

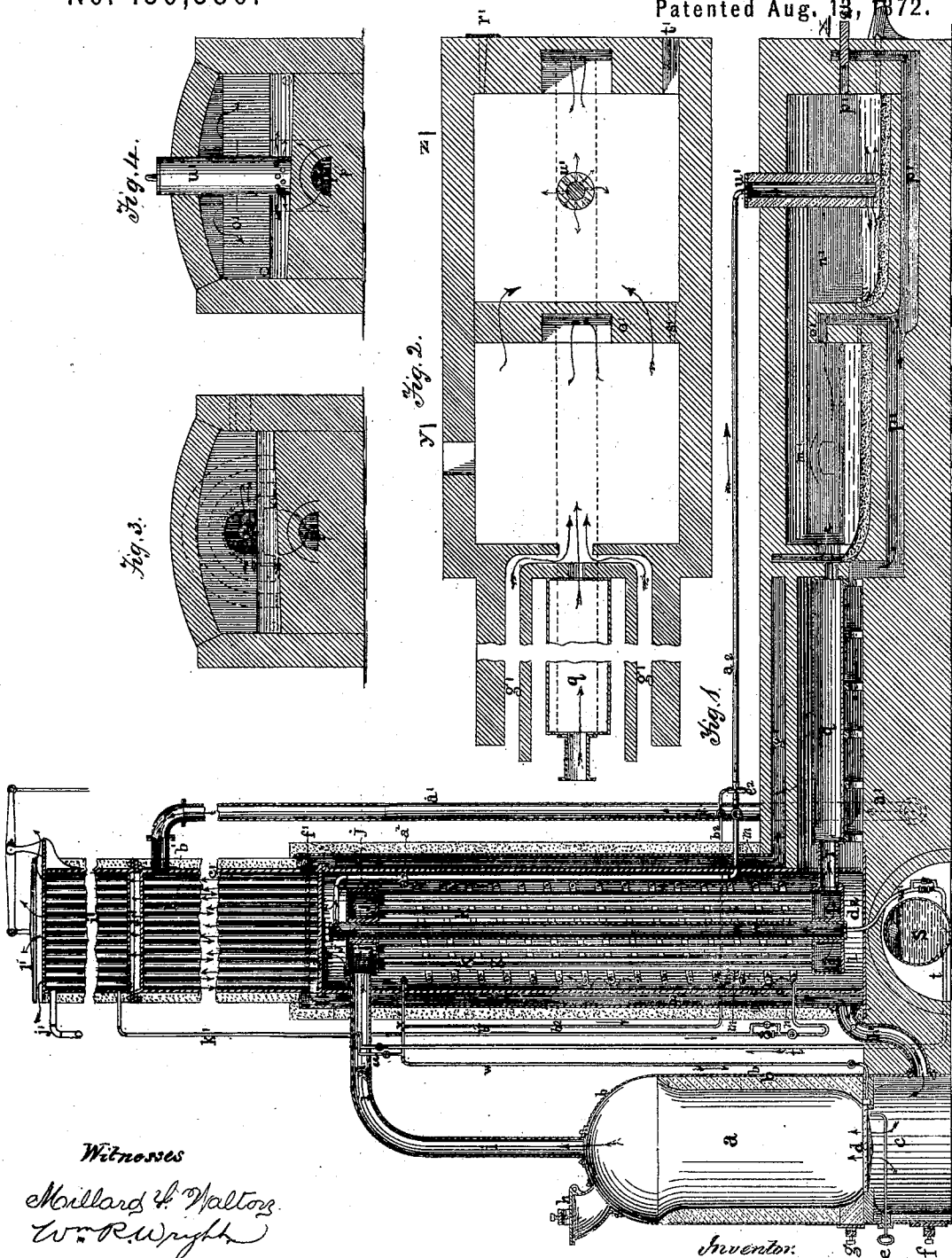
T. S. C. LOWE.

2 Sheets--Sheet 1.

Improvement in Apparatus for Refining Iron and
Making Steel.

No. 130,380.

Patented Aug. 13, 1872.



Witnesses
Maillard & Walters
Wm. R. Wright

Inventor.

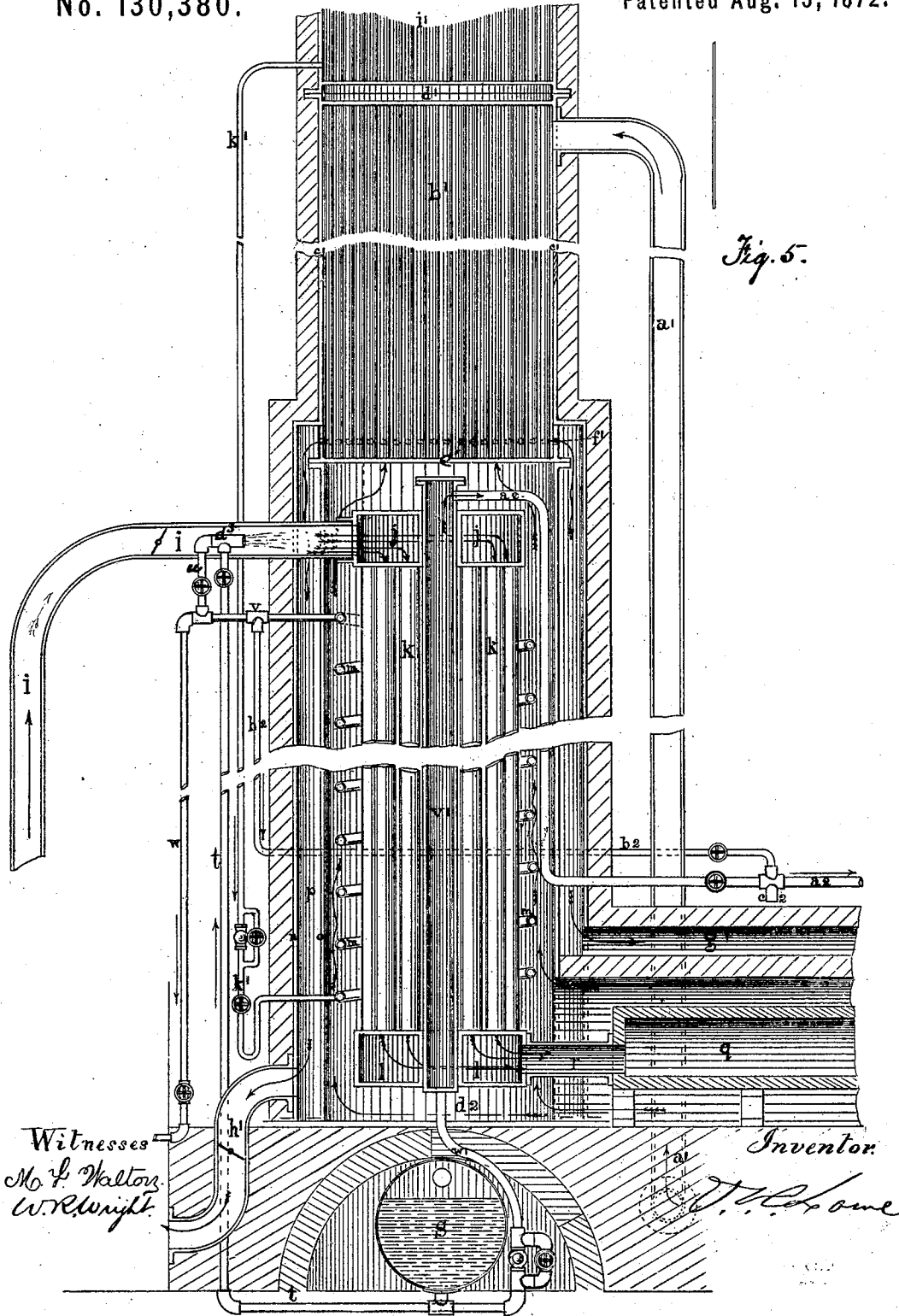
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UNITED STATES PATENT OFFICE.

THADDEUS S. C. LOWE, OF NORRISTOWN, PENNSYLVANIA.

IMPROVEMENT IN APPARATUS FOR REFINING IRON AND MAKING STEEL.

Specification forming part of Letters Patent No. 130,380, dated August 13, 1872.

Specification describing a Process and an Apparatus for Refining Iron and Making Steel, invented by THADDEUS S. C. LOWE, of Norristown, Montgomery county, Pennsylvania.

My invention consists principally of the manner in which I purify the iron, first, while melting the same; but chiefly after it is melted, by extracting from it all or nearly all of the impurities, such as phosphorus, sulphur, excess of carbon, &c., and by afterward recarbonizing the iron to any desired extent, varying from soft or malleable iron to the hardest steel, by a continuous operation in different compartments of the same furnace. My process also enables me while purifying and recarbonizing the iron to save all the gases generated in the charges, and to save the surplus gases for general purposes. My process being applicable to many forms of furnaces, I include in the annexed drawing an inexpensive form of furnace which I consider well adapted to the purpose.

In the annexed drawing, Figure 1 is a vertical section of the complete apparatus; Fig. 2, a horizontal sectional plan of the furnace on the plane of the line *x*, Fig. 1; Fig. 3, a transverse vertical section of the furnace on the line *y* of Fig. 2; and Fig. 4, a similar view on the line *z* of Fig. 2. Fig. 5 is a vertical section of the apparatus (shown in Fig. 1) on an enlarged scale.

a, Fig. 1, is a vertical retort, constituting the primary gas-generator, consisting of a case of cast-iron or other suitable material, *b*. *c* is an air-tight ash-pit, across the top of which I arrange a set of grate-bars, *d*, which are hollow lengthwise and pierced by a number of small holes laterally, as shown. *e* is a rake, provided with teeth to pass up between the grate-bars for removing ashes and cinders. The ash-pit is provided with an ordinary air-tight door, *f*. *g* is an air-tight hand-hold for the removal of cinders and such non-combustible matters as do not, on account of their size, pass down between the grate-bars. *h* is an air-tight door, through which coal or other carbonaceous materials are put into generator *a*. *i* is a pipe or flue for conducting the gases and oleaginous vapors formed in the primary generator *a* into the annular chamber *j*. A series of vapor-converting tubes, marked *k*, are con-

nected at their upper ends with the chamber *j*, and at their lower ends with the similar chamber *l*. *m* is an iron pipe coiled around the tubes *k*. *n* and *o* are cylinders of iron, inclosing the coiled pipe *m*. *p* is an air-space between said cylinders. *q*, Figs. 1 and 2, is a retort, of fire-clay or other suitable refractory material connected by an iron pipe with chamber *l*. *s* is a strong air-tight tank containing oil and compressed air. *t* is a pipe for conveying the oil into the flue *i*. *u* is a steam-pipe, connected at one end with the steam-supply coil *m* by a branch, *v*, terminating in the nozzle *d*³ of the oil-pipe *t*, as shown. The steam-pipe *u* has another branch, *w*, which leads down to and connects with the hollows in the grate-bars *d*. *a*¹ is an air-flue, through which atmospheric air is forced by a fan-blower or other suitable device, into the space surrounding the series of tubes *b*¹ inclosed in the cylindrical casing *c*¹ and the heads *d*¹ and *e*¹. There is a series of holes, *f*¹, in the casing *c*¹ for admitting the air into space *p*. *g*¹, Figs. 1 and 2, is an air-space, connected with the space *p*, as shown. *h*¹ is an air-flue for admitting hot air into the ash-pit of the generator *a*. *i*¹ is an ordinary tubular boiler or water-heater, having a supply-pipe, *j*¹, and a drawing-off hot-water pipe, *k*¹, the lower end of which connects with the lower end of coil *m*. *l*¹ is an ordinary damper for regulating the draft. *m*¹ and *n*¹, Figs. 1, 2, and 4, compose a furnace in two compartments divided by a vertical partition of masonry, *o*¹, extending from the bottom to near the top arch, as shown in Fig. 4, the bottom of compartment *n*¹ being lower than that of compartment *m*¹. *p*¹ is a flue for carrying off the waste products of combustion. *q*¹ is a damper for controlling the flue *p*¹. *r*¹ is an ordinary tap-hole and spout for drawing off the refined metal in a molten state. *s*¹ is a similar tap-hole for drawing the crude liquid metal into the refining compartment *n*¹. The tap-hole *s*¹ is opened and closed by a bar inserted through the hole *t*¹, Fig. 2. *u*¹, Figs. 1, 2, and 4, is a fire-clay tuyere or pipe closed at its bottom end, and pierced with a number of small holes laterally, as shown, near its bottom. *v*¹ is an iron tube or retort for generating gas from liquid hydrocarbons (preferring petroleum.) It is connected at its lower end with

the oil-tank *s* by a tube, *w'*, as shown in Figs. 1 and 5. *b*² is a steam-pipe, branching from the main steam-pipe *u*, connected to the tube *a*², and provided with an ordinary globe-valve, as shown in Figs. 1 and 5. *c*² is an air-pipe, shown cut off. It is intended to be used for admitting air under pressure into the tube *a*².

When it is desired to refine crude or pig-iron, or convert the same into wrought-iron or steel, the crude iron is placed in the melting-compartment *m'* of the furnace, and I introduce into the generator *a* bituminous coal, coal-dust, wood, sawdust, tan-bark, leather-scrap, peat, straw, wood-shavings, or other carbonaceous combustible solid substances, which are ignited at the bottom where a limited amount of atmospheric air is admitted sufficient to keep up a slow combustion on the grate-bars *d*. The gases and oleaginous vapors thus generated pass off through the flue *i* into the union-chamber *j*, and down through the vapor-converting tubes *k* into the chamber *l*, and thence through the tubes *r* into the retort *q*, from which it discharges into the melting-compartment *m'* of the furnace, where it is ignited, the flame passing into the flue *p'*, back under the retort *q*, thence into the chimney-space *d*², and up through the tube of the air-heater *b*¹, and thence through the tubes of the water-heater *i'*, from which the waste products of combustion pass out into the open air, thus heating the retort *q*, tubes *k*, casing *o*, tubes *b*¹ and *i*. At the same time atmospheric air to support combustion is forced by a blower or other suitable means into tube *a*¹, from which it enters the space around tubes *b*¹ in the air-heater, passing down which it discharges through the openings *f'* into the space *p*, between the casings *n* and *o*, from which a small portion of this heated air is drawn through the flue *h'* into the ash-pit of the generator *a*, for supporting the slow combustion in this generator, the remainder passing through the space *g'*, where it is admitted into the melting-compartment *m'* of the furnace, and is used for supporting combustion therein. While melting the first charge in the compartment *m'*, at the beginning of the operation, I open the damper *q'*, which consists of a fire-tile, made to close the flue when the damper *q* is open. A part of the flame passes over the bridge-wall *o'* to heat the refining-compartment *n'*, preparatory to the introduction into it of the charge of molten metal; and when this compartment has become thus heated the damper *q'* may be pushed into place, closing that part of the flue *p'*. After the retort *q*, tubes *k*, and coil *m* has become heated by the circulation around them of the hot products of combustion from the furnace *m' n'*, I admit water through tube *k'* into the lower end of the coil *m*, where the same is converted into steam. A small jet of this is drawn off through the tube *v* into the flue *i*, where it mingles with the gases and oleaginous vapors from the generator *a*, the mixed vapors and gases passing together into the chamber *j*, and thence through

tubes *k*, where the steam is decomposed, forming additional carbonic oxide, and hydrogen, thus increasing the purity, quantity, and richness of the gases. A small portion of steam is also admitted into the generator *a* through the tube *w* and the hollow grate-bars *d*, for the purpose of preventing a deposit of carbon in generator *a*. The iron in compartment *m'* being now melted and sufficiently heated, a blast of dry super-heated steam is admitted through the tube *b*² into the tube *a*², and thence into tuyere *u'* under pressure. At the same time the melted iron is allowed to run through the tap-hole *s'* into the compartment *n'* of the furnace, and the steam which is being forced through the small holes at the lower end of the tuyere *u'*, either in a pure state or mixed with atmospheric air, comes in contact with the melted iron, freeing it from carbon, sulphur, phosphorus, and other impurities, and converting it into wrought or soft malleable iron. After the iron has become sufficiently purified, I open the valve in the tube *a*², between the petroleum and carbon gas-generator *v'* and the tuyere *u'*, and immediately shut off the steam and air; and close the valve in the pipes *b*² and *c*². The pure carbon gas being forced through the molten iron, carbonizes it, and, at the same time, the surplus hydrocarbon-gas unabsorbed by the metal, having a special affinity for sulphur and phosphorus, carries off with it any remaining impurities of that nature. As soon as the iron has become sufficiently carbonized in this way to produce the required quantity of steel (determined by the usual tests) the same may be drawn off and cast into ingots, or used otherwise, as desired.

When steam is used, as above described, for purifying iron, its oxygen, mingling with the carbon contained in the metal, forms carbonic oxide, and this, with the free hydrogen, passes over the bridge-wall *o'*, carrying with them the impurities of the iron, where they come in contact with a hot-air blast, mingling and burning therewith, and producing an intense heat, which serves, in a great measure, to melt the fresh charge in the compartment *m'* of the furnace. The same is also the case while the operation of recarbonizing the molten iron, as described, is going on. The surplus carbon, or that portion which does not remain in the metal, mingles with sufficient oxygen of the air to keep up an intense heat in both compartments of the furnace.

The oil in the tank *s* is kept under sufficient pressure, by a pump or other suitable means, to force it into the carbon-gas generator *v'*, where it is converted into gas, which is forced, by the pressure in the tank *s*, through the molten metal in the compartment *n'* of the furnace. There is also sufficient pressure in the steam-coil *m*, obtained from the elevation of the water-tank or otherwise, to force the steam through the molten metal; but where air is used an air-pump or other sufficient machinery is required to compress the air sufficiently to enable it to force itself through the molten

metal. When steam is used little, if any, atmospheric air is required to purify the metal.

It will be seen from the arrangement of valves in the steam, air, and carbon-gas pipes that each of these elements can be used separately or mixed in any proportion desired for producing different qualities of metal, and for regulating the heat in the metal.

It will be seen that by the arrangement of the furnace I will not only utilize the gases from the compartment *n'* of the furnace, but I also catch, in the melting-compartment *m'*, all the particles of iron driven off by the pressure-blasts through the molten metal. In the use of the ordinary converters these particles would be blown out and wasted.

Air alone may be used, if desired, for decarbonizing and purifying the metal, which afterward may be recarbonized in the manner above described; but I prefer to use superheated steam, either wholly or in part, for the purpose of purifying the metal.

After the apparatus has been put in operation, and the tubes *k* and the retort *q* have become heated, the damper in the flue *i* may be closed and the production of gas in the primary generator *a* stopped; and to supply the necessary gaseous fuel I open the stop-cock in the pipe *t* sufficiently to allow oil from the tank *s* to be forced into the nozzle *a*³, Fig. 5, and come in contact with a jet of steam; and from this point the operation is the same as above described.

I claim—

1. The combination of the oil-tank *s* and retort *v'*, constructed and arranged and operating in the manner and for the purpose substantially as set forth.

2. The double furnace, composed of two compartments, *m'* and *n'*, divided by a bridge-wall, *o'*, provided with tap-holes *s'* and *r'*, or their equivalents, all constructed and arranged in the manner and for the purpose substantially as set forth.

3. The combination of the furnace *m' n'*, the vertical tuyere *u'*, tube *a*¹ with branch-tubes *b*² and *c*², constructed and arranged in the manner and for the purpose substantially as set forth.

4. The introduction of steam, atmospheric air, and carbon-gas together into the molten metal, for purifying and carbonizing purposes, substantially as set forth.

5. The introduction of steam and carbon-gas together into the molten metal, for purifying and carbonizing purposes, substantially as set forth.

6. The combination of the oil-tank *s*, retort *v'*, pipe *a*², and tuyere *u'*, for the introduction of carbon-gas into the molten metal, substantially as set forth.

7. The combination of the oil-tank *s*, retort *v'*, pipe *a*², steam-pipe *b*², and tuyere *u'*, for the introduction of mixed carbon-gas and steam into the molten metal, substantially as set forth.

8. The combination of oil-tank *s*, retort *v'*, pipe *a*², steam-pipe *b*², atmospheric-air pipe *c*², and tuyere *u'*, for the introduction of air, steam, and gas, together or separately, into the molten metal, substantially as set forth.

T. S. C. LOWE.

Witnesses:

MILLARD L. WALTON,
WM. R. WRIGHT.