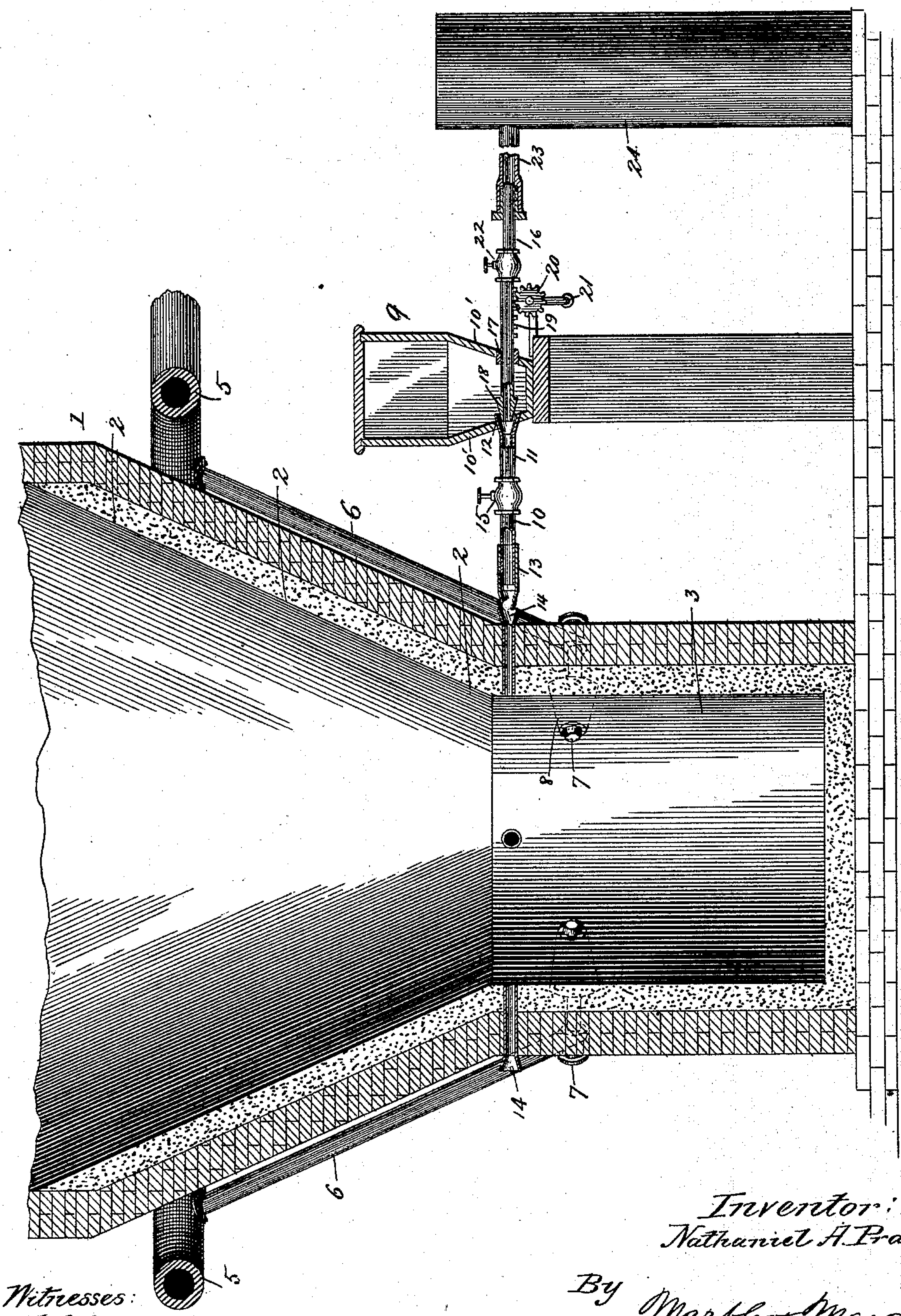
(No Model.)

N. A. PRATT.

PROCESS OF SMELTING IRON ORES.

No. 413,552. Patented Oct. 22, 1889.



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PROCESS OF SMELTING IRON ORES.

SPECIFICATION forming part of Letters Patent No. 413,552, dated October 22, 1889.

Application filed June 2, 1888. Serial No. 275,943. (No specimens.)

To all whom it may concern:

Be it known that I, NATHANIEL A. PRATT, a citizen of the United States, residing at Atlanta, in the county of Fulton and State of Georgia, have invented certain new and useful Improvements in the Process of Smelting Iron Ores; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to processes of smelting ores for dephosphorizing and otherwise refining metals; and it consists in the improved process of smelting the ore and dephosphorizing the metal by a single treatment in the blast-furnace, as hereinafter fully disclosed in the description and claims in connection with the drawing.

The objects of my invention are, first, to smelt ore and dephosphorize and otherwise purify and refine metal by a single treatment in the blast-furnace; second, to introduce finely-comminuted basic flux into the smelting-furnace at or near the zone of fusion; third, to shield and protect the ore and molten metal from contact with silica or other acids; fourth, to smelt the ore at the lowest temperature possible compatible with fusion; fifth, to obtain the molten metal in as small particles, bodies, or globules as possible, and, sixth, to introduce oxygen into direct contact with said small particles or globules of the molten metal. I accomplish these objects in connection with the apparatus shown in the accompanying drawings, forming part of this specification, in which the same reference-numerals indicate the same parts, and in which the figure represents a vertical section of a construction of apparatus which may be employed for carrying out my process, showing the furnace and one of the flux feeders or injectors and their belongings.

In the drawing, the numeral 1 indicates the furnace, the boshes 2 and crucible 3 of which are provided with a lining 4 of any suitable basic compound which does not contain any silica or silicious compound or other acid. The bustle or blast-pipe 5 surrounds said furnace, and is provided with the usual drop-pipes 6, having the blast-nozzles 7, which enter said furnace through the tuyeres 8 at the lower part of the boshes. A number of flux-injectors (only one of which is shown) for injecting pulverized basic flux into the furnace are arranged around said furnace and provided with hoppers 9, having discharge-pipes 10 extended through the walls of the furnace, preferably at a short distance above the tuyeres; but like result may be effected by arranging them at or within said tuyeres. These flux injectors or feeders may be of any suitable construction, since all that is required of them is that they shall be capable of injecting finely-comminuted flux against the outward pressure of the blast in the furnace, either through special flux-nozzles or through the air-main and blast-nozzles. However, for the purpose of giving an example of a feeder or injector that is capable of use in practicing my process, I herein illustrate and describe an apparatus which forms the subject of an application for Letters Patent filed by me simultaneously herewith, Serial No. 275,942. In this apparatus the hoppers 9 are formed at their lower ends with inwardly-converging sides 10′ and supported a short distance outside of the furnace, and are preferably arranged at equal distances around the same. Each of these hoppers is provided with a discharge-pipe 10, the inner end 11 of which is formed in the shape of a funnel or hollow cone 12 and secured within said hopper, and its outer end is provided with a slidable coupling or tube section 13, which registers with and is adapted to enter with its outer tapering end into a flux-nozzle 14. This flux-nozzle passes through the wall of the furnace, preferably in the lower part of the boshes and a short distance above the tuyeres and blast-nozzle; but it may be arranged below the latter. A suitable stop cock or valve 15 is placed in the discharge-pipe 10 between the sliding coupling 13 and the hopper 9. A compressed-air or injector pipe 16 slides in a stuffing-box 17 in the side of the hopper, diametrically opposite the funnel-shaped inner end of the discharge-pipe, and is provided with a conical mouth-piece 18, which finds a seat in said funnel-shaped end of the discharge-pipe. This injector-pipe 16 is also provided outside of the stuffing-box 17 with a rack 19, which is engaged by a cog-wheel or pinion 20, which is provided with a suitable handle 21, or similar means for revolving it. A stop cock or valve 22 is also provided in said injector-pipe 16 outside of said rack; also, the outer end of this pipe is adapted to slide in the packed end of a blast-conveying pipe 23, which extends from a compressed-air receiver 24, which is fed from a suitable air-compressor or blowing-engine; or said pipe may be fed directly from the air-compressor or blowing-engine.

The operation of this form of flux feeder or injector is as follows: After the hopper of the apparatus has been charged with finely-comminuted flux, and when the compressed-air reservoir has also been charged or the compressor or blowing-engine started, and when the furnace has been started in operation, the sliding coupling is drawn out to enter the flux-nozzle. Then the injector-pipe 16 is slid back by the pinion and rack, so as to open the funnel-shaped end 12 of the discharge-pipe 10. Then the stop-cock 15 in said discharge-pipe is opened, and then the stop-cock 22 in the injector-pipe is also opened. The blast of compressed air in the injector-pipe will then draw the finely-comminuted flux into the funnel-shaped end of the discharge-pipe and blow it through said pipe, the sliding coupling, the nozzle, and into the body of the furnace. The feed of the apparatus may be stopped by sliding the injector-pipe into its seat in the funnel-shaped end of the discharge-pipe, when the stop-cocks may be closed and the coupling 13 slid back from the flux-nozzle. The supply of flux forced into the furnace and the quantity of the same in proportion to the strength of the forcing-blast may be regulated by adjusting the injector-pipe toward or from the funnel-shaped end of the discharge-pipe. For instance, by drawing said injector-pipe away from said funnel-shaped end a greater supply of flux will be fed into the furnace, but with comparatively less air-force, and by pushing said injector-pipe farther toward said funnel-shaped end a less supply of flux will be fed, but with comparatively greater air-force. The force of the blast may also be regulated by the stop-cocks upon the discharge and injector pipes.

In the present process, which may be carried out in the above-described apparatus, when the furnace is charged with ore and fuel in the usual manner, the furnace set in operation, and the blast started, care must be taken that the metal which drops or trickles down in small globules or bodies from the ore shall not come in contact with any silicious or other acid, excepting what may be naturally present in the fuel or ore. As the globules or small particles of molten metal drop down through the boshes and into the crucible of the furnace they are acted upon by the blast which supplies the necessary oxygen thereto, and by the finely-comminuted flux, which comes into intimate contact with each particle thereof, and thus the molten metal by the combined action thereon of said blast and comminuted flux will be completely dephosphorized, desiliconized, and otherwise purified and refined and delivered into the crucible in a perfect state, as the basic finely-comminuted flux will have had the desired effect upon it by having been introduced under the most favorable circumstances at or near the zone of fusion. Care must be taken in operating the furnace that as low heat is maintained within the same as is consistent with reducing the metal in the ore to a fluid state, since high heat tends to increase the absorption of silicon, and, as experience shows, renders the elimination of phosphorus far more difficult. However, to effect a proper operation of the furnace to this end it is not possible to specify the necessary or exact pressure of blast, or to state given pyrometric tests of the necessary temperature therein, as it is well known that these conditions must be varied in accordance with the character of the different kinds of ores undergoing treatment and of the fuels and fluxes employed. There are no predetermined characteristics or conditions of ore, fuel, and flux, as they vary in different localities, and consequently the degrees of heat for properly reducing the metals have to be varied accordingly. Therefore as the character or structure of the ores will often differ the required or necessary amount of heat in the furnace must be left to the experience and judgment of the attendant, who must in all instances observe that not enough heat is applied to effect the absorption of foreign matters by the molten metal or to prevent proper elimination of phosphorus therefrom.

The novelty or distinguishing characteristics of my process will best appear from a detailed explanation of the working thereof. The furnace, being "blown in," is supplied with the usual charge of fuel and ore, all limestone flux being omitted, and in its place is added an equal weight of additional ore. As combustion goes on below, this mass of ore and fuel descends slowly through zones of increasing heat and practically maintains its original bulk and proportions. The ore, essentially a ferric oxide, parts with its oxygen and is slowly reduced to a lower oxide and ultimately to porous or spongy metal, and at the same time the carbon of the fuel and of the ascending gases impregnates the mass of spongy metal and carbonizes the same. No other reactions take place in the upper boshes and stack. The impurities of the ore—viz., clay, sand, &c.—sink with the ore and fuel, practically unchanged, down into the boshes, where the heat becomes sufficient to fuse or soften the carbonized spongy iron. The clay, sand, and other impurities, being more infusible than the spongy iron, remain practically unchanged. At this point, however, the finely-comminuted flux that has been injected and diffused below rises in a fine dust with the ascending gases, is brought into intimate contact and chemical union with the silica, alumina, and other gross impurities of the ore and forms a fusible slag or cinder, which trickles down with the fused metal toward the hearth and crucible. In thus descending to the lower boshes and zone of fusion and greatest heat the fine deposited carbon that coats and impregnates the spongy iron and all solid matter in the furnace reacts on the impurities of the ore and fuel, reducing sand, clay, phosphates, sulphates, titanates, &c., respectively, to silicon, aluminium, phosphorus, sulphur, titanium, &c., all of which unite readily with the molten metal and form impure alloys, and in this condition descend to the fusion and oxidation zone of greatest heat just above the plane of the tuyeres and blast-nozzles.

Under existing methods the slags and fluxes have so far deteriorated in quality as to be incapable of active basic reaction on the oxidized impurities of the metal, the silicious-acid linings of the furnaces adding to the difficulty and perhaps yielding their own silicon to the metal, the iron itself being thus frequently oxidized or burned for want of proper protection by a fusible flux and falls to the crucible hearth as the impure unrefined pig-iron of the trade. On the other hand, with my process, as the impure molten metal in its descent enters the oxidizing-zone and passes in little streamlets or showers of globules or drops it is immersed in the oxidizing atmosphere of the blast, in which floats and is ever present the active basic flux, which, in the absence of an acid lining and its surroundings, unites instantaneously with the oxidized impurities—silicic, sulphuric, phosphoric, and titanic acids—and floats them away in the slag. In the conduct of my process, if desired, a basic oxidizing flux may be diffused, thus increasing the intensity of the action in the oxidizing zone, whereby the percentage of carbon in the metal may be reduced, resulting in the production of grade steel.

It is a well-known fact that the temperature at which a blast-furnace is operated should be the lowest used in the processes of making iron and steel, and this low temperature is the greatest safeguard against excessive reduction of silicon, titanium, manganese, and other impurities, and at same time it is the greatest promoter of the oxidation and removal of phosphorus and sulphur. Under this treatment of ore by my process the metal is drawn from the furnace in a purified and dephosphorized state, the refining having been accomplished in one operation in one and the same furnace. My process thus does away with the necessity of subsequent purifying or refining the metal in an open-hearth furnace, refiner, or converter; also, a greater output of metal is effected in the same space of time by my process than by those commonly employed, inasmuch as in my process more ore is introduced. The flux is introduced in a finely-comminuted state, low-down in the boshes in the zone of fusion, and diffused into pre-existing spaces, where it will immediately act upon the globules or small bodies of the molten metal. In the commonly-employed processes the flux is charged into the stack, together with the ore and fuel, in lumps of varying sizes, and occupies from one-third to one-half of the space in the stack, which should be available for ore; also, in such processes, as the flux, ore, and fuel gradually descend into the zones of increasing heat, the flux has very little effect upon the ores, and, while occupying undue space, will simply be calcined, whereas under my process this space is occupied by an equal bulk of ore; also, when the flux employed in former processes arrives at the zone of fusion, where it is required to exert the basic reaction as essential to the removal of the phosphorus from the metal, its basic quality and activity are so far neutralized and expended that it fails to effect such removal of the phosphorus and its union with the impurities as is required for properly refining the metal, whereas this result is fully effected in my process by the finely-comminuted flux, which acts, together with the oxygen of the blast, directly upon the globules or small bodies of metal while in its fresh and undiminished state of activity and strength; also, as the ore is protected from contact with all silicious and aluminous matters in my process, it will not be affected thereby, excepting by such as may be present in the ore and fuel, and for this reason the the basic lining of the boshes and crucible of the furnace performs an important part in my process. In this manner all the conditions necessary for dephosphorizing the metal—viz., first, a state of molten metal which will present a large oxidizable surface; second, the oxygen supplied by the blast in the shape of atmospheric air, or in other suitable shape; third, the presence of an active basic oxide, supplied by the pulverized flux, and, fourth, the lowest possible degree of heat consistent with securing proper fluidity of the metal—are all provided for in the smelting-furnace by my process, so that what has hitherto been accomplished by two separate processes—the smelting of the ore in the blast-furnace and the dephosphorizing and refining or purifying of the metal thus produced in an open-hearth furnace, refiner, or converter—is accomplished by me in one process and in one furnace.

Having thus fully described the various steps of my improved process and its subdivisions and the advantages thereof, what I claim as new is—

1. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining, in shielding the ore and molten metal from contact with silicious or other acids, and in introducing finely-comminuted basic flux at or near the zone of fusion and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

2. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining, in shielding the ore and molten metal from contact with silicious or other acids, and in introducing finely-comminuted basic flux at or near the zone of fusion and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

3. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining and at the lowest temperature compatible with fusion, and in introducing finely-comminuted basic flux at or near the zone of fusion and into direct contact with the globules or small bodies of metal while being smelted, substantially as described.

4. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining and at the lowest temperature compatible with fusion, in shielding or guarding the ore and metal from contact with silicious or other acids, and in introducing finely-comminuted basic flux at or near the zone of fusion and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

5. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining and in introducing the blast at the zone of fusion, and in introducing finely-comminuted basic flux at or near the zone of fusion above said blast and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

6. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining, in shielding or guarding the ore and metal from silicious and other acids, in introducing the oxidizing-blast at the zone of fusion, and in introducing finely-comminuted basic flux at or near the zone of fusion above said blast and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

7. The improved process of smelting ores and dephosphorizing and otherwise purifying and refining metal in a single blast-furnace, which consists in smelting the ore in the presence of a basic lining and at the lowest temperature compatible with fusion, in omitting the admixture of flux with the ore and fuel at the top of the stack, in shielding or guarding the ore and metal from silicious and other acids, in introducing the oxidizing-blast at the zone of fusion, and in introducing finely-comminuted basic flux at the zone of fusion at or above said blast and into direct contact with the globules or small bodies of molten metal while being smelted, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

NATHANIEL A. PRATT.

Witnesses:
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