

N. W. WHEELER.

Metallurgical Furnaces and Processes.

No. 156,244.

Patented Oct. 27, 1874.

Fig. 2,

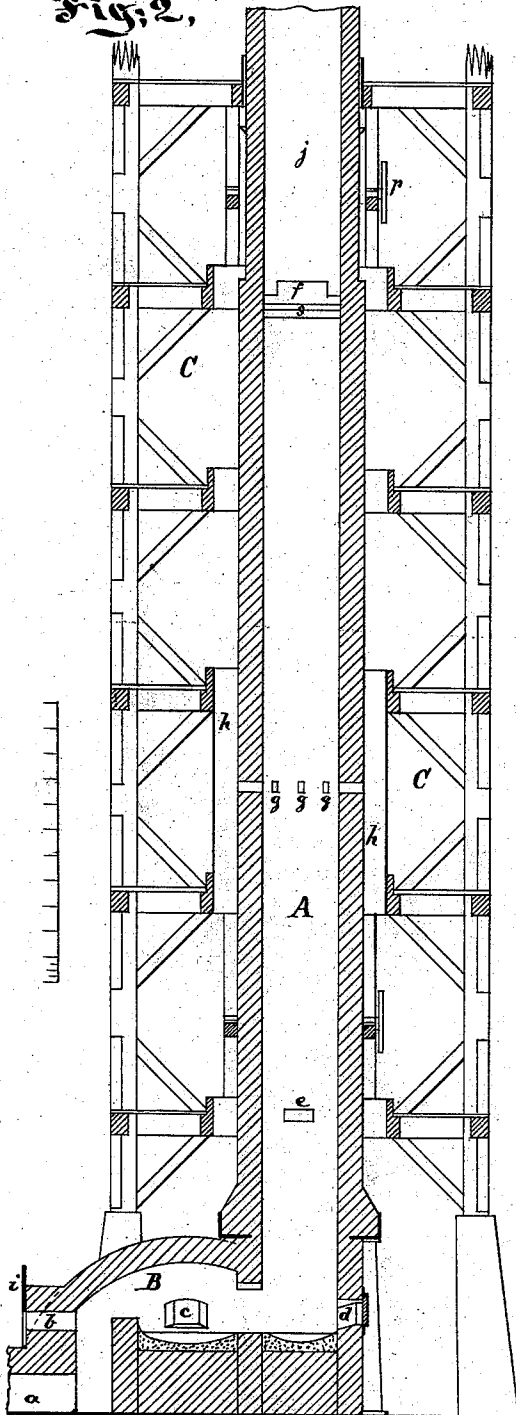
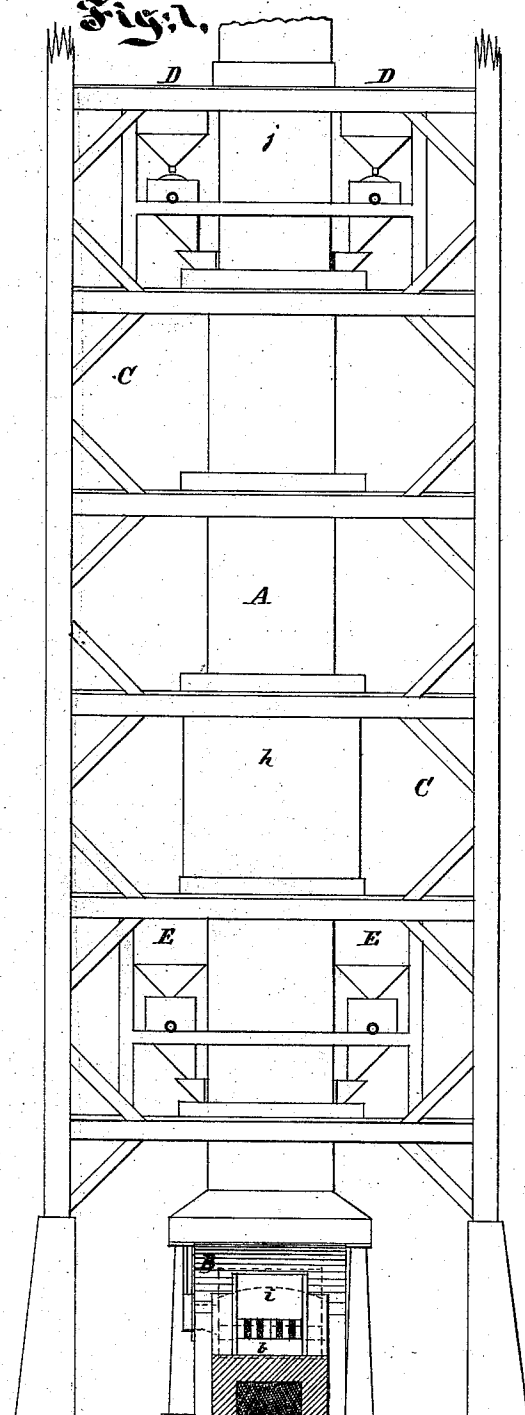


Fig. 1,



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N. W. Wheeler. Inventor.
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Fig. 3.

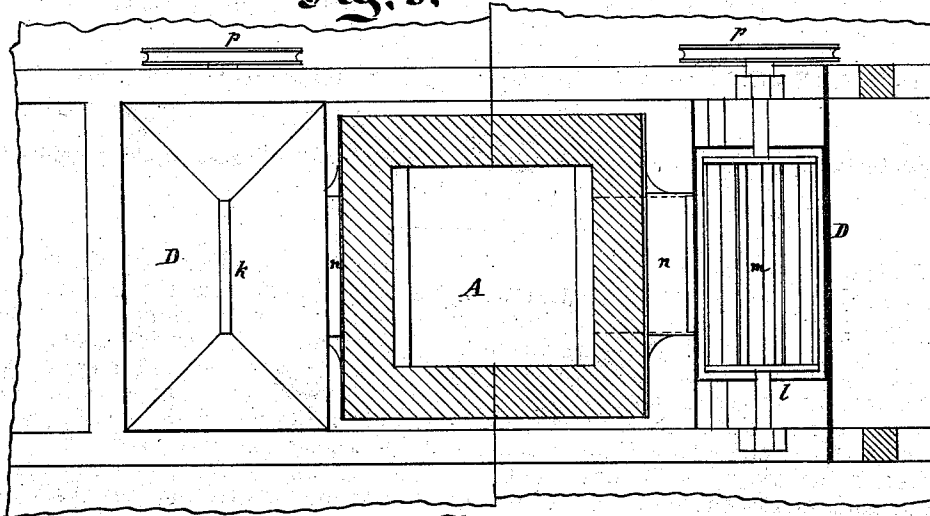
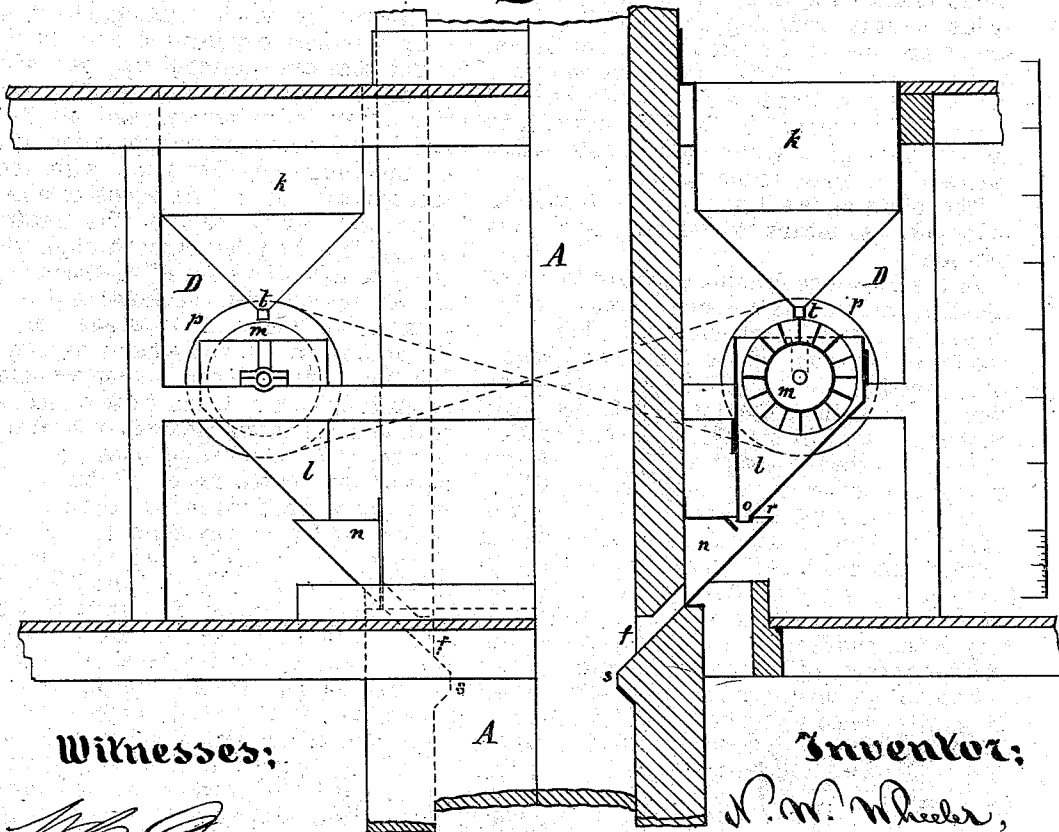


Fig. 4.



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UNITED STATES PATENT OFFICE.

NORMAN W. WHEELER, OF NEW YORK, N. Y.

IMPROVEMENT IN METALLURGICAL FURNACES AND PROCESSES.

Specification forming part of Letters Patent No. **156,244**, dated October 27, 1874; application filed April 23, 1874.

To all whom it may concern:

Be it known that I, NORMAN W. WHEELER, a resident of the city, county, and State of New York, have invented an Improvement in Metallurgical Furnaces and Processes, of which the following is a specification:

This invention relates chiefly to a process for a reduction of metals from the oxides thereof, wherein the ore to be reduced is in the form of sand, and is showered down through a double atmosphere composed of a column of flame immediately over a column of carbonic oxide or other reducing gas; and its objects are to provide for the production, regulation, and management of the necessary shower of ore or ores and reagents for the proper treatment of the product of the ore shower after its fall through the aforesaid double atmosphere of flame and reducing-gas.

The following is a description of what I consider the best means of carrying out the invention:

In the drawings forming a part of this specification, Figure 1 is an end elevation of an improved metallurgical furnace. Fig. 2 is a sectional elevation of the same; and Figs. 3 and 4 sectional and half full plans and elevations of parts thereof upon an enlarged scale, showing more fully the details of construction.

Similar letters of reference indicate corresponding parts wherever they recur.

A is a reducing-shaft built of fire-brick or other refractory material, so constructed as to form and confine the double atmosphere or column of gases and flame during the process of reduction, and to serve simply as a chimney to the puddling or balling furnace B during the process of balling or melting. C C is a frame-work to support several platforms for the convenience of workmen, and for the support of auxiliary apparatus; and D D and E E are feeding apparatus for the introduction and regulation of the ore, flux, and reagents. The reducing-shaft A and balling furnace B, taken together, resemble, in general appearance and construction, an ordinary puddling-furnace and chimney fitted to work with gaseous fuel, *a* being the gas-conduit leading from a gas-producer or a gas-well; *b*, an air-inlet fitted with the regulating-door *i*, and *c* the

furnace or puddling door, below which is seen the balling-hearth, separated from the gas-conduit by a bridge-wall. This furnace differs, however, from the common puddling-furnace in that there is fitted an extra door, *d*, in the wall at the chimney end, and a hearth immediately under the shaft A, so disposed that a mass of matter having fallen down the shaft A may be conveniently pushed over into the balling-hearth from the shaft-hearth with tools put through the door *d*.

Matters resting upon the balling-hearth may be treated by simple heating, as in an ordinary reverberatory furnace, and the flame to which they are subjected may be made either reducing or oxidizing by the proper regulation of the inflowing gas and air through *a* and *b*, and the usual manipulation of balling or puddling may be made with tools put through the door *c*. At a considerable height above the hearth—say, for the treatment of some ores, at half the height through which the ore is to fall—the sides of the reducing-shaft A are pierced with air-holes *g g g* of such area as to allow the entrance of enough air to burn the reducing-gases as they rise to the level of the full combustion air-holes *g g g*, when the doors *c*, *d*, and *b* are closed, and but little or no air enters the shaft or the furnace below the full combustion-holes *g g g*. The result of this arrangement of things is the reducing-gases coming in from the gas-producer, which may be of any suitable sort, will pass through the furnace B and rise through the shaft A, taking up as it goes heat from the walls of the furnace and shaft if they have been previously heated by full combustion in the furnace B. At the level of *g g g*, the rising gas column may be ignited, and the continual indraft of air will support full combustion, so that the part of the shaft A above the level of *g g g* will be filled with a column of flame which will have great and instantaneous heating power over particles of sand ore which may fall through it.

Assuming, for the present, that a stream of ore in the form of sand is let fall from each of the inclined feed-holes *f f*, and is directed toward the middle of the shaft A by passing over the projections *s s*, and so scattered pretty

evenly over the area of the shaft in a shower. The effect of the heat upon each particle will be to heat, and, perhaps, to fuse it before it shall have fallen to the level of *g g g*, and also the sudden exposure to heat will cause the larger particles to crack and break up into smaller particles by reason of differences in expansion, so that the particles composing the shower will fall out of the flame above *g g g* into the reducing-gases below *g g g* in the best possible condition for the prompt action upon them of the reducing-gases, which action will result in the extraction of the oxygen while they are falling through the reducing-gases to the hearth at the bottom of the shaft, and the reducing action will continue upon the successive layers of the resulting heap formed upon the shaft-hearth.

It is intended that the flame and reducing-gases shall be enabled to act upon the ore with sufficient promptitude to accomplish reduction within the time occupied by its fall from *f f* to the hearth, and the time of subsequent exposure, by reason of the great surface exposed compared to the mass, which is a result of its granular form of sand, and the finer the sand the greater will be the time occupied in falling through a given distance, and the less will be the time required for its reduction, so that the finer the sand to be operated upon the less may be the height of the reducing-shaft A.

When treating iron ore this apparatus will be worked in this wise: The fuel gases will flow in through the conduit *a*, and the door *i* will be opened to supply air for full combustion in the oven B, and this will be continued until the inner surfaces of the oven B and lower parts of the shaft A are heated to a white heat; then the door *i* will be closed, and the gases be fired at the full combustion air-holes *g g g*, thus establishing the conditions of reduction, and then the streams or shower of ore from the feed-holes *f f* will be established and continued until a sufficient heap of reduced metal or iron sponge shall have accumulated at the foot of the shaft A. The shower of ore will then be stopped, the door *d* be opened, the sponge be quickly pushed over into the balling-hearth, and the door *d* closed, so as to expose the iron sponge to the oxidizing action of the air for as short a time as possible. The door *i* will then be opened and the gases be fired in the oven B, and the flame regulated to oxidize or carbonize the sponge upon the hearth, as may be required, and the sponge compacted into balls suitable for further working by squeezers or hammers in the usual way.

If particles of ore strike and adhere to the sides of the reducing-shaft while reduction is going on, the adhering masses will be melted off during the next balling term, and only a thin glazing of oxides be left upon the surfaces, which will not be objectionable.

There will be but little fluxing required if the ore be reasonably pure, and especially so

if there be a dust-chamber included in the conduit *a*, leading from the gas-producer, to arrest and retain silicious dust, which might otherwise be carried along by the current of gases.

This apparatus differs essentially from those in which operations are carried on by solid fuel burned in contact with the ore and in which the earths of the fuel, as well as those of the ore, have to be fluxed to be got rid of.

So much fluxing material as may be required should be reduced to sand or powder, and mixed with the ore in definite proportions previous to its introduction into the furnace, as has been done in many single atmosphere-furnaces—notably in Mouchell's furnace—or, for the sake of a more sure and even diffusion of the flux with the ore, the flux should be introduced, say at *e*, into the reducing-shaft by means of a feeding device similar to that used for the introduction and regulation of the ore, the ore and the flux-feeding machinery being connected together to feed proportionately, and at the same time so that the flux will be mingled with the ore as it falls through the shaft in a shower.

Whenever it is desirable that the fluxing powder be exposed to the action of the flame-column, the flux-feed holes *e* and accompanying feeding apparatus should be removed from the positions in which they are shown, and attached to the reducing-shaft A above the level of *g g g*. It will be convenient to make such attachments above the level of the feed-holes *f f*, for the reason that an extra admission of air above that level will do no harm, whereas if the attachment be made with the height of the reducing-column, the flux-feeding apparatus must be made so as to exclude air, otherwise some of the reducing-gas would be burned at the level of the flux-feed holes.

A form of feeding apparatus is shown in Figs. 3 and 4. At each of the feed-holes *f f* is attached, to the reducing-shaft A, a hopper, *n*, with a partly-open top. To the frame-work is attached another hopper, *l*, with a narrow opening, *o*, at the bottom, to deliver into the opening in the top of *n*, at *r*, which opening *r* is so large as to permit the insertion of a bar into the feed-hole to clear away any obstruction which may form, and also large enough to permit a stream of air to be drawn through the feed-holes *f f*, and across the open mouth *o*, so that, if ore be falling from *o*, the current of air will tend to break up any loosely-compacted lumps as they fall through it.

The current of air mentioned will exist by reason of the height of the shaft A above the feed-holes *f f*, which is for the primary purpose of carrying the products of combustion above the uppermost platform of the frame-work. These currents of air may be increased by the attachment of a fan-blower, should such increase be necessary. The feed-holes *f f* are placed opposite each other, in order that

the incoming currents may meet and form eddies, which will tend to scatter the ore-shower evenly over the area of the shaft A. A feed-cylinder, *m*, is mounted upon suitable bearings, so as to be revolved within the hopper *l*. This cylinder *m* is composed of a plain cylinder, to which projecting wings are added in such a way that any two contiguous wings and the projecting heads will form a trough. Over the feed-cylinder *m* is mounted the hopper *k*, into which the sand is to be put in mass. The outlet of *k* is a narrow nozzle, *t*, somewhat shorter than the feed-cylinder *m*, and placed over and near the wings, so that, when the cylinder *m* is at rest, the ore will pass through the nozzle *t*, and fill the uppermost troughs, but will not pass beyond the periphery of the cylinder *m*, because the natural angle of rest of the sand will make the surfaces of the heap fall below the upper edges of one or another of the wings upon each side. If the cylinder *m* be revolved, each trough will be filled as it passes under the nozzle *t*, and afterward spill its contents into the hopper *l*, whence it will pass by force of gravity into the reducing-shaft A. If both cylinders be revolved at equal speeds, equal feeds will occur at each side of the shaft A. These cylinders are to be connected with each other and with a steam-engine or other motive power by means of suitable mechanism—pulleys and belts or chains, for instance—so that the rate of feed may be governed by the speed of the prime mover, and changed relatively thereto by well-known means.

The flux-feeding apparatus will be of the same character, and be operated in the same way, the required quantity of flux relatively to that of the ore being regulated by either different dimensions or by different speeds.

The shield *h* surrounds the reducing-shaft A at the level of the full combustion air-holes *g g g*, to prevent the air from blowing directly into any of the air-holes *g g g*, and making the action irregular. The same object can be attained by inclosing a part or the whole of the frame-work C C.

Apparatus for the reduction of metals with gaseous fuel has been constructed, whereby the ore was exposed by charges, and by large surfaces, first to the heating action of a full combustion-flame, and, after the charge had become fused or sufficiently heated, the flame was suppressed, and a stream of hot carbonic-oxide gas was directed upon the charge. The necessary surface of exposure was obtained by a sort of tumbling action in a revolving oven, and the result is said to be excellent. According to deductions from known facts, metals which are not reducible, *per se*, by simple exposure to the heat of a neutral flame should be reduced by this intermittent process at a cheaper rate than by the common processes, involving exposure to only the heat and chemical action of a carbonic-oxide flame, or of a flame largely composed of carbonic oxide, for,

by utilizing only the heat resulting from combustion to carbonic oxide, the potential heat of combustion from carbonic oxide to carbonic acid is wasted; and such waste of potential heat must occur in all processes wherein both heating and reduction by carbonization is effected or sought to be effected by exposure to any single atmosphere or flame, whether the exposure be by shower, by mixture with solid fuel, by heaps upon hearths, or by charges in a tumbling-furnace, and this waste will bear a direct relation to the quantity of carbonic oxide which escapes.

Taking the above-indicated tumbling-furnace as the best or most economical, *per se*, heretofore known, and contrasting it with the apparatus now under consideration, we see that, although the tumbling-furnace utilizes the heat of full combustion during the term of heating the ore, it necessarily wastes the potential heat of so much carbonic oxide as escapes during the term of reduction, and much must be allowed to escape for the reason that the fact of reduction dilutes the reducing-gas by formation of carbonic acid, and largely-diluted reducing-gases are not sufficiently effective; whereas in the new apparatus, although the reducing-gases are diluted, the residue is constantly burned at the air-holes *g g g* to form the flame-column. Even when a carbonizing-flame is used in balling, the residue of carbonic oxide is burned at *g g g*, and much of the resultant heat absorbed by the walls of the reducing-shaft A, to be afterward utilized in exalting the heat of the regular flame-column, so that at no time will the carbonic oxide go wholly to waste.

In treating ores of precious and other metals which are reducible, *per se*, by exposure to simple heat, and do not absolutely require such a preponderance of affinity for oxygen as results from exposure to reducing-gases, this apparatus is useful, in that simple heat may be replaced to a great extent by direct affinity, and less fuel be used than has before been necessary.

When using this apparatus for the reduction of iron ores, either carburized cast-iron, steel, or neutral iron free from carbon may be produced by the proper regulation of the volume, richness, and height of the column of reducing-gases. Neutral iron will be more easily and surely produced than uniformly-carburized iron, for the reason that if the gases and heat be so regulated as not to reduce all of the original oxide, but so as to leave a small part of it in the mass, to be fused or kept fused during the balling term, such fused oxide will work out of the balls in the form of slag, when under the hammer, and a considerable variation in the conditions of reduction will result in a variation in the quantity of slag produced rather than in a variation in the quality of the iron. In actual practice a considerable amount of such slag is desirable, because much impu-

rity is carried out of the ball with it when the ball is hammered or squeezed.

If at any time the iron sponge at the foot of shaft A is found to be over-carburized, the mishap can be remedied by having the hearth lined with oxide of iron fettling and the puddlings of the mass in the ordinary way.

It is not essential that each particle of iron ore is reduced to a homogeneous neutral state during its fall through the reducing-shaft. The larger particles will be under-carburized, and each contain a nucleus of oxide, with an outer shell of carburized iron, and an inner shell of neutral iron, while the smaller particles will be completely carburized; but the general average will be equal to neutral iron, with an excess of oxidized or carburized iron, as the case may be, and the intimate mixture of the particles and heat to which they are exposed will favor the even diffusion of the carbon throughout the mass of reduced iron.

The preferable method of making steel with this apparatus is, to shower the ore down through the double atmosphere, and receive it in a bath of fused carburized iron upon the hearth, which should be extended for this purpose all across the bottoms of the shaft and oven B to the bridge wall. The metal bath may be fused and kept fused by the occasional firing of the gases in the oven B, as for balling. After the bath has been first made of carburized iron, the formal renewal of it will be unnecessary so long as the apparatus continues in action, because we have the means within the apparatus of so regulating the carburization of the sponge that a continuous bath may be maintained upon the hearth by tapping off a part only of its contents at any time.

If at any time the bath is shown by samples, cooled and tested, to be deficient in carbon the shower of ore may be decreased, or the volume and speed of reducing gas may be increased, so as to make up the deficiency, and vice versa, if the bath is too highly carburized.

The great affinity which chromium exhibits for iron renders it easy to make chrome steel directly from the ore with this apparatus.

It is well known that neutral iron melted in a crucible, along with chrome oxide, produces chrome-steel, and that the union of chrome with iron is more persistent or stronger than the union of iron with carbon; hence it is possible and easy to mix together in definite proportions the iron and chrome ores, and shower them down the reducing-shaft containing a double atmosphere of flame and reducing-gases, and receive the product in a bath of molten iron, carbonized or chromized in the manner hereinbefore described.

By reason of the preponderance of affinity before noted the shower of iron may be under-carburized, and a residue of iron oxide left in the mass by way of slag, so as not only to get the benefit of expelling impurities with the slag, but to prevent the mixture of carbu-

rized iron with the chromized iron; and it will be well when the reducing process is intermitted, and the gases fired in the oven B, for the purpose of maintaining the heat of the bath, to make the heating-flame strongly oxidizing, so as to extract from the surface of the bath any carbon which may have been absorbed from the reducing-gases during the previous term of reduction. The carburization of the bath may be mitigated or prevented by the vitreous slag, which will result from the use of flux with the ore. The chrome oxide may be mixed with the flux in different proportions, and so introduced in relative quantities to those of the ore.

This apparatus differs from all previous shaft-furnaces, in that the shaft A has its walls pierced by the full combustion air-holes *g g g*, at a height above the hearth sufficient to secure the reduction of the pre-heated granulated ore during the time required for its fall through the reducing-gas column, extending from the hearth to the level of the holes *g g g*, and also the walls are pierced by the feeding-holes *f f*, at an additional height, sufficient to secure the requisite pre-heating of the granulated ore, during the time required for its fall through the full combustion flame of residual reducing-gas, from the feeding-holes *f f* to the holes *g g g*; and to describe this shaft, including the above-mentioned peculiarities, the words "reducing-shaft" are hereinafter used.

I claim—

1. The feeding apparatus D or E, consisting of the combination of the chambered cylinder *m*, and hopper *n*, *l*, and *k*, substantially as and for the purposes described.

2. The combination of the feeding apparatus D or E, with the reducing-shaft A, substantially as and for the purposes described.

3. The combination of the ore-feeding apparatus D, with the flux-feeding apparatus E, and the reducing-shaft A, substantially as and for the purposes described.

4. The reducing-shaft A, having the full combustion air-holes *g g g* and feed-holes *f f*, substantially as and for the purposes described.

5. The reducing-shaft A, having full combustion holes *g g g* and feeding-holes *f f*, and separate flux-holes *e*, substantially as and for the purposes described.

6. The combination of the reducing-shaft A, with the reverberatory furnace B, air-conduit *b*, door *i*, and gas-conduit *a*, substantially as and for the purposes described.

7. The process of treating crude metal reduced from the ore during its fall through a column of flame over a column of reducing-gas, by transferring it from the foot of the reducing-shaft A to the hearth of the reverberatory furnace B, and therein exposing it to the action of the flame, produced and controlled substantially in the manner and for the purposes described.

8. The process herein described of making carbon steel—that is to say, by showering

granulated iron ore down through a double atmosphere, consisting of flame over reducing-gas, into a bath of carbonized iron maintained in a state of fusion, substantially as and for the purposes described.

9. The process herein described of making chrome steel—that is to say, by showering the ores of chromium and iron in measured relative quantities down through a double at-

mosphere, consisting of flame over reducing-gas, and receiving the product upon a hearth or in a bath of molten metal, substantially as and for the purposes described.

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