(85.)

9 Sheets--Sheet 1.

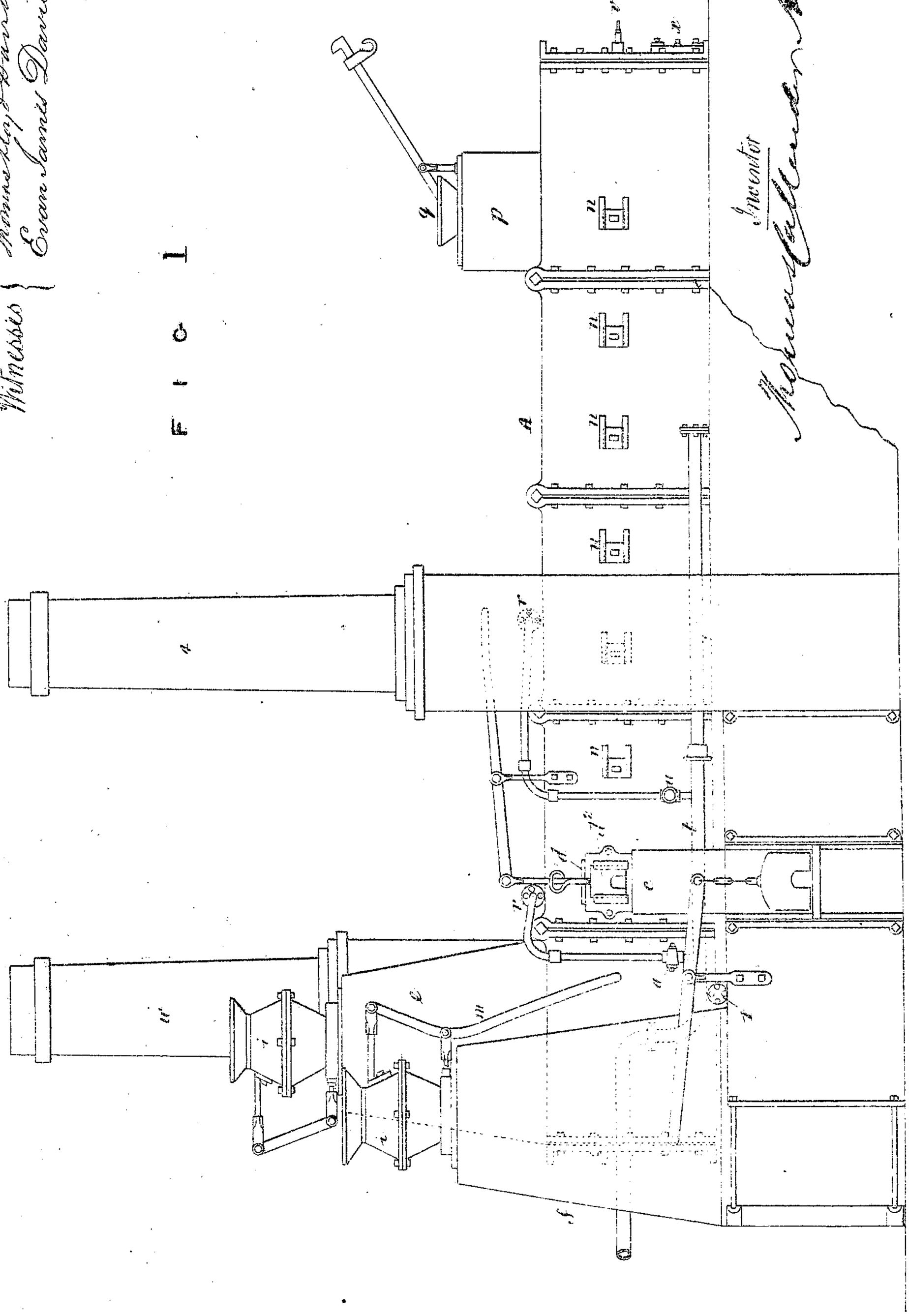
THOMAS C. HINDE.

Improvement in the Manufacture of Iron and Steel and in Furnaces for the same.

No. 121,872. Patented Dec. 12, 1871.

Witnesses { Thomas Kay 2d Pennsylvania
Evan Lewis Pennsylvania

Fig 1



Inventor
Thomas C. Hinde

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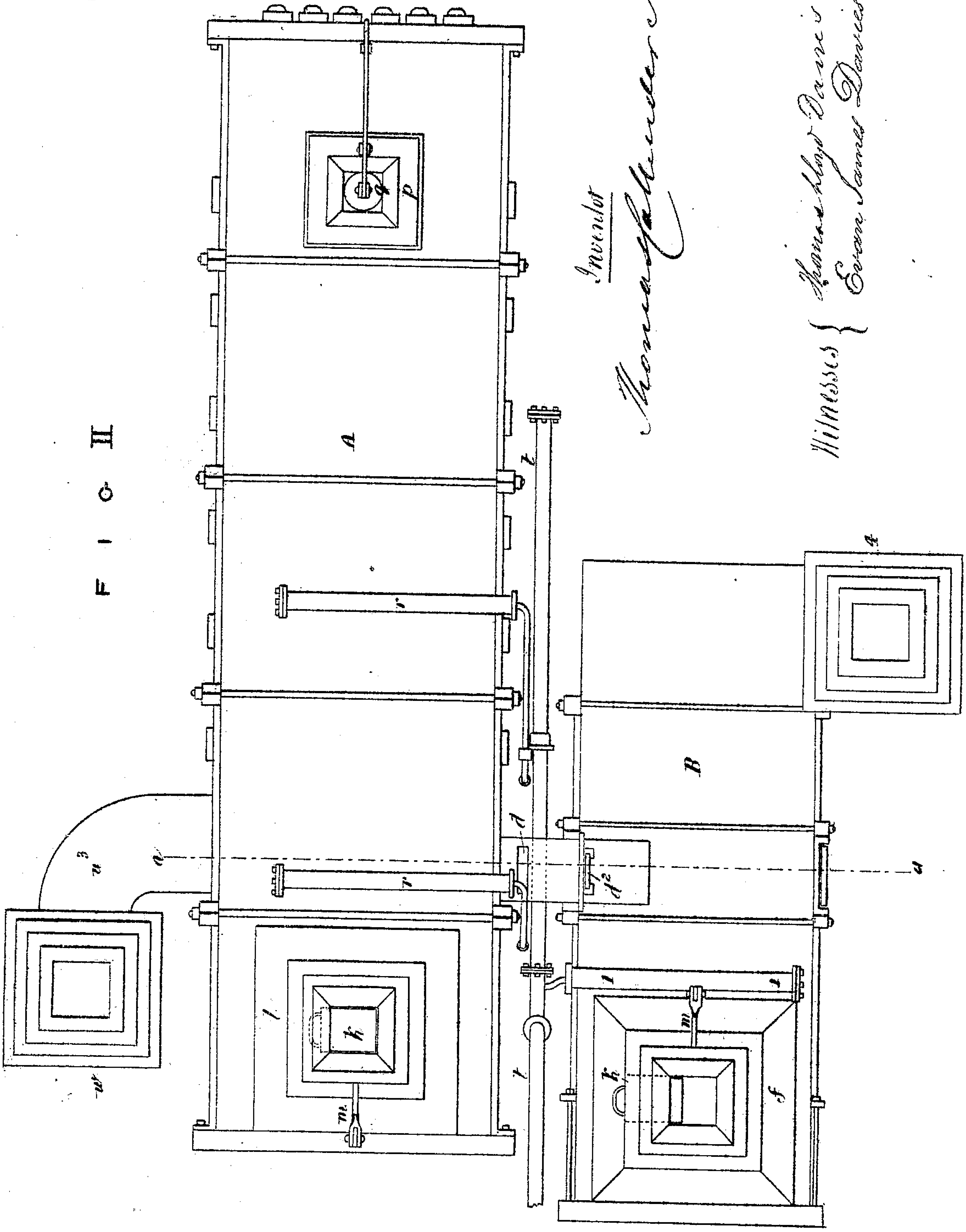

Inventor
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Witnesses { Thomas Lloyd Davies
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(85.)

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THOMAS C. HINDE.

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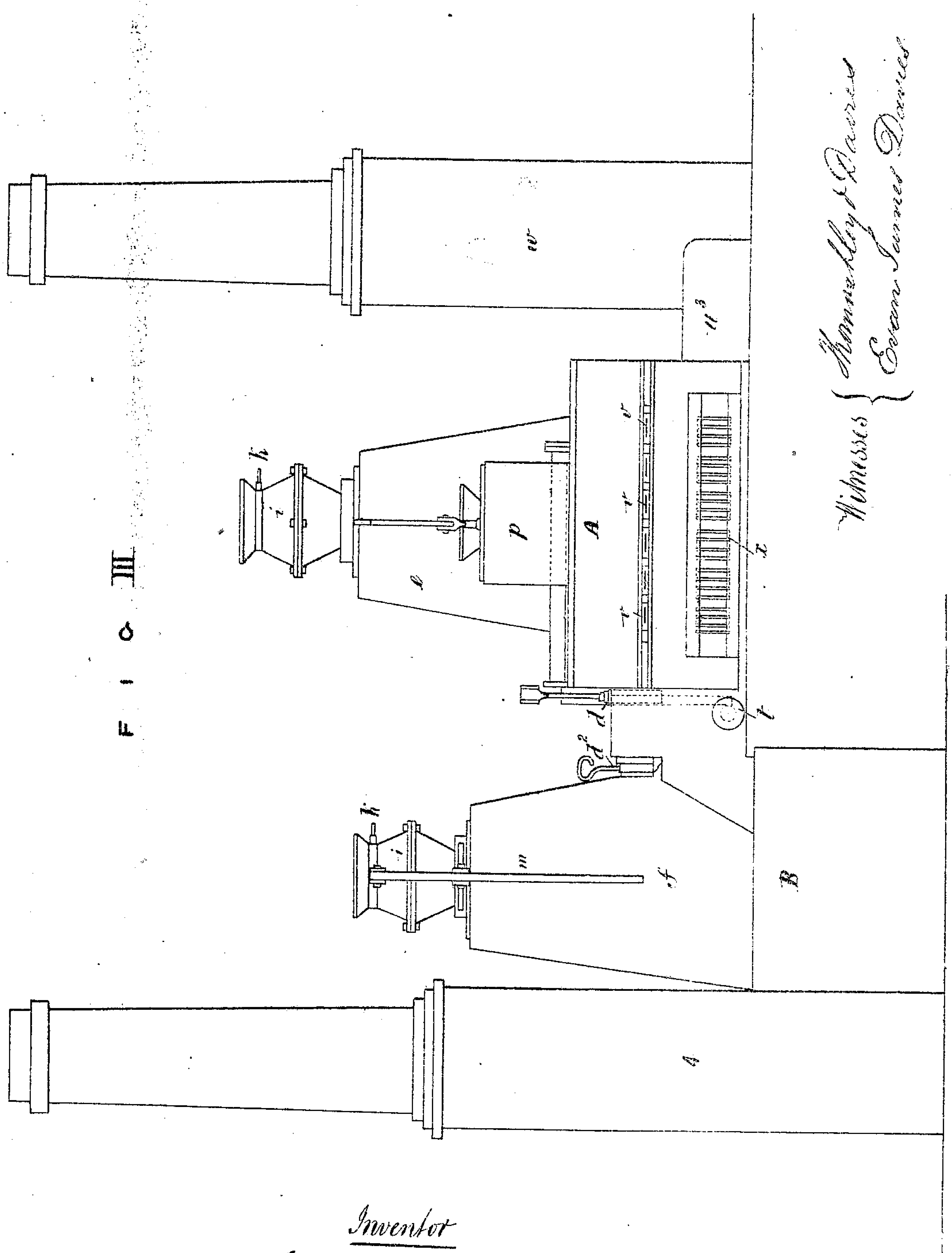
FIG. III



Witnesses { Thomas Lloyd Davies
Evan James Davies

Inventor
Thomas Callender Hinde

AM. PHOTO-LITHOGRAPHIC CO. N.Y. (OSBORNE'S PROCESS.)

(85.)

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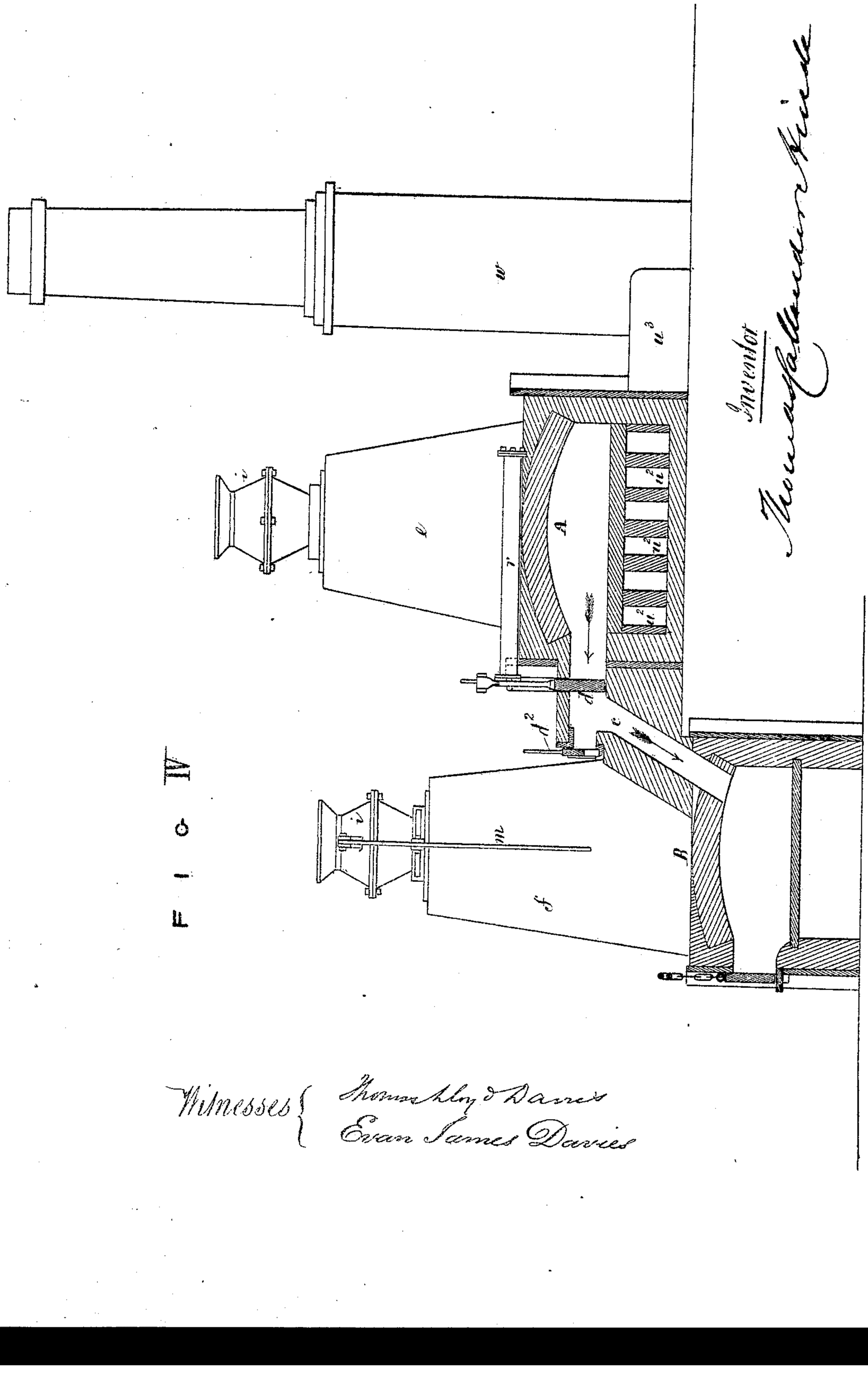
FIG IV



Witnesses { Thomas Alby Davies
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(85.) 9 Sheets--Sheet 5.

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Improvement in the Manufacture of Iron and Steel and in Furnaces for the same.

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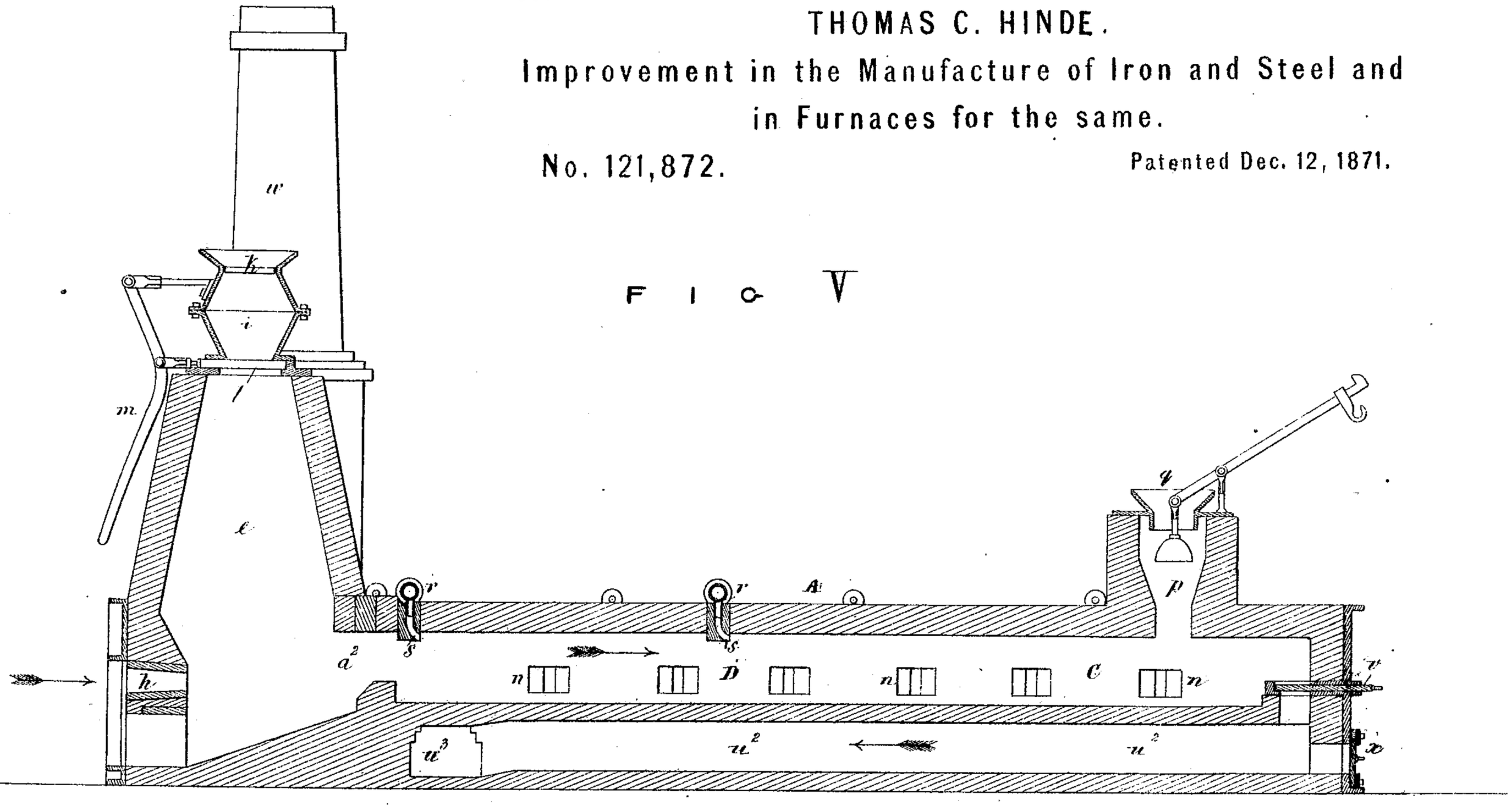
FIG V



Inventor
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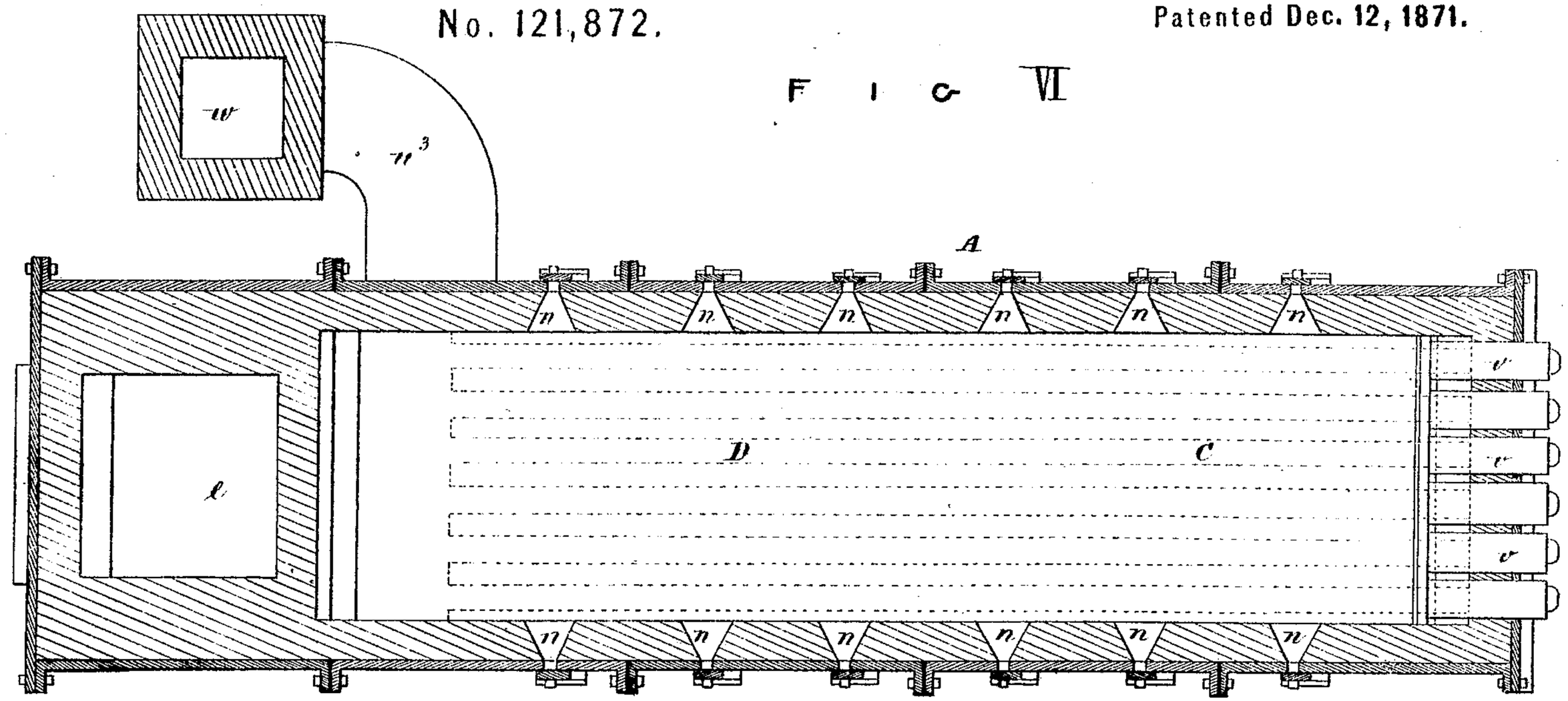
No. 121,872. Patented Dec. 12, 1871.

FIG VI



Inventor
Thomas Callender Hinde

Witnesses { Thomas Lloyd Davies
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(85.) 9 Sheets--Sheet 7.

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Improvement in the Manufacture of Iron and Steel and in Furnaces for the same..

No. 121,872. Patented Dec. 12, 1871.

FIG VII

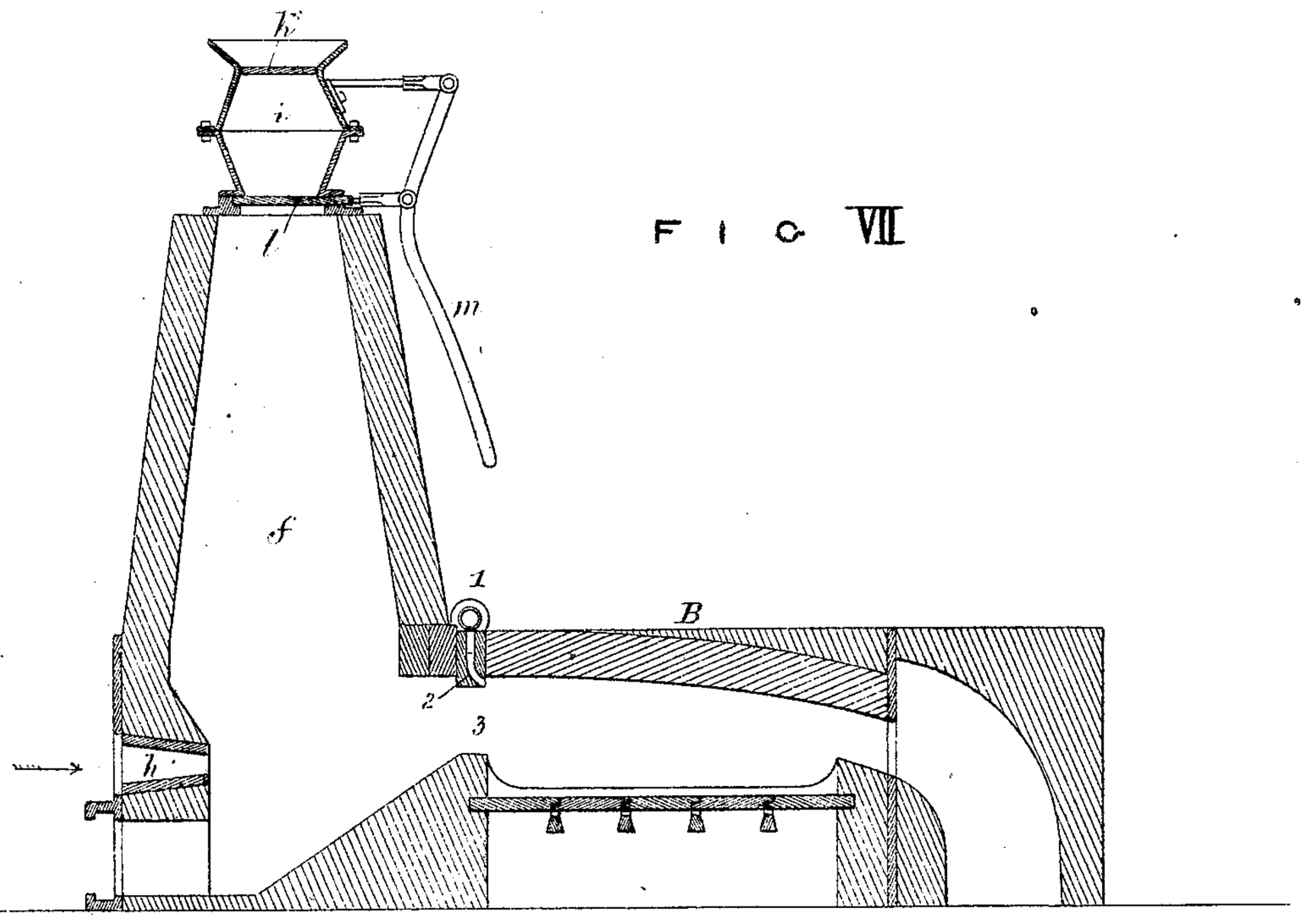
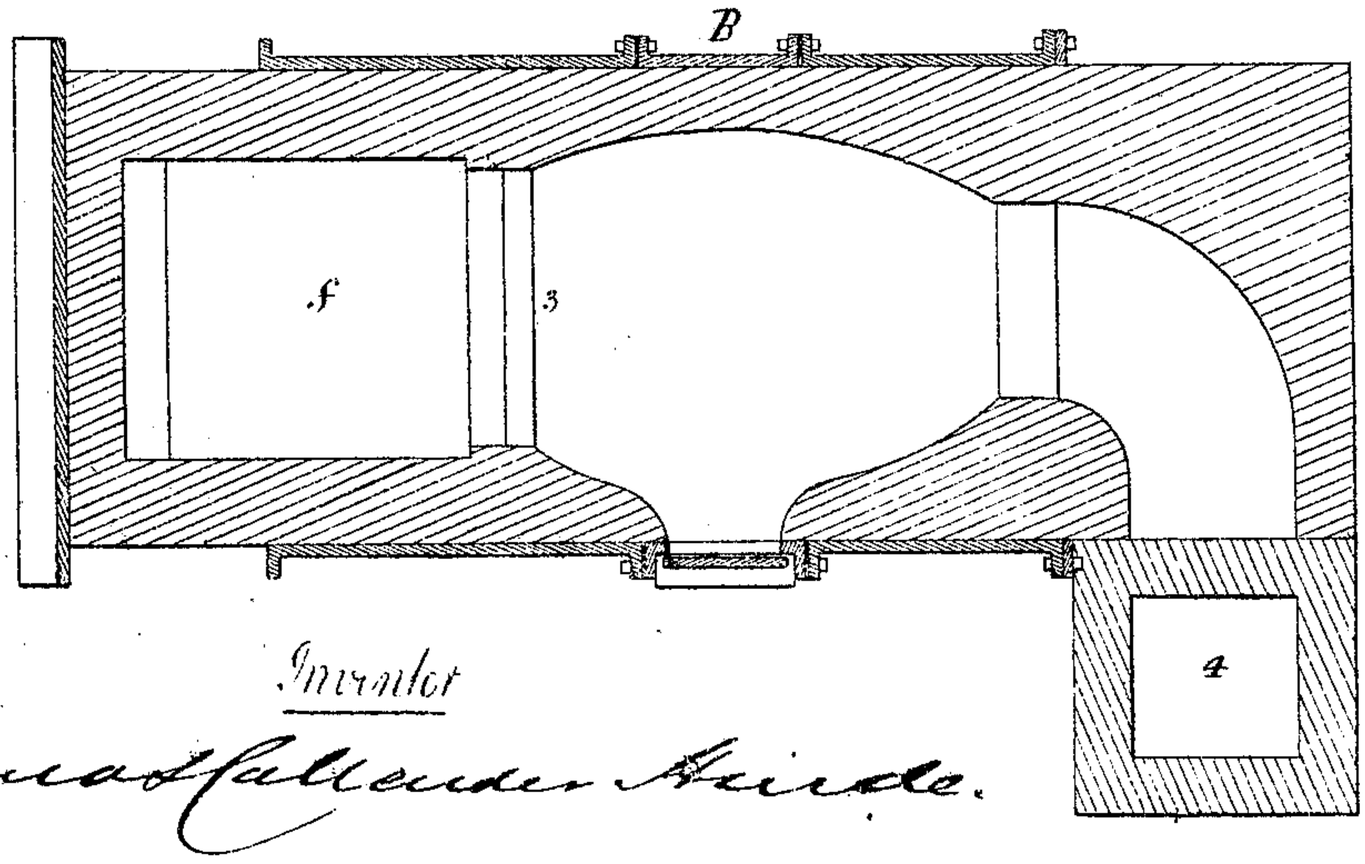


FIG VIII



Inventor

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Witnesses { Thomas Lloyd Davies
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(85.) 9 Sheets--Sheet 8.

THOMAS C. HINDE.

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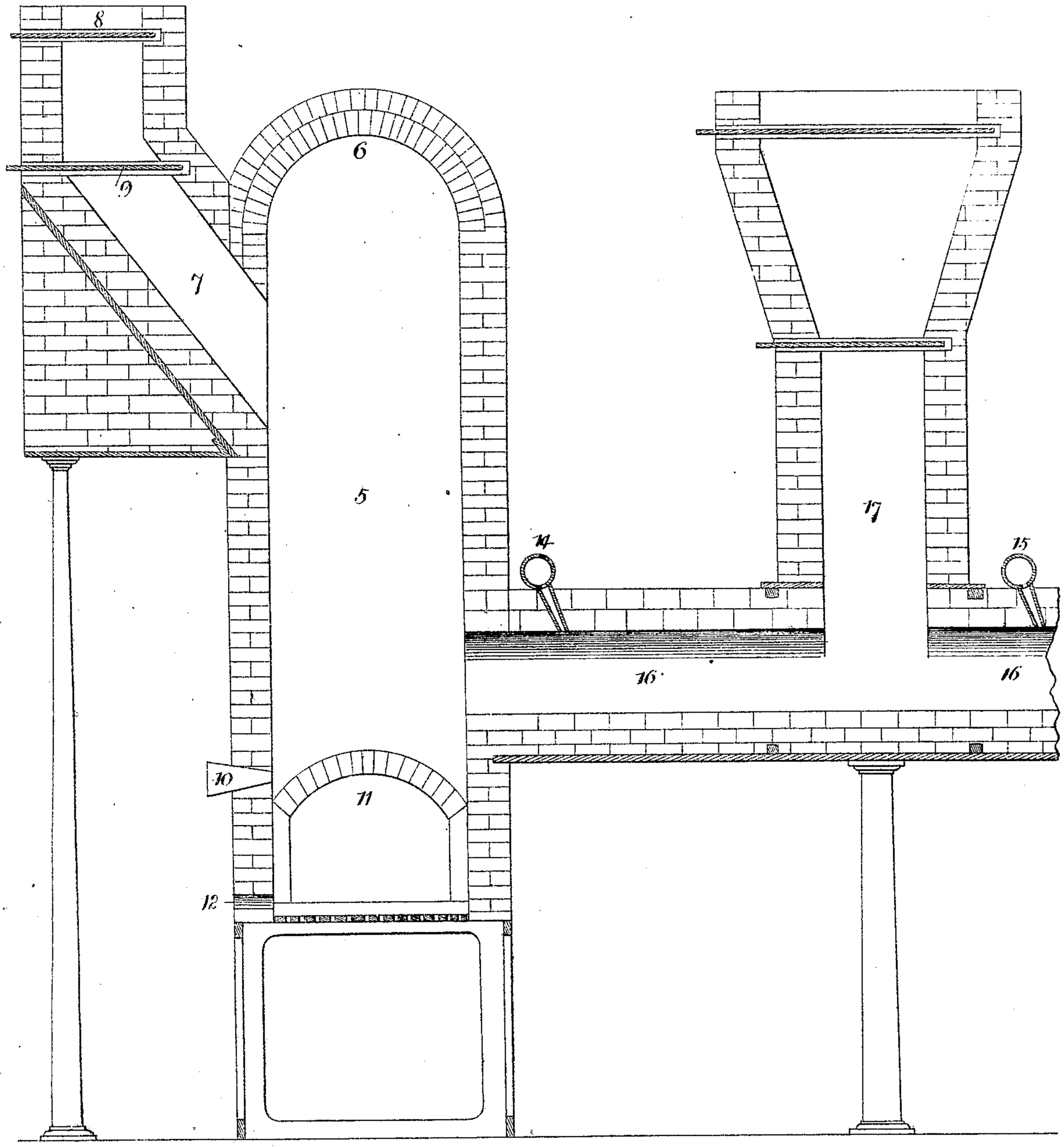
FIG IX



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(85.) 9 Sheets--Sheet 9.

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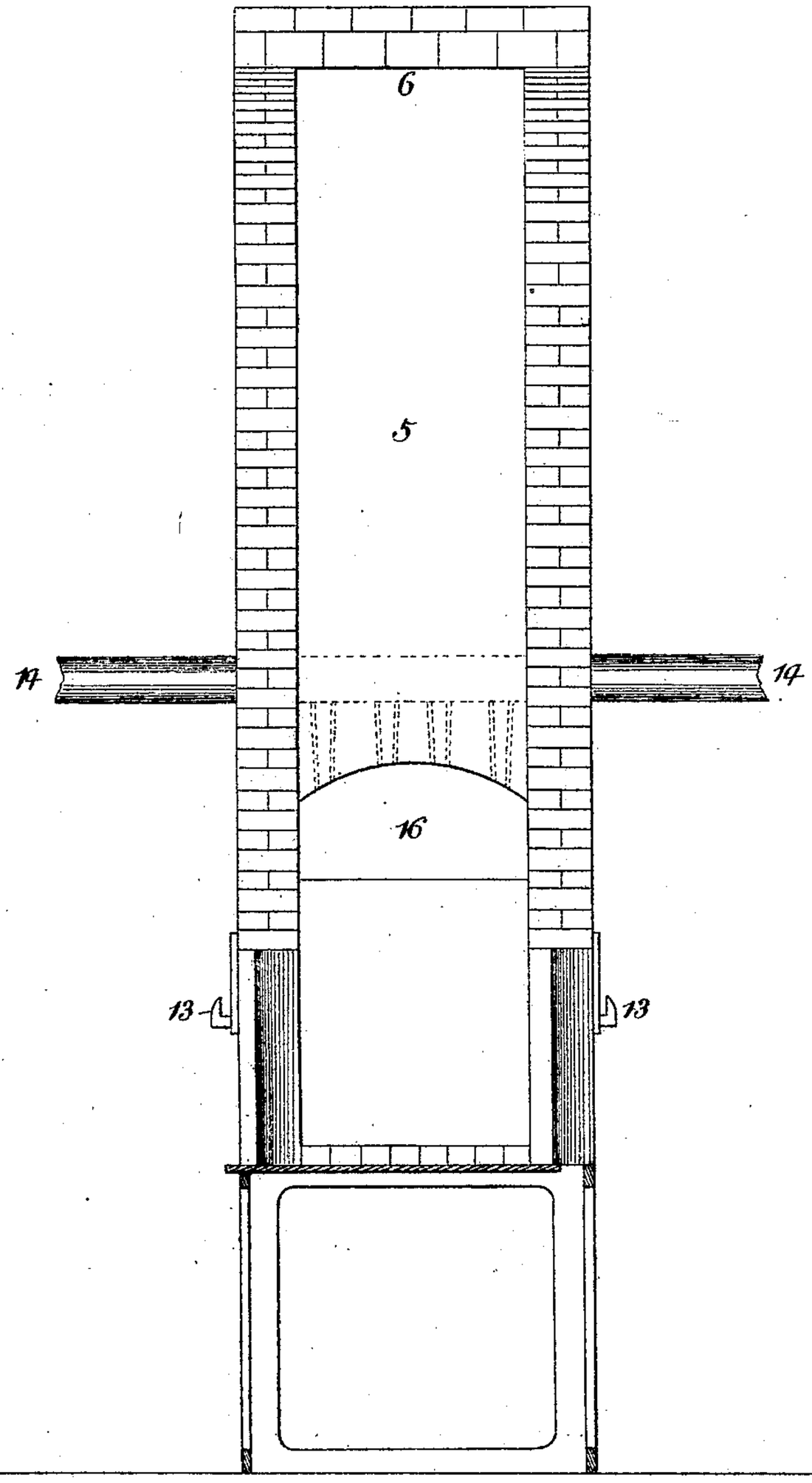
FIG X



Inventor

Witnesses { Thomas Lloyd Davis
Evan James Davies

UNITED STATES PATENT OFFICE.

THOMAS CALLENDER HINDE, OF FOWNHOPE, NEAR HEREFORD, ENGLAND.

IMPROVEMENT IN THE MANUFACTURE OF IRON AND STEEL, AND IN FURNACES FOR THE SAME.

Specification forming part of Letters Patent No. 121,872, dated December 12, 1871.

To all whom it may concern:

Be it known that I, THOMAS CALLENDER HINDE, of Fownhope, near Hereford, England, colliery proprietor, am the inventor of Improvements in the Manufacture of Iron and Steel, and in Furnaces and Apparatus to be used in the said manufacture, parts of which improvements may also be applied to other purposes; and I, the said THOMAS CALLENDER HINDE, do hereby declare the nature of the said invention, and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement thereof—that is to say:

I will describe the manufacture of iron or steel as conducted according to my invention, which description will comprise both the nature of my improvements in the said manufacture and in the furnaces and apparatus I employ.

In preparing the ores from which the iron or steel is to be manufactured I employ the ordinary grinding and washing processes; or I subject dry-crushed ore to agitation without water, by which agitation the lighter earthy matters are wholly or chiefly separated from the denser parts constituting the true ore. The crushing and washing or separating may be done at the mine, thereby saving carriage. If done at the smelting-works, I prefer to conduct these preparatory processes at a high level, so that the prepared ore may be transferred to the chambers or furnaces hereinafter described by falling therein, or without having to be lifted. When steel is to be manufactured I avoid the use of ores which are not free or cannot be artificially freed from sulphur or phosphorus, or compounds of sulphur and phosphorus, or other injurious substances. When iron has to be manufactured the quality of ore is of less importance, as by this invention pure or nearly pure infusible malleable iron is obtained, in the first instance, from the ore, while the impurities being either fusible by themselves, or rendered fusible by the action of the fluxes, liquate out from the infusible malleable iron in the intense heat of the smelting-chamber. The prepared ore is subjected in succession to the processes of drying, calcining, reducing, and, when necessary, carbonizing; and finally smelting or blooming, and welding. These processes are conducted in a furnace consisting of a series of connected chambers, or in one chamber, different parts of which are devoted to these processes respectively, or in a chamber which is in succession used for these several processes. In connection with the reduction and smelting-chambers are generators, in which combustible heated reducing-gases are produced by the burning under the requisite conditions of coke or other fuel. The hot reducing-gases from the gas-generators are either passed direct into the smelting or reducing-chambers or are superheated before entering the said chambers by being passed through a labyrinth or reticulated mass of brick-work, which, by the burning of a portion of the said gases, has been raised to a high temperature, the reducing-gases in passing through this heated labyrinth becoming superheated before entering the reducing-chamber; or the current of reducing-gases may be superheated by being passed through flues, tubes, or pipes, heated externally by the waste heat from the smelting-chamber, or by the combustion of a portion of the gases themselves; or they may be superheated by being ignited and burnt, and then again passed through coke or other suitable fuel; or the current of heated gases may be divided, one portion passing into the body of the reducing-chamber and the other being passed under the sole or hearth of the reducing-chamber and there burned with atmospheric air, so as to heat the reducing-chamber by external heat. The current of heated gases is supplied under pressure by fans or other blowing apparatus, so as to prevent the entrance of atmospheric air from without. The current of heated reducing-gases may first pass into the smelting-chamber, next into the reducing and carbonizing-chamber, next into the calcining-chamber, and lastly into the drying-chamber; or the current of heated reducing-gases may be divided, one portion going into the smelting-chamber and the other into the reduction and calcining-chambers. On arriving at the calcining-chamber a portion of air is introduced and the heated reducing-gases are burned and produce an oxidizing atmosphere. The prepared ore passes through the series of chambers in a direction contrary to that in which the combustible gases pass through them. In the first chamber the ore is dried; in the second chamber where the gases are burned the ore is roasted or calcined; in the third or reducing-chamber it is reduced to metallic iron

in a fine state of division. From this chamber the iron particles are passed to the smelting-chamber.

When the smelting or balling together of the particles of iron is conducted in a separate chamber from the series of chambers hereinbefore described, the said separate smelting-chamber may be furnished with a separate gas-generator, and placed at a lower level than the reduction-chamber, and a communication opened between the two to allow of the passage or transmission of the charge from the upper to the lower chamber, the passage or opening being kept full of reducing-gases under the pressure to prevent reoxidation of the iron particles. The heat of the smelting-chamber may be increased by burning a portion of the heated combustible gases therein, but in no case to such an extent as to reoxidize the iron particles. Such fluxes as the chemical constitution of the ores shows to be requisite for fusing any earthy impurities are applied either in the solid state in the reduction-chamber, or in a solid or fused state in the smelting-chamber.

When cast iron is to be produced an excess of carbonaceous matter is mixed with the ore in the reducing-chamber, and the operation prolonged until the requisite degree of carbonization is reached. The carbonized iron particles are passed into the smelting-chamber, where they are fused under a layer of vitreous flux, by which means any remaining earthy matter is separated—as cinder—the carbonized melted cast iron falling to the bottom.

When steel is to be produced a sufficient quantity of the uncarbonized iron particles from the reducing-chamber may be introduced into the smelting-chamber and dissolved in the bath of cast-iron to bring the composition of the mixture to that of steel; or the reduced iron particles may be carbonized in the reducing-chamber to the cast-steel forming point at once in the same manner as the cast iron, but limiting the time and degree of carbonization, and then melted under the vitreous flux.

In making pure malleable iron, the iron particles are passed into the smelting-chamber in the reduced metallic but non-carbonized, or very slightly carbonized, state. Spiegeleisen may be mixed with the steel for the purpose of introducing manganese into it. Nitrogenous matters mixed with alkaline bases may be introduced into the reducing-chamber for the purpose of generating cyanogen compounds. The ore in the different stages of its treatment may be kept in motion by rakes or rabbles, either worked by hand or by mechanical means; or the reducing-chamber may rotate on a horizontal axis so as to turn over the ore during the whole course of its treatment in the said reducing-chamber. In this case the heating of the reducing-chamber must be effected by the labyrinth or other methods already described, instead of by external heat. The temperature of the reducing and calcining-chambers is kept below the point at which the ore or reduced iron would melt or agglutinate, as it is desirable that the iron shall pass from the reducing-chamber in a non-coherent state. The drying and calcining-chambers may be placed above the reducing-chamber, so that the calcined ore may fall into the reducing-chamber. When I employ but one chamber the different parts of it are made to possess the necessary reducing, calcining, and heating properties by the introduction at the required places of atmospheric air to combine with the reducing-gases; or a single chamber may be first employed as a drying-chamber by the use of a small quantity of reducing-gas from the gas-generator mixed and burned with atmospheric air. Afterward the supply of mixed air and gases may be increased to convert the chamber into a calcining-chamber, and subsequently, the atmospheric air being shut off, the chamber is converted into a reducing-chamber. The arrangement of apparatus described or modifications thereof, but essentially the same in principle, may be applied to treating ores other than iron ores and to generating steam.

I will now proceed to describe, with reference to the accompanying drawing, the manner in which I carry my invention into effect.

Figure 1 represents in side elevation, Fig. 2 in plan, Fig. 3 in end elevation, and Fig. 4 in cross-section—taken on the line *a*, Fig. 2—furnaces and apparatus which I employ. Fig. 5 represents in vertical longitudinal section, and Fig. 6 in horizontal section, the calcining and reducing-chamber of the same detached; and Fig. 7 represents in vertical longitudinal section, and Fig. 8 in horizontal section, the smelting-chamber of the same detached.

The same letters of reference indicate the same parts in Figs. 1 to 8.

The said furnaces consist of two horizontal chambers situated parallel to one another and marked, respectively, A B. The chamber B is situated at a lower level than the chamber A, (see the cross section, Fig. 4,) the said chambers being connected together by the inclined passage *c*, which passage is opened and closed by the fire-brick sliding door *d*. Each of the chambers A B is provided with an independent gas-generator marked, respectively, *e f*, the blast forced through the ignited coke or carbonaceous matter in the said gas-generators being supplied under pressure to the tuyeres *h h* in any convenient way. The coke or carbonaceous matter is fed to each of the gas-generators, so as to prevent the escape of gas, by a hopper, *i*, at the top of the said generator, the said hopper being provided with a hand-slide, *k*, at the top, and a slide, *l*, at the bottom, worked by the lever *m*. When the lower slide is withdrawn the coke in the hopper falls into the generator, the hopper being closed at top by the hand-slide *k*. When the bottom slide *l* is pushed inward the hopper can be filled, the gas-generator being closed by the said bottom slide *l*. Both of the slides *k l* may be worked by a lever. The lever in this case turns on a center midway between the two slides. With some descriptions of fuel inconvenience may occur by small particles of the fuel in the gas-generator being carried over with the gases.

This is prevented, when necessary, by placing an intercepting or filtering-bed of coke or fire-bricks, so placed that the gases have to pass through it on their way from the generator to the reduction or smelting-chambers. The ashes and clinker in the gas-generators are fluxed out in the usual way; but means of access to the interior of the said generators are provided for removing any clinker that may be formed in the said generators. The reducing-chamber A consists of a long furnace provided with a reverberatory arch and bed, the prepared ore being supplied to the said chamber by the hopper *p* closed by the valve arrangement at *q*. In the sides of the chamber A is a series of holes, *n n*, through which the workman passes his rabble to push the ore toward the top of the chamber, as hereinafter explained. Across the said chamber A are air-pipes *r r* for admitting air-blast to the interior of the said chamber for burning the gases therein. These air-pipes *r r* are supplied by the main pipe *t*, the quantity of air supplied to the chamber being regulated, or the supply entirely cut off, by the stop-cocks *u u*. To the cross-pipes *r r* a series of jets, *s s*, is connected. (See Fig. 5.) The heated reducing-gases from the generator *e* enter the chamber A by the passage a^2, and, after passing through the said chamber, the said gases and products of combustion descend to the flues u^2 u^2 under the bed of the said chamber, and from thence escape by the flue u^3 to the chimney *w*. The draught through the chamber A is regulated by the slides *v v*. Where the combustion of the gases has not been wholly effected in the chamber A it may be completed in the flues u^2 u^2 by means of atmospheric air admitted at *x* under pressure, or by the draught of the chimney *w*. The lower or smelting-chamber B resembles an ordinary heating-furnace with a reverberatory arch and bed, an air-pipe, 1, provided with jets 2, conveying air-blast to the said chamber for burning the gases. The heated reducing-gases from the gas-generator *f* enter the smelting-chamber at 3, and, after passing through the said chamber, the said gases and products of combustion escape by the chimney 4. Both the upper and lower chambers A B are worked with such a pressure of gas as to exclude the entrance of atmospheric air, the object of excluding the atmospheric air by this internal pressure being to prevent the reoxidation of the reduced iron. Means, however, are provided, as before described, for admitting air for the purpose of burning the gases to any required degree.

In working the upper chamber A, when one portion is used for reduction and the other for calcining and heating, blast is forced into the chamber by the jets at *s s* and the gas burnt. The prepared ore fed by the hopper *p* into the part marked C of the chamber A is thereby heated and the ore oxidized, and water and carbonic acid and other volatile impurities driven off. The iron-ore is heated at the part C of the chamber as highly as practicable without its becoming agglomerated or commencing to melt. It is then moved by the workman by a rabble or other tool passed through the holes *n n* nearer to the top of the chamber—that is, to the part marked D—where it is turned over and exposed to the action of the heated reducing-gases until its complete deoxidation or reduction is effected. At the said part D of the chamber A, owing to the less quantity of air mixed with the gases, the said gases have a reducing action. In some cases the air is wholly shut off from the pipe *r*, and jets *s* situated near the passage a^2, and when air is admitted at the said pipe and jets it is necessary that its quantity be so limited as not to impair the reducing character of the gases at the part D of the chamber. By the treatment described the ore is reduced to metallic iron in a fine state of division. If desired, the metallic iron-dust or particles are carbonized to the required degree by means of pure powdered carbonaceous matter, passed into the chamber through one of the openings *n*, or through an opening in the arch of the chamber. When the reduction-chamber is used successively for heating and calcining and then for reducing and carbonizing, the whole of the said chamber A is filled with the prepared ore, and blast is forced into the chamber by the jets *s s*, and the gas ignited and burned. The charge of ore in the chamber A is turned over by the rabbles passed through the holes *n n* until the whole has been heated to a point which it will bear without incipient fusion. The air-blast is now shut off, and the heated iron ore turned over in the heated reducing-atmosphere of the gas alone and reduced to a metallic powder or dust; and, if needed, carbonaceous matter is added to carbonize the metallic particles to the required degree.

The metallic powder or reduced iron ore produced in either of the ways described is now transferred to the smelting-chamber B by opening the fire-brick slide or door *d* and drawing the said powder or reduced iron ore, by a rabble or other tool, down the inclined passage *c*, the rabble or tool being introduced at the door d^2. In the smelting-chamber B the metallic dust or particles are smelted and bloomed or welded together, a limited quantity of air to burn the gases being admitted into the said chamber by the pipe and jets 1 2. Lime or other flux may either be added dry in the reducing-chamber A either separately or with the ore, or a bath of vitreous cinder may be employed in the smelting-chamber B. The bath of vitreous cinder in the smelting-chamber, into which the iron particles from the reduction-chamber are transferred, is of such chemical composition as will flux the earthy matter mingling with the reduced iron particles. When a welding heat is reached in the smelting-chamber B, the workman gathers up the iron particles into a ball or bloom, which is taken to the hammer or squeezer, and the earthy matter, which has fused and become cinder by the flux is expelled from the ball or bloom by its compression under the hammer or squeezer. When, instead of malleable iron, cast iron is to be produced, an excess of carbonaceous matter is mixed with the ore in the reducing-chamber A, and the opera-

tion prolonged until the requisite degree of carbonization is reached. The carbonized iron particles are then transferred, by the inclined passage *c*, between the two chambers, into the smelting-chamber B, where they are fused under a layer or bath of vitreous flux, by which means any remaining earthy matter is separated as cinder, the carbonized melted cast-iron falling to the bottom. When cast-steel is to be produced a sufficient quantity of the uncarbonized iron particles from the reducing-chamber A may be introduced into the smelting-chamber B and dissolved in a bath of cast-iron prepared in the manner last described, to bring the composition of the mixture to that of steel. Or the reduced iron particles may be carbonized in the reducing-chamber to the cast-steel forming point at once, in the same manner as the cast-iron, but limiting the tone and degree of carbonization, and then melted under vitreous flux. The cast-iron or cast-steel produced in the manner described is removed from the chamber B by tapping the said chamber and running the cast-iron or cast-steel into ingot or other molds, as is well understood. The working of the smelting-chamber B is so regulated by valves or stop-cocks for the admission of blast into the gas-generator *f* for forming the gases, and by valves or stop-cocks for admitting the air-blast into the said chamber B for burning the gases that at no period of the operation is there such an excess of free oxygen or carbonic acid as to reoxidize the iron. Instead of using a horizontal smelting-chamber a vertical reducing and smelting-chamber, combined with a horizontal calcining-chamber, may be employed. The heated reducing-gases in this case may first pass through the vertical chamber and then into the horizontal chamber. In using this arrangement the calcined ore is transferred from the calcining-chamber to the vertical reducing and smelting-chamber below it, and after the said vertical chamber has been filled with the heated calcined ore the heated reducing-gases from the gas-generator or gas-generators are forced up and through the ore until its reduction in the form of metallic particles is effected, and if malleable iron be required the reduced metallic particles are welded together and removed through an opening for the purpose in the breast of the chamber. If cast-steel or cast-iron is desired, carbonaceous matter is introduced into the calcined ore, and the operation prolonged until the requisite degree of carbonization is attained, and the cast-steel or cast-iron fused and tapped out at the lower portion of the chamber. Lime or other flux may be added, either in a calcining-chamber or in the vertical portion of the furnace. In the last-described arrangement of furnace the gases, after effecting the reduction of the ore in the vertical smelting-chamber pass to the calcining-chamber and are burnt. Although I prefer to arrange the smelting-chamber separate from the calcining and reduction-chamber, (except when the vertical smelting portion is combined with the calcining chamber,) yet a single furnace or chamber or series of chambers, connected together, in which the processes of drying, calcining, reducing, carbonizing, smelting or blooming, and welding are effected, may be employed. The smelting-chamber may be worked with superheated gases, and the blast of air forced into the smelting-chamber, for burning the gases, may also be heated. When the gases are superheated the superheating apparatus is arranged by preference between the gas-generator and the entrance to the smelting-chamber. In order to prevent the burning or melting of the filling-hoppers of the gas-generators, especially when blowing out the generators for repairs or other purpose, I prefer to construct the said generators with fire-brick arched tops, the filling-hoppers being placed at the side. Fig. 9 represents, in vertical longitudinal section, and Fig. 10 in transverse vertical section, this modification of the gas-generator. 5 is the body of the gas-generator; 6, its arched top, of fire-brick; 7, the inclined feeding-passage by which it is supplied with fuel. 8 and 9 represent, respectively, two slides or valves, by which the feeding-passage 7 is opened and closed. 10 is the tuyere; 11, a door at the bottom of the generator 5, by which door any ash or clinker may be removed which will not flow from the tapping-hole 12. By means of the hooks 13 13 bars may be supported across the generator, thus forming a grate for the fuel, while the door 11 is opened for the removal of ash or clinker. 14 15 are air or blast-pipes opening into the gas-passage 16. 17 is a second or supplementary fuel-chamber for feeding coke into the gas-passage 16. The coke so fed into the gas-passage 16 constitutes a filter, which obstructs any particles of carbon or dust which may be carried over by the gases from the generator 5. The said coke in the gas-passage 16 also serves, by its partial combustion, to maintain the gases at their highest state of reducing power as well as to superheat them. The use of the said coke in the gas-passage 16 is optional—that is, generators of the construction represented may be employed without the supplementary fuel-chamber 17; or, when constructed with the said chamber 17, they may be employed as though constructed without it by the non-supplying of coke to the said chamber 17. By a careful regulation of the blast introduced by the pipes 14 15 the exact chemical character of the gases passing out of the passage 16 may be determined, and their temperature within considerable limits controlled. The gas-generator or gas-generating furnace, represented in Fig. 9, is especially applicable to the generation of gases for heating steam-boilers and the reducing-chamber A, represented in Figs. 1 to 8 of the accompanying drawing, is applicable to the calcining or roasting of the ores of copper and zinc.

Having thus described the nature of my invention, and the manner in which the same is to be performed, I wish it to be understood that I do not limit myself to the precise details herein described and illustrated, as the same may be varied without departing from the nature of my invention; but

I claim as my invention—

1. The treatment of iron ores for the manufacture of iron and steel in the manner or by the processes hereinbefore described, whereby the said ores are completely reduced without fusion or agglutination in the form of fine metallic particles or dust before being bloomed or welded into wrought-iron or melted into cast-iron or steel.

2. The furnaces and apparatus, constructed and arranged for operation substantially as hereinbefore described, and illustrated in the accompanying drawing, to be used in the manufacture of iron and steel, or in the roasting or calcining of ores other than iron ores, as set forth.

3. The gas-generator or furnace hereinbefore described, and illustrated in Figs. 9 and 10 of the accompanying drawing.

THOMAS CALLENDER HINDE.

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