(No Model.) 4 Sheets—Sheet 1.

H. C. BULL.

APPARATUS FOR MANUFACTURING IRON AND STEEL DIRECTLY FROM THE ORE.

No. 282,266. Patented July 31, 1883.

Fig. 2.

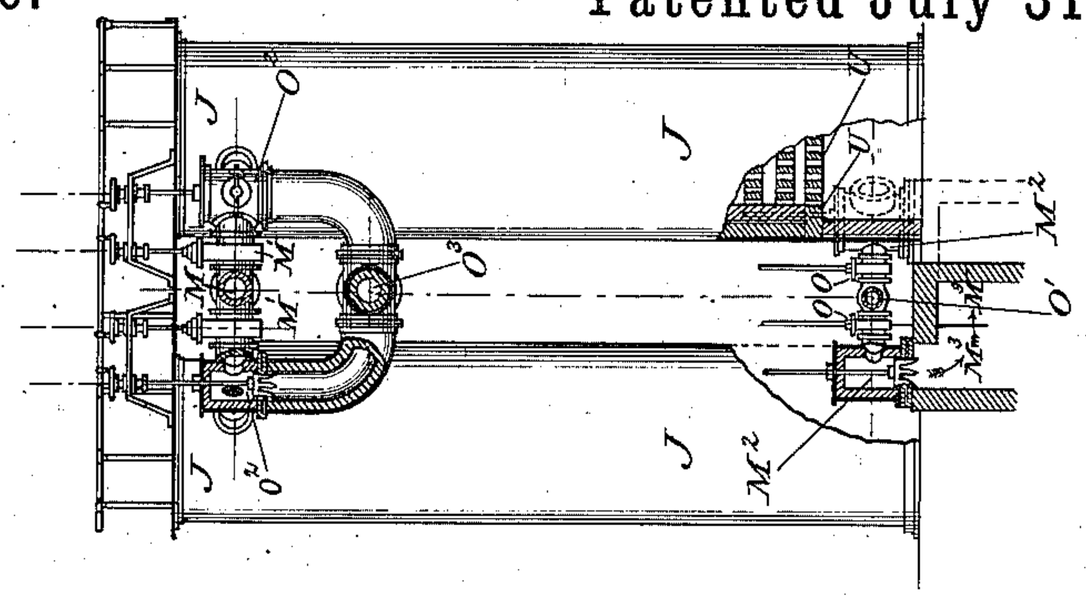

Fig. 1.

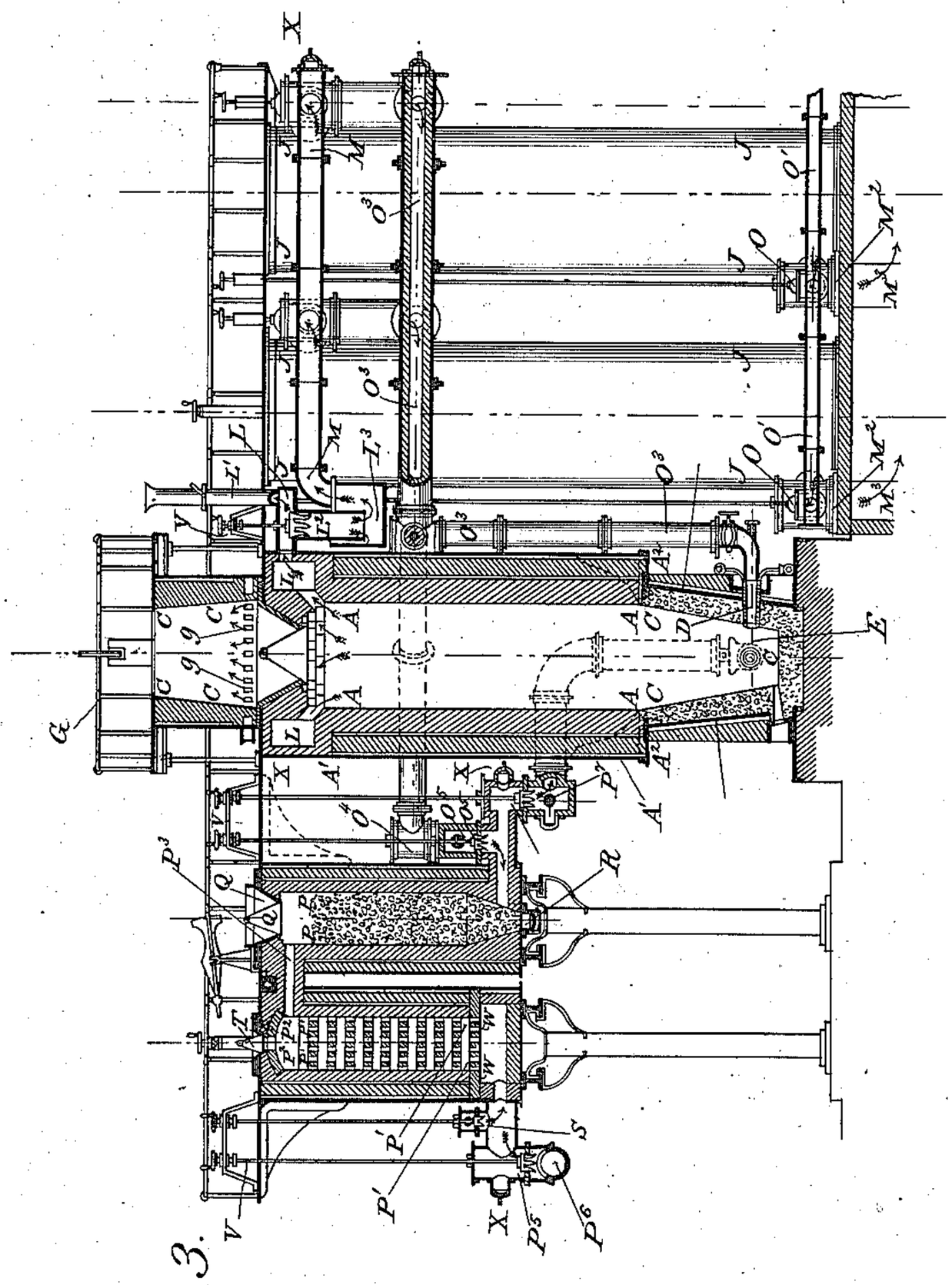

Fig. 3.

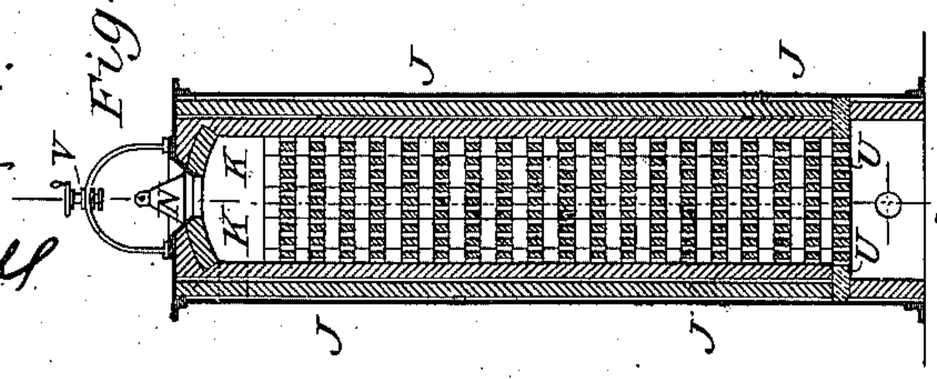

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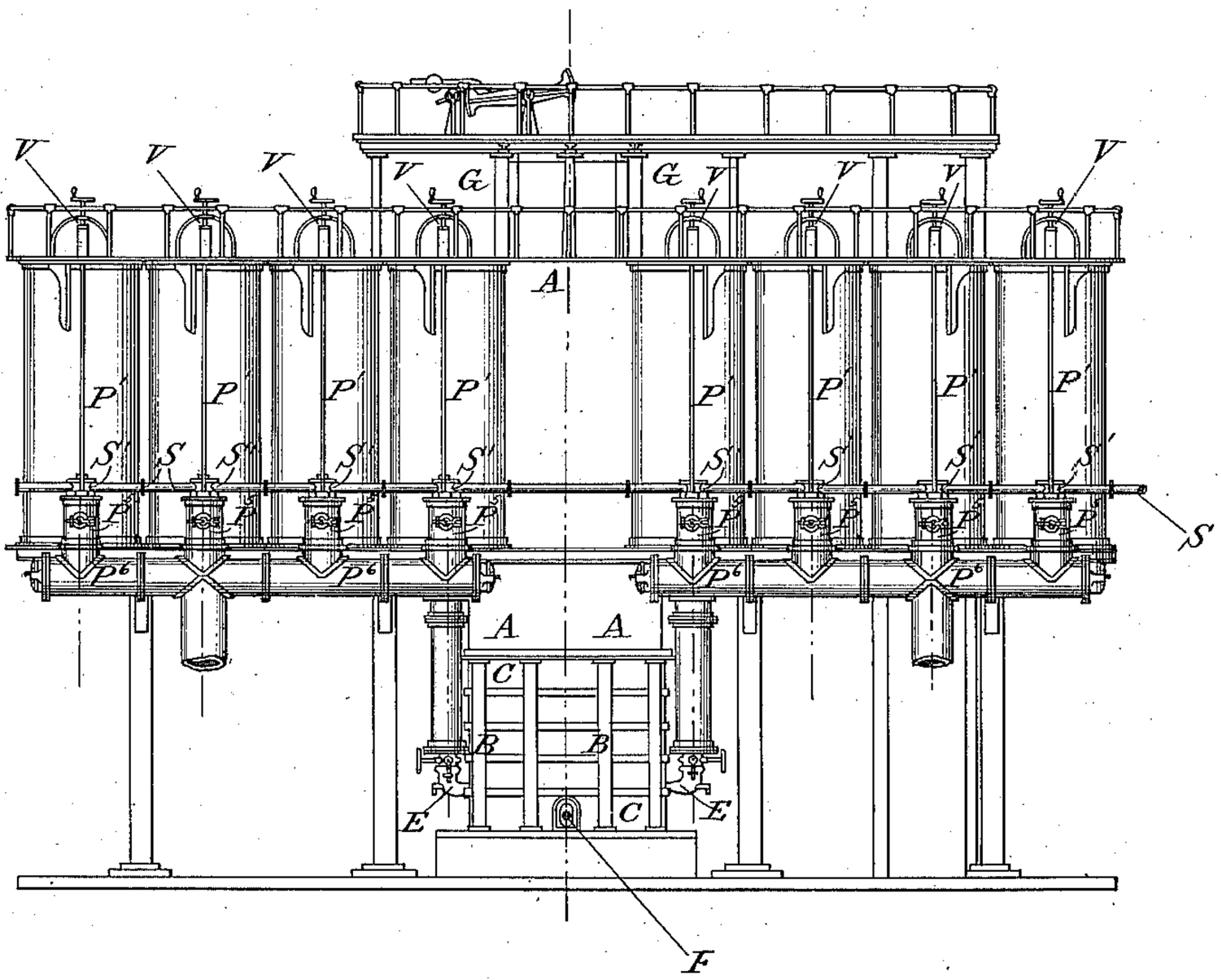
Fig. 4.



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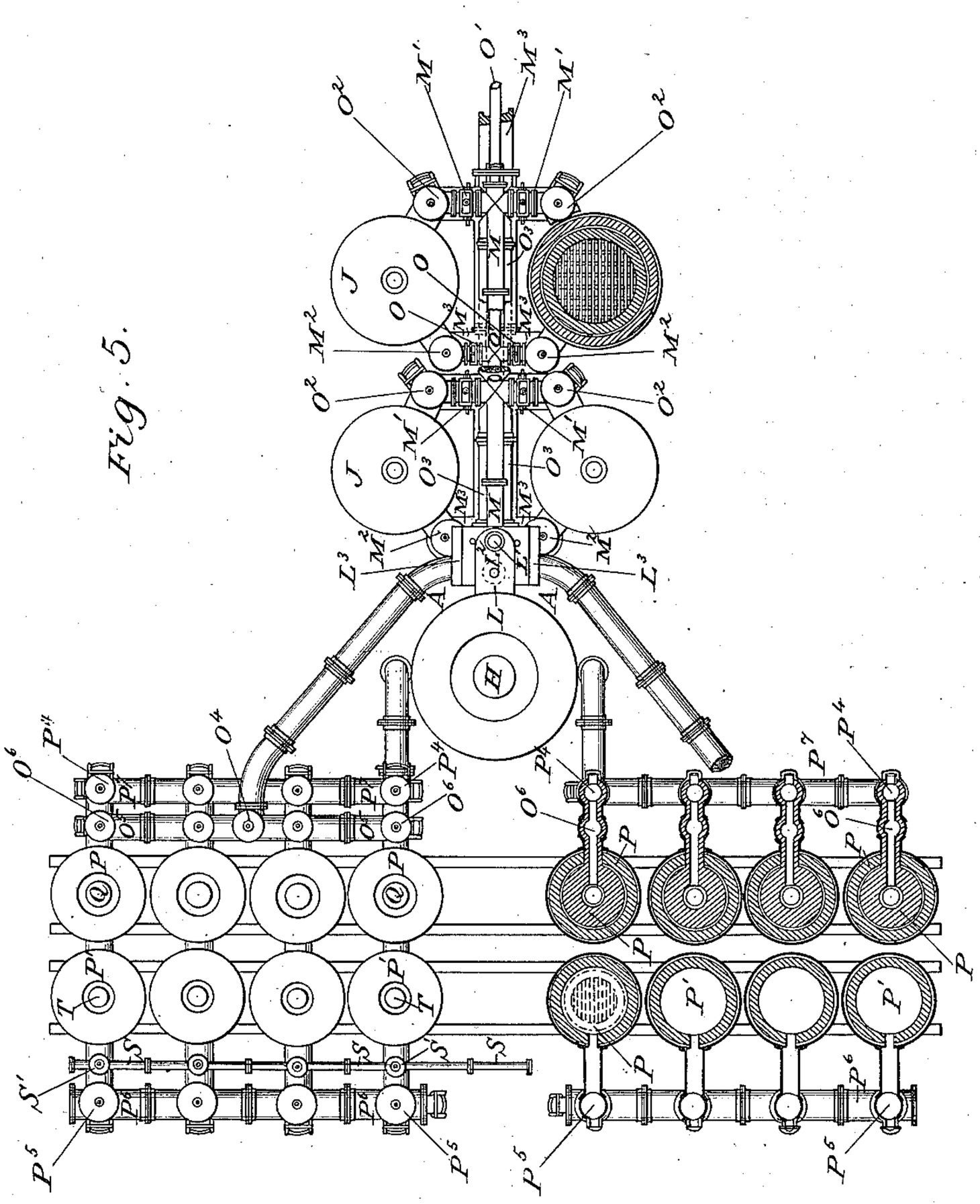
APPARATUS FOR MANUFACTURING IRON AND STEEL DIRECTLY FROM THE ORE.

No. 282,266. Patented July 31, 1883.

Fig. 5.



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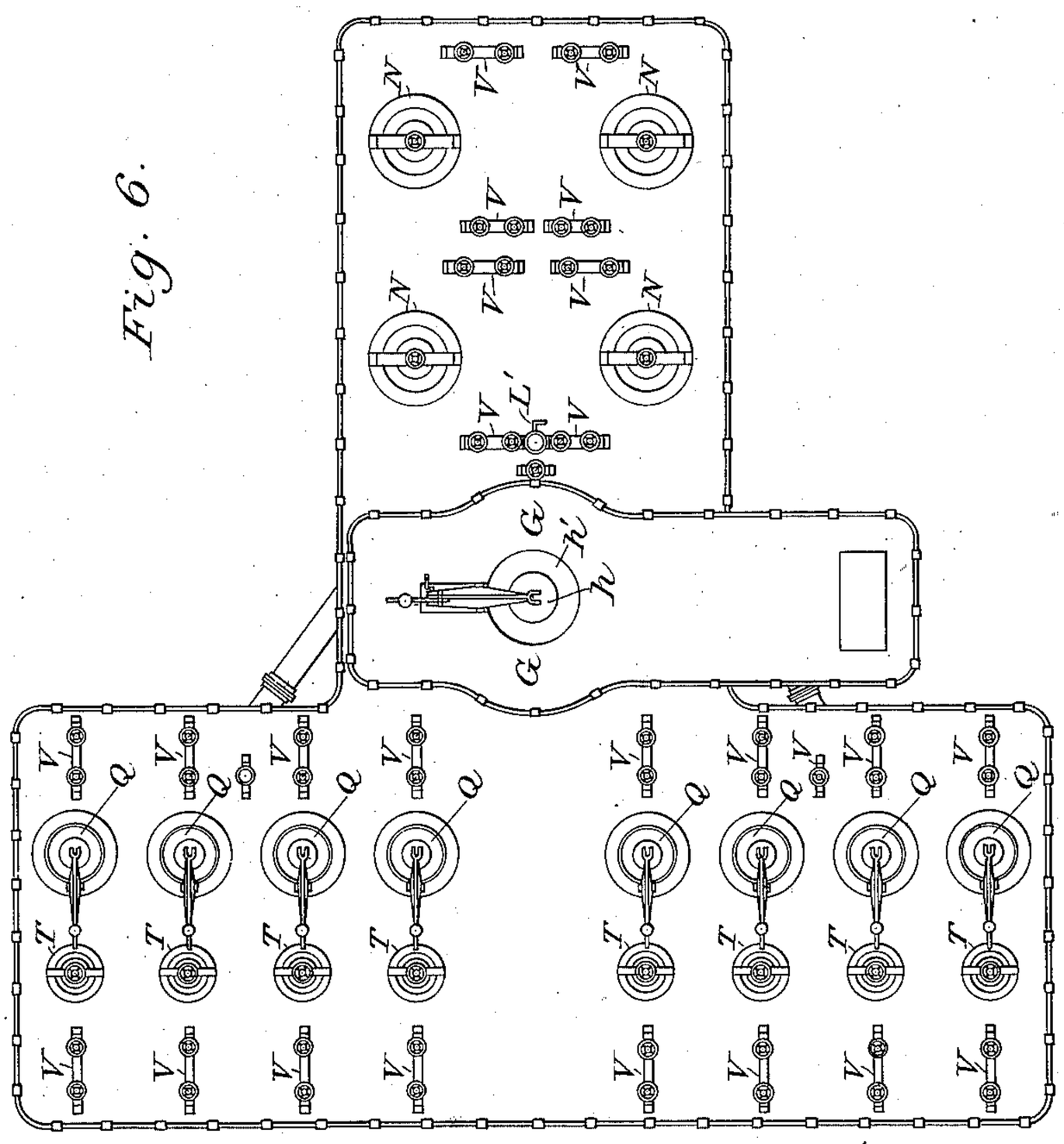
APPARATUS FOR MANUFACTURING IRON AND STEEL DIRECTLY FROM THE ORE.

No. 282,266. Patented July 31, 1883.

Fig. 6.



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UNITED STATES PATENT OFFICE.

HENRY CLAY BULL, OF LIVERPOOL, COUNTY OF LANCASTER, ENGLAND, ASSIGNOR TO BULLS IRON AND STEEL COMPANY, (LIMITED,) OF SAME PLACE.

APPARATUS FOR MANUFACTURING IRON AND STEEL DIRECTLY FROM THE ORE.

SPECIFICATION forming part of Letters Patent No. 282,266, dated July 31, 1883.

Application filed November 20, 1882. (No model.) Patented in England April 13, 1882, No. 1,763; in France May 20, 1882; in Belgium May 22, 1882; in Germany May 30, 1882, No. 22,984, and in Austria September 9, 1882, No. 18,684.

To all whom it may concern:

Be it known that I, HENRY CLAY BULL, a citizen of the United States, but at present residing at the city of Liverpool, in the county of Lancaster, in that part of the United Kingdom of Great Britain and Ireland called England, have invented certain new and useful Improvements in Apparatus to be Used in the Manufacture of Iron and Steel directly from the Ore, (for which I have obtained a patent in Great Britain, No. 1,763, bearing date April 13, 1882; also in France on May 20, 1882; in Belgium on May 22, 1882; in Austria application for patent for fourteen years, patented May 30, 1882; in Germany application for patent dated May 30, 1882;) and I do hereby declare that the following is a description of my invention in such full, clear, and distinct language as to enable any one skilled in the art to which it belongs to put the same into practice, reference being had to the sheets of drawings hereto annexed, and to the letters and figures of reference marked thereon, like letters and figures being used to denote the same or corresponding parts throughout the various views.

Referring to the drawings, Figure 1 is a sectional elevation of a blast-furnace and accessory appliances constructed and arranged according to my invention. Fig. 2 is an end elevation of the valves and conduits and heating-stoves shown at Fig. 1. Fig. 3 is a sectional elevation, showing the internal construction of the heating-stove. Fig. 4 is an end view of the gas-producers and their accessory parts. Fig. 5 is a plan taken in section through X X, Fig. 1. Fig. 6 is a plan view.

My invention consists of certain new and useful improvements in apparatus to be used in the manufacture of iron and steel directly from the ore, the points of novelty in said apparatus being designated by the claims concluding this specification.

According to my invention I construct the blast-furnace A as shown in the drawings, the upper part of the furnace being built of ordinary fire-brick within a common brick lining surrounded by a casing, A′, having a bottom plate, A^2, held by brackets, as shown in dotted lines, there being spaces left between the fire-brick and the common brick, or equivalent substance, and between the common brick and the casing, the whole structure being supported on columns B, Fig. 4, based on the foundation. By so constructing the upper portion of the blast-furnace A, I relieve the lower or hearth and crucible portion C from the superposed weight of the upper portion.

I construct the hearth and refractory lining forming the crucible C thus: Between the casing C′, which forms the outer shell, and an interior metal mold of the shape of the crucible C, I ram a concrete compound of freshly-burned lime, or any substance possessing the same properties, with about ten per cent. of silica sand, mixed with tar, oil, or other substance which will evaporate from the concrete and escape through openings or interstices in the outer casing, C′, without permitting the lining to shrink or crack. This lining C is subjected to an intense heat sufficient to melt out the inner metal mold. This operation bakes the lining into a very solid substance before the furnace A is put into blast. The air-tuyere D, and the gas-tuyeres E E, and the tapping-opening F are formed in the hearth in the manner usual to blast-furnaces. This method of relieving the refractory lining C from the weight of the upper portion of the furnace A enables me to use the above-described substance for the lining of the crucible and hearth of the furnace. This or similar substance, although capable of standing the most intense heat, will support very little weight. By my construction, through the furnace A being supported independently of the crucible C, I am enabled to use a temperature in the crucible C sufficiently high to allow of the withdrawal of the metal in a fluid state when the carbon in the metal is exceedingly low, and the cinder follows the metal through the same opening, also in a fluid state.

In converting ordinary blast-furnaces to as-

similate to those of my invention it is only necessary to alter the hearth C and support the upper portion of the furnace A as just described.

In the further carrying out of my invention I erect a chamber, G, forming a calcining-oven, lined with fire brick or equivalent substance directly over the charging-opening H of the blast-furnace A, which opening H may be fitted with a bell, *h*, and cup *h'*, as shown. The bell *h* and cup *h'* are supplied with water-jackets, (not shown in the drawings,) to protect them from the heat. The lower portion of the calcining-oven G is provided with openings *g*, for the admission of atmospheric air, and during the operation of calcining the bell is slightly opened, so as to admit sufficient waste gas from the furnace A to cause, in combination with the atmospheric air admitted through the opening *g*, a combustion just above the bell *h* and the cup *h'*. The calcining-oven G is open at the top for feeding the charge and for the escape of the aqueous vapors given off from the charge while calcining. By this means the ore and flux are delivered into the furnace A in a dry and highly-heated state without additional labor and cost of fuel, and therefore the waste gases given off from the furnace A are comparatively free from aqueous vapor, and are thus capable of producing an intense heat by their combustion in the air-heating stoves. The effect of calcining and drying the ore previous to its entering into the furnace A is to remove the zone of preparation from the furnace A and to raise the zone of production very high in the furnace A, thus considerably increasing the quantity of metal produced from a furnace in a given time.

In the further carrying out of my invention I reverse the usual construction and working of the air-stoves J—namely, instead of forming the combustion-chamber at the bottom of the stove J, as done in the Whitwell and Cooper stove, I form the combustion-chamber K (see Fig. 3) at the top of the stove J. By this means the brick-work of the combustion-chamber K and the bricks used to absorb the heat are relieved from the weight of the main brick-work of the stove J. The intense heat which I require renders the brick-work of the combustion-chamber K very weak, and if such heat were used at the bottom of the column of brick-work the brick-work would crush in; but by my arrangement this difficulty is overcome, and that portion of the stove J which is subjected to an intense heat has to support very little weight. The waste gases from the blast-furnace A are thus led to the combustion-chamber K of the stove J—namely, through passages into the conduit L', which is provided with a relief-chimney, L', for surplus gases, and a valve, L^2, which gives communication to the dust-box L^3, and from thence to the combustion-chambers K of the heating-stoves J, through the conduit M and valves M'. Air is admitted into the combustion-chamber K of the stove J through the safety-valve N at the top of the stove J, for the purpose of supporting the combustion of the said waste gases in the combustion-chamber K. The flames resulting from this combustion pass downward through the stove J, which is filled with brick-work, and finally the residue escapes through the valves M^2 at the bottom of the stove J into the culvert M^3, which leads to a chimney-shaft when the brick-work within the stove J has been brought to an intense white heat. The gas and air supply to the combustion-chamber K is shut off, and the valve M^2 is also closed. Then a valve, O, communicating with a cold-air-supply pipe, O', is opened, giving admission through the casing of the valve M^2 for such cold air to enter the bottom of the stove J. The air passes up through the heated brick-work in the stove, and passes therefrom in a heated state through the valve O^2 into the main O^3. The heated air is led from the main O^3 to the hearth C of the furnace A through the tuyere D. The supply can be throttled at the tuyere by a valve, as shown. By preference four of the hot-air stoves J are used, three of which are constantly under the process of heating, while one is giving up the stored heat to the air passing up through it.

In the further carrying out of my invention I construct the gas-producers thus: Each gas-producer, of which there may be a group of eight, consists of two chambers, P P', suitably lined with brick-work. The chamber P is filled with coal, coke, or other carbonaceous material, which is ignited and brought to an intense heat by a blast of hot air from the hot-air main O^3, and delivered by branches through the valves O^4 into the hot-air conduit O^5, and from thence through the valves O^6 into the chambers P. Each chamber P is provided with a cup and bell, Q, for renewing the charge of carbonaceous material, and with a metal box, R, at the bottom, provided with tumbling door for withdrawing the cinder which collects in the said box, the hot air bringing it down in a liquid state. The second chamber, P', of the gas-producer is filled with fire-brick or equivalent substance, and is provided with a combustion-chamber, P^2, the same as in the air-heating stoves, at its top. The two chambers, P P', communicate at the top through the pipe P^3. The chamber P communicates at the bottom through the valve P^4 to the main P^7, and thence to the tuyere E. The chamber P' communicates at the bottom through a valve, P^5, with the main P^6, leading to a chimney or equivalent outlet.

S is a steam-main, which supplies steam from a steam-generator through the valves S' to the bottom of the chambers P'.

T is a safety-valve, through which air is admitted into the combustion-chamber P^2, to assist combustion therein.

The operation of the gas-producer is as follows: The carbonaceous material in the cham-

ber P being ignited, the hot air passes up through such carbonaceous material in the chamber P, imparts to it a white incandescence, and the gases given off are led through the pipe P^3 into the combustion-chamber P^2 of the chamber P′, and air is admitted through the safety-valve T into the chamber P^2, where combustion takes place, and the heat therefrom, passing down through the brick-work filling of the chamber P′, brings such brick-work to an intense heat, the gases eventually passing through the valve P^5 and the main P^6, from whence they are led away. When the brick-work in the chamber P′ has become sufficiently heated, the hot-air supply to the chamber P is shut off by closing the valve O^6, and the escape from the chamber P′ is also shut off by closing the valve P^5. The safety-valve T is also closed, and steam under pressure is then admitted through the valve S′ into the bottom of the chamber P′, and such steam, passing up through the intensely-heated brick-work, becomes highly superheated, and in that condition enters the chamber P, and, passing down through the incandescent carbonaceous material therein, results in the generation of a gas composed chiefly of hydrogen and carbonic acid, and in passing through the incandescent carbon the carbonic acid takes up another equivalent of carbon and becomes carbonic oxide, which gas is then driven by the direct steam-pressure through the valve P^4, which is opened into the gas-main P^7, and from thence through the tuyere E to the crucible C of the blast-furnace A, where it arrives in a highly-heated state, owing to the fact that the steam has been intensely superheated in the chamber P′, and also to the incandescent carbon in the chamber P being at an intense heat, through its having been blown with hot air. Thus a constant stream of intensely-hot gas is maintained through the tuyeres E and mingles with the hot-air supply from the tuyere D, thus supporting combustion, a constant stream of hot gas being maintained and driven into the crucible C without the intervention of forcing appliances.

Any suitable number of gas-producers thus described may be used, one or more of which is always being revived by generation of heat, while the gas from the others is being used in the blast-furnace A.

The following is a description in detail of the construction of the various parts.

The hot-air stoves, valves, and conduits.—The stoves are built with a fire-brick or equivalent lining, surrounded by a common or equivalent brick casing within a metal casing, spaces being left between the lining and the common brick and the metal casing. The linings are supported by a perforated metal grid, U, upon which the interspaced brick-work which fills the stove is built. The valves at the top of the stoves are opened and closed by a screw-and-worm gear, V. All the conduits and valve-casings used to convey heated air from the stoves to the blast-furnace A and to the gas-producers P are lined with non-conducting materials, as shown in the drawings, and the valve-seats, where requisite, are water-lined.

The gas-producers, valves, and conduits.—The chambers P P^6 are constructed with a filling of fire-brick or equivalent material, surrounded by a common brick or equivalent casing and a metal casing, spaces being left between the lining and the common brick and between the common brick and the metal casing. The chamber P′ is provided with a metal grid, W, at the bottom, which is used to support the loose brick-work with which the chamber is filled. The conduits and valves which convey the gas from the producers to the blast-furnace are lined with non-conducting materials, as shown in the drawings.

In working the direct process according to my invention the charge in the furnace A is maintained at different heights to produce different amounts of carbon in the metal. The carbon in the metal is derived from the carbonic oxide in the gas, which is ascending from the hearth C through the ore in the furnace A, reducing the ore to a metallic state and impregnating the metal with carbon. To produce metal with different percentages of carbon, in order to make the various grades of metal—such as cast-iron, steel, and wrought-iron—it is only necessary to vary the height of the charge in the furnace A. The higher the charge is carried the greater will be the amount of carbon in the metal produced.

It is well known that in the Catalan forge wrought-iron has been produced direct from the ore which contained very little carbon. In my process as hereinbefore described sufficient heat is maintained in the hearth C of the furnace A to keep metal in a fluid state when it is comparatively free from carbon, so that in that state it can be withdrawn from the furnace A and cast into ingots.

The operation of my process of manufacturing iron or steel is as follows: The furnace A is put to work, as an ordinary blast-furnace, with coal, coke, or charcoal, hot air being blown in through the air-tuyere D, which in this case is preferably in rear of the furnace. When all is working correctly, gas in a highly-heated state, made as before described, is forced into the furnace, preferably from two tuyeres, E E, on opposite sides of the furnace A, and the coal, coke, or charcoal is gradually removed until the class of metal produced is of the quality required. When it is required to produce metals very low in carbon, suitable for boiler-plates and like purposes, all of the coal, coke, or charcoal is removed, and then the height of the charge is lowered in the furnace A until the metal produced is of the quality desired. By removing the coal, coke, or charcoal from the blast-furnace A it is relieved from the zone of gasification, and thus prevents the great reduction in temperature which takes place in an ordinary blast-furnace. When the carbonic acid produced by the combustion of the fuel

is reconverted into carbonic oxide by contact with the incandescent coal, coke, or charcoal in the furnace, using the gas and air in the before-described highly-heated state reduces the quantity of air required to be forced into the furnace A in order to maintain the necessary temperature, reducing the volume of nitrogen to a minimum.

Having now described my improved process, as a whole, of manufacturing iron and steel directly from the ore, and also the entire apparatus employed by me in the practice of said process, I claim as my invention the following features of novelty in said process and apparatus:

1. In an apparatus to be used in the above-described process of manufacturing iron and steel directly from the ore, the combination of a blast-furnace, A, with a calcining-oven, G, having bell *h*, provided with means for admitting gas and air, said oven being placed directly on top of the blast-furnace, and heated partly by the combustion in said furnace and partly by the combustion in said oven, supported by the union of atmospheric air with the waste gases generated in said furnace, substantially as described.

2. In an apparatus to be used in the above-described process of manufacturing iron and steel directly from the ore, the combination of a blast-furnace, A, calcining-oven G, provided with air-inlets *g g*, and a bell, *h*, around which waste gases from the furnace enter said oven, the calcining-oven being placed directly on top of said blast-furnace, substantially as described, for the purpose specified.

3. In an apparatus to be used in the above-described process of manufacturing iron and steel directly from the ore, a blast-furnace, A, and calcining-oven G, provided with means for admitting gas and air, in combination with hot-air stoves J, in which a portion of the dry waste gases from the said furnace is united with atmospheric air and ignited, substantially as described, for the purpose specified.

4. In an apparatus to be used in the above-described process of manufacturing iron and steel directly from the ore, the combination of a blast-furnace, A, air-stoves J, and gas-producers P P′, connected by suitable pipes and valves, as described, one part of the superheated air issuing from said stoves being utilized to furnish the hot-air blast to the said furnace, and the other part to furnish the blast to the gas-producers, substantially as described.

5. In an apparatus to be used in the above-described process of manufacturing iron and steel directly from the ore, the combination of a blast-furnace, A, calcining-oven G, provided with means for admitting gas and air, heated as described, air-stoves J, and gas-producers P P′, all co-operating substantially as described, for the purpose specified.

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