB REESE, of the city of Pittsburg, in the county of Allegheny, and State of Pennsylvania, have invented a new and useful improvement in the Process of Refining Iron, Steel, and other Metals; and I do hereby declare the following to be a full, clear, and exact description thereof.

My invention consists in certain improvements in the process of refining iron or steel, and may be applied to the ordinary refinery fire or other furnaces or refining-chambers, and does not necessarily involve the use of any apparatus of novel construction, or any material alteration in the furnaces heretofore employed for the refinery process.

These improvements, which constitute my invention are, first, the use of a bath or layer of melted oxide of iron in the chamber of the refinery fire, between the fuel which floats on the surface and the melted metal which lies below it, for the purpose, chiefly, of preventing the carbon of the fuel uniting with the metal to be refined; second, the use, in the process of refining iron or steel, of hydrogen in a gaseous state, or combined with carbon as a fluid hydrocarbon, for the purpose of decarbonizing the metal and removing the sulphur and phosphorus which may be combined with it.

The first-mentioned improvement is designed to be used where coke or other fuel is employed in the process of refining, and may be employed in combination with the use of hydrogen as a decarbonizing and purifying agent, or when oxygen or atmospheric blast is resorted to for that purpose. The second improvement is applicable to the process of refining either with or without separate fuel, and may be advantageously employed, in combination with the use of atmospheric air, for decarbonizing and purifying the metal.

The old refinery or run-out fires are made with brick or stone bottoms, the chamber being formed of cast iron, water boshes forming three sides, and enclosed on the further side by a dam-plate. Two or three tuyeres are placed on each side, projecting downwards over the tops of the boshes, communicating with blast pipes to force atmospheric air into the melted metal. The chamber being first heated with a fire of coke or coal placed therein, the melted metal is run into the refinery from the blast-furnace, and the heat being kept up by the fuel, (coke,) the metal is exposed to a blast of atmospheric air for about two hours, after which it is run out into moulds and cooled with water. This process causes a great waste of iron, owing to the long-continued action of the oxygen on the metal, rendered necessary by the constant accession of carbon to the iron, from the fuel with which it is in immediate contact. Although, by this process, the iron is ultimately deprived of nearly all of its carbon, (which it received in the blast-furnace,) yet the loss by oxidation is about twenty per cent. of the metal. To obviate this waste the pneumatic process was adopted, which consists in running the iron into a chamber, and there without the use of separate fuel, blowing blasts of air, either hot or cold, up and through the liquid iron; the oxygen in the air combining with the carbon in the iron, causing a greatly increased heat and boiling in the metal, thus decarbonizing the iron. In this process the carbon in the metal serves as fuel to the oxygen of the blast and greatly expedites the operation, but still there is a considerable waste by oxidation, amounting to about twelve per cent. in removing five per cent. of carbon.

My improvement is designed to obviate this loss of iron by the use of a bath of melted oxide of iron in the following manner: When the refinery is ready, the coke or other fuel is put in and lighted, and the blast being applied, the furnace is thoroughly heated. The metal to be refined, having been melted in a cupola or air furnace, is run into the chamber of the refinery. Melted oxide of iron is then run in until it lies to the depth of ten or twelve inches on top of the melted iron, being of less specific gravity; and the coke, being still lighted, floats on top of the melted oxide. The mouths of the tuyeres being about on a level with the top of the melted iron, and below the surface of the oxide, the blast enters the mass of metal, and uniting with the carbon decarbonizes it and causes a violent agitation. This ebullition results in the admixture of some of the melted oxide with the mass of iron, which has the effect of scouring it and removing such earthy or metallic impurities as may be mechanically admixed with the metal. The melted oxide, which separates the fuel from the iron, serves to protect it effectually from admixture with the carbon of the fuel, so that the benefits of the heat caused by the fuel are secured without the deleterious effect of the constant carbonizing of the metal resulting from the presence of the fuel, when not thus separated from the metal. It is true that the carbon in the metal is sufficient to keep up a great heat, while the oxygen of the air is passing through it, without the use of other fuel,

but so soon as the carbon is eliminated or burned out the fuel is gone, and the metal at once begins to chill, so that it is necessary at once to run it out of the chamber or vessel in which it has been treated by the pneumatic process. By my improvement, however, I am enabled, by means of the coke on top of the bath of melted oxide, to keep up the heat in the iron after the carbon has been removed for the purpose of treating the iron with carbide of iron or otherwise, in order to produce the required degree of carbonization for the grade of steel to be manufactured, or for the further refining of the metal; it being important to the quality of the steel that the carbide introduced after the decarbonization has been effected should form a chemical combination, and not a mere mechanical union with the iron, as is apt to be the case where separate fuel is not employed.

In the various processes of refining iron or steel heretofore in use, oxygen is employed as the agent for producing the necessary decarbonization. I propose, however, to use, either in place of the oxygen or in combination with it, hydrogen, which I have found to possess several advantages peculiar to itself. Oxygen is, in itself, the cheapest element which can be used, owing to its presence in atmospheric air; but its strong affinity for iron renders its use a source of great waste. Hydrogen, on the other hand, possesses the necessary affinity for carbon to render it an efficient agent for decarbonizing iron, while it has little or no affinity for the iron, and produces no injurious effect on that metal; it is also peculiarly adapted to the refining of iron which contains sulphur and phosphorus, by its affinity for those substances. The pneumatic process of refining iron before referred to, depending, as it does, on the use of oxygen, will not remove these impurities (sulphur and phosphorus) from the metal. If the phosphorus be combined with the iron ore as phosphate of lime it will pass off in the slag of the blast-furnace, but if present as phosphoric acid, the action of the blast-furnace is to cause it to combine with the metal as a phosphuret. Now, as oxygen has a much larger affinity for iron at 3,000° Fahrenheit, (the working point of iron,) than it has for phosphorus, it would be necessary to oxidize all the iron before the phosphorus would be eliminated, and thus it arises that steel made by the pneumatic process contains as much phosphorus after treatment as before. If, however, hydrogen be used for the decarbonization of the metal, having no affinity for the iron, it combines freely with the phosphorus, forming by chemical union $P. H_2$, passing off as phosphuretted hydrogen. Although sulphur sublimes at 170° Fahrenheit, the maximum temperature at which it vaporizes is about 185° Fahrenheit, so that at the heat of melted iron or steel it will not pass off as vapor; its affinity for oxygen also diminishes as the temperature increases above 170° Fahrenheit, so that at 3,000° Fahrenheit to 5,900° Fahrenheit it is impossible to separate it from the iron by means of oxygen. Hydrogen, however, unites with sulphur at a high temperature, forming a chemical union as $S. H_2$, and passed off from the iron as sulphuretted hydrogen.

Thus, it happens that hydrogen, when applied to the refining of iron or steel, carries off from it two of the foreign substances which are most injurious to the steel, and which it is almost impossible to remove by the use of the pneumatic process. In using hydrogen as the agent for decarbonizing and refining molten cast iron or steel, I employ the refinery fire before described, together with the bath of oxide, blowing hydrogen gas or the vapor of hydrocarbon fluid, such as petroleum, benzole, and gasoline, into the melted metal through the tuyeres in the same manner as already described in reference to the use of an atmospheric blast. In this case the fuel on top of the melted oxide serves to keep up the requisite heat, the hydrogen unites with the carbon of the metal and carries it off burning, when it reaches the coke above the oxide bath. It also unites with and eliminates the sulphur and phosphorus, thus ridding the metal of these injurious elements, while the bath of oxide prevents the carbon of the fuel from uniting with the metal, and retarding the process of decarbonization.

In this process, and that before described, the only change needed in the construction of the refinery furnace is to increase the depth of boshes so as to accommodate the bath of oxide without reducing the working capacity of the furnace.

The hydrogen to be used for my process may be procured in any ordinary or convenient method. As a hydrocarbon vapor answers the purpose very well, the well-known hydrocarbons before mentioned may be conveniently and economically employed. The light hydrocarbons, benzole and gasoline, are extremely cheap, and the lighter the grade of hydrocarbon the larger proportion of hydrogen it contains, so that by choosing the lighter or heavier oils, or hydrocarbon fluids produced from petroleum, the required proportion of carbon and hydrogen may be secured. The quantity of hydrogen required for any specified charge of metal of known quality may be ascertained with sufficient accuracy as follows: Suppose a charge of ten thousand pounds of metal containing five per cent. or five hundred pounds carbon, one per cent. or one hundred pounds sulphur, one-half per cent. or fifty pounds phosphorus. Now, as one atom of hydrogen unites with six atoms of carbon, or with sixteen atoms of sulphur, or with thirty-one atoms of phosphorus, forming respectively carburetted hydrogen, sulphuretted hydrogen, and phosphuretted hydrogen, the entire charge would theoretically require, for five hundred pounds carbon, eighty-three and one-half pounds hydrogen; for one hundred pounds sulphur, six and one-quarter pounds hydrogen; for fifty pounds phosphorus, five pounds hydrogen, equal to ninety-four and three-quarter pounds hydrogen, or about twenty pounds of hydrogen to each ton of metal; but as in practice the hydrogen cannot be all utilized, it is better to provide for fifty pounds of hydrogen to each ton of iron. The hydrogen may be conveniently applied in the form of hydrocarbon vapor, by vaporizing the light hydrocarbon fluids before mentioned, or otherwise, as may be desired; it being safer not to use the liquid hydrocarbons without evaporation, as the enormous expansion on being suddenly exposed to so high a heat might be attended with dangerous results.

I have described the use of my oxide bath in a refinery furnace in connection with a blast of atmospheric air, and also with a blast of hydrogen or of hydrocarbon vapor; but as both atmospheric air and hydrogen or hydrocarbon vapor or gas may be employed with a refinery at the same time, I will proceed to explain the manner of such use.

The refinery being heated as before described with coke, and the blast of air turned on, the melted metal

is run in from the cupola, and then the molten oxide is introduced until it lies to the depth of ten or twelve inches between the coke and iron. The blast of atmospheric air causes a violent agitation of the metal, mixing a part of the melted oxide with the mass, but not permitting the carbon of the fuel to reach the iron below the oxide. While the process of decarbonizing is progressing, say in ten minutes or so after the commencement, a stream of hydrogen, as a gas, or of hydrocarbon vapor is introduced into the metal through the same or other tuyeres. The effect of this is that while the oxygen is removing the carbon from the metal, the hydrogen removes the sulphur and phosphorus as before described and by their joint action the metal is refined, purified, and reduced from crude cast iron to cast steel. After the operation has been continued for the space of thirty or forty minutes the violent agitation ceases, and if semi-steel is required the metal is immediately tapped out into suitable moulds, care being taken to stop the flow as soon as the metal ceases and the oxide begins to appear, by closing the tap hole. The oxide remaining in the furnace will answer for several heats. When hydrogen is employed as the purifying agent, some fuel, as coke, must be employed, but when oxygen is also used in conjunction with the hydrogen, my process of decarbonizing and purifying iron by hydrogen may be successfully and advantageously employed without other fuel than that supplied by the carbon in the iron. In this case the separate chamber may be resorted to and the refinery fire dispensed with, and the amount of hydrogen necessary for the process will be considerably diminished; as its chief purpose, when used with oxygen, is to remove the sulphur and phosphorus from the iron.

Having thus described my improved process for refining iron and steel, I do not claim the use of a blast of atmospheric air in a refining furnace with coal or coke as fuel, as that is an old and well-known method.

Neither do I claim refining iron or steel in a furnace with a blast of atmospheric air without the use of additional fuel, known as the pneumatic process.

Nor do I now claim a patent for the use of hydrogen gas or liquid hydrocarbons for the deoxidizing of metallic oxides in a molten condition, as I have previously obtained Letters Patent therefor.

But what I do claim as my invention, and desire to secure by Letters Patent, is—

1. Refining iron, steel, and other metals, by means of a blast of atmospheric air or other decarbonizing blast in a refinery or furnace heated with coke or other carbonaceous fuel, when a layer of metallic oxides is interposed between the fuel and the metal under treatment, for the purposes hereinbefore set forth.

2. The use of a covering of metallic oxide for protecting metals from the influence of carbon, substantially as hereinbefore described.

3. The use of hydrocarbon liquid, vapor, or gas, in the process of refining iron or steel, in the manner substantially as hereinbefore described.

4. The use of a hydrocarbon liquid, vapor, or gas, for the purpose of removing sulphur and phosphorus, or either of them, from iron, steel, or other metals in the process of refining, substantially as hereinbefore described.

In testimony whereof I, the said JACOB REESE, have hereunto set my hand in presence of—

JACOB REESE.

Witnesses:

A. S. NICHOLSON,
GEO. H. CHRISTY.