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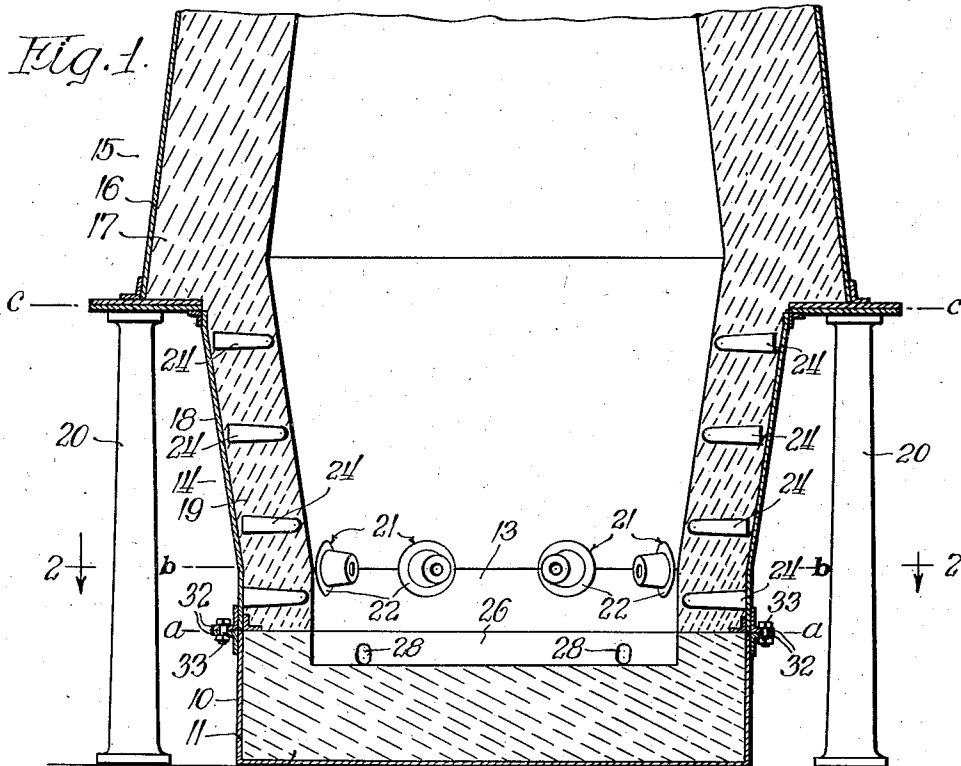
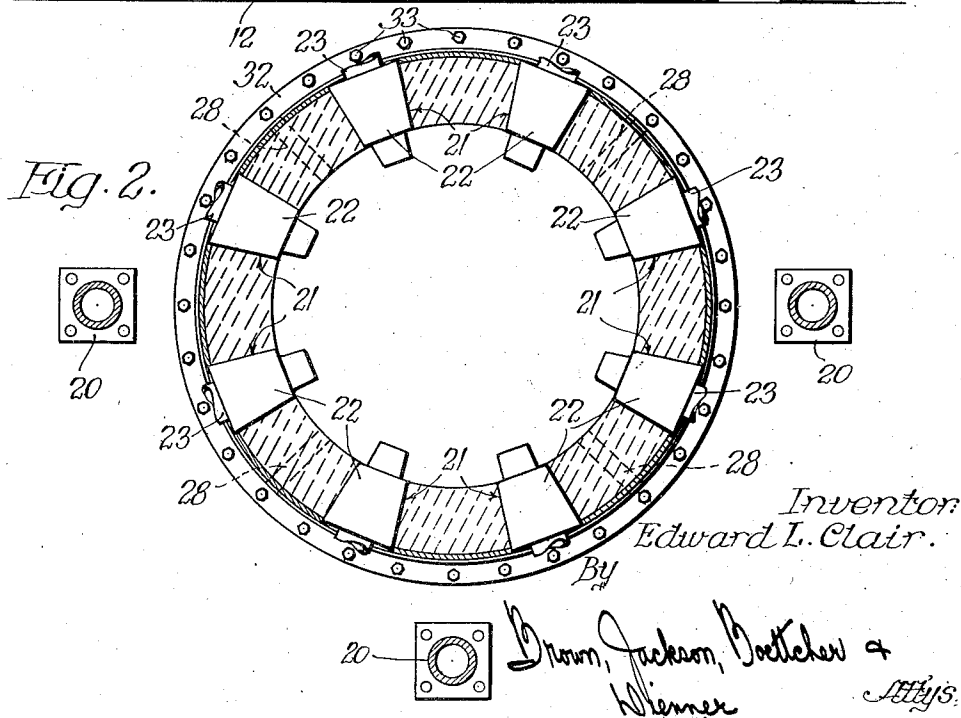
E. L. CLAIR

2,136,360

PROCESS FOR REDUCING IRON IN A BLAST FURNACE

Filed June 10, 1935

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 3.

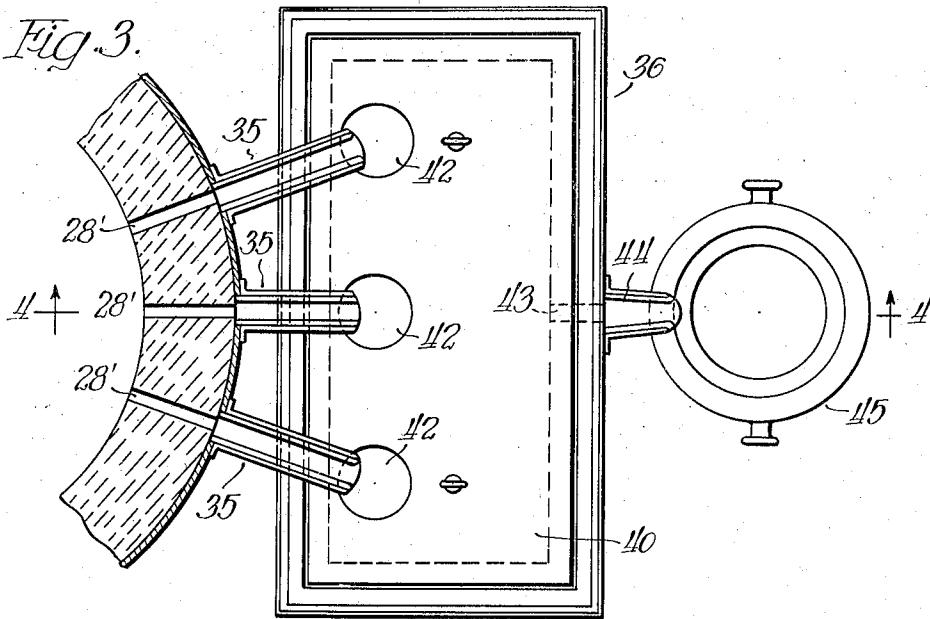
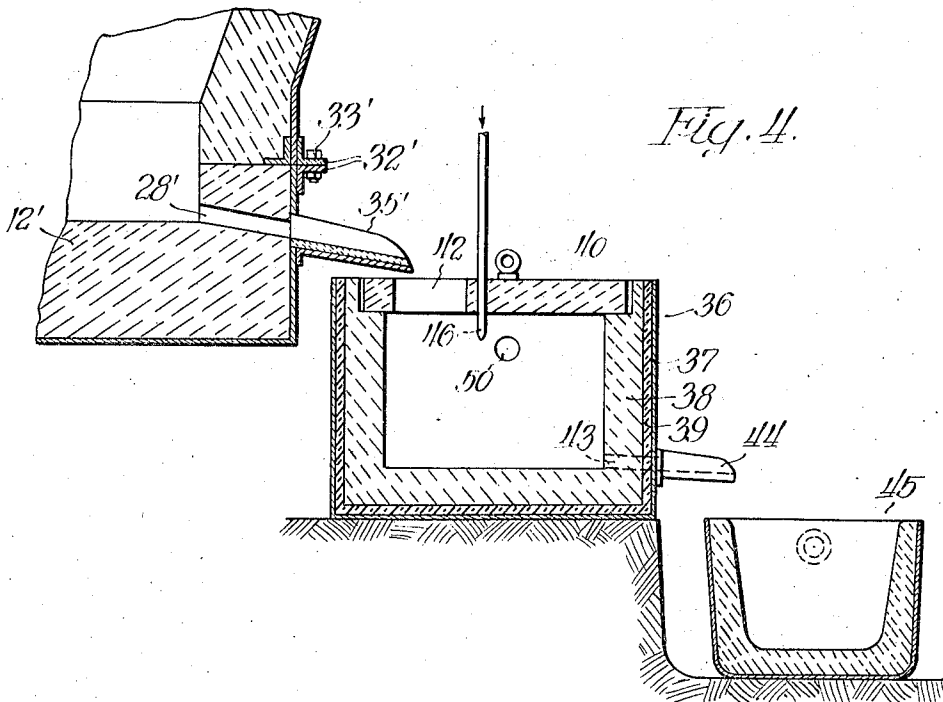


Fig. 4.

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UNITED STATES PATENT OFFICE

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PROCESS FOR REDUCING IRON IN A BLAST FURNACE

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5 Claims. (Cl. 75—41)

My invention relates to a metallurgical apparatus and process to be used for the purpose of producing low carbon pig iron, and, more particularly, to an improved blast furnace for this purpose.

The procedure followed in producing pig iron is to charge the stack or furnace to a point well up in the stack or to the stockline. The charge is made up of iron oxide or ore, solid fuel (usually coke), and limestone, dolomite, or other suitable flux. The air blast usually enters the furnace through copper water-cooled tuyères. The air, at a point very close to the tuyères, is converted into carbon monoxide (CO) and passes upward, reducing the iron oxide to an impure iron. The hearth and lower part of the bosh is filled with coke or other solid fuel at high temperature. As the process proceeds, the impure iron and slag in the molten form drips down through the column of coke at high temperature. The finished product, i. e., pig iron, collects in the hearth or crucible of the furnace, from where it is periodically tapped. The slag floats on the molten iron and is removed from the furnace at the same time the iron is tapped out and also between taps by draining it from the slag notch or "monkey".

During the descent of the molten iron through the high temperature coke, it absorbs carbon. And during the time intervals between tapping, the finished product collecting in the hearth is intimately mixed with the high temperature coke and continues to absorb carbon.

In the typical blast furnace the portion of the furnace below the tuyère zone, i. e., the hearth or crucible, is of a depth normally at least twice the depth of the tuyère zone portion of the furnace. And, in the typical furnace, this deep bottom or hearth portion contains a single iron notch for the removal of the iron and one or more suitable openings at a higher level in the furnace than the iron notch for the removal of the slag. It is customary in the typical blast furnace to open the single tap hole or iron notch and drain the furnace at regular intervals, commonly every four, five or six hours.

As a result of the deep hearth or crucible portion below the center line of the tuyères and the time intervals between tapping the finished product from the single iron notch, the production of pig iron in a typical blast furnace results in a type of pig iron containing approximately a total of four percent of carbon. This carbon content results in pigs having relatively great carbon segregation, which carbon segregation

makes the grain structure non-uniform and reduces the strength of the iron.

The object of the present invention is to provide an improved blast furnace and process for the production of iron of carbon content lower than is possible in a typical blast furnace and without treatment of the hot metal after it leaves the blast furnace.

According to its more specific aspects, the present invention attains the desired reduction in the amount of carbon contained in the iron product by reducing the duration of contact between the molten iron and the high temperature coke or other solid fuel. This reduction in the duration of contact between the molten iron and the high temperature fuel is attained, in turn, by substantially reducing the depth of the hearth or crucible, or eliminating the hearth or crucible entirely, and by eliminating the time intervals between tapping of the iron to provide for a practically continuous flow of the finished iron product from the furnace.

Another object is to construct the improved iron blast furnace so that the operation in the desired manner will be practically possible and successful, and, further, to apply to the improved iron blast furnace a type of construction that will make necessary repairs possible with facility and in a minimum of time.

Another object is to provide the furnace with a removable bottom detachably secured to the bottom of the tuyère zone. This will permit removal of the bottom section and substitution of another similar section or relining the removed section in order to facilitate repair and reduce the delay to a minimum.

Further objects and the features and advantages of the present invention will be apparent from the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary vertical sectional view through a blast furnace embodying the present invention;

Figure 2 is a horizontal section taken on the line 2—2 of Figure 1, with the tuyères in elevation;

Figure 3 is a fragmentary horizontal section through the bottom of a blast furnace embodying the present invention and showing an alternative arrangement of iron tapping holes and a fore-hearth for receiving the molten iron from the furnace; and

Figure 4 is a fragmentary vertical section taken on the line 4—4 of Figure 3, showing a

portion of the blast furnace, the fore-hearth, and a ladle for receiving the molten iron from the fore-hearth.

The blast furnace shown in the drawings comprises the bottom section 10 closing the bottom of the hearth or crucible of the furnace and consisting of a steel shell 11 lined with a refractory material 12. In the particular embodiment of the invention illustrated in the drawings the furnace has a bosh 14 in the form of an inverted frustum of a cone, but this may vary widely. The bosh 14 extends up generally to the line c-c at the belly or lower end of the conical stack 15.

The shaft, stack, or inwall 15 has a steel shell 16 provided with a refractory lining 17. The upper portion of the stack or inwall 15 is not shown, for it, in no manner, differs from the stack or inwall of a typical blast furnace. The bosh 14 has a steel shell 18 provided with a refractory lining 19. The overhanging lower portion of the stack 15 is supported upon four supporting posts 20 arranged equi-distantly around the lower portion of the furnace. The tuyère zone 13 has the proper openings 21 to permit inserting the tuyère coolers 22 and tuyères or tuyère nozzles 23 through which the blast of air under pressure is delivered into the furnace in the usual manner. The center line of the tuyères 23 is indicated by the line b-b. The bosh walls may be cooled by the typical arrangement of copper cooling plates 24, as well understood in the art.

The crucible or hearth 26, closed at the bottom by the bottom section 10, is of a depth substantially less than the depth of the hearths or crucibles heretofore employed. In the typical blast furnace prior to the present invention the hearth or crucible below the center line b-b of the tuyères is, as already pointed out, of such fixed depth that the normal result is a high rate of carbon absorption by the molten iron, whereas in the illustrated embodiment of the present invention the depth of the hearth or crucible 26 below the center line b-b of the tuyères is substantially less than prior practice so as to shorten the period of contact of the molten iron with the solid fuel in order to control the carbon content in the molten pig iron produced.

This radical reduction in the depth of the hearth or crucible substantially reduces the duration of contact between the molten iron and the high temperature coke or other solid fuel as the iron drips or descends down through the column of coke to the hearth or crucible 26. And this substantial reduction in the duration of contact between the molten iron and the coke reduces the amount of carbon absorbed by the iron, and thereby produces a lower carbon pig iron than possible heretofore.

The particular amount of reduction in the depth of the hearth or crucible may, of course, vary widely within the scope of the present invention and may, if desired, depend upon the character of the charge introduced into the furnace and the carbon content desired in the finished iron product.

The bottom section 10 is provided with two or more iron notches or tapping holes through which the molten iron is tapped from the bottom of the furnace. In the embodiment of the invention shown in Figures 1 and 2, four iron notches or tapping holes are shown at 28. The particular number and arrangement of these tapping holes may be varied within the scope of

the present invention. There are, however, preferably two or more of these holes, as distinguished from the single iron notch of the prior art. In Figures 1 and 2, the four tapping holes 28 are arranged equidistantly about the bottom of the furnace.

In operation, the iron is tapped from one iron notch 28 after another in such manner and at such times as will prevent undue wear or burning of any single notch 28 and, at the same time, permit of keeping the flow of iron from the furnace practically continuous. This practically continuous flow of iron from the furnace from one notch after another prevents prolonged contact between the molten iron and the high temperature coke or other fuel which, with the hearth or crucible reduced in depth or eliminated, further reduces the carbon content of the resulting pig iron. The holes 28 may be closed in any suitable or desired manner, as by means of a mud or clay gun as well understood in the art, and may be opened one after another in any suitable or preferred manner, as by drilling or by means of a sledge or bar, or by burning with a jet of oxygen.

With the plurality of iron notches or tapping holes 28 and the substantially continuous flow of iron from the furnace by tapping one hole 28 after another, the usual slag openings at a higher point in the furnace for the removal of slag may be eliminated. The slag is removed with the molten iron through the iron openings 28, and may be separated from the iron after removal of the same from the furnace. This removal of the slag from the molten iron may be accomplished in a fore-hearth or after-hearth by permitting the slag to collect upon the top of the molten iron and draining the same periodically therefrom.

By draining the finished molten iron practically continuously from the bottom of the furnace, as formed, from one tapping hole after another, undue wear or burning such as would result if it were attempted to tap the molten iron continuously from a single iron notch is prevented.

Due to the type of operation, the wear on the bottom of the furnace will be more severe than is commonly the case. The bottom section 10 is therefore made removable and is attached along the line a-a by means of angle brackets 32 and bolts 33 to the portion of the furnace immediately above the bottom section. This will permit removing the bottom section 12 and substituting another similar section or relining the removed section in order to facilitate the repair and reduce the delay to a minimum.

In the embodiment of Figures 3 and 4, only three iron tapping holes 28' are shown, and these holes are arranged in close proximity to deliver the molten iron through spouts 35 into a fore-hearth 36. The tapping holes 28' open through the bottom section 12' as in the preceding embodiment of the invention, and this bottom section 12' is removably attached by means of angle brackets 32' and bolts 33' to the immediately overlying portion of the furnace.

The fore-hearth 36 has a steel shell 37 provided with a refractory lining 38. A layer of insulation 39 is interposed between the shell 37 and the lining 38. The removable top 40, which is preferably formed of refractory material, has a plurality of openings 42, one beneath each of the spouts 35, so that as the molten iron is tapped from the respective holes 28' it will enter the

fore-hearth 36. At its opposite side, the fore-hearth 36 has an iron tapping hole 43 for delivering the molten iron from the fore-hearth through a spout 44 into a ladle 45 for transferring the iron to a pig molding or casting machine, or elsewhere, as desired.

For the purpose of heating the fore-hearth 36 to maintain the hot metal in liquid condition and against cooling to a thickened or pasty condition, the fore-hearth is provided with a suitable burner, indicated more or less diagrammatically at 46. This burner 46 is directed downwardly through the removable top 40 and upon the hot metal in the fore-hearth 36. The fuel for the burner 46 may be gas, oil, or powdered coal, coke or the like. In the illustrated embodiment of the invention, suitable gaseous fuel is delivered under pressure by means of a pipe-line connected to the burner 46. A suitable supply of air may be provided for the gas supplied to the burner. The fore-hearth 36 is provided with an opening 50 at a higher level than the iron tapping hole 43 for the removal of slag, or the slag which will float on the hot metal in the fore-hearth may be removed therefrom in any other suitable or preferred manner.

In the operation of the embodiment of the invention shown in Figures 3 and 4, the iron ore, coke, or other fuel, and limestone, dolomite, or other flux, are charged into the stack of the furnace as in the preceding embodiment, and the air blast enters the furnace through the copper water-cooled tuyères as shown in the preceding embodiment. As the process proceeds, the impure iron and slag in the molten form drip down through the column of coke at high temperature. The iron and slag are tapped from one tapping hole 28' after another to provide a practically continuous flow of iron and slag from the furnace and to prevent prolonged contact with the high temperature coke. The tapping holes 28' may be opened and closed one after another in the manner set forth in connection with the preceding embodiment of the invention, or in any other suitable or preferred manner.

Upon entering the fore-hearth 36, the iron and slag may remain there for a sufficient time to permit the slag to collect upon the top of the molten iron, all without increasing the contact of the iron with the high temperature coke or other fuel, and without further collection of carbon. Then, as already pointed out, the slag may be skimmed or drained from the slag notch 50 and the molten iron tapped out through the tapping hole 43 and into the ladle 45.

The type of construction and the degree of departure from the typical furnace, both as to depth of bottom and number of iron notches more than one, may be changed in my invention according to the character of the charge and the carbon content desired in the finished iron product. The particular character of the equipment

may be varied to suit the desired operation and the analysis of the iron to be produced.

I do not intend to be limited to the precise details shown or described.

I claim:

1. In the smelting of iron bearing ore in a blast furnace having tuyères for delivering a blast of air into the furnace, the improvement which comprises reducing the descent of the molten iron through the furnace below the center line of the tuyères to a distance substantially less than existing practice, and tapping the molten iron from the furnace at different locations one after another and in practically a continuous stream so as to shorten the period of contact of the molten iron with the solid fuel in the furnace in order to control the carbon content in the molten pig iron produced.

2. In the smelting of iron bearing ore in a blast furnace having tuyères for delivering a blast of air into the furnace, the novel step which comprises tapping the molten iron from the furnace at different locations one after another and in practically a continuous stream so as to shorten the period of contact of the molten iron with the solid fuel in the furnace in order to control the content of carbon in the molten pig iron produced.

3. In the smelting of iron bearing ore in a blast furnace having tuyères for delivering a blast of air into the furnace, the improvement which comprises controlling the depth of descent of the molten iron through the furnace below the center line of the tuyères so as to control the period of contact of the molten iron with the solid fuel in the furnace and thereby control the carbon content in the molten pig iron produced.

4. In the smelting of iron bearing ore in a blast furnace having tuyères for delivering a blast of air into the furnace, the improvement which comprises controlling the depth of descent of the molten iron through the furnace below the center line of the tuyères so as to control the period of contact of the molten iron with the solid fuel in the furnace and thereby control the carbon content in the molten pig iron produced, and tapping the molten iron from the furnace at different locations one after another and in practically a continuous stream.

5. In the smelting of iron bearing ore in a blast furnace having tuyères for delivering a blast of air into the furnace, the novel step which comprises tapping the molten iron from the furnace at different locations one after another generally circumferentially about the furnace and in practically a continuous stream so as to shorten the period of contact of the molten iron with the solid fuel in the furnace in order to control the content of carbon in the molten pig iron produced.

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