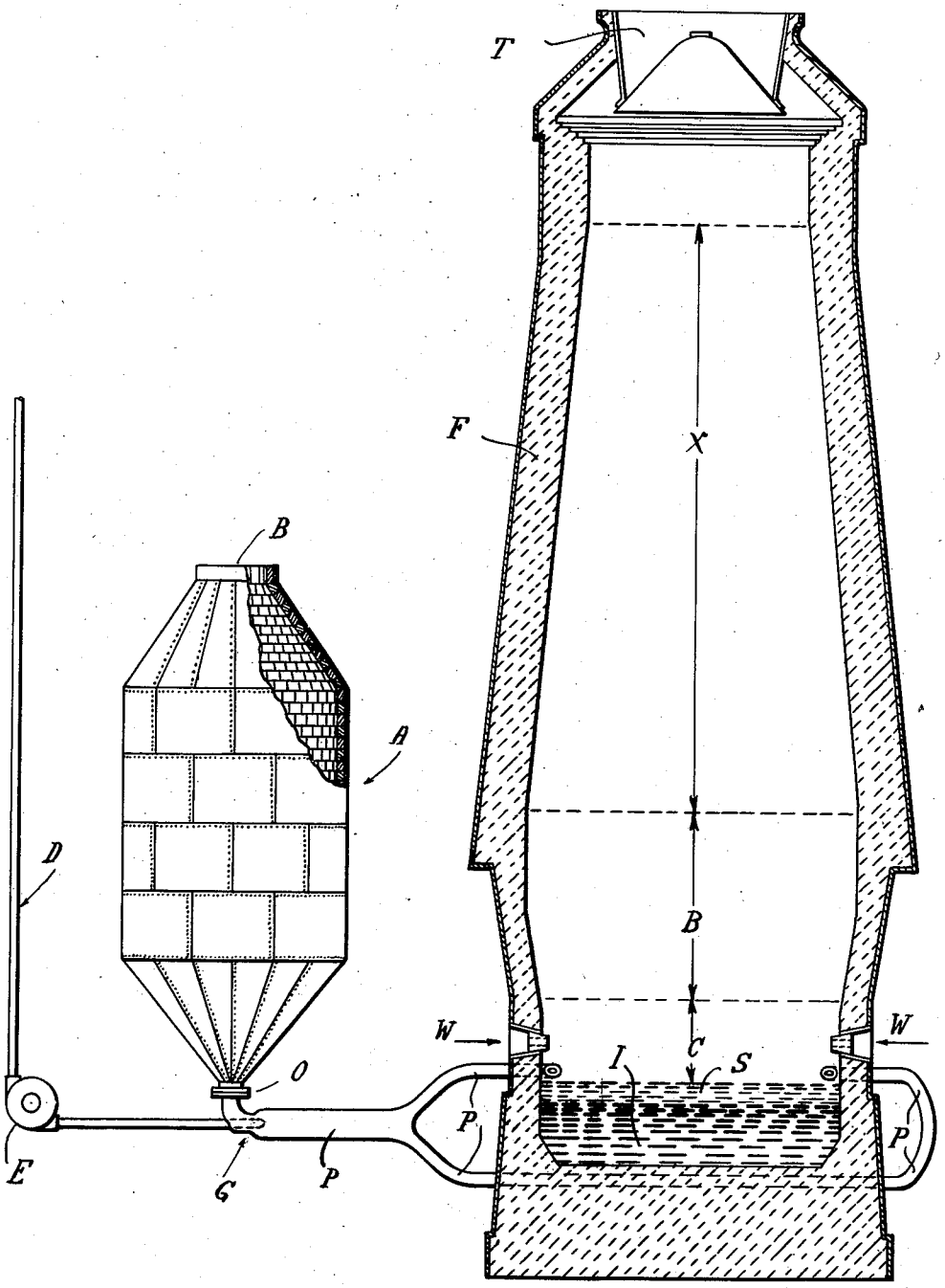
April 14, 1942. C. G. HOGBERG ET AL 2,279,399

BLAST FURNACE PROCESS

Filed Oct. 4, 1939



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Patented Apr. 14, 1942 2,279,399

UNITED STATES PATENT OFFICE

2,279,399

BLAST FURNACE PROCESS

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Application October 4, 1939, Serial No. 297,940

2 Claims. (Cl. 75—41)

This invention relates to metallurgy and more particularly to the manufacture of pig iron in a blast furnace, and one of the objects of the present invention is to provide an improved blast furnace process. Another object is to introduce required flux materials within the blast furnace at the point the said materials are needed. Still another object is to increase the operating efficiency of a blast furnace. Other objects and advantages will be apparent as the invention is more fully hereinafter described.

In accordance with the above objects we have discovered that the greater portion of the fluxing material, limestone or similar calcareous material, which is added to the usual burden fed to the blast furnace in admixture with the ore and coke, serves no useful purpose and is in fact deleterious to the desired ore reduction, until the said flux material reaches the lowest heat zone in the furnace, and that the same may be most advantageously omitted in major part from the burden mixture and fed instead to the furnace at the said lowest heat zone, with marked advantage on the furnace efficiency and on the furnace capacity, as well as more effectively performing its intended function of de-sulfurizing the pig iron product produced in the furnace.

In the operation of the blast furnace process, the materials within the furnace undergo a series of transitions between the molten, solid, and gaseous states. These transitions are generally confined to various zones. In order to more clearly describe these zones within the blast furnace, reference will be made to the attached drawing wherein is illustrated in vertical cross-section a typical blast furnace, together with the improved means of the present invention, the latter being shown partly in elevation and partly in fragmentary section.

In general, the usual blast furnace process is a countercurrent reaction of descending solid and molten material with that of ascending gases. The solid constituents of the blast furnace charge consist of fuel (carbon), iron-bearing material (ore), and fluxing material (limestone). These are dropped into the top T of the furnace F in more or less admixture wherefrom they descend by gravity through the various zones and meet with the action of the ascending gases. The air blast, blown through the tuyères W, reacts with the carbon in the charged fuel and burns in the combustion zone C, generating the heat of the process and forming carbon-monoxide.

In ascending through the furnace, the carbon monoxide reacts with the various iron oxides of the burden constituents in zones B and X, reducing those oxides and transforming the carbon monoxide to carbon dioxide. The region X is generally one of preheating, reduction of iron oxides, and calcination of fluxing material. Calcination occurs when the flux, usually limestone, is heated sufficiently to drive off the carbon dioxide from the calcium carbonate of the limestone. The carbon dioxide gas thus liberated unites with the ascending gas mixture and passes through the stock column and out of the furnace. In region X the constituents of the charge are predominantly in a solid state. In region B, however, the solid constituents of the charge become molten as they pass downward through the hotter zone and drop into the furnace hearth, where the slag layer S forms above the iron layer I.

Region B is an important one for it is here where the gangue materials of the charge melt and unite to form slag. The ease of penetration and uniform distribution of gases passing through this region, the contact of the gases with the unreduced iron-oxides, and the rate of movement of material through the furnace, are greatly dependent upon the amount and physical characteristics of the slag formed.

The production of slag, although it be incidental to the production of metal, is important in that it sets a limit upon the chemical and thermal requirements of the process as a whole. The slag is formed by fusion of certain impurities in the materials charged into the furnace. In practically all cases, the chemical balance of impurities in the charged fuel and metal-bearing materials is such that the fusion of those impurities alone results in the formation of a slag whose properties are conducive neither to smooth and economic furnace operation nor to adequate desulfurization of the metal product. As a result, it is necessary to charge additional limestone material, known as flux, in such proportion as to form a slag whose properties will permit smooth furnace operation and chemically inhibit the inclusion of certain undesirable constituents in the metal product.

The common means of obtaining a properly fluxed slag is to charge the fluxing material, usually in the form of limestone or a similar calcareous material, into the top of the furnace in admixture with the carbon and ore wherefrom it descends into the hotter zones of the furnace and in the descent is first calcined to calcium oxide and then is melted.

A large proportion of the flux added at the top of the furnace is added solely for the pur-

pose of fusion with oxides of the coke ash. The nature of the blast furnace process is such that the greatest portion of the oxides in the coke ash is not available for fusion with the flux until the ash is liberated as the coke is burned at the tuyères.

The melted flux material has little or no effect upon the removal of deleterious constituents in the metal product until it is thoroughly fused with the molten oxides contained in the iron-bearing and fuel materials. This condition does not exist excepting in the slag bath which is located below the tuyères and in one of the lowest zones of the furnace. Indeed, the presence of this added flux material in furnace zones above that of the molten slag surface is essentially detrimental to the smooth and economic operation of the furnace for the following reasons:

1. The presence, in zones where it is not necessary to the successful operation of the process, of a large portion of calcareous fluxing material, either in a molten or solid state, is detrimental to the process in that it (*a*) impairs the contact of the unreduced metal-bearing materials with that of the gases, thus delaying the reduction of that material and (*b*) decreases the reducing power of the furnace gases as a result of a liberation from the flux of inert carbon dioxide gas which dilutes the gas mixture and makes less effective the strong reducing power of carbon monoxide.

2. The presence of a high lime (CaO) content flux in the higher fusion zones of the furnace results in the production, in those zones, of a slag whose melting temperature is considerably in excess to that of a slag formed from the fusion of the impurities of the charge other than those introduced by the fluxing material.

3. The smooth and economic operation of the furnace is impaired by the higher viscosity inherent with the higher lime content molten mixtures as exist before the fusion of the oxides of that slag with the more siliceous and aluminous oxides of the coke ash.

4. Experience has proved that the rate of iron production decreases when the slag formed is excessively limy, that is, excessively high in calcium oxide.

For reasons outlined above, the present invention proposes to add either part or all of the flux to the materials within the furnace in a manner and at a point in the furnace that will result in the elimination, to a great degree, of the disadvantageous conditions as outlined above.

We propose to accomplish this result by adding a calcined preheated fluxing material to the aggregate within the furnace F at a point below the normal fusion zone of the furnace by means of the apparatus illustrated in the drawing. We have determined that by adding the preheated calcium oxide to the charge in the furnace at a point below the normal fusion zone of the furnace the disadvantageous aspects associated with the higher lime content slags in the slag fusion zone of the furnace (zone B) may be eliminated without deleteriously affecting the elimination of sulfur in the blast furnace process, while at the same time increasing the reduction efficiency of the process and the capacity of the furnace.

The apparatus used to practice the process of the invention comprises an insulated container A into which a powdered preheated calcined flux material is charged at B. The flux material flows by gravity down the inclined bottom walls of the container A through outlet opening O into an aspirating chamber G. Preheated air obtained from a hot blast main by a pipe D is passed first through a compressor E which forces the air blast through the aspirator G. The fluxing material falling through opening O is carried by the stream of the air blast into one or more pipes P leading to the interior of the furnace F at a point (or points) below the normal fusion zone B.

Thus introduced, the preheated calcium oxide (calcined limestone) in finely divided form readily fuses and reacts with the impurities in the melting and melted charge to form a fluid slag overlying the molten metal I on the hearth of the furnace F. The oxygen content of the preheated gases from the hot blast main, augment the usual air blast supplied by tuyères W and increase the sensible heat energy being supplied to the furnace F.

Having hereinabove disclosed the present invention generically and given one specific embodiment of the same, it is believed apparent that the same may be widely varied without essential departure therefrom and all such modifications and adaptations of the same are contemplated as may fall within the scope of the accompanying claims.

What we claim is:

1. The method of reducing iron ores in a blast furnace which includes charging into the upper part of the furnace iron ore admixed with carbon, preheating finely divided calcinated limestone, blowing by preheated air the preheated finely divided calcinated limestone into the lower part of the furnace at a point below the normal fusion zone thereof but above the zone of molten material on the furnace hearth, regulating the introduction of the preheated air and the preheated finely divided calcinated limestone to produce stratification of the limestone in a layer immediately adjacent to and overlying the surface of the molten metal bath within the furnace hearth, and continuing the introduction of the preheated air blast and the preheated finely divided calcinated limestone until there has been introduced to the blast furnace a quantity of limestone approximately equivalent to that required by the ash in the carbon burned.

2. The method of reducing iron ores in a blast furnace which includes charging into the upper part of the furnace iron ore admixed with carbon, preheating finely divided calcinated calcareous fluxing agent, blowing by preheated air the preheated finely divided calcinated calcareous fluxing agent into the lower part of the furnace at a point below the normal fusion zone thereof but above the zone of molten material on the furnace hearth, regulating the introduction of the preheated air and the preheated finely divided calcinated calcareous fluxing agent to produce stratification of the said fluxing agent in a layer immediately adjacent to and overlying the surface of the molten metal bath within the furnace hearth, and continuing the introduction of the preheated air blast and the said fluxing agent until there has been introduced to the blast furnace a quantity of the latter which is approximately equivalent to that required by the ash in the carbon burned.

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