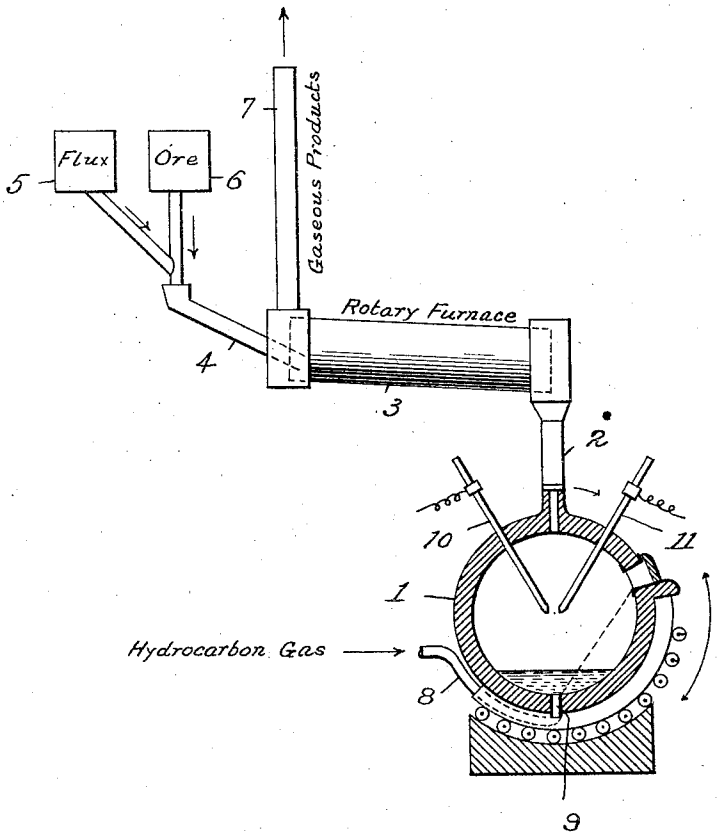
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ELECTRIC FURNACE CONSTRUCTION.

APPLICATION FILED JULY 22, 1918. RENEWED JAN. 25, 1922.

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ELECTRIC-FURNACE CONSTRUCTION.

1,427,436. Specification of Letters Patent. Patented Aug. 29, 1922.

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To all whom it may concern:

Be it known that I, WALTER E. F. BRADLEY, a citizen of the United States, residing at Nyack, in the county of Rockland and State of New York, have invented certain new and useful Improvements in Electric-Furnace Construction, of which the following is a specification.

The present application is a division of my prior application entitled Method of producing iron and steel, filed July 17th, 1918, Ser. No. 245,368.

In the said prior application I have described a method and apparatus for reducing iron ore, including in the term "ores", all materials containing iron chemically united with oxygen, such as for example, hematite or other concentrates and the like. The process described involves the use of an electric furnace for supplying heat to the material under treatment, while at the same time passing through the material a hydrocarbon gas, such as for example natural gas or methane.

The invention contemplated by the present application resides in the mechanism or apparatus by which a reducing gas is introduced into the material to be reduced and by which this material is supplied with the necessary heat.

As already explained in my said prior application, the introduction of a reducing gas into a molten mass of material requires for commercial considerations a tuyère of particular material, and the requirements are not satisfied by use of metal or ordinary refactory materials. It is also necessary for the performance of certain functions involved in the reduction of iron ore by gaseous reducing agents that the furnace be of the tilting type, that is to say, capable of manipulation by which the tuyère may at one time be disposed beneath the molten bath, and at another time be withdrawn therefrom. The principles of construction and operation by which the required functions are performed according to the present invention will be more clearly understood from the description of a specific embodiment of the invention in an ore reduction system.

The accompanying drawing shows in purely diagrammatic form an ore reduction system in which an electric furnace constructed and operated in accordance with the invention is employed.

In said drawing, 1 indicates an electric arc furnace, 2 the feed conduit normally connected with and leading thereto, 3 a rotary drum furnace discharging into said feed conduit 2, 4 the feed conduit for introducing to furnace 3 the ground flux and ore from hoppers 5 and 6, while 7 may represent the stack by which gaseous products of the system are finally discharged. Hoppers 5 and 6 are assumed to be properly supplied with finely divided flux and ore which pass therefrom into the supply conduit 4 from which they are introduced into the rotary drum furnace 3. In passing through the furnace 3, the flux and ore are thoroughly mixed by tumbling and sliding movement imparted to then by the rotation of the drum, and the mixture is discharged through the feed conduit 2 into the interior of the electric furnace 1. The electric furnace is closed to the atmosphere and the hydrocarbon gas such as for example, natural gas, or methane, is introduced from a suitable source such as supply pipe 8 through tuyère 9. The charge during the reducing stage covers the mouth of tuyère 9, so that the gas passes upwardly through it. At the high temperature maintained by the electric arc between electrodes 10 and 11, the charge is in a state of fusion.

The temperature at which the hydrocarbon gas is here exposed, effects dissociation of the gas in the presence of the iron oxide, the chemical action involving the reduction of iron oxides by carbon and leaving the gas in the form of a mixture containing carbon monoxide and hydrogen, as will be more fully explained hereinafter. The mixture containing the carbon monoxide and hydrogen is discharged through the mouth of the electric furnace into the feed conduit 2, and thence it passes into the rotary drum furnace 3 where the ore and flux are being mixed. These gases leaving the electric furnace 1 at a high temperature, and still possessing reducing properties, preheat the ore and flux which is being mixed within the rotary drum furnace 3, and effect a partial

preliminary reduction of the iron oxide contained therein. Assuming, for example, the treatment of magnetite, the chemical action taking place within the preheating furnace 3 may be represented by the equation

$$2CO+8H+Fe_3O_4= Fe+2FeO+CO+CO_2+H_2O+6H.$$

The remaining gas containing carbon monoxide, carbon dioxide, water vapor and free hydrogen, passes out through stack 7 and may be used as fuel to supply heat for any purpose.

Referring again to the final reduction which occurs in the electric furnace 1, the chemical action may be represented as follows:

$$Fe+2FeO+2CH_4=3Fe+2CO+8H.$$

A flux which I have found satisfactory for the operations herein described, is one containing, or made up of sodium carbonnate or sodium chloride. The electric furnace is preferably of the basic lined type having for example, a lining of pure magnesia or magnesite brick. To protect this lining from attack by the flux or slag, it is desirable to maintain a basic condition in the slag. The sodium carbonate or chloride answers this purpose alone or it may be supplemented by additional basic material which need not have such low melting point, such as lime, magnesia, or the like. The amount and composition of the flux depend on the amount of SiO_2, Al_2O_3, and other impurities in the ore.

As already stated, the successful use of hydrocarbon gas as a reducing agent, requires a particular construction and manipulation of the electric furnace, an important detail of which resides in the provision of a suitable form of tuyère through which the gas is introduced into the molten charge. I have found metal to be entirely unsuitable as a material for the construction of the tuyère, because of its high heat conductivity and relatively low fusion point. When artificially cooled, it tends to become stopped up. At the temperatures employed, it is chemically acted upon by the carbon or reducing agent. Tuyères of refractory materials such as magnesia, silica and the like are chemically active, and furthermore are useless because they rapidly wear away or become stopped up. I find, however, that tuyères composed of carbon answer the requirements. They have comparatively low heat conductivity, withstand the high temperature to which they are subjected, and are protected from chemical action with the charge by the atmosphere of reducing gas which is passing through them.

When the reduction is complete, it is necessary to stop the flow of gas through the charge, since to continue the supply of gas would alter the resulting composition of the steel or iron, and would not permit of separating the slag and steel, due to the agitation. It is impossible to turn off the gas supplied to the tuyère while it is below the level of the liquid charge without causing the tuyère to stop up, therefore it is essential that the furnace be of the tilting type, so that the tuyère may be removed from below the level of the bath. The gas may then be turned off completely or partly as desired. The furnace is preferably arranged to have its intake or mouth suitably connected with the feed conduit 2 when the furnace is moved into receiving position, but permitting disconnection to be made for tilting the furnace and pouring off the slag and metal.

In the system shown, the supply of mixed ore and flux to the electric furnace takes place continuously over a considerable period of time during which the reduction is continuously proceeding. Thus the mixture is treated as fast as introduced and the entering fresh material is continuously delivered upon the surface of the molten mass, where it is most directly exposed to the heat of the arc and thus most effectively acted upon. The introduction of heat from the electrodes above into the charge beneath is in this way much more advantageously accomplished, than where the entire charge is introduced into the furnace before the heating stage begins. When the operations are proceeding properly and uniformly throughout the several parts of the system, the temperature within the electric furnace remains constant. As the various parts of the system are dependent upon each other with respect to chemical, thermal, and mechanical conditions uniformity of operation can be obtained by proper adjustment of the gas supply, the rate of feed, and the supply of electric power with respect to each other.

Having deoxidized the ore and obtained the metal in substantially pure form, the slag containing the impurities is poured off, after which the necessary additions are introduced to make the quality of steel desired and the heat continued long enough to obtain the necessary commingling of the ingredients into a uniform homogeneous state. Carbon, manganese, nickel and any other ingredients required to make steel of a specified analysis can be added as alloys or compounds. Carbon can also be added by passing an additional quantity of hydrocarbon gas through the steel after the removal of the slag.

By this process, it is possible to produce a very high grade of pure iron or steel of practically any analysis desired.

I claim:

1. Reduction apparatus comprising in combination an electric furnace having suit-

able electrodes and a carbon tuyère independent of said electrodes and means for supplying a reducing gas to said tuyère.

2. Reduction apparatus comprising in combination an electric furnace of the tilting type provided with suitable electrodes, a carbon tuyère independent of said electrodes and disposed in position to be covered by the molten charge in one position of the furnace, and removed therefrom in another, and means for supplying a reducing gas to said tuyère.

3. Reduction apparatus comprising in combination an electric furnace of the tilting type, provided with suitable electrodes and, having an outlet for pouring, and a carbon tuyère independent of said electrodes and disposed in position to be covered by the molten charge in the reducing position of the furnace and removed therefrom in the pouring position, and means for supplying a reducing gas to said tuyère.

4. An ore reduction apparatus comprising in combination an electric furnace of the tilting type provided with suitable electrodes and having an inlet through which the charge is received and an outlet through which the slag and reduced charge may be poured, a rotary drum furnace having suitable communication with the electric furnace inlet for delivering materials into the furnace and receiving gaseous products therefrom, a carbon tuyère independent of said electrodes and disposed in position to be covered by a molten charge in the electric furnace in the receiving and reducing position, and to be removed therefrom in the pouring position, and means for supplying a reducing gas to said tuyère.

WALTER E. F. BRADLEY.