(No Model.) 3 Sheets—Sheet 1.

# J. HENDERSON.

## FURNACE FOR THE MANUFACTURE OF IRON AND STEEL AND FOR OTHER PURPOSES.

No. 282,315. Patented July 31, 1883.

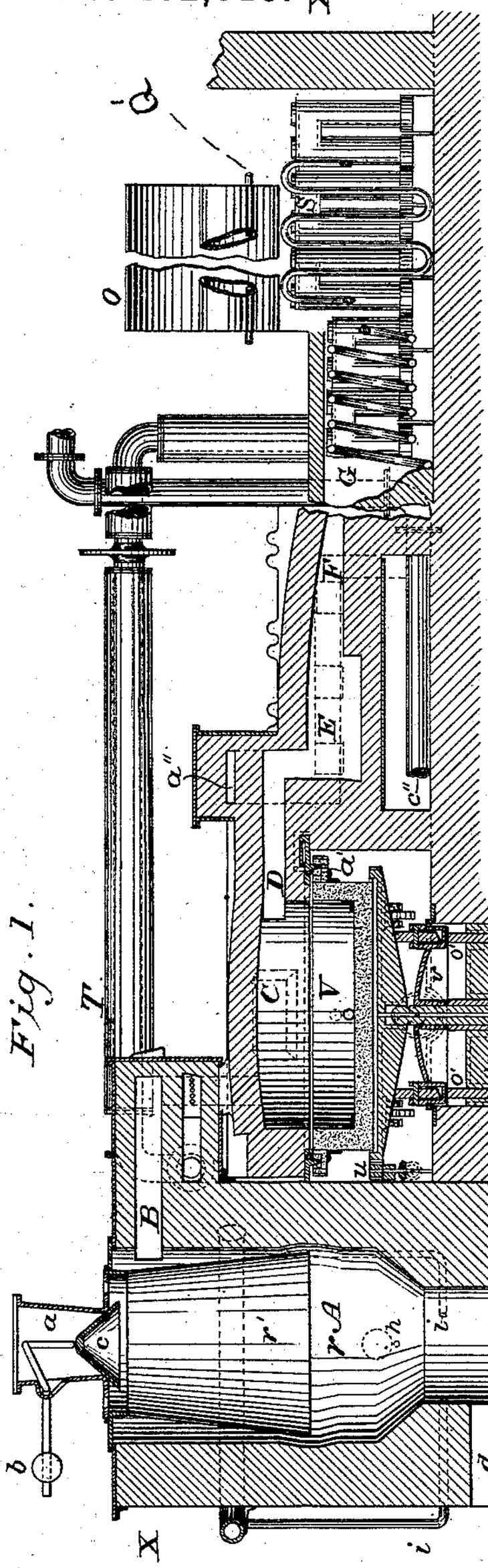


Fig. 1.

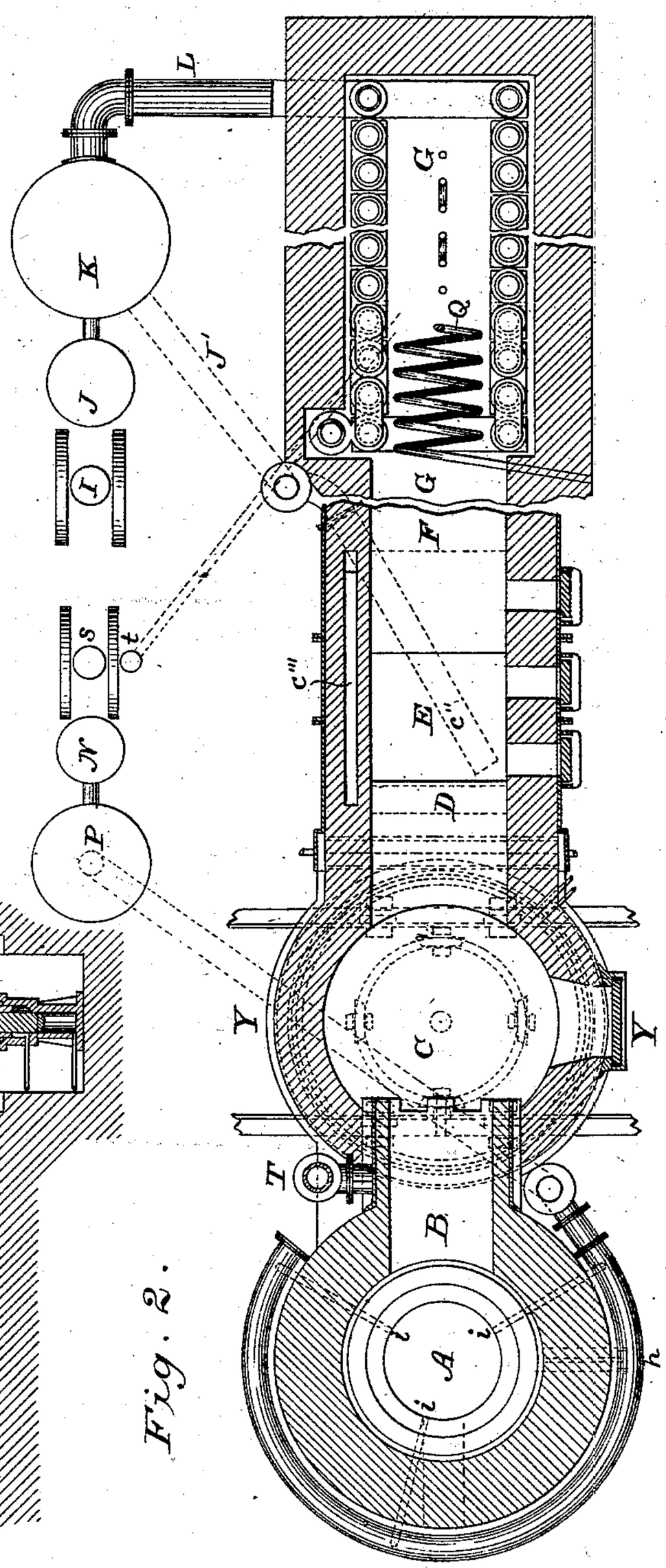


Fig. 2.

WITNESSES

Wm. A. Skinkle

Alfred C. Newman.

INVENTOR

James Henderson

(No Model.) J. HENDERSON. 3 Sheets—Sheet 2.

FURNACE FOR THE MANUFACTURE OF IRON AND STEEL AND FOR OTHER PURPOSES.

No. 282,315. Patented July 31, 1883.

*Fig. 3.*

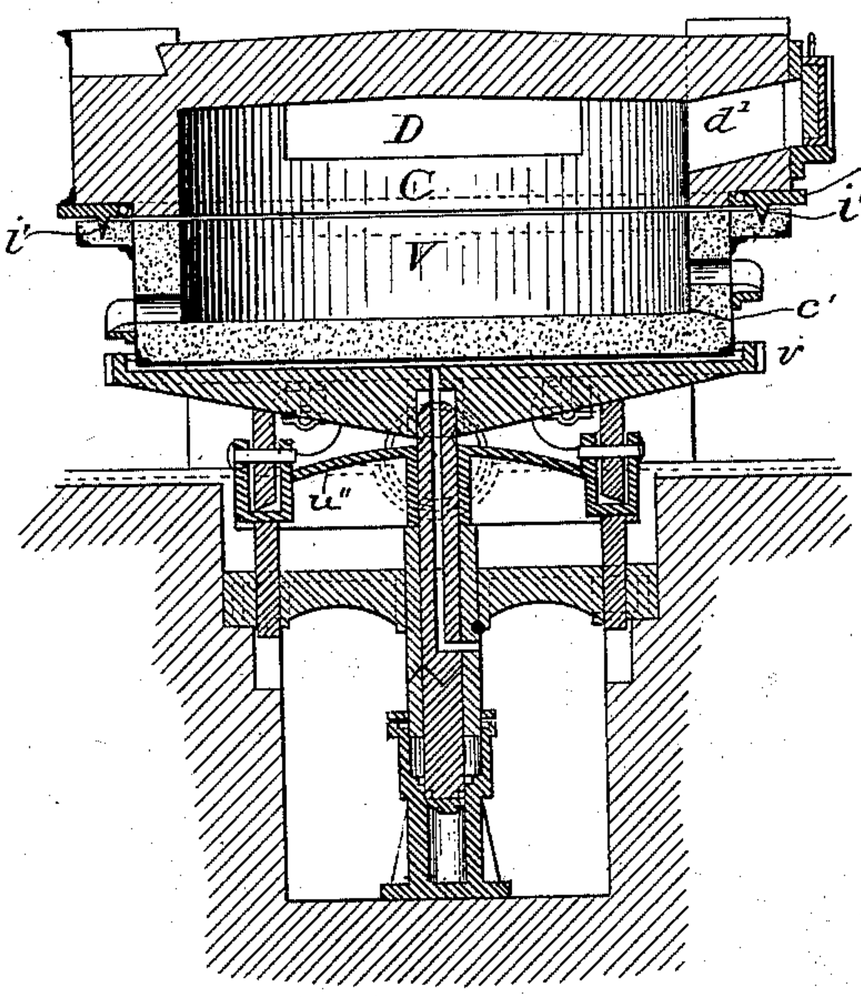



*Fig. 4.*

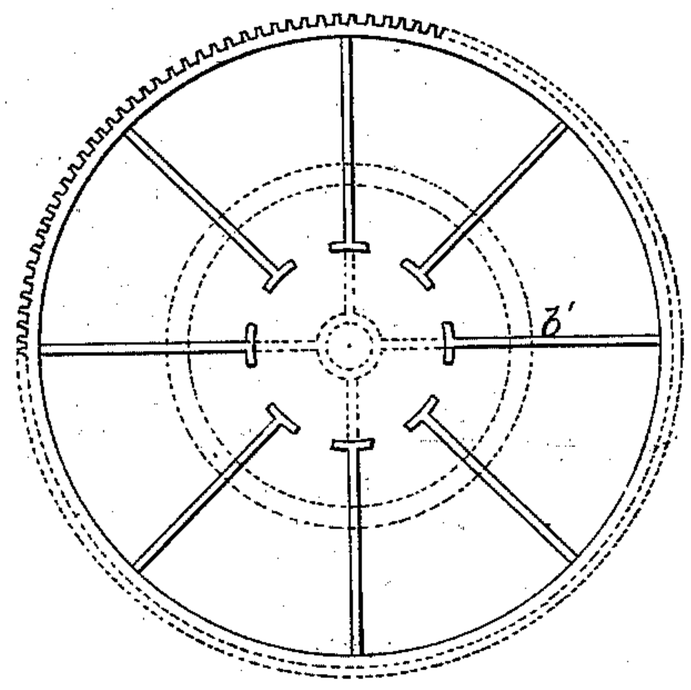



*Fig. 8.*

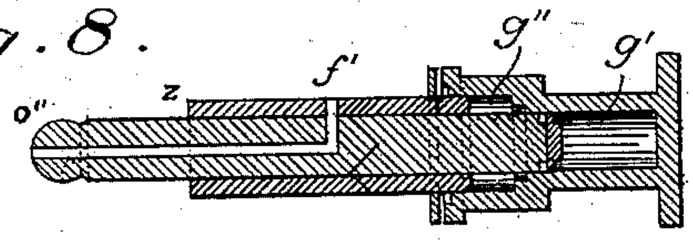



*Fig. 5.*

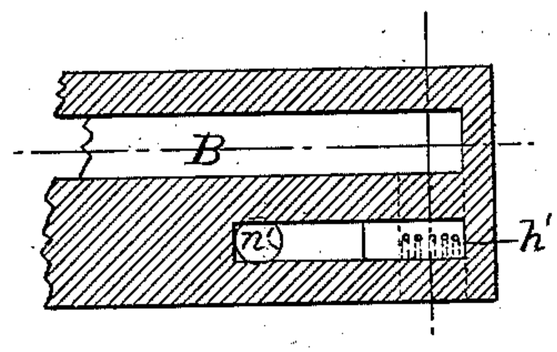



*Fig. 6.*

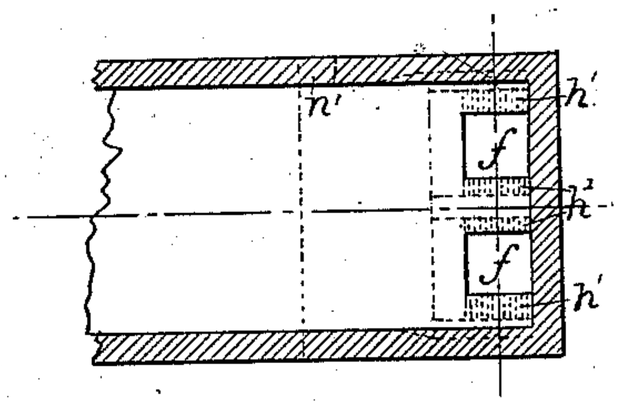



*Fig. 7*

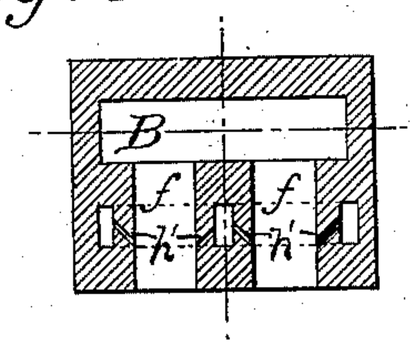
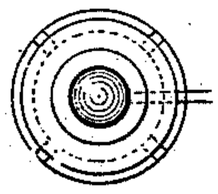



*Fig. 9.*



WITNESSES

Wm A. Skinkle

Alfred E. Newman.

INVENTOR

James Henderson

(No Model.) 3 Sheets—Sheet 3.

# J. HENDERSON.

## FURNACE FOR THE MANUFACTURE OF IRON AND STEEL AND FOR OTHER PURPOSES.

No. 282,315. Patented July 31, 1883.

*Fig. 10.*

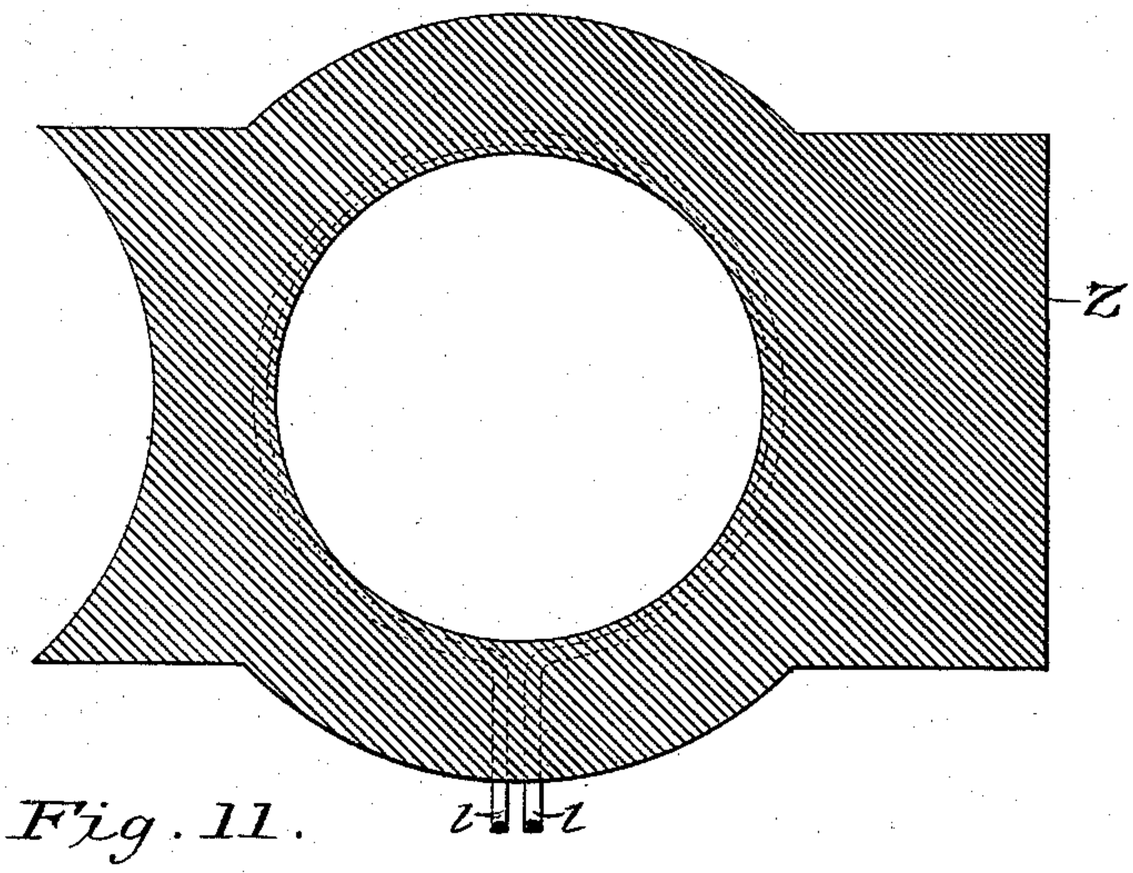
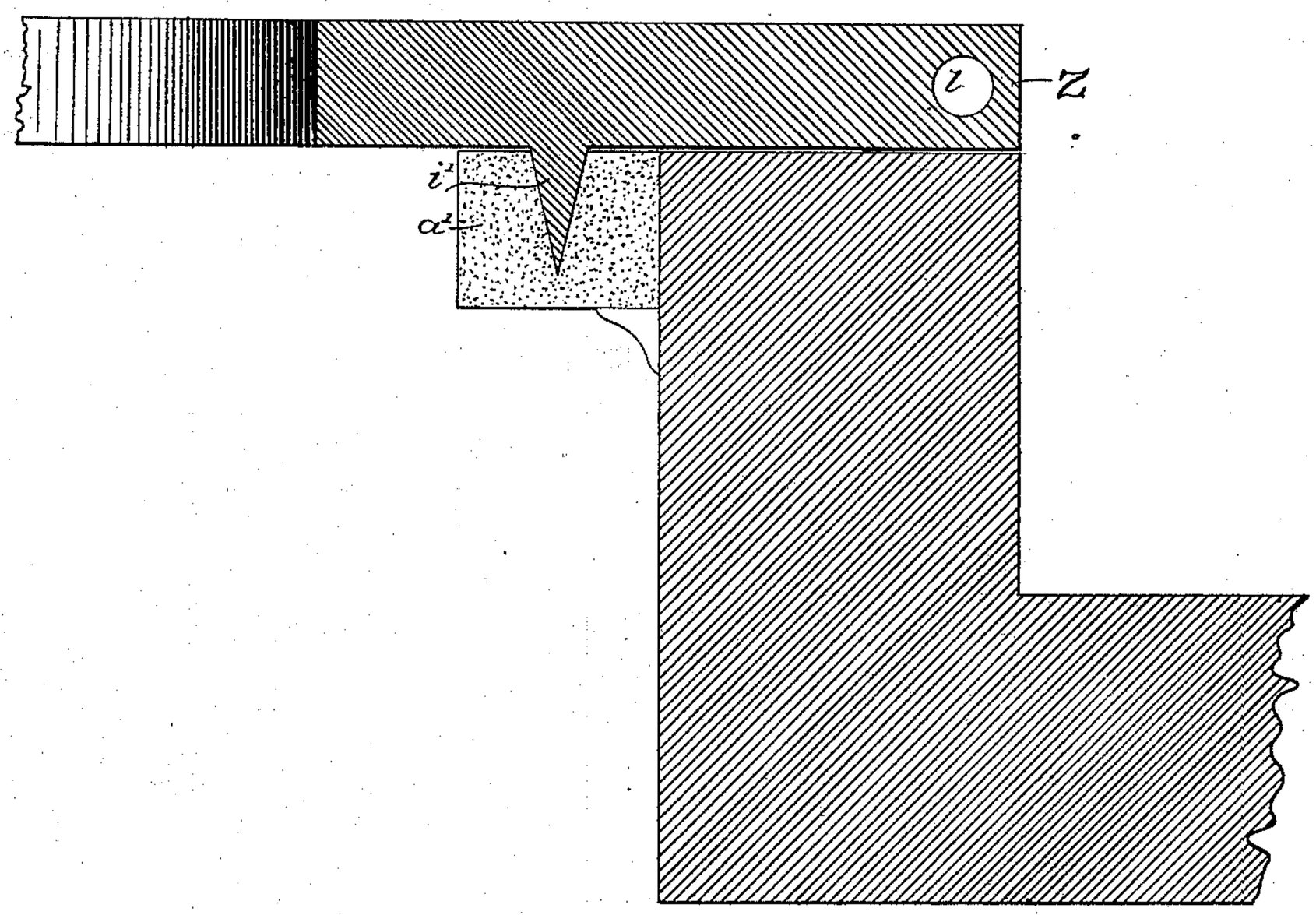



*Fig. 11.*




WITNESSES

Wm A. Skinkle

Alfred C. Newman.

INVENTOR

James Henderson

# UNITED STATES PATENT OFFICE.

JAMES HENDERSON, OF BELLEFONTE, PENNSYLVANIA.

## FURNACE FOR THE MANUFACTURE OF IRON AND STEEL AND FOR OTHER PURPOSES.

SPECIFICATION forming part of Letters Patent No. 282,315, dated July 31, 1883.

Application filed June 29, 1883. (No model.)

*To all whom it may concern:*

Be it known that I, JAMES HENDERSON, of Bellefonte, county of Centre, and State of Pennsylvania, have invented certain new and useful Improvements in Furnaces for the Manufacture of Iron and Steel, and for other purposes, of which the following is such specification as will enable those skilled in the art to understand and practice the same, being a division of application No. 87,393, filed March 2, 1883.

This my invention consists of novel combinations of elements in apparatuses for metallurgical and other uses, as shown in drawings, in which—

Figure 1 is a longitudinal section. Fig. 2 is a horizontal section of the apparatus through the line *x x* of Fig. 1. Fig. 3 is a vertical transverse section on the line Y Y, on an enlarged scale, of Fig. 2. Fig. 4 is a plan view of the cast-iron truck, showing the ribs upon which the hearth V rests. Fig. 5 is a longitudinal section of the gas and air passage in the outlet-neck of the producer. Fig. 6 is a plan view, and Fig. 7 a transverse vertical cross-section, of the same on an enlarged scale. Fig. 8 is a vertical cross-section of the hydraulic ram, and Fig. 9 is a plan of the same. Fig. 10 is a plan view of the cast-iron plate supporting the roof of the reverberatory chamber C. Fig. 11 is a sectional view of the seal-joint which closes the space between the roof and hearth of the reverberatory chamber C.

The same letters refer to the same parts in the different figures.

The principal parts of the furnace represented in the said drawings are the gas-producer A, from which the flue B of the inlet-neck of the furnace is the outlet for the resulting gases, as well as the inlet into the heating-chamber C, the movable revolving hearth V, the flue D of the outlet-neck of the furnace to a second heating-chamber, E, the flue F of the outlet-neck of the second heating-chamber, G, beneath the boiler O, and thence through its flues to the chimney to the external air.

The hearth or bottom of the furnace, V, is moved vertically by being mounted on a table or platform, *v*, raised and lowered by the upper end of a hydraulic ram, W, and also has wheels on the bottom of the truck upon which it sets, so that it may be moved away from under the arch after being lowered.

The top of the hydraulic ram is spherical, which fits into a corresponding socket in the bottom of the truck, and thus forms a pivot and a ball-and-socket joint, so that the hearth may revolve around it and be kept in its place when tipped to pour its contents. A platform, *u''*, with wheels upon the top, fitted in brackets, carries the hearth when it revolves by means of a track corresponding to the wheels, cast on the under side of the hearth. The surface of the wheels is beveled or inclined to correspond to the bevel or inclination of the track. The brackets are arranged, as shown, with hollow space for water, in which the wheel revolves. Wooden disks may be placed between the wheels and the outside bracket to take up the friction.

The hearth is revolved by means of the spur-wheel *u*, working in corresponding teeth in the rim of the hearth. The hearth is maintained in its vertical position by the guide-plate *m* and the four guide-rods *o'*, passing through it. The hearth, when in its raised position in the furnace, is sealed, so that there cannot be any passage of heat or gases from it to the external air, by an annular open box, *a'*, at the top, filled with sand or water, in which a ring, *i'*, on the bottom plate, Z, Fig. 3, supporting the chamber C, dips nearly to the bottom. The plate is provided near its inner edge with an iron pipe or passage, *l*, cast therein, in which water or air circulates to cool the plate and prevent injury from the heat of the furnace.

Fig. 10 is a plan view of the plate Z, showing the cooling-chamber in dotted lines, and Fig. 11 is a sectional view of the sealed joint made by the ring *i'* on the bottom, dipping into the annular box *a'*.

The hearth V is preferably divided in two parts. The hearth proper, in which the iron is treated, is preferably made of rolled plate of pure soft steel low in carbon and having great extension under pulling stress, (say under 0.10 per cent. of carbon, with twenty-five per cent. extension under strain,) to enable it to expand and contract with heating and cooling without

liability of bursting. This pan or hearth rests in the cast-iron platform upon raised ribs or projections *b'*, (shown in Fig. 4,) and the platform, having the sides reaching to the under side of the lower spout or tap-hole of the hearth, forms a shallow dish, which enables the use of water or air therein for cooling the bottom of the hearth. If desired, there is a narrow open space about one inch wide, surrounding the hearth, and between it and the sides of the pan, which enables the ingress or egress of air for cooling the hearth, if air is used.

The air or water is introduced through the opening in middle of the hydraulic ram, as hereinafter described.

The movable hearth or bottom V is provided with a lining, *c'*, of refractory material, which may be coke or plumbago and fire-clay, (such as is used for steel-melting crucibles,) oxide of iron, lime, magnesian lime, magnesia, sand, or silicious linings, depending upon the amount of heat required and the kind of operation performed therein. When reagents are used they are generally spread over this lining by introducing them through the door *d'*, or by lowering the hearth from the chamber C for that purpose. The iron used or treated may be placed in the hearth in the same way, or the roof may be made movable and removed for these purposes.

The gases employed to heat the reverberatory chamber C and convert the charge enter through the flue B. The combustible gases pass from flue B, descending thence, by the vertical flues *f f*, to chamber C. In the flues *f f* these gases are mixed with regulated quantities of atmospheric air, preferably heated to from 700° to 1200° Fahrenheit, whereby the gases are inflamed and perfect combustion produced. From the chamber C the products of combustion are conveyed away by the flue D. The heated air passes into such flues or passages *f f* from the tuyeres *h'*, Figs. 5, 6, and 7, which communicate at their rear with air-passages to a flue, *m'*, and thence by the pipe T, Figs. 1 and 2, to the cast-iron air-heating pipes S, placed at each side of the boiler-chamber G, where the air is heated by the spent gases from the furnace, (or the air may be heated in any other suitable air-heating apparatus, either attached to or detached from the furnace,) which is connected with a pipe, L, leading from the blast-receiver K.

The gas-producer A is constructed at one end of the reverberatory furnace. The interior of the gas-producer is formed of two fuel-chambers, *r r'*, the former, *r*, being beneath the iron reservoir or hopper *r'*, and being therefore designated the "lower fuel-chamber," while the hopper or reservoir *r'* is a distinct fuel-chamber, where a different gas process is carried on. It is therefore designated as the "upper fuel-chamber." It is designed that the interior of the gas-producer A shall at all times when working be charged to the top with fuel, that will fall automatically as it burns away at the bottom, thus supplying the fire, while the fuel becomes gradually heated, decreasing in temperature to the top. *a* is the top of the fuel-hopper; *b*, a weighted lever to close the hopper air-tight by raising the cone *c* when charging the fuel at *a*. *d* is a port or opening at the bottom of the gas-producer, for removing the contents and igniting the fuel.

In operating the apparatus kindling is inserted at *d* and the fuel at *a*. The kindling being ignited, the fuel-blower N is brought into action. The air from it passes by a pipe to a reservoir, P, to equalize the pressure, and thence by a pipe surrounding the gas-producer. From this circular pipe the air enters the lower fuel-chamber, *r*, through the air-passages or tuyeres *i i*, and acts upon the fuel in the gas-producer, decomposing the fuel. The gases resulting from the decomposition, rising up through the interstices of the fuel, escape by the gas-flue B and gas-channels *f f* into the reverberatory chamber. The heat incident to the decomposition of fuel in the lower fuel-chamber, *r*, acts upon the fuel in the coal-reservoir or upper fuel-chamber, *r'*, effecting a distillation of the fuel therein and causing the fuel to evolve gases. These gases are forced, by the pressure made by their distillation, down and into contact with the incandescent fuel in the chamber *r*, whereby the tarry matters therein become decomposed and pass with the other gases through the annular space between the retort and the wall of the gas-producer, and pass thence into the space about the upper retort to the flue B. As perfect combustion of carbonic oxide is effected when mixed with one-third of its volume of hydrogen, I use, preferably, superheated steam in regular measured proportions, injected through one or more tuyeres, *h*, in the gas-producer, from twelve to twenty inches above the air-tuyeres *i i*, when cold air is used and the fuel is of small size, (if coke or anthracite, of size of walnuts.) A pump, *t*, is attached to the crank-shaft of the blast-engine *s*, which pumps at each revolution a certain regulated required amount of water. The revolution of the blast-engine *s* pumps a certain amount of air, and also pumps a certain required amount of water. The water passes through a pipe, Q', placed in the front end of the boiler-flue, to the rear end, and thence under the boiler back to the front in zigzag vertical form, and near the end terminates in a coil, Q. This arrangement enables all of the water to be gradually converted into steam and to become highly-superheated steam by the time it reaches the end of the coil. The superheated steam then passes through a covered pipe (not shown in the drawings) to the tuyere *h* in a highly-superheated state, or at a temperature of 600° to 800° Fahrenheit, and thence into the gas-producer among the incandescent fuel, where it decomposes to hydrogen and oxygen, the latter combining with part of the carbon of the fuel to form

carbonic oxide. The carbonic oxide and hydrogen thus produced mix with the carbonic oxide formed by the combustion of the fuel with the air from the tuyeres, and pass from the producer through the flue B to the flues *f*, where they are burned with heated air. About three-fourths of a cubic inch of water reduced to superheated steam is the proportion that I have found—with four feet of cubic air introduced in the lower part of the gas-producer *r*, with anthracite to give the required proportions of hydrogen and carbonic oxide—to produce perfect combustion when burned with sufficient air.

In order to increase the durability of the superheating apparatus, the part where the superheating takes place, and from thence leading to the gas-producer, should be made of cast-iron. The part where steam is formed should be of wrought-iron, as the superheated steam rapidly oxidizes wrought-iron and has but little effect on cast-iron, and as there is practically no appreciable pressure used, cast-iron is better than wrought-iron for this purpose.

I preferably effect the combustion of the gases passing through the outlet B by air supplied by a distinct blast-machine, of which I is the steam-cylinder, and J the air-cylinder, the pistons being connected by a cross-head. The air passes from the blast-cylinder through an air-conduit system, as follows: K is an air-receiver, into which the air is delivered from the blast-machine J in a measured quantity. The pipe L delivers the air, when perfect combustion with a neutral or oxidizing flame is required, to vertical cast-iron pipes S, Fig. 1, ranged under the boiler along the side walls, as shown in the plan in Fig. 2. The blast enters the rear end and passes up and down through these pipes, which are heated by the waste or spent gases of the furnace. The air thus heated passes from the pipes to the pipe T, thence to the channel *n'*, Fig. 5, in the outlet-neck of the gas-producer, to the tuyeres *h'*, Figs. 5, 6, and 7, where it impinges upon the gases passing through the flue B and the vertical flues *f f*.

When the fuel used in the gas-producer is anthracite and the greatest intensity of heat is required, the blast-machine should deliver to the cast-iron air-heating apparatus about four hundred and forty-five cubic feet of air to burn each pound of hydrogen in the anthracite and that produced by the decomposition of the superheated steam, and 72.5 cubic feet of air for each pound of carbon converted into carbonic oxide in the producer by the oxygen of the air and of the decomposed superheated steam therein acting upon the incandescent fuel; and when an oxidizing-flame with less heat is required a greater quantity of air should be used. If one-half more air is used, the temperature is reduced to about two-thirds of that realized from the use of the above proportions.

Fig. 8 shows the hydraulic ram of Fig. 1 on an enlarged scale for raising and lowering the hearth V of the furnace. The head of the ram *o'''* is spherical and fits into a socket in the platform *v*, Fig. 3. The socket is preferably made of hard wood when water is used in the table *v*, or when air is used Babbitt or other metal or iron is used, care being taken to make either air or water tight joints. The ram is recessed slightly below the head to allow it to turn in the socket and keep the joint tight. *f'* is a central passage in the ram, through which the air or water passes in or out of the table or platform *v*. The air or water is pumped through the passage *f'* of the ram to the space beneath the wrought-iron hearth V and cools it as far as the table extends up its sides. The platform rests upon the top of the ram, which fits in its socket and on the shoulder *z*. When it is desired to pour the contents of the pan or hearth, if water is used, the water is run out of the table through openings *f'*, and the ram lowered by discharging the water from the chambers *g'* and *g''*, the platform and hearth resting on the shoulder *z* and the head *o''*. The side oppcsite the spout is then raised enough to give proper inclination to the hearth to pour the metal. When the hearth is again ready for use, the water is again pumped into the ram, and thus raises the hearth to its required place in the furnace.

What I claim, and desire to secure by Letters Patent, is—

1. The combination of a movable hearth, guide-plate *m*, their intermediate connecting mechanism, and the guide-rods *o'*, substantially as specified.

2. The combination of a hydraulic ram with ball top and hollow center and a table and hollow socket communicating with a cooling-chamber beneath the hearth of the furnace, substantially as described.

3. The combination, in a gas-furnace, of the boiler, the hot-blast pipe, and the superheater both beneath said boiler, as specified.

4. The hearth provided with means for rotating the same, and the rollers and recessed brackets, in combination with the platform *u''*, substantially as described.

5. The hydraulic ram with ball top, in combination with table and socket and hearth, substantially as described.

6. The hydraulic ram with ball top, in combination with a socket-joint, with the platform *u''* and table and hearth, substantially as specified.

7. In combination with the hearth of a metallurgical furnace and a supporting-table, the hydraulic ram with ball top and hollow center, as described.

8. In combination with the hearth of a metallurgical furnace and a supporting-table, the duplex hydraulic ram with ball top and hollow center and two water-chambers, substantially as described.

9. The seal-joint formed by the ring-plate on which the walls of the reverberatory cham-

ber rest, in which is a cooling-chamber, and the upper edge of the hearth provided with an annular groove containing a sealing material, substantially as specified.

10. The seal-joint formed by the ring-plate on which the walls of the reverberatory chamber rest, in which is a cooling-chamber, and the upper edge of the hearth provided with an annular groove containing a sealing material, into which a circular downwardly-projecting lip on the ring-plate dips, substantially as specified.

JAMES HENDERSON.

Witnesses:
JOSEPH J. SULLIVAN,
JOHN E. ELMENDORF.