5 Sheets—Sheet 1.

C. W. SIEMENS.
Manufacture of Iron and Steel.

No. 205,980. **Patented July 16, 1878.**

FIG.1.

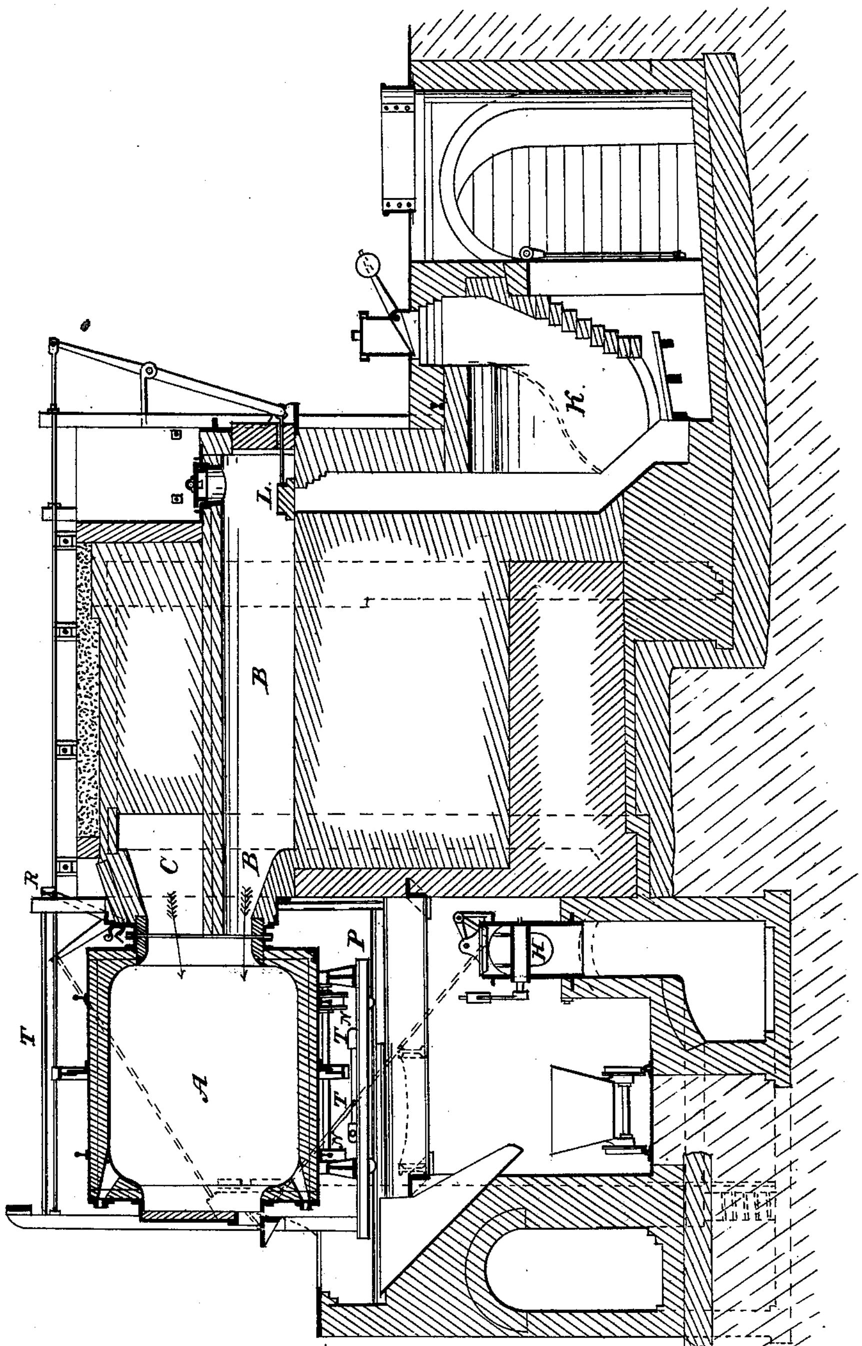

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FIG. 2.

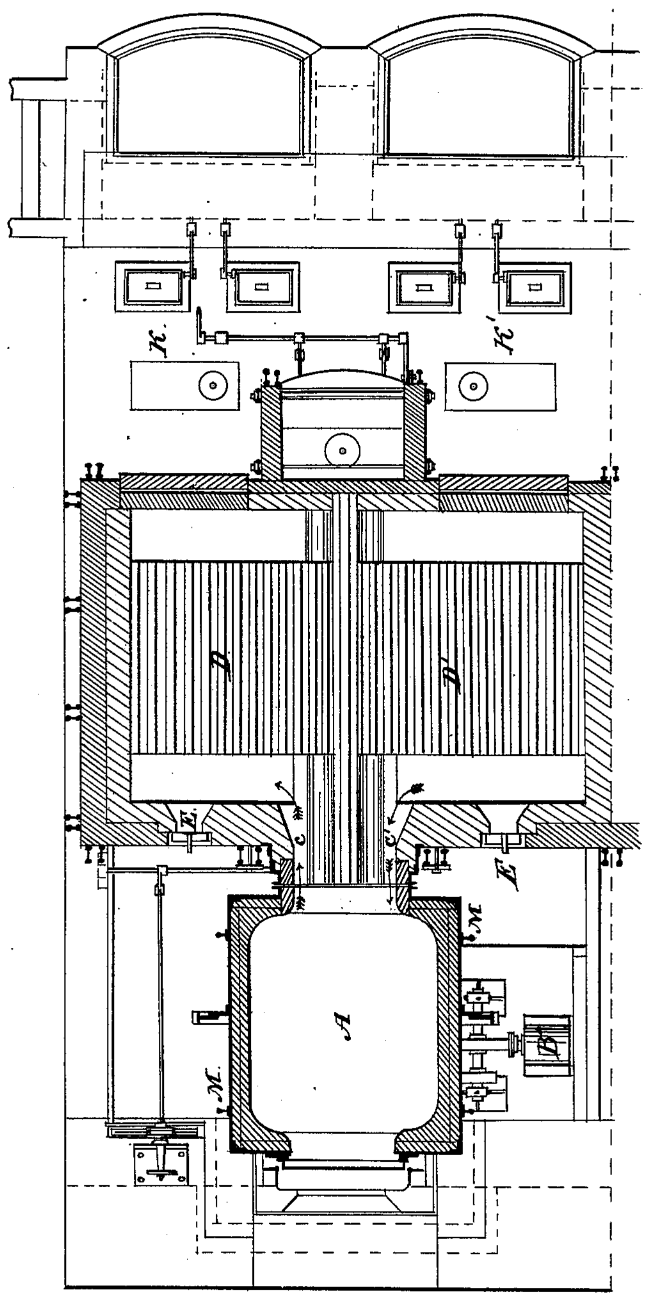

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FIG. 3.

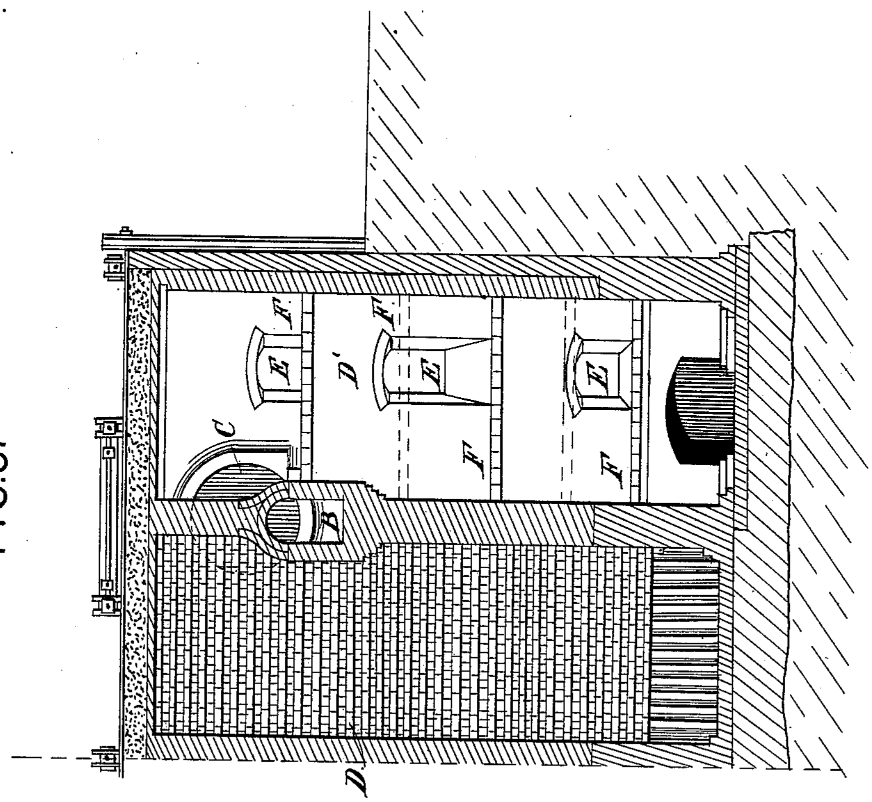

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FIG. 4.

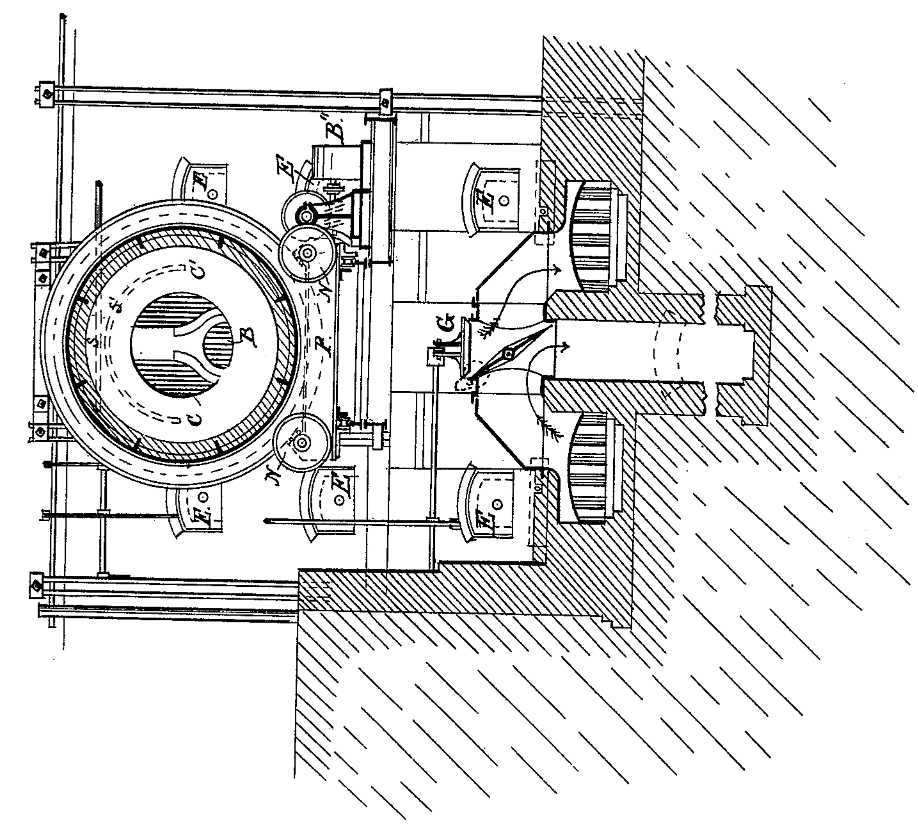

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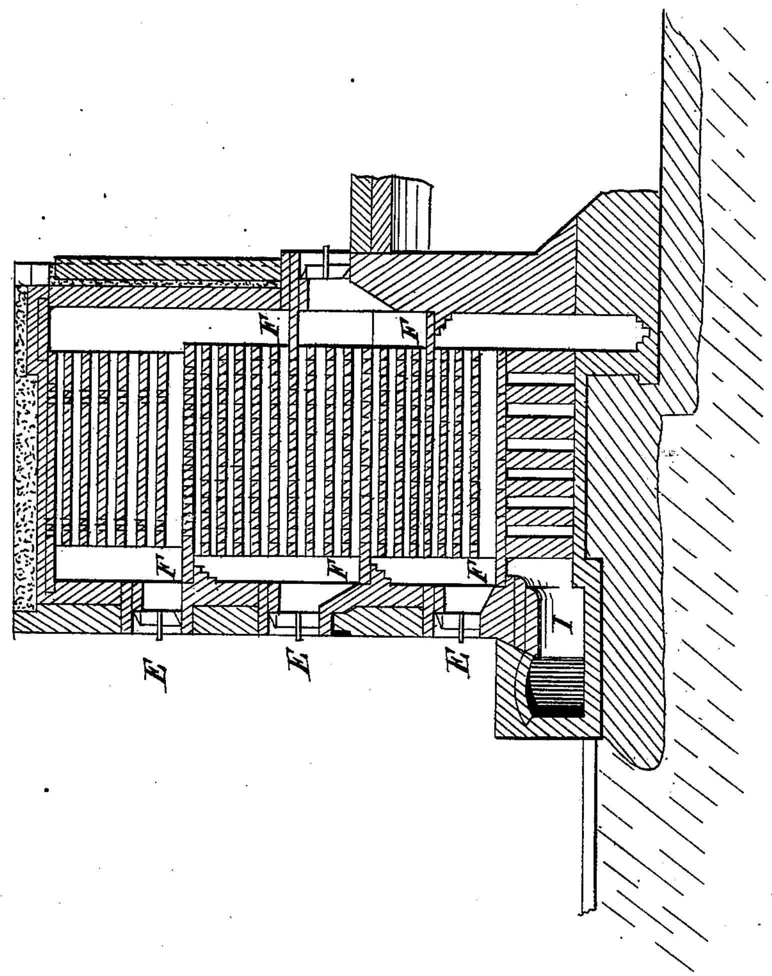
FIG. 5.



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UNITED STATES PATENT OFFICE.

CHARLES W. SIEMENS, OF WESTMINSTER, ENGLAND.

IMPROVEMENT IN MANUFACTURE OF IRON AND STEEL.

Specification forming part of Letters Patent No. **205,980**, dated July 16, 1878; application filed December 2, 1876.

To all whom it may concern:

Be it known that I, CHARLES WILLIAM SIEMENS, of Westminster, in the county of Middlesex, England, have invented an Improved Process and Apparatus for the Manufacture of Iron and Steel; and I do hereby declare that the following is a full, clear, and exact description thereof, that will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

My invention relates to that class of processes for the manufacture of iron and steel which are conducted in rotative furnaces; and the nature thereof consists in certain improvements upon the processes described in United States Letters Patent No. 159,712—that is to say, in conducting the process of producing wrought-iron direct from the ore in such a manner that the ore is crushed and mixed with such proportions of other ores or fluxing materials as will give a fluid slag, to be formed at a comparatively low temperature, which slag is tapped off before a welding-heat is attained, in order that a second and welding cinder may be formed within the rotator without the earthy matters so removed, to assist in balling up the metallic iron, substantially as herein described.

The rotative regenerative furnace made use of in manufacturing iron and steel according to my improved process is illustrated in the accompanying drawings, in which—

Figure 1 represents a longitudinal section. Fig. 2 is a sectional plan. Fig. 3 represents, on the left side, a half transverse section, and on the right side a half transverse section. Fig. 4 represents a sectional elevation. Fig. 5 is a transverse section.

In the drawings, A is the rotative furnace, in shape cylindrical, with flat ends. It is mounted on rollers, and, instead of clutch-gearing, each furnace may be driven by a small independent engine. The throat or neck of the furnace A is in communication with three flues, B and C C′. The lower opening B is for gas only, and the flue brings it direct from the producers K K′ at the back. The two lateral parts C C′ communicate, respectively, with the regenerators D D′. These regenerators are used for heating air only, and are built in stages, provided with cleaning-doors E. The bricks are laid so as to form longitudinal channels, and at intervals stoppings F are carried across, as shown in Fig. 5, so that the air and products of combustion going to and from the furnace pass backward and forward several times.

G is the regulating-valve, by which air is admitted to the furnace, and communicates with regulators D D′ by means of the reversing-valve H. The air flows in on one side of the flap H into one regenerator, while the products of combustion coming from the furnace pass from the other regenerator to the other side of the flap H, and thence to the chimney-flue I. Thus when one regenerator is heated sufficiently by the issuing products of combustion, and the other is cooled by the incoming air, a reversal of the flaps H effects a change in the direction of the currents, and the heat accumulated is returned to the furnace.

The gas-producers K K′ are of any usual well-known construction, and therefore need no description.

The gas produced rises from the producers K K′ continuously, and flows out hot through the regulating slide-valve L, of which two are shown, one to each producer, into the gas-flue, along which it passes to the rotative chamber A. Thus the gaseous or other fuel flows in continually through the port B, while the lateral ports *c c′* serve alternately to give ingress to the hot air and egress to the products of combustion.

The rotative chamber A is constructed of wrought-iron plates, bound together by strips and angle-iron, riveted on, and further secured by two rings of rails, (shown at M M,) which also serve to support the chamber on the rollers N N. The whole is placed on a carriage, P, made of cast and wrought iron, and resting on four wheels, running on a pair of rails. Thus the rotative chamber may be moved toward or away from the regenerator-neck.

The rotary motion is shown as imparted by a small independent engine, B′, provided with suitable gearing. There may be one such engine to each furnace, and this arrangement may be used instead of the clutch-gearing described in my previous patent. This engine may also be connected with the carriage P, and employed for moving the rotative chamber A to or from the regenerator-neck.

The neck of the furnace, opposite the door, is composed of two channel-irons, or of iron plates bent U-shaped. They are circular pieces, one fastened onto the back plate of the rotative chamber A, and the other similarly secured to the neck-like extension of the regenerator-flues, which also is made of wrought-iron plates, firmly riveted together, and kept in position by the tuck-staves and tie-bolts R.

Above the neck-joint a perforated pipe, S, sends a spray of water over the plates and neck, to prevent their corrosion by the flame. The water is prevented from entering the neck-joint by the semicircular piece of angle-iron S′ immediately below the perforated pipe S.

At T are shown the perforated tubes for projecting water upon the casing of A, in order to cool the furnace-lining, and for other purposes.

The rotative chamber A may be also cooled by making the casing hollow, and allowing water to circulate in the annular space.

This form of furnace, as above described, is well adapted for the use of petroleum or other oil-vapors, or for powdered fuel, as well as for ordinary gaseous combustibles.

In making the lining of the rotative chamber, scale or other oxides of iron, as also oxides of manganese, chromium, or titanium may be used together or separately, or in combination with a rich cinder, such as that obtained from reheating and puddling furnaces. A rich aluminous cinder is also very useful for admixture in certain cases.

In using an oxide lining I operate as follows: On the rotator-casing, protected by brickwork or otherwise, an initial lining of oxide of iron is first melted and set around to the depth of a few inches. Then a charge of oxide and rich cinder, mixed, is melted and set around. On this bed an ordinary charge of ore-fluxes, &c., is worked. When the charge has come to the metallic condition and the iron is partly aggregated, the fluid scoria is tapped off in the usual manner. The heat is then raised, the balls are formed, and at the same time a second cinder appears, derived partly from the balls and partly from the lining. This should be a true welding-cinder of the approximate formula $2FeOSiO_2$. After the balls are taken out this cinder is not tapped off, but is enriched by the addition of some of the before-mentioned oxides. Some of it is then splashed on the furnace ends, and the remainder is allowed to set, so as to form a new working-face for the lining. In order to cool the furnace for this purpose the admission of air and gas is stopped or greatly diminished, and water is projected on the casing in jets from perforated tubes placed above and below the outside of the rotative chamber.

If the lining is to be increased all around, the chamber is allowed to rotate slowly while the cooling takes place; but if it be desirable to form a flat side to the lining, to prevent the sliding of subsequent charges, the rotation is stopped, and, after enriching the cinder with scale or other oxides, lumps of titanium, or chromium, or of other refractory materials, such, for example, as rich calcined ironstone, or lumps of hematite, or magnetic iron ore, which, by preference, have been previously warmed to avoid decomposition, are thrown into the bath and well coated with cinder. The water is then turned onto the bottom of the rotative chamber, and the flat is quickly solidified. The lumps set in give a rough surface, and not only materially assist in preventing the charge from sliding, but also help to keep it continually turning over and exposing fresh surface to the action of the flame. In this way each charge contributes to the lining for a subsequent one, and loss of iron is avoided.

A carbon or carbonaceous lining may be used with advantage, especially if fluid steel, spiegel, ferro-manganese, or spongy iron is to be formed. For such purposes I use graphite (plumbago) or the graphitic deposit found in gas-retorts. Anthracite or coke may also be employed. These materials are to be ground up and mixed with about twenty-five per cent. of fire-clay, so as to form a thick pasty mass, which is then rammed into position or molded into suitable blocks for lining the furnace.

Having now described the improvements in my rotative furnace and the mode of forming the lining, I will proceed to explain my new method of working.

The ore-reducing agents and fluxes to be used are first crushed small enough to pass through holes about three-eighths of an inch diameter. Then, if the ores contain volatile matter, they may be calcined by any suitable means previous to being charged into the rotator. The hot ore, after such preliminary treatment, is mixed with a suitable proportion of reducing agents and fluxes.

In selecting the fluxes, my aim is to form a slag easily fusible, and capable of carrying off the sulphur, phosphorus, and earthy matters in the charge at the first tapping, which takes place at a comparatively low temperature, and just as the reduced iron begins to aggregate. If the ore be silicated, bases, such as lime and alumina, should be added; or, if it be a basic ore, then silica must be added. In either case, the oxygen in the silica (as SiO_2) should be at least about half that contained in the bases. If these conditions be assured only a small quantity of iron will be carried off in the slag.

If the ore contains much sulphur and phosphorus and refractory earthy matter, I add an ore containing manganese, so as to insure a fusible and cleansing slag at the first tapping.

The mixture of ore, flux, and reducing agents is charged into the heated volatile chamber, and rotation slowly commenced as soon as the charge is heated up thoroughly and the slag begins to run. The heat is then slightly raised until the reduced spongy pieces of iron begin to aggregate in a bath of slag. This is now nearly all tapped off, and the heat is then raised to the welding-point of iron. At this stage some of the lining begins to melt, and a second small bath of cinder is formed, in which the balling-up goes on rapidly. As soon as ready, the balls are quickly removed and shingled straight into blooms and rolled into puddled bars. This cinder, which is approximately a true welding-cinder of the composition $2FeO,SiO_2$, is not tapped off, but is at once set around or in a flat, being evolved by the water from the perforated tubes below the rotator, and the furnace is ready for the next charge. From time to time the welding-cinder should be enriched and lumps set in, as previously described.

If hard-grained or steely iron be required, I add granulated pig-metal, refined metal, spiegel, or ferro-manganese to the charge immediately after the first tapping. The carbon becomes associated with the iron in the charge, while the silicon and manganese go into the cinder, to be set around as lining. In the charge which follows, the manganese silicate comes out in the first tapping, and serves to cleanse the charge from impurities.

The apparatus herein described forms the subject-matter of another application for Letters Patent, and is not herein claimed.

In the process for manufacturing iron and steel for which Letters Patent of the United States were granted to me February 9, 1875, the mixed material was introduced into a slowly-rotating furnace and heated nearly to the fusing-point of the ore, whereupon was added a quantity of the reducing agent, previously crushed, but not ground fine; or charcoal or wood, previously dried and cut into pieces. By the slow rotation of the furnace the carbonaceous matter became covered by the heated ore, with which it was gradually mingled, while fresh intensely-heated surface was continually presented to the mixture. When the reaction was complete the rotation of the furnace was stopped and the scoria tapped off, so as to liberate the metallic iron resulting from the reaction. A fuller supply of gaseous fuel was then turned on, and the furnace was caused to rotate five or six times more rapidly than before, which had the effect of agglomerating the iron into balls.

If it was desired to convert the balls into cast-steel, or into a pure cast metal intermediate between cast-steel and cast-iron, after the balls were formed the rotation of the furnace was stopped and the fluid scoria again tapped off, whereupon the furnace was again caused to rotate slowly. Some hard carbonaceous substance, such as crushed anthracite or coke, was then introduced, while the heat of the furnace was raised to a high intensity. The balls, combining with the carbon, became fused into a fluid mass, which could be tapped or cast into form or molds; or, instead of introducing hard carbonaceous substances to effect the fusion of the balls, broken pig-metal, or spiegeleisen, or ferro-manganese was employed for the same purpose.

Having thus described the nature of my invention and the manner in which the same is to be practically carried out, I claim—

The improvement in the art of producing wrought-iron direct from the ore, hereinbefore described, which consists in charging the crushed ore into the rotator, together with such proportions of other ores or fluxing material as will give a fluid slag, tapping off the said slag before a welding-heat is attained, and reducing and balling the metallic iron in the presence of a second and welding cinder formed within the rotator after the earthy matters have been removed, whereby the balling up of the metallic iron is aided, substantially as described.

C. WILLIAM SIEMENS.

Witnesses:

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EDWARD C. INGERSOLL.