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REDUCTION AND SMELTING OF ORES

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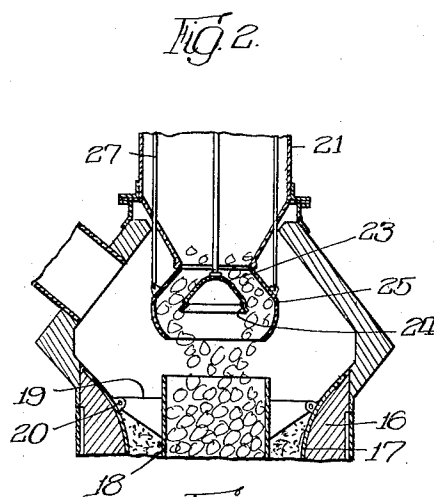
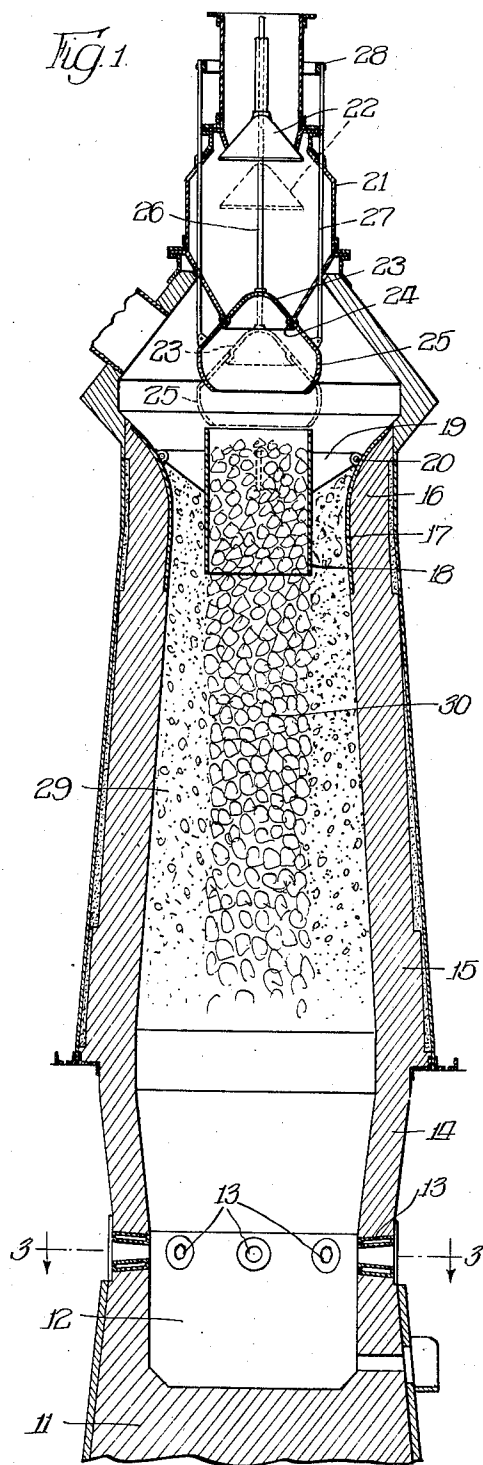


Fig. 3.

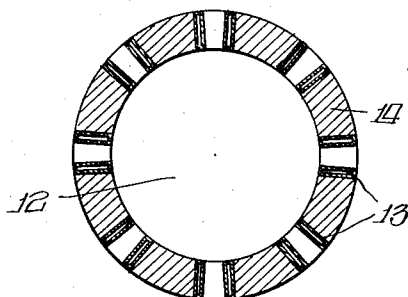


Fig. 4.

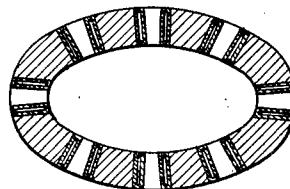
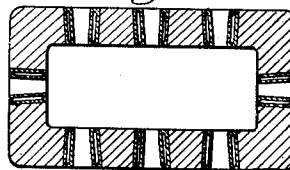


Fig. 5.



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REDUCTION AND SMELTING OF ORES

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11 Claims. (Cl. 75—17)

This invention relates to the reduction and smelting of ores, particularly iron ores, and more particularly to the production of a metal low in carbon and at the same time the provision of a material saving in fuel consumption and cost.

In the usual blast furnace operation the fuel is metallurgical coke. The coke is charged with the ore and flux stone in layers or more or less intimately mixed. As a result of its size and the universally adopted method of feeding the charge into the furnace by means of a large bell, the coke travels largely to the center of the furnace, the fine ore mostly remaining around the periphery next to the walls. This results in a cone of coke forming in the center of the hearth extending upward into the bosh and lower stack, particularly with the large hearth diameter now in common use. The oxygen of the blast, in the form of O or CO₂, does not reach more than a few feet into the interior. Consequently a dead center is created in the hearth and the presence of this mass of coke in contact with the bath of molten iron which collects in the hearth causes the iron to saturate itself with carbon. The release of coke ash in the molten metal is also a detriment. Another disadvantage is the reduced production per unit of hearth area of the larger furnaces. Another objection to the blast furnace using coke as a fuel in the ordinary manner is that the coke although, in good practice, less than one half the weight of ore occupies roughly five times the volume in the furnace, which has necessitated the construction of large and high stacks to obtain the capacities required by modern practice.

I materially overcome these objections by my invention, an object of which is to produce a metal low in carbon direct from the ore. A further object is to reduce the size of the blast furnace for a given output. It is also an object to separate and use each size of ore to its best advantage in the reduction and melting process. It is an additional object to enable the use of other fuels than blast furnace coke of the usual size and quality. It is a further object to decrease radiation losses. It is also an object to enable the use of very high blast temperatures. Another object is to substitute reduced ore or so-called sponge iron for coke in the center areas of the hearth. It is a further object to reduce a column of ore substantially free from fines with CO gas in the absence of reactive carbon. A still further object is to reduce the ore fines by direct reduction substantially removed from the current of ascending gases, thus largely preventing flue

dust losses and carbon deposition on the ore. Other and further objects will appear as the description proceeds.

In order to accomplish these objects, I have invented a new method of blast furnace operation which consists in dividing the ore into coarse and fine, and charging them separately and charging a smaller fuel than the present blast furnace coke with the fines and placing them next to the wall, whereas the coarse ore I place, preferably without fuel, in the center of the furnace. The flux stone may be divided between the two columns and sized accordingly.

I have shown in the accompanying drawing one form of apparatus adapted for carrying out my invention.

In the drawing,

Figure 1 is a vertical section of a blast furnace;

Figure 2 is a fragmentary section of the top of the furnace, showing the charging bells in a different position;

Figure 3 is a section taken on line 3—3 of Figure 1;

Figure 4 is a view similar to Figure 3, showing a modified form of construction; and

Figure 5 is a view similar to Figure 3, showing a further modified form.

The blast furnace shown in Figure 1 comprises a base 11, hearth 12, tuyère coolers 13, bosh 14 and shaft section 15. The upper portion of the shaft is shown as flared outwardly at 16, above the normal stack line and protected by the stack line plates 17. A charge distributing tube 18 is suspended in the upper portion by the arms 19 connected to the plates 17 at 20.

The charging hopper 21 is supported on top of the furnace and its upper end is closed by the small bell 22. The lower end of the hopper 21 is closed by the lower bell 23 which has a peripheral flange 24 underlying the upper edge of the distributing hopper 25. The bell 23 is raised or lowered by the rod 26 while the distributing bell 25 is operated by rods 27 which are shown connected to yoke 28. In Figure 1, the positions of the bells 23 and 25, when both are lowered are shown in broken lines. In Figure 2 the bells are shown in the relative positions which they assume when the bell 23 only is lowered. The fine material adjacent the wall is shown at 29 and the core of coarse material at the center is shown at 30.

The furnace may be circular in cross section as shown in Figure 3, or oval in cross section as shown in Figure 4 or it may be rectangular in cross section as shown in Figure 5.

In the use of the furnace the fine ore and the fine fuel are placed adjacent the walls of the furnace and some fine flux material may be placed with them. This is accomplished by placing the fine charge in the hopper 21 and then simultaneously lowering both bells 23 and 25 to the broken line position of Figure 1. The angle of the upper face of the bells causes the fine material to flow outwardly against the furnace wall and the distributing tube 18 and the lower portion of the bell 25 prevent these fines from flowing from the wall to the center.

In charging the coarser material, the hopper 21 receives the charge and then the small bell 23 only is lowered. The coarse material then flows over this bell against the inside of the bell 25 which returns the material toward the center and into the tube 18.

By placing my fines with the preferably small sized fuel next to the walls, I prevent the current of gas from ascending adjacent to the walls, forcing them up through the column of relatively coarse ore in the center. By coarse ore, I mean ore from which fines have been removed and of such a size that the column will be permeable to the flow of gas without excessive pressure. The lower the furnace the smaller the size of coarse ore that can and should be used, because the lower height means less resistance and smaller sizes require less time for reduction, providing the column is kept permeable to the gases through the absence of fines. By keeping the gases away from the ore fines descending next to the wall, I keep the wall areas cool, decrease radiation and flue dust losses and at the same time my method tends to prevent the dangerous reaction of CO in the ascending gases in presence of iron oxide, depositing molecular carbon in these fines next the wall and forming CO₂, this carbon deposition having been the cause of many destructive explosions.

The fine ore is charged mixed with the fuel, which may consist of small sized coke, pea coke or screenings, or it may consist, all or in part, of correspondingly sized preferably non-coking coal. In any case sufficient fuel is charged with the fine ore to reduce it by direct reduction. Additional fuel may be injected through tuyères into the hearth to furnish additional heat required for melting and/or any additional CO required for reducing the center column of coarser ore. Or a deficiency of carbon in the melting zone may be made up by adding coke or other slow reacting fuel to the ore charges.

While some of the carbon charged with the ore fines will be absorbed during the descent in reduction of ore, the balance will arrive in front of the tuyères, preheated by radiation and convection from the hotter-interior of the furnace. I employ a highly heated blast, preferably above 1600° F. which accelerates combustion and combined with the higher reactivity and the relatively large carbon surfaces offered by the smaller fuel charged, as compared to blast furnace coke, which is both hard and large, shortens and intensifies the zone of combustion, producing also a maximum of CO gas within a given zone. The heat thus created will rapidly melt the reduced and highly preheated ores descending in the center. There being no carbon masses in the center, the melted iron will remain low in carbon. If a small carbon content is desired in order to obtain desirable fluidity of the metal, the same may be derived from additional fuel charged at the top or admitted through the tuyères. If on the other

hand a very low carbon melt is desired the ratio of the fuel charged at the top to the total fuel is decreased, additional heat or fuel being supplied through tuyères.

To carry out my invention I can use the ordinary blast furnace now in common use, or I may use the type of furnace described in co-pending applications, Ser. No. 549,722 filed July 8, 1931 and Ser. No. 553,250 filed July 27, 1931, particularly if a considerable proportion of fuel injected at the bottom is used. Or I may use a furnace of oval or rectangular shape, as shown in Figures 4 and 5 in which case there is the advantage of carrying the heat of combustion further in toward the center. It has been found that with the use of small fuel and highly preheated blast that the zone of combustion becomes very limited in extent and the highest temperatures will not prevail beyond approximately 12 inches from the tuyères. It is therefore desirable to reduce the distance between opposing tuyères in order to obtain as high a temperature as possible in the center of the hearth where the melting of the iron sponge takes place. In a furnace having a circular cross section this can only be accomplished by decreasing the hearth diameter which in turn involves a bosh with a flat angle. This is objectionable owing to the tendency of the fine materials to hang up on the bosh walls. If the furnace is rectangular or oval opposing tuyères may be brought closer together without requiring a flat bosh or any bosh at all. In any case my furnace for the same rate of output will not be nearly as large as the present blast furnace.

Various changes may be made in carrying out my invention, as for example some iron or steel scrap may be added to the ore as is done in blast furnace practice in order to increase the output or melt up cheap materials of that character which may be available.

The furnaces shown in the accompanying drawing and the method of operation described are to be understood as illustrative only as the method may be carried out in other furnaces and the method may be varied to meet different conditions and requirements and I contemplate such changes and modifications as come within the spirit and scope of the appended claims.

I claim:

1. The method of producing a metal of low carbon content from iron ores in a single shaft furnace operation which comprises reducing the coarser portion of the ores with carbon monoxide gas produced in the hearth and bosh of the furnace and the finer portion by direct reduction with carbon monoxide formed in direct contact with the ore from solid carbon charged with the ore.

2. The method of producing a metal of low carbon content from iron ores in a single shaft furnace operation which comprises reducing the coarser portion of the ores with carbon monoxide gas produced in the hearth and bosh of the furnace and the finer portion by direct reduction with solid carbon charged with the ore and melting the two portions together.

3. The method of producing a metal of carbon content below two per cent from iron ores in a single shaft furnace operation which comprises reducing the coarser portion of the ores with carbon monoxide gas produced in the hearth and bosh of the furnace and the finer portion by direct reduction with carbon monoxide formed in

direct contact with the ore from solid carbon charged with the ore.

4. The method of producing in a shaft furnace a metal low in carbon from iron ores which comprises separating the ore into coarser and finer ore portions, thereafter separately charging small fuel mixed with the finer portion of the ore into the vertically extending portion of the furnace adjacent the walls, charging the coarser ore substantially free of fuel into the vertically extending central portion of the furnace, and reducing and smelting both coarse and fine ores in a single furnace operation.

5. The method of producing in a shaft furnace a metal low in carbon from iron ores which comprises separating the ore into coarser and finer ore portions, thereafter separately charging small coal mixed with the finer portion of the ore into the vertically extending portion of the furnace adjacent the walls, charging the coarser ore substantially free of fuel into the vertically extending central portion of the furnace, and reducing and smelting both coarse and fine ores in a single furnace operation.

6. The method of producing in a shaft furnace a metal low in carbon from iron ores which comprises separating the ore into coarser and finer ore portions, thereafter separately charging coke braize mixed with the finer portion of the ore into the vertically extending portion of the furnace adjacent the walls, charging the coarser ore substantially free of fuel into the vertically extending central portion of the furnace, and reducing and smelting both coarse and fine ores in a single furnace operation.

7. The method of charging a blast furnace which comprises placing ore fines and fuel adjacent the furnace wall and placing the coarser ore substantially free of fuel in the center of the furnace.

8. The method of charging a blast furnace

which comprises first separating the coarser ores from the finer ores, mixing fuel with the fine ores, then charging them separately into the furnace stack, the finer ores adjacent the furnace walls and the coarser ore substantially free of fuel in the center of the furnace.

9. The method of reducing carbon deposition on the ore fines descending in a shaft furnace which comprises charging the ore fines with the fuel in one vertically extending section of the furnace, charging the coarse ores substantially free of fuel in a separate section of the furnace, causing them to descend through said section in countercurrent movement to the gases ascending in said section, and reducing and smelting the ores in the furnace.

10. The method of producing a low carbon melt of iron in a shaft furnace which comprises charging coarser ores in one vertically extending portion of the furnace, collecting such coarser portion of the reduced and melting ores in one portion of a furnace hearth in the absence of substantial amounts of carbon, bringing the balance of the ores down mixed with carbon in another vertically extending portion of the furnace and simultaneously reducing and smelting both the coarse and fine ores.

11. The method of producing a low carbon melt of iron in a shaft furnace having tuyères which comprises charging the coarser portion of the ores in the vertically extending central portion of the furnace, collecting such portion of the reduced and melting ores in the center of a furnace hearth in the absence of substantial amounts of carbon, charging the balance of the ores mixed with carbon around the periphery of the furnace and bringing them down at the periphery of the hearth and in front of the tuyères, and simultaneously reducing and smelting both the coarse and fine ores.

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