(No Model.) 2 Sheets—Sheet 1.

W. F. M. McCARTY.

APPARATUS FOR THE PRODUCTION OF STEEL DIRECT FROM THE ORE.

No. 414,654. Patented Nov. 5, 1889.

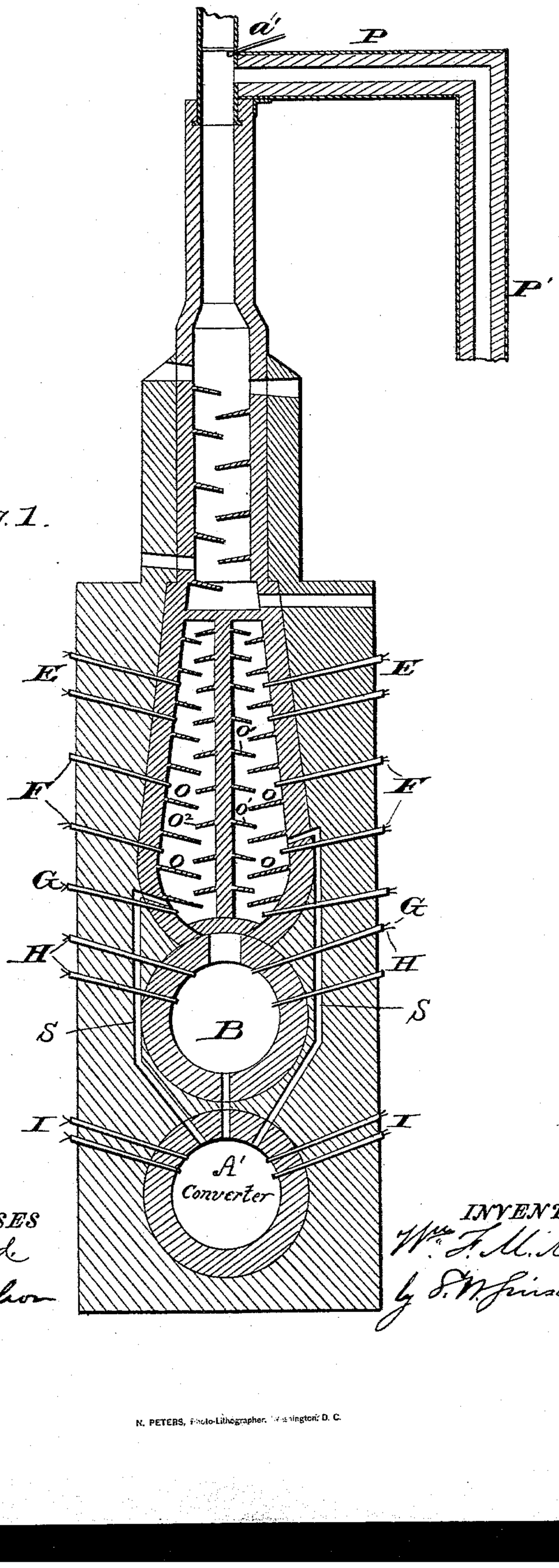

Fig. 1.

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(No Model.) 2 Sheets—Sheet 2.

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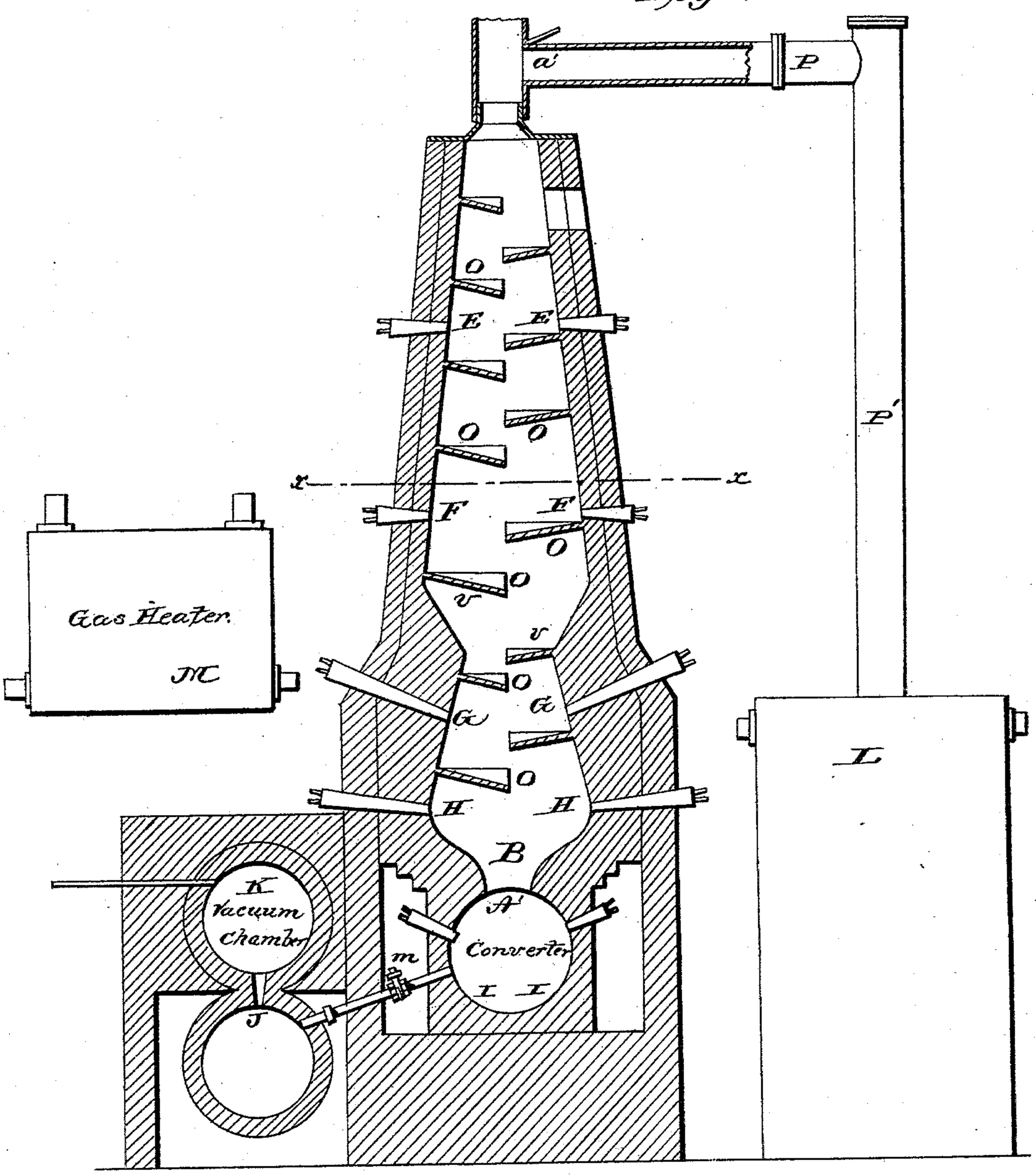
Fig. 2.



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UNITED STATES PATENT OFFICE.

WILLIAM F. M. McCARTY, OF HAGERSTOWN, MARYLAND, ASSIGNOR, BY DIRECT AND MESNE ASSIGNMENTS, OF THREE-FOURTHS TO JANE LOGAN, OF SAME PLACE, CATHERINE EISHON, OF PHILADELPHIA, PENNSYLVANIA, AND HERMAN D. WALBRIDGE, OF WASHINGTON, DISTRICT OF COLUMBIA.

APPARATUS FOR THE PRODUCTION OF STEEL DIRECT FROM THE ORE.

SPECIFICATION forming part of Letters Patent No. 414,654, dated November 5, 1889.

Application filed March 5, 1889. Serial No. 301,902. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM F. M. McCARTY, a citizen of the United States, residing at Hagerstown, in the county of Washington and State of Maryland, have invented new and useful Improvements in Apparatus for the Production of Steel Direct from Ore; and I do hereby declare the following to be a full, clear, and exact description of the said invention, reference being had to the accompanying drawings, and to the letters and figures of reference marked thereon, which form a part of this specification.

My invention relates to an improved apparatus for producing steel direct from the ore.

The invention consists in a novel construction of stack and converter having tuyeres to communicate with the stack through which hydrogen and carbonaceous matter is introduced in the different zones or belts of the stack.

It further consists in combining with the stack and converter and the tuyeres for the introduction of the hydrogen and carbonaceous matter a vacuum-chamber communicating with the converter.

It further consists in providing the stack with the inclined shelves or supports, with their inner edges overhanging the ones next below, whereby the metal is caused to fall by gravity from shelf to shelf while under the calorific energy of the gaseous fuel introduced through the tuyeres.

It further consists in providing the stack with flues communicating therewith and with the converter outside the bosh, for carrying off the gas and products of combustion in blowing the metal while converting it into steel, and conducting it into the lower part of the stack, where the gas and its heat may be utilized in reducing the ores without acting on the charge in the bosh, thereby forming one and a continuous heat without handling the metal, and also in certain details in the construction and arrangement of parts, all as hereinafter explained. The converter is connected with the lower part of the stack by means of flues S, whereby the gases from the converter may be passed outside of the bosh B and into the body of the ore in the stack to assist in its reduction.

In the accompanying drawings, Figure 1 is a transverse section of a blast-furnace, showing one manner of constructing the stack, in which the bosh thereof is shown in spherical form and communicating with a converter through a narrow passage-way. Fig. 2 is a similar section of another manner of constructing the stack, or modification showing the vacuum-chamber, also in section, and also the air and gas heaters.

The stack, except in the particulars mentioned, may be constructed in any preferred way, and which is provided at some distance from the lower end with an annular offset to support the charge of fuel and ore introduced into the stack. Below the offset is located a chamber which I term the "bosh" B of the stack, which communicates through a central opening with the converter A'. In Fig. 1 the bosh is made in spherical form, and communicates with the converter through a contracted passage-way, while in Fig. 2 said bosh B is made in tapering cylindrical form, with its lower portion adjacent to the converter contracted to form a narrow passage-way between it and the converter, the object of forming the passage-way between the bosh B and converter is to permit of withdrawing the molten metal into the converter to be blown with hydrogen and atmospheric air for the purification of the metal and for introducing the carbon to form steel.

With the form of communicating passage-way between the bosh and converter as shown in Fig. 1 I am enabled to use any kind of fuel, as said fuel connot pass through the converter, while the form shown in Fig. 2 is particularly adapted for use when coke or coal is used as fuel.

In Fig. 1 I have shown flues or passage-ways S, connecting with the converter and with the stack above the cylindrical bosh, for carrying off the gas and products of combustion in blowing the metal while converting it into steel without acting on the charge in the

bosh, forming one and a continuous heat without handling the metal, and also preventing the wasting of the heat-units escaping from the converter and utilizing the same in the stack of the furnace and the heater. The upper end of the stack has an outlet *a* for the gases and products of combustion, and has a side flue P, controlled by a damper *a'*, for the purpose of directing the products of combustion either out at the top or into the side flues P, which latter communicate with a downward flue O' or pipe P', leading to the air-heater or hot-blast producer L.

On the opposite side of the stack is shown a heater M for heating the gases to be used in working the charge. The converter below the bosh of the stack communicates through a valve-pipe *m* with a second converter or gas-extractor J, this pipe opening into the converter A' at some distance from the bottom, in order that the molten metal of the upper part of the converter A' may flow out, as it is treated, into the gas-extractor or converter J. The converter J communicates through a suitable opening with a vacuum-chamber K or some equivalent device for producing a vacuum.

At different heights in the stack I provide suitable tuyeres for the introduction into the charge at different zones of gas or gases, or combined air and gas, as hereinafter described. The uppermost set E of tuyeres I prefer to arrange at such a point that the gases introduced thereby may pass directly into the upper part of the charge of ore, while the next lower set of tuyeres F is at some distance above the offset *v*. A third set of tuyeres G is introduced just below the offset *v*, and another set H into the bosh of the stack, and a final set into the converter A'.

Formed in the internal wall of the stack, and projecting therefrom, are a series of shelves O, inclining inward, with their inner edges overhanging the next below, as shown in Fig. 2; or the stack is provided with a central wall O', having shelves O^2 projecting therefrom alternately with those projecting from the wall of the stack, the edges of each overlapping the others, for a purpose hereinafter explained.

In the operation of the apparatus, after the ore has been sorted it is cracked up in sizes suitable for the crusher, and after being crushed it is passed to the ore-mill to be reduced to powder, when a proper charge thereof, with sufficient flux and coke or other fuel to start the operation, is introduced into the stack through the charging-opening D and falls upon the shelving. Atmospheric air, with carbonic oxide and hydrogen, is then introduced through the tuyeres E and ignited to start the fire. Hydrogen and carbon oxide are next introduced through the tuyeres F into the body of the charge, and also at H, if desired, until the mass is in a state of combustion. I then introduce into the upper part of the charge through the tuyeres E pure hydrogen gas, to thoroughly deoxidize and reduce the ore by the removal of oxygen and sulphur contained therein, leaving the iron in a free metallic state or spongy mass.

Although I have said that carbonic oxides should be introduced through the intermediate tuyeres F G H with the hydrogen, I wish it to be understood that the necessary carbon may be there introduced with the hydrogen by other means. For instance, powdered carbon or liquid hydrocarbon oil or carbonic oxide may be introduced with the hydrogen; but I prefer carbonic oxide. The relative proportions of hydrogen and carbon introduced through the intermediate tuyeres will vary to some extent with the character of the ores under treatment. As soon as the metal begins to fuse under the intense heat produced by the introduction of the gases and air at different zones, as above described, the molten metal will commence to fall down through the bosh into the converter A', when the pure hydrogen and superheated air are turned on through the tuyeres I to decarbonize and purify the molten metal, which has been partly acted upon by gases introduced through the tuyeres H in its descent through the bosh B of the furnace. The oxygen of the air and the hydrogen introduced into the molten metal in the converter A' produce an intense heat and remove the silicon and other impurities and a large portion of the carbon in the metal, and by regulating these gases according to the nature of the ores under treatment a pure homogeneous steel will be produced. In some instances where it is found that the molten metal in the converter A' has not received sufficient carbon in its descent through the furnace, the proper proportion of carbon in the form of finely-divided graphite spiegeleisen with cyanogen and air may be introduced through the tuyeres I. When it is determined that the steel is of the desired quality, the valve in the outlet-pipe *m* is opened and the overflow of the metal takes place into the second converter J. When this chamber has been filled with sufficient metal for the run, the valve in the pipe *m* is closed and connection with the vacuum-chamber is opened. This will insure the withdrawal from the molten mass of any gases which may have remained therein. Homogeneous steel is thus produced, free from the usual defects, such as blow-holes, honey-combs, and other faults.

The operation, as will be readily seen, can be made continuous by connecting the opening D with a hopper, which can be so arranged as to govern the supply, so that a continuous fusion is going on automatically, the metal falling in the form of ore and flux, intimately mixed, from shelf to shelf of its own gravity, the shelves being arranged on a proper incline, and the material falling in a

continuous manner from shelf to shelf while receiving the calorific energy of the gaseous fuel.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an apparatus for the production of steel direct from the ore, the combination, with the stack having a series of tuyeres leading to different zones thereof, of a chamber or bosh located below or connected with said stack and a converter located below the bosh, substantially as specified.

2. In an apparatus for producing steel direct from the ore, the combination, with the stack and converter and the tuyeres entering the stack at different zones or belts for the introduction of hydrogen and carbonaceous matter, of a second converter communicating with the first and a vacuum-chamber communicating with the second chamber, substantially as and for the purpose specified.

3. In an apparatus for producing steel direct from the ore, the stack provided with the inclined shelves or supports, with their inner edges overhanging the ones next below, and the tuyeres for the introduction of the gaseous fuel in the different zones or belts of the stack, substantially as described, whereby the metal is caused to fall from shelf to shelf while under the calorific energy of the gaseous fuel introduced through the tuyeres, as set forth.

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

WM. F. M. McCARTY.

Witnesses:
ALEX. MOHN,
JOHN G. CENTER.