No. 809,291. PATENTED JAN. 9, 1906.

E. FLEISCHER.

ART OF MANUFACTURING IRON OR STEEL.

APPLICATION FILED JULY 26, 1904.

Fig. 1.

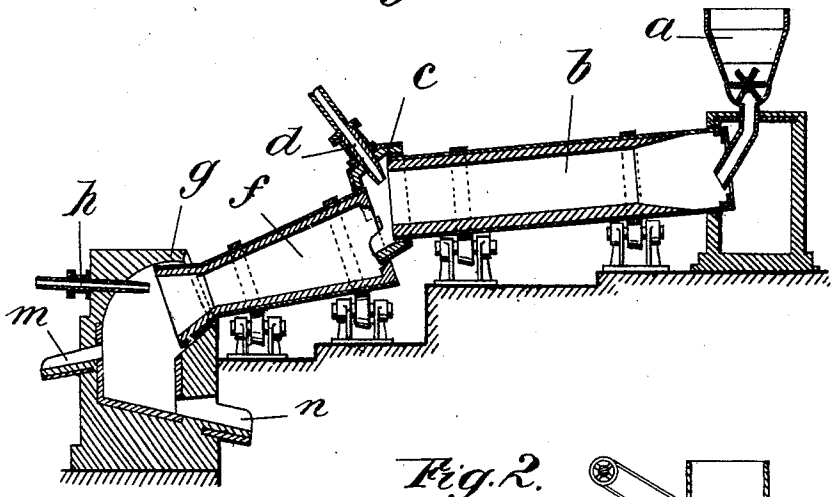
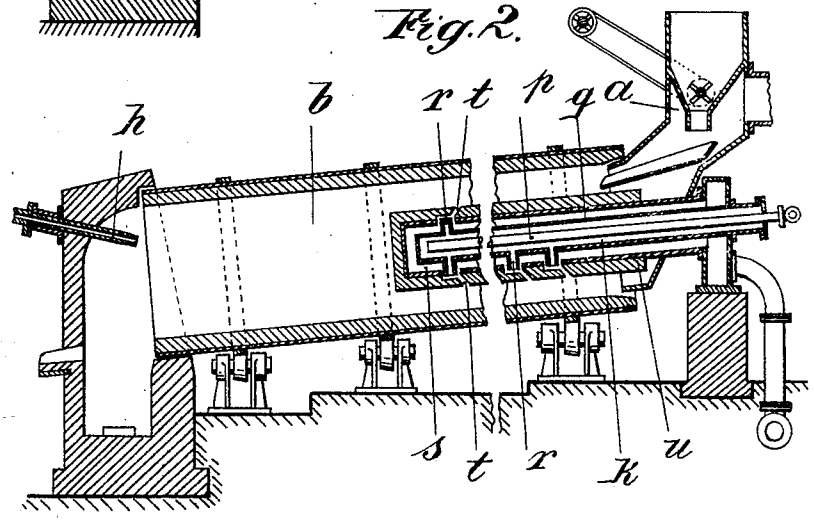


Fig. 2.



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ART OF MANUFACTURING IRON OR STEEL.

No. 809,291. Specification of Letters Patent. Patented Jan. 9, 1906.

Application filed July 26, 1904. Serial No. 218,284.

To all whom it may concern:

Be it known that I, EMIL FLEISCHER, doctor of philosophy, chemist, residing at Dresden-Strehlen, Tiergartenstrasse No. 32, in the Kingdom of Saxony, Germany, have invented new and useful Improvements in the Art of Manufacturing Iron or Steel, of which the following is a specification.

The object of my invention is to enable iron or steel to be manufactured direct from the ore by the employment of rotating tubular furnaces with water-gas fuel.

It is not easy to attain this end, since it is necessary to produce the flame in a special manner, while the various effects resulting in the ore from the action of the flame must be caused to follow a definite sequence. In the first place, it is impossible with an ordinary rotating furnace to reduce the ore to metallic iron and to simultaneously melt the latter to a practically sufficient degree even with the employment of a reducing water-gas flame, because the absorption of heat and the reaction which take place during the passage of the ore beneath only a single flame are insufficient, so that although in general a material reduction and also the formation of a small quantity of spongy iron does take place there is no fusion of the material lying beneath the surface effected at the same time, and the necessary formation of a slag does not take place. For this purpose it is necessary to supply the heat from at least two sources, this being best effected by the employment of a furnace having two rotating tubular drums, each with its own twyer or burner through which the fuel-gas is introduced, the one being connected immediately behind the other. It is, however, possible to successfully employ a furnace having but one drum, if this be a drum of sufficient length and if heat is supplied from both ends simultaneously from two twyers or burners. It is then possible to supply a sufficient heat to the iron ore and to the iron sponge in process of formation to effect complete fusion. In order to attain this object, regard must be had to the configuration of the flames, for upon this the effectiveness of the reduction depends, the steps to be taken being based upon the following considerations:

Iron ore suffers reduction to spongy iron at comparatively low temperatures if the process is carried on in a suitable atmosphere. At a temperature of 850° the reduction will take place if the surrounding atmosphere contains carbon monoxid and carbon dioxid in the proportion of not less than two and one-fourth volumes of the former to one of the latter. On the other hand, the spongy iron thus formed does not undergo oxidation later on, even when the ratio of carbon dioxid to monoxid in the flame is much greater and even if the temperature does not rise above the fusion-point. This still holds good when the flame contains equal parts of carbon monoxid and dioxid. Furthermore, it is to be noted that (other things being equal) it is not possible to produce a strongly-reducing flame of the same degree of heat as a neutral or oxidizing flame. In view of these considerations according to the new process the first flame is a reducing one of comparatively low temperature—say between 800° and 1,000°—under whose influence a reduction of the iron ore to spongy iron takes place within the rotary tubular furnace. In this furnace the reducing-flame contains, preferably, more than two volumes of carbon monoxid to one of carbon dioxid. Such a flame may be termed "strongly-reducing." The spongy iron is thereafter exposed to the action of a much hotter flame which is neutral or preferably weakly-reducing in character, so that the products of combustion contain equal parts of carbon monoxid and dioxid. This second flame must supply a much greater amount of heat than the first, it being necessary that its temperature should be as high as 1,700° centigrade. It is however, by no means easy to produce a flame so hot and at the same time slightly reducing in character by simply burning water-gas with the corresponding quantity of air. On the contrary, it is well known to be necessary to previously heat the interacting gases, especially the air, to several hundred degrees of temperature—say about 500°. The iron sponge is fused under the action of this hot reducing-flame, and if suitable fluxes have been previously introduced a slag will form, which prevents the reoxidation of the iron.

The reduction of the ore is facilitated if the ore previous to its introduction into the furnace is mixed with such a quantity of carbon as will be nearly consumed on leaving the first drum. On the other hand, a great ex-

cess of carbon renders the fusion of the ore more difficult. Whereas it is necessary to employ a drum-shaped furnace for the reduction of the ore in order to be able to successfully treat it when in a pulverulent or fine granular condition, other types of furnace—such, for example, as a reverberatory furnace—are suitable for the second part of the process—*i. e.*, the fusion of the iron—if only a neutral or preferably a slightly-reducing flame be employed.

It is needless to add that the reducing-flame might be produced in a variety of ways so long as it possesses the necessary properties. Water-gas appears to be the most suitable combustible agent for this purpose; but other gases of high calorific value might be employed, whereas those of lower calorific value as also solid combustibles are inadmissible. Furthermore, it is evident that by selecting a suitable proportion of carbon and by properly regulating the flame steel may be produced instead of iron.

In the accompanying drawings, which illustrate two practical forms of plant for carrying out the process, Figure 1 is a longitudinal section through a furnace having two rotary tubular drums. Fig. 2 is a similar view of a furnace having a single rotary tubular drum with two burners.

Referring to Fig. 1, the ore mixed with a flux and also, it may be, with carbon is delivered from the hopper *a* in regulated quantities into the first drum *b*, which is rotatably mounted in an inclined position in the ordinary manner. The lower end of this drum rotates within a fixed structure or "connecting-piece" *c*, through which the downwardly-directed twyer or burner *d* also passes. The ore reduced for the most part by the action of this flame passes into the second drum *f*, whose lower end extends into the fixed hearth *g*. This second drum is heated by the burner *h*. The molten iron, together with the slag, runs into the hearth *g*, which is provided with two discharge-orifices, the one, *m*, for the slag and the other, *n*, for the iron. The waste gases from the second drum may either (if carbon has been used) be passed into the first drum or (as also the gases from the first drum) into a regenerator, wherein they may be burned, and the waste heat can thus be utilized for heating the air-blast.

In the apparatus shown in Fig. 2 there is also a hopper *a*, which distributes the ore into the long drum *b*. The burner *h* projects into the lower end of the drum *b* in the ordinary way, while in the upper portion of the drum is arranged a burner *k* of special construction. This burner *k* comprises a gas-pipe *p*, which passes through the wider pipe *q*, so that the gas flowing from the mouth of the inner tube into the outer one becomes strongly heated on its passage. The outer tube *q* is provided with branch nozzles *r*, which extend into the air-tube *s* and cause a mixture of gas and air to be blown through the outlets *t* of the tube *s* and of its fireproof covering *u*. It is to be noted that the process is the same whether a single furnace be employed, as in Fig. 2, or a double one, as in Fig. 1, and I would have it understood that in the following claims when a "furnace" is mentioned I refer to either of the forms shown in the drawings or to any other form of furnace that may be adapted for the purpose.

What I claim is—

1. The art of producing iron or steel direct, which consists in subjecting the ore to a continuous transversely-rolling and a continuous forwardly-progressive motion, and simultaneously acting upon it by consecutive gas-flames, the first of which is a reducing-flame.

2. The art of producing iron or steel direct, which consists in subjecting the ore, in the presence of fluxes, to a continuous transversely-rolling and a continuous forwardly-progressive motion, and simultaneously acting upon it by consecutive gas-flames, the first of which is a reducing-flame.

3. The art of producing iron or steel direct, which consists in subjecting the ore, in the presence of fluxes and pulverized carbon, to a continuous transversely-rolling and a continuous forwardly-progressive motion, and simultaneously acting upon it by consecutive gas-flames, the first of which is a reducing-flame.

4. The art of producing iron or steel direct, which consists in subjecting the charge to a continuous transversely-rolling and a continuous forwardly-progressing motion, and simultaneously acting upon the charge, at the initial stage of its forward travel, by a reducing-flame, and, at the terminal stage of its travel, by a melting-flame.

5. The art of producing iron or steel direct, which consists in subjecting the charge to a continuous transversely-rolling and a continuous forwardly-progressing motion, and simultaneously acting upon the charge, at the initial stage of its forward travel, by a strongly-reducing flame, and at the terminal stage of its travel, to a substantially neutral melting-flame.

In testimony that I claim the foregoing as my invention I have signed my name, in presence of two witnesses, this 9th day of July, 1904.

EMIL FLEISCHER.

Witnesses:
HERMANN WEIL,
CARL WEIHE.