No. 693,062. Patented Feb. 11, 1902.

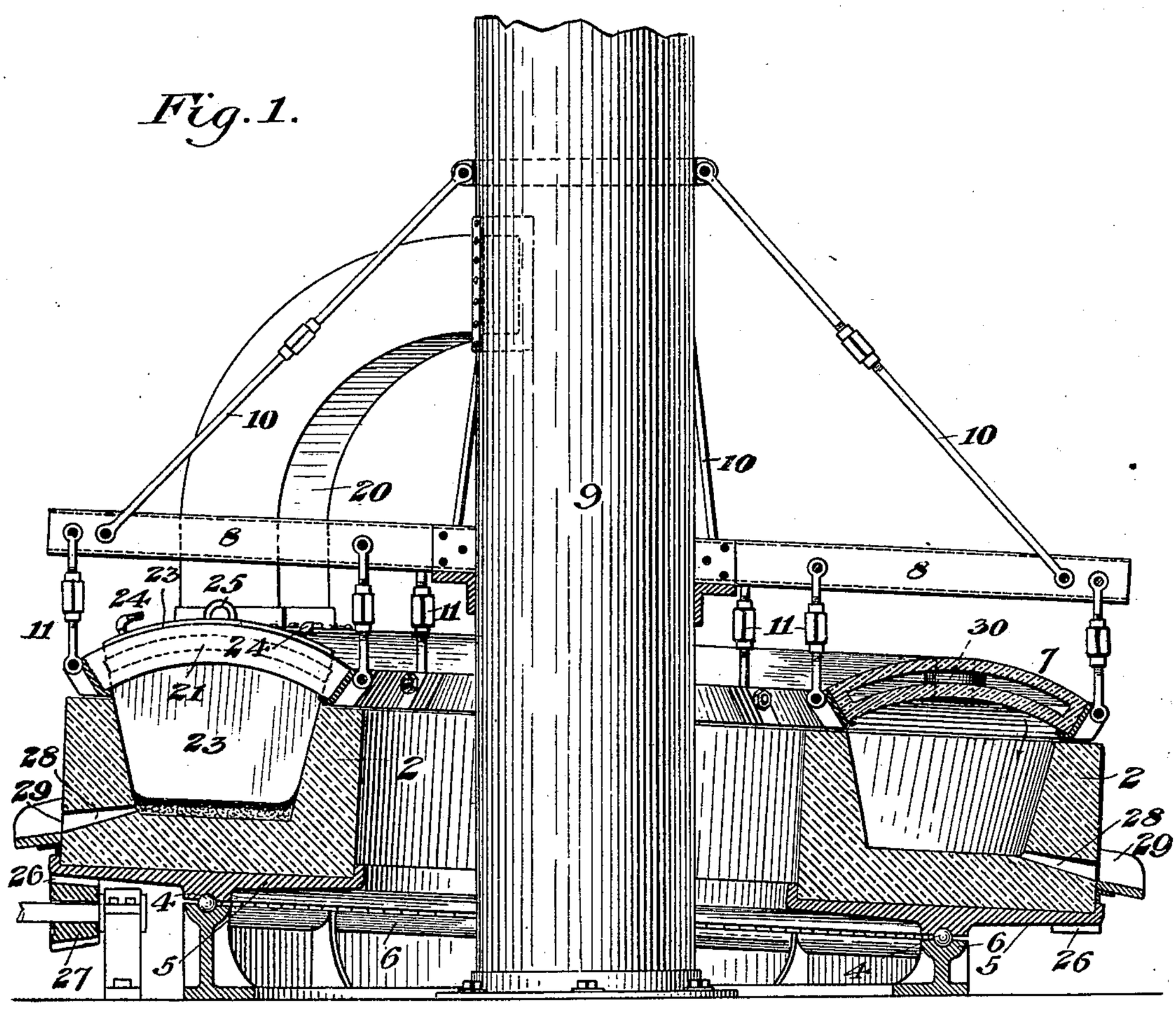
J. A. POTTER.

MANUFACTURE OF PIG IRON.

(Application filed July 11, 1901.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.



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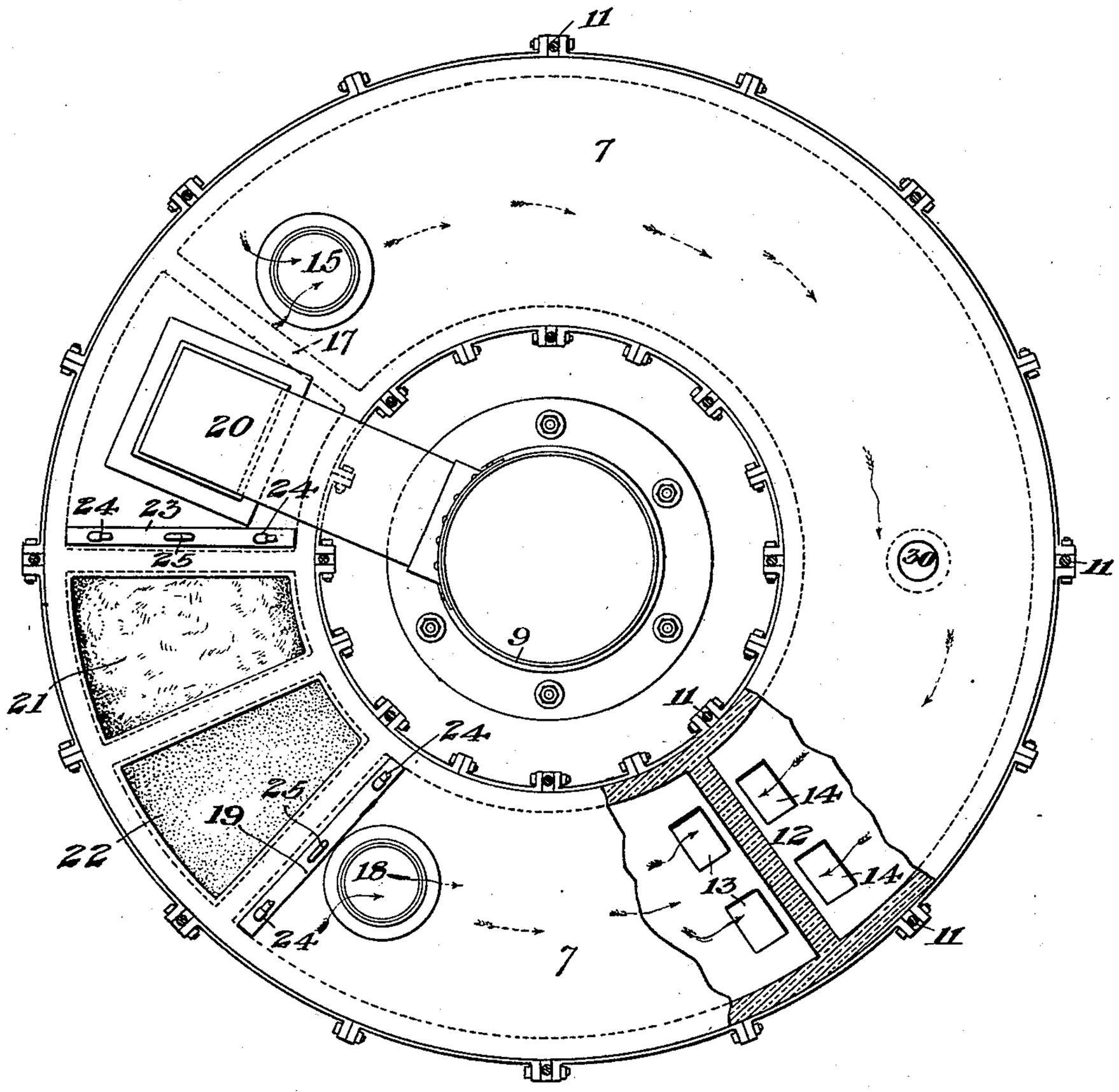
(No Model.) 3 Sheets—Sheet 2.

Fig. 2.



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No. 693,062. Patented Feb. 11, 1902.

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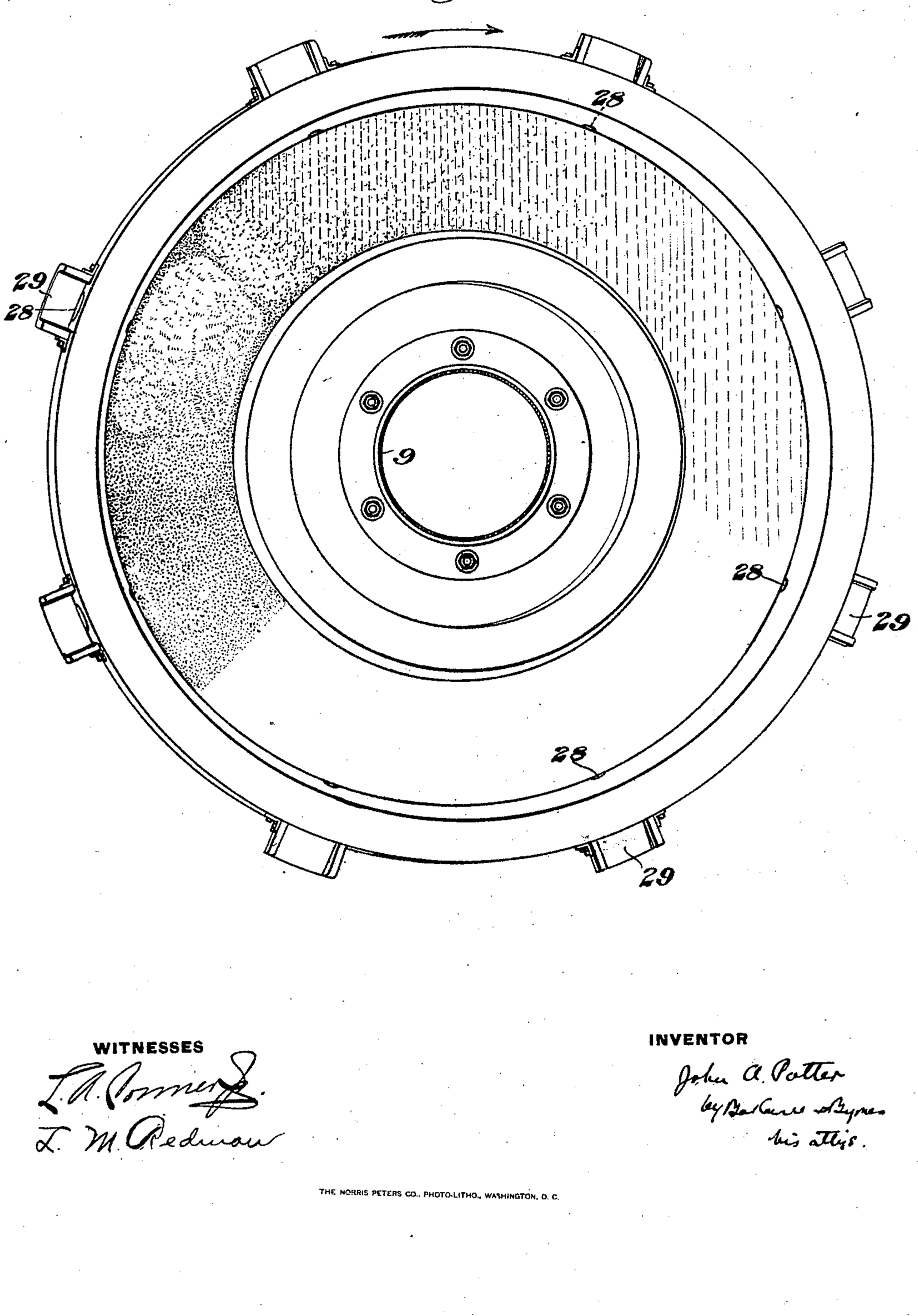
MANUFACTURE OF PIG IRON.

(Application filed July 11, 1901.)

(No Model.) 3 Sheets—Sheet 3.

Fig. 3.



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UNITED STATES PATENT OFFICE.

JOHN A. POTTER, OF CAMDEN, NEW JERSEY.

MANUFACTURE OF PIG-IRON.

SPECIFICATION forming part of Letters Patent No. 693,062, dated February 11, 1902.

Application filed July 11, 1901. Serial No. 67,853. (No specimens.)

To all whom it may concern:

Be it known that I, JOHN A. POTTER, of Camden, Camden county, New Jersey, have invented a new and useful Improvement in the Manufacture of Pig-Iron, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a sectional side elevation showing my preferred form of apparatus. Fig. 2 is a top plan view of the same, partly broken away; and Fig. 3 is a plan view of the hearth with the roof portion removed to illustrate the condition of the material at different points.

My invention relates to the making of cast or pig iron, which is suitable for steel-making in the open-hearth process, being low in metalloids—such as silicon, carbon, phosphorus, arsenic, and sulfur—and is designed to provide an improved process for obtaining the same from all grades of iron ore or from cold or molten pig metal high in impurities or metalloids or from all of these materials combined.

I will first describe my invention as carried out with a continuous reduction of iron ore and without the use of additions of pig metal after the operation has been started.

In the drawings, in which I show my preferred form of apparatus for carrying out the process, 2 represents an annular hearth mounted upon bearings 3, which I have shown as provided with antifriction-balls 4, interposed between the annular casting 5, which forms the base of the hearth, and a supporting-track 6. The furnace is set at an incline, so that upon one side it is considerably lower than at the opposite side. A roof 7 of annular form is supported above the hearth by means of beams 8, projecting from a central stack 9. Tie-rods 10 are provided, which connect the upper portion of the stack to the outer parts of the beams, these tie-rods being preferably made adjustable, so that the level of the roof may be changed as desired, and for the same reason the roof is preferably supported from the beams by means of adjustable hangers 11, secured to the beam. This roof is hollow throughout a major portion of its length and at a point near the lowest side of the furnace is provided with a partition 12, on one side of which are provided gas-ports 13 and on the opposite side air-ports 14, both sets of ports opening downwardly upon the hearth. The air enters through a port 15 on one side of a depending roof-shield 17 and flows through the hollow roof in the direction shown by the arrows to the air-ports 14. The gas is supplied through a port 18, adjacent to a vertically-adjustable depending diaphragm 19, and flows thence through the hollow roof to the gas-ports 13. The stack-flue 20 leads upwardly from the hearth and through the hollow roof to the stack 9, as indicated in Figs. 1 and 2, and between it and the charging-openings 21 and 22 is a vertically-sliding depending damper or diaphragm 23, which is similar to the diaphragm 19. Both of these diaphragms are preferably made hollow and water-cooled by suitable inlet and outlet pipes 24. They may be raised or lowered by chains or flexible connections extending to the loops 25 upon them, and these diaphragms serve to cut off the draft from those parts of the hearth beneath the charging-openings. The hearth is rotated as desired by means of any suitable connections, and I have shown its base as provided with a circular rack 26, with which intermeshes a pinion 27 on the shaft, to which motion is imparted. The hearth is provided at suitable intervals with tap-holes 28, leading to spouts or fore-plates 29.

In carrying out my improved process the bottom of the furnace is formed of ordinary refractory material, such as magnesite or dolomite, and the furnace is heated by means of the preheated air and gases, which enter the hearth-chamber at the gas and air ports near the low side and then circulate around to the stack-flue. In starting the furnace I charge in through the opening 21 a quantity of pig-iron—say two or three tons. I then charge in through opening 22 a thin layer of carbonaceous and lime materials—such as coke-dust, fine coal, charcoal, limestone, &c.—this being discharged upon the bottom immediately in the rear of the pig-iron, and as the bottom of the furnace is moved forward under opening 21 I charge upon these carbonaceous and lime materials a layer of iron ore of any desirable thickness—for example,

six inches. The furnace-bottom is then turned forward intermittently, and charges of carbonaceous and limey materials, together with layers of ore, are successively charged upon the successive portions of the hearth which are brought beneath the charging-openings. The pig-iron is gradually heated, and when it reaches the hotter zones of the furnace it melts and envelops, covers, and dissolves the highly-heated iron ore charged in the rear of it. It will be noted that before the iron ore is thus absorbed it will have been slowly rotated into hotter zones and largely freed from its moisture, sulfur, arsenic, &c., by its exposure to the oxidizing conditions during its travel from its charging-opening to the reducing and melting zone. As the furnace is again turned the liquid metal will flow over and cover another portion of the ore which sticks to the bottom of the furnace and is carried beneath it, and after the ore is dissolved the carbonaceous and basic materials charged under the ore are set free and will rise up and into the liquid bath. The carbon will then be absorbed by the liquid metal, while the lime will associate with the silica and phosphorus, &c., in the ore and form a basic slag. The carbon thus added to the hearth will replace the carbon of the pig metal which has been consumed by uniting with the oxygen of the ore. As the bath of liquid iron becomes increased in bulk a portion of it is drawn off from time to time, as desired, as is also the slag, and the operation is made continuous by carrying successive portions of the basic material, carbon, lime, and ore into and beneath the molten bath and tapping off portions of the bath as it increases in size. The hearth after it passes through the bath will be substantially bare and will be again supplied with the materials at the charging-points 22 21. The carbon contained in the liquid bath is utilized to combine with the oxygen in the ore as it washes over and submerges the successive portions thereof, and to keep it up to the desired percentage necessary to carry on the reduction and keep the bath liquid the carbon is added to the materials charged in any desirable amount.

In working finely-divided ores they are mixed with the lime and carbon and the whole mixture charged in on the furnace-bottom. In this case I have found by experiment that when lime is present with carbon and oxid of iron a flux is sometimes formed before the oxygen has been removed from the ore. This is due to the combining of the lime and silica at a lower temperature than that necessary to reduce iron ore to metallics, and to prevent this fluxing from taking place I propose charging with this finely-divided ore sufficient carbon to reduce the oxygen contained in the ore. I would then also place on the bottom of the furnace lime and carbonoceous matter, as outlined above, to act as a recarburizer for the liquid metal and a flux for the silica after the metal has been reduced.

Instead of charging only iron ores with or on carbon and basic materials I may operate the process by adding successive portions of molten pig-iron through a hole 30 in the roof at the low side of the furnace or through a top hole on the ascending side of the furnace. In this case molten pig metal is charged into the low side of the furnace to form a bath at this point. Iron ore and basic material (or carbon, if desired) are then charged in upon the hearth at the charging-openings, and as the bottom is turned the mixture will be carried into roasting zones of increasing temperature and finally be carried beneath the molten metal, which will flow over the ore and absorb the metal in it, as above described. The molten metal will thus be reduced in carbon, &c., and the metal extracted from the ore. The molten product can be partially or wholly drawn off and a new charge of molten metal poured in.

If it is desired to use scrap, cold pig, &c., in the process, the ore, lime, and carbonaceous matter may be charged, if desired, and the pig, scrap, &c., then charged upon it, these successive charges being carried into and under the bath, as before. The process used with the successive additions of molten pig is especially desirable in making an iron low in silicon, phosphorus, and carbon for use in the acid open-hearth furnaces, the metal being taken liquid directly from the revolving furnace to the open-hearth furnace. The amount of carbon in the iron tapped from the revolving furnace may be regulated by the amount of carbonaceous matter charged with or under the ore. This carbonaceous matter may be omitted at intervals, so that at certain periods the liquid bath would not be recarburized and would become low in carbon before tapping off, thus making this process very desirable in connection with the open-hearth process. By this process iron-ore or metal high in sulfur, phosphorus, and other impurities may be utilized for steel, thus making ores of this character available for open-hearth practice.

The advantages of my invention are many. The operation is continuous by means of the carrying of successive portions of ore and basic material beneath the liquid bath of iron. The basic slag thus formed carries off the impurities and metalloids, and carbon is supplied to the bath as desired to replace that consumed by uniting the oxygen with the ore. The ore will adhere to the bottom of the furnace by becoming pasty and will thus be carried down under the liquid bath, the best conditions being thus provided for its complete reduction and the absorption of the metal contained in the ore. The carbon-gases formed during preheating of the ore and charge will associate with the oxygen of the ore and aid in preparing it for reduction, the reducing-gas acting

as in a blast-furnace, where the gases rise through the charge.

Many variations may be made in the apparatus employed, as well as in the materials used, without departing from my invention.

I claim—

1. The method of reducing iron ore, consisting in forming a bath of molten pig-iron and carrying into and under said bath a mixture of iron ore and basic material, substantially as described.

2. The method of reducing iron ore, consisting in forming a bath of pig-iron and carrying iron ore, carbonaceous material and basic material into and under said bath, substantially as described.

3. The method of reducing iron ore, consisting in successively carrying beneath a bath of molten pig-iron successive additions of iron ore and basic material, substantially as described.

4. The method of reducing iron ore, consisting in forming a bath of molten pig-iron upon a continuous hearth, carrying successive portions of iron ore, carbon and basic material on the hearth into and under the bath, and feeding such material to successive portions of the hearth, substantially as described.

5. The method of reducing iron ore, consisting in forming a bath of molten pig-iron, submerging iron ore and basic material in said bath, tapping out the bath, replacing it with fresh molten pig-iron, and carrying a further supply of ore and basic material into and under said bath, substantially as described.

6. The method of reducing iron ore, consisting in forming a molten bath of pig-iron upon one portion of a continuous hearth, adding iron ore and basic material to the hearth, carrying them into and under the liquid bath, tapping off a portion of the bath, and continuing the additions of ore and basic material, substantially as described.

In testimony whereof I have hereunto set my hand.

JOHN A. POTTER.

Witnesses:
JOHN STILLÉ,
ELEANOR STILLÉ.