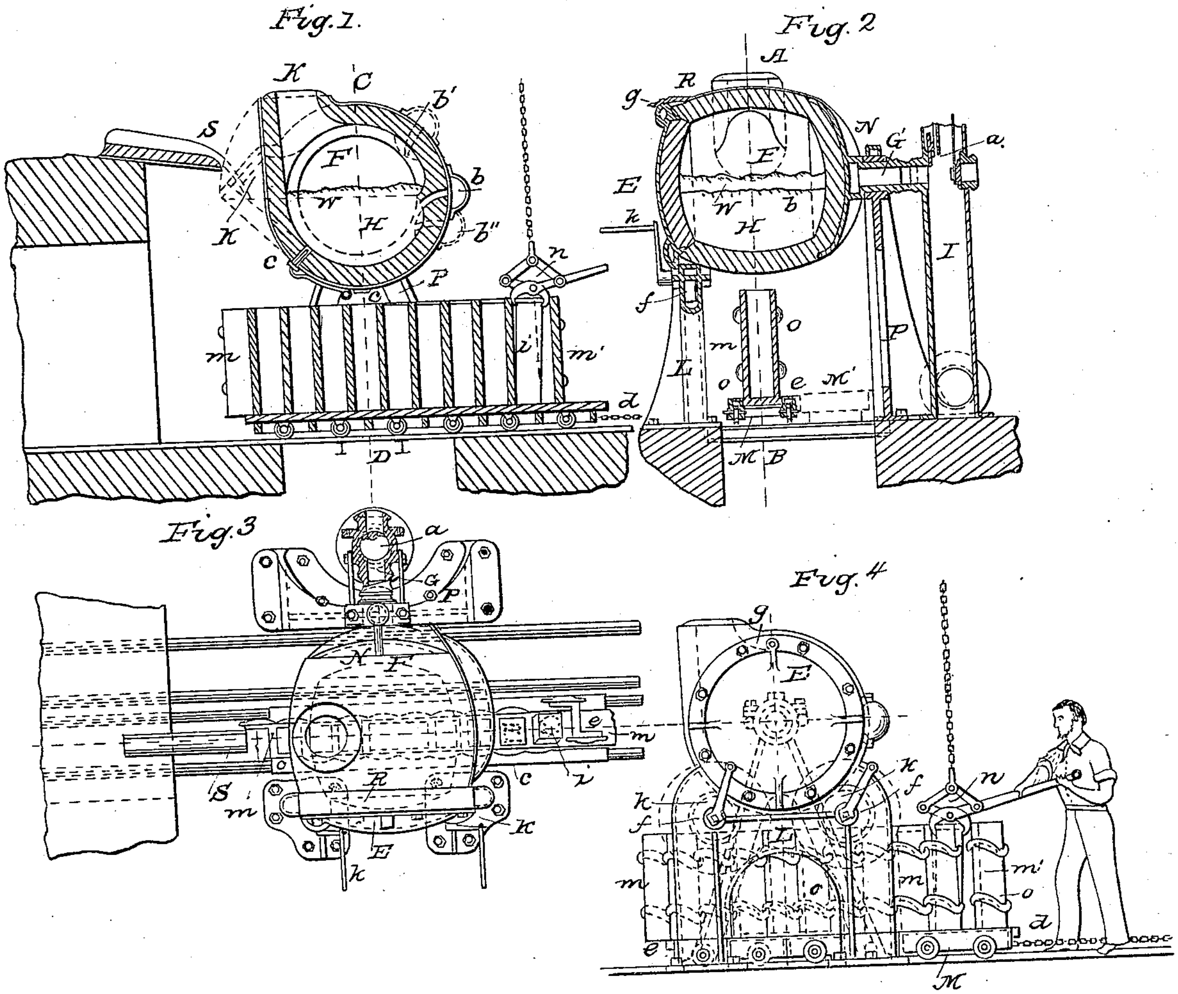
J. W. NYSTROM.

Apparatus for Refining Iron.

Patented April 3, 1866.

No. 53,658.

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# UNITED STATES PATENT OFFICE.

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## IMPROVED APPARATUS FOR REFINING IRON.

Specification forming part of Letters Patent No. **53,658**, dated April 3, 1866.

*To all whom it may concern:*

Be it known that I, JOHN W. NYSTRÖM, of Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in the Method of and Apparatus for Refining Metals; and I hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawings.

In the well-known pneumatic process of refining crude iron into steel or malleable iron the blast has heretofore been applied so as to agitate the molten iron as much as possible, in view that the air should penetrate every particle of the same. In order to accomplish this agitation the tuyeres have been placed so as to lead the blast into the fluid iron from the bottom, or thereabout, of the converting vessel or furnace, which operation requires a very powerful blowing apparatus to force in the air under great pressure—say twenty pounds to the square inch—and the desired agitation is attained. In the cupola-shaped converting-vessels the tuyeres have been placed near the bottom, and also eccentrically to the cylinder, to give the molten iron an agitating rotary motion; but in all cases the most important object—namely, to free the crude iron from its impurities—has not yet been and cannot thus be attained, for while the metal is kept in such a violent agitation some of the impurities, such as sulphur and phosphorus, have no chance to separate or escape from the iron.

To accomplish a more thorough refinement of the crude iron with the least possible expense of manual labor and of machinery is the object of my improvements; and they consist, first, in keeping the fluid metal in the converting-vessel as quiet as possible during the process of refinement, so as to allow the impurities to ascend or to be drawn toward the surface of the metal, which is accomplished as hereinafter specified; second, in making the tuyeres of an oblong or rectangular section at the point where they enter the furnace, in order to bring the air into immediate contact with the metal operated upon, as hereinafter shown and described; third, in making the tuyeres of a curved shape, so that the air may enter the fluid metal in the desired direction with the shortest possible tuyere, as hereinafter shown and described; fourth, in turning the converting-vessel, by the combination of cranks and friction-rollers, for placing it in any desired position, as hereinafter described; fifth, in moving the ingot-molds under the converting-vessel to receive successively the refined metal direct from the furnace, as hereinafter described; sixth, in forming the ingot-molds of a Z shape, so as to fit one another, as hereinafter described; seventh, in connecting the ingot-molds successively with clamps, as hereinafter specified; and, eighth, in lining the inside of the furnace, and also the inside of the ingot-molds, with a composition of silicate of oxide of iron and plumbago or fire-clay, for the purpose hereinafter specified.

To enable others skilled in the art to make and use my improvement in the pneumatic process of refining metals, I shall now proceed to describe the construction, arrangement, and operation of the furnace, referring to the accompanying drawings, in which—

Figure 1 represents a cross-section of my improved furnace and ingot-molds through the line A B, Fig. 2, also the heating-furnace for molds and the casting-pit; Fig. 2, a longitudinal section of the same through the line C D, Fig. 1, showing the trunnion and blast-pipe conveying the air from the blowing apparatus. Fig. 3 represents a plan of the furnace and ingot-molds, and Fig. 4 a front elevation of the same, showing the connection-clamps of the ingot-molds.

The converting furnace or vessel F, it will be seen, is formed in the shape of a barrel, placed horizontally and supported at one end by a hollow trunnion, G, resting in a suitable bearing in the frame P, while at the other end it is held in position by means of two friction-rollers, *f f*, supported in the frame L. The outer shell of the furnace I prefer to make of wrought-iron, riveted to a cast-iron back, N, and to the front ring, R.

The front cap, E, is screwed or clamped or otherwise securely attached to the end of the furnace, so that it may be easily removed when the inside of the furnace is to be built up, repaired, or cleaned out. When the cap E is to be put on it is first hung on the pin $g$, on which it is guided home.

The inside of the converting-furnace is lined with fire-brick and other refractory materials, such as silicate of oxide of iron mixed with fire-clay or plumbago, which I have found to answer the purpose very well. The silicate of oxide of iron is ground to a fine powder and mixed with as much fire-clay as will keep it together. The composition is made very fluid with water and put in the mold by a brush. For the furnace the composition is made only sufficiently damp with water to acquire a plastic consistency while ramming or dubbing it into the furnace.

In the drawings, H represents the mass of crude molten metal to be refined by the improved pneumatic process. The air or carbureted gases are forced by suitable machinery through the pipe I, valve $a$, trunnion G, tuyere-box, and tuyeres $b$ into the molten metal H.

When crude cast-iron is operated upon only atmospheric air is blown in; but when operating on crude copper or matte (Swedish skärsten) the air is mixed with hydrocarbon.

The furnace F is capable of rotation by means of the cranks $k$ $k$ and friction-rollers $f$ $f$. When the fluid crude metal is to be received into the converting vessel or furnace F the latter is turned by the cranks $k$ $k$ until the mouth K occupies the position K′ under the spout S leading from the furnace or ladle—*i. e.*, the source from which the crude metal is derived—until the converting-furnace F is about half full, which is observed through the mouth K′. Now the apparatus is ready for operation. To this effect, turn on the blast by the valve $a$, which then will blow air into the furnace through the tuyeres in position $b'$. The furnace is then turned until the tuyeres occupy the position $b''$, and the operation of refining is commenced.

When cast-iron is operated upon a dark-green smoke, consisting principally of silic oxide and carbonic oxide, is ejected from the mouth K into a suitable chimney for a few minutes' time, the length of which depends on the kind of iron operated upon. When this smoke becomes lighter or somewhat transparent, turn the furnace back until the tuyeres occupy the position $b$, so that the air is blown in immediately under the surface of the molten iron, as shown in Fig. 1.

The process of refining the iron will now go on as follows: The oxygen in the air will now combine partly with the carbon, forming oxide of carbon or carbonic acid, and with the iron and silicon, forming a silicate of oxide of iron or slag W. The most important part of the refining process is now going on between this slag and the iron, similar to that in the old refining process, where the air is blown on the top of the iron, or as in the puddling process, where the silicate of oxide of iron is kept in contact with the fluid iron by manual labor, while heat is supplied from a separate fire. In the puddling-furnace the heat is not high enough to make the molten iron sufficiently fluid for a prompt liberation of its impurities. The greater part of the silica, which is mechanically mixed with the iron, is squeezed out by machinery; but the sulphur and phosphorus, which may be chemically combined, will still remain in the puddled iron and greatly impair its character.

In the pneumatic process as herein described, where a high heat is kept up to boil the fluid iron a sufficient length of time for its required grade of refinement, which point is acquired by experience and signs peculiar to each kind of iron operated upon, the sulphur and phosphorus combine with the oxygen in the slag. A slow circulation is going on and every particle of iron, with its impurities, takes its turn toward the tuyeres until refined.

This process requires more time per weight of metal than that known as "Bessemer;" but the additional time brings the process under a better control and secures more satisfactory and uniform results, while the pressure of the blast need not be more than about four pounds to the square inch, which can be taken from that of the blast-furnace, where no extra blowing machinery would be required for the pneumatic process.

In the Bessemer process the action is so violent and the indications of the grade of refinement so sudden that it has been found impossible to stop the process at the desired point; for which the iron has been first over-refined, (burned,) and then a composition of manganese and molten crude cast-iron is added to restore the requisite carbon for the desired steel. Analyses have shown that the steel so obtained contains about one per centum of sulphur and about one-half per cent. of phosphorus, much of which, perhaps, were put in with the last-mentioned composition; and the process has not yet given a uniform and quite satisfactory result, while the blast requires separate blowing machinery to produce the necessary pressure of some twenty pounds to the square inch.

In one experiment made by me I admitted the air through only one tuyere in one corner, in or near the surface of the iron in the furnace, which was found sufficient to decarbonize and refine the whole mass of crude iron; but I prefer to group several tuyeres together on one side in the converting-furnace, as at $b$, Fig. 2. Two or more groups of tuyeres near the corners or around the furnace, applied in or immediately under the surface of the iron, will also answer.

If the same number of tuyeres, with the same section and pressure of air, were evenly distributed, as has been done in the cupola-shaped converting-vessels, sufficient heat could not be kept up in the fluid metal required for the proper refinement of the iron.

When a new and unknown iron is operated upon the tuyeres are turned out of the metal at short intervals, for the purpose of taking out samples with a small hand-ladle, which are poured into ingots of about three-fourths of an inch of sectional area. Samples are also taken on the end of an iron spit, for the purpose of proving the condition of the process.

When the iron is considered sufficiently refined t[illegible] furnace K *b c* is turned by means of the [illegible]s *k k* and friction-rollers *f f* to the pos[illegible] *b′ c′*. On account of the center of [illegible] of the fluid metal being always perpendicular beneath the axis of the furnace, [illegible] no lifting force required on it. The [illegible]ave only to overcome the friction in t[illegible]nals, while in the Bessemer furnace some heavy hydraulic machinery, working with a pressure of some four hundred pounds to the square inch, is required for operating the furnace, and a steam-engine, besides, to work the hydr[illegible]lic machine.

Th[illegible] iron plug *e* is covered nearest the melted met[illegible] with moist fire-clay, which is either forced in by [illegible]he plug or forced out through the hole by an iron spit from the inside. Take out the iron plug, which now occupies the position *c′*, and the refined metal will run directly into the ingot-molds, which are moved successively under the jet for that purpose, as shown in Figs. 1 and 2. When each mold is nearly full the mold-carriage M is drawn forward by any mechanical contrivance, as by a rack and pinion-lever, or preferably by a chain, *d*, until the next empty mold comes under the jet to receive the metal.

The top of the mold-carriage is covered with a refractory substance, *e*, such as fire-clay or brick, to save it from the heat of the ingots.

When the ingot is sufficiently cold and settled so as to bear handling the outer part, *m′*, of the mold is lifted aside, the ingot taken hold of with a pinch-hook, *n*, as shown in Figs. 1 and 4, and carried to any convenient place.

The ingot-carriage M is made in parts, on which one or more ingots can be taken to a rolling-mill or heating-furnace. The shaking of the ingot by drawing it on the railroad while fluid tends to diminish its porosity.

The ingot-molds *m* are made of a shape with clamps *o* to fit into one another, as shown in the drawings. The inside of the molds is covered with a composition of a silicate of oxide of iron and plumbago or fire-clay, which is dried and heated in a heating-furnace (shown in the drawings) previous to receiving the fluid metal. The object of so coating the inside of the molds is to prevent any possibility of the fluid metal melting or sticking to the mold. It also gives more solidity and smoother surface to the ingot than can be obtained by casting in a smoked or clean cast-iron mold.

The arrangement shown in the drawings suits best for ingots for rails or bar-iron or steel; but for plates and large castings it is preferred to place another carriage, M′, on another track, so that the mold will rest on the two carriages M and M′.

Under the furnace is a casting-pit for casting rollers, shafts, or other heavy castings directly from the steel-furnace.

The ingot-molds can be moved on a circular railway or turn-table extending under one or more furnaces, according to local requirements.

My process of refining requires smaller furnaces per weight of metal operated upon than is used in the Bessemer process. The cubic capacity of the Bessemer furnace is about six times and the weight of the same is about four times that of the metal operated upon. The capacity of my furnace is only double and its weight actually less than that of the metal operated upon.

The tuyeres are made in a curved shape in order to give the desired direction of the blast into the furnace. One or more tuyeres are made in each brick of a circular section at the tuyere-box, terminating in an oblong or rectangular section in the furnace, as shown at *b*, Fig. 2. The longest side of the section can enter the furnace horizontally, vertically, or under any desired angle. It is shown vertically in Fig. 2.

The tuyeres are made of a rectangular or oblong section in order to bring the fluid metal in immediate contact with the air or gases, for as such section has a greater perimeter than a circular or square section the gases are brought so much sooner in contact with the metal for the prompt action of its oxygen and the impurities therein.

Having thus fully described my invention, what I claim, and desire to secure by Letters Patent, is—

1. The herein-described method of and apparatus for refining metals so that the oxidizing-blast shall be admitted into the converting-furnace under the molten mass at elevations with respect to the surface of the metal higher as the work of refining progresses, as set forth.

2. In a converting-furnace constructed and operating as herein described, forming the tuyeres of an oblong or rectangular sectional area at the point where they enter the furnace, substantially as and for the purposes set forth.

3. In a converting-furnace constructed and operating as herein described, forming the tuyeres of a curved form, substantially as and for the purposes herein set forth.

4. The combination, with the converting-furnace constructed and operating as herein described, of cranks and friction-wheels, substantially as and for the purposes specified.

5. The employment, in connection with a converting-furnace constructed and operating substantially as herein described, of movable ingot-molds so as to allow of their being brought under the furnace, in the manner and for the purposes set forth.

6. Forming the ingot-molds of Z-shaped pieces, substantially as and for the purposes specified.

7. Clamping the molds together successively, substantially as and for the purposes herein explained.

8. The lining of the inside of the converting-vessel, and also of the ingot-molds, with a composition of silicate of oxide of iron and fire-clay or plumbago, as described.

In testimony whereof I have signed my name to this specification before two subscribing witnesses.

JOHN W. NYSTRÖM.

Witnesses:

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EDM. F. BROWN.