

Nov. 1, 1932.

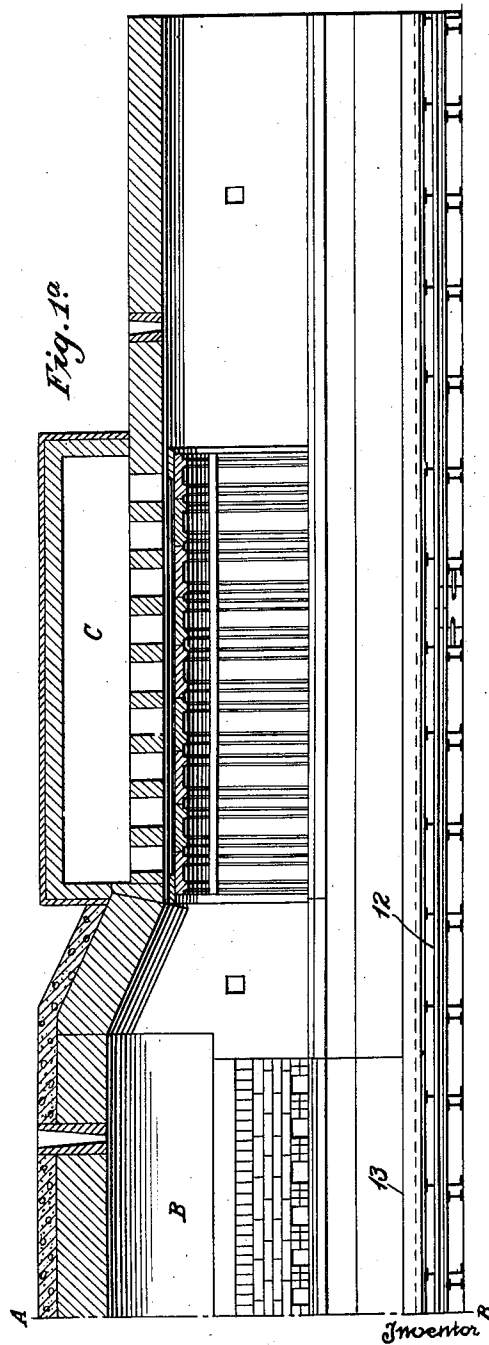
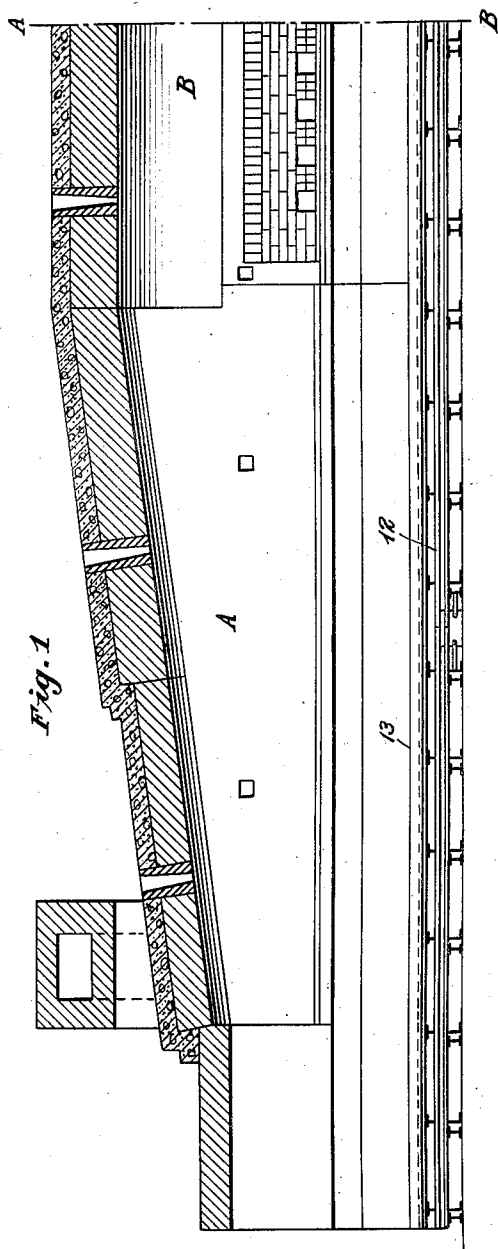
K. M. SIMPSON

1,885,381

PROCESS FOR THE PRODUCTION OF IRON

Filed June 30, 1930

2 Sheets-Sheet 1



Inventor
Kenneth M. Simpson

By *Bracour & Jones*
Attorneys

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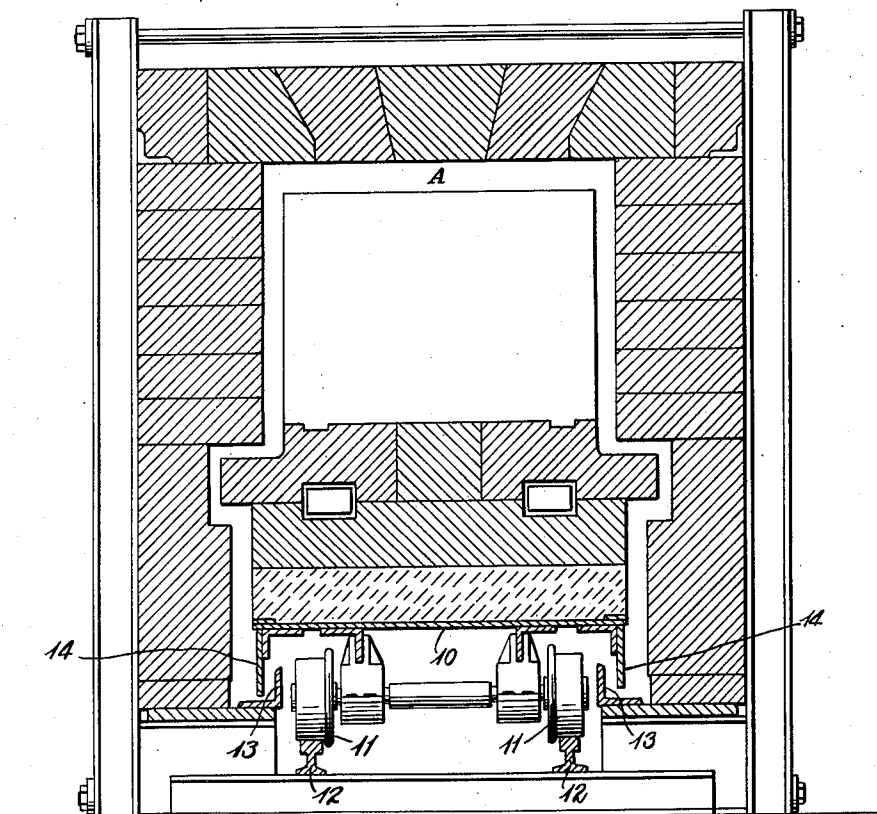
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Fig. 2.



Inventor

Kenneth M. Simpson

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Bacon & Shonka

Attorneys

UNITED STATES PATENT OFFICE

KENNETH M. SIMPSON, OF NEW YORK, N. Y.

PROCESS FOR THE PRODUCTION OF IRON

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My invention relates to a process for the production of iron and pertains more particularly to a process of smelting iron from its ores at the lowest practical temperature at which the metal can be completely melted and obtained directly from its ore in a congealed or solid form.

In the production of iron from its ores according to present processes of manufacture, the smelting operations are carried out under conditions which make difficult the control of an economical operating temperature and to this extent are quite wasteful. Under the usual processes for smelting iron ore, it is extremely difficult to control to any great extent the introduction of large amounts of impurities into the final product. My invention deals with a process for the production of iron whereby an accurate and economic temperature control is possible and a great portion of the impurities hitherto encountered are eliminated from the final product. The process of my invention also contemplates a clean-cut separation of impurities from the metal, the impurities separating as slag during the fusing of the metal, both slag and metal being cooled to a congealing point before being separated. Separation of the slag and metal may be effected after withdrawal by physical methods.

My invention contemplates a process for the production of iron directly from its ores. In carrying out my process, I utilize a tunnel kiln the character of which is such that the ore is passed through a reduction zone, then through a maximum heating zone in which the reduced metal is melted, being then drawn through a zone in which the charge is cooled to solidify the same, the temperature of the charge at the exit of the cooling zone being sufficiently low to permit easy handling of the charge.

Tunnel kilns are easy to operate dispensing with the necessity of continual careful supervision of expert manipulators. The

temperatures of a tunnel kiln can be controlled very accurately with a minimum of trouble and expense. A type of tunnel kiln used is shown in the accompanying drawings.

Referring particularly to the drawings:

Figures 1 and 1a represent a longitudinal sectional view of a tunnel kiln of the type used in my process;

Figure 2 represents a transverse sectional view of the same showing in position therewith one of the cars carrying the charge of ore to be treated, which is used in connection with the tunnel kiln.

The kiln or furnace has been shown generally as divided into zones A, B, and C. A represents the initial heating zone; B represents a central heating zone in which a maximum temperature is maintained sufficient to effect fusion of the reduced metal; and C represents a cooling zone in which the charge is gradually cooled as it leaves the central fusion zone, being removed from the exit end of the kiln or furnace at a temperature about that of room temperature.

The tunnel kiln cars indicated at 10 upon which the ore to be reduced is placed, are provided with wheels 11 adapted to run along rails 12 which are positioned on the kiln floor. A sand seal or equivalent seal is maintained between the cars and the kiln wall by means of flanges 13 and 14 which cooperate to hold the heat insulating sand. The sand seal so formed retains the heat within the upper portion of the kiln and enables the car wheels to operate under low temperature conditions unaffected by the high temperatures within the kiln.

In the process of my invention, the iron ore and the reducing agent, usually a carbonaceous material such as coal, is loaded on the individual cars which are successively passed into and from the kiln furnace. The cars having the ore to be treated, together with a reducing agent loaded thereon, are heated progressively as they pass through the kiln, pass-

ing through temperature ranges within which the reduction of the ore is probably completed, and is then successively heated to a temperature in the central portion of the kiln sufficient to fuse the reduced iron. The charge is maintained at the fusion temperature for a length of time such that the reduced metal is completely fused to a fluid state after which it is withdrawn from the maximum heating zone and subjected successively to decreasing temperatures, the fused metal solidifying and reaching the exit portion of the kiln at approximately room temperature. The gangue and similar impurities separate by gravity from the fused metal during the fusing step, and after the charge is withdrawn from the kiln may be separated from the metal easily by physical methods.

A preferred form of my invention is as follows:

A suitable iron ore is mixed with a quantity of reducing agent and is placed upon the tunnel cars 10 which are provided with small, open hearths of the size approximately one foot in width, three feet in length, and six inches in depth. A suitable lining to resist the action of the molten iron is provided in the hearths. The hearth is preferably designed to hold a charge of about 125 pounds of mixed ore and coal, the charge consisting of about 100 pounds of ore and about 20 to 25 pounds of anthracite coal which is preferably ground. Forms of carbon other than coal may be used as is understood by the art. The cars are passed into the kiln successively, one each hour, a car being withdrawn from the exit end of the kiln and being replaced at the entrance end by another car. The cars within the kiln, together with the charge thereon, are moved forward likewise every hour, the charge on the cars undergoing a successive increase in temperature from the entrance of the kiln to the maximum heating zone where the temperature is maintained at approximately 2800° F. The time to which the charge is subjected to a maximum temperature is sufficient to reduce it to a completely fluid state. The cars pass from the maximum heating zone to the cooling zone where they undergo successive cooling being congealed and solidified long before reaching the exit portion of the kiln.

The kiln is designed preferably to cool the cars to approximately room temperature at the point in which they are withdrawn from the kiln.

It will be seen from the above discussion of my process, that I have effected in an efficient and simple manner the direct production of iron from its ores. In addition to maintaining the process as continuous or semi-continuous, I am enabled by virtue of the accurate control of temperature possible in tunnel kiln operations, to control the amount of heat necessary to perform the required

smelting. This gives great heat economy. In addition, it is possible by regulation of the maximum temperature to which the reduced metal is subjected, to prevent the absorption of large quantities of undesirable impurities into the fluid metal. The temperature at which the iron is melted may be maintained at a minimum to prevent the solution in the iron of substances which would diminish its purity and its desirability as a commercial quality. It will readily be seen that a metal of a high degree of purity may be obtained due to temperature regulation, the solid impurities separating as slag from the fused metal by a difference of specific gravity, the congealed reduced charges withdrawn from the furnace then being treated by physical methods to remove the layer of slag from the metal.

I claim as my invention:

1. A process for the production of iron from its ores which comprises passing a charge of ore in the presence of an amount of reducing agent sufficient to reduce the ore, into a zone in which reducing temperatures are maintained, holding the charge at reducing temperatures until substantial reduction has taken place, then introducing the charge so reduced into a zone in which the temperature is maintained sufficiently elevated to effect fusion of the reduced metal, holding the charge in said zone until the metal in the charge is reduced to a fluid state, then withdrawing the charge into a zone which is maintained at temperatures lower than the fusion point of the metal, the charge being maintained in said last named zone until it solidifies.

2. A process for the production of iron from its ores which comprises passing a charge of iron ore, together with an amount of carbonaceous material sufficient to completely reduce the ore, into a zone in which reduction temperatures are maintained, holding the charge at such reduction temperatures until the ore is substantially reduced, then introducing the charge into a second zone the maximum temperature of which is higher than the fusion point of the metal, holding the charge in said zone for a period of time such that the metal is reduced to the fluid state, withdrawing the charge from said second heating zone into a zone in which the temperatures are successively decreased from the temperature of the second zone to a point below that at which the metal solidifies, holding said charge in said last named zone until it has congealed, and passing the charge through said last named zone with successively decreasing temperatures until it has sufficiently cooled, then withdrawing the charge from said last named zone.

3. A process for the production of iron from its ores which comprises passing a charge of the ore, together with an amount

of reducing agent sufficient to completely reduce the ore, into an initial heating zone, passing the charge through said heating zone at successively increasing temperatures until
 5 reduction temperatures are attained, holding the charge at such reduction temperatures until it is substantially reduced, further increasing the temperature of the charge, withdrawing the charge from said initial
 10 heating zone into a second zone in which a temperature higher than the fusion point of the metal is maintained, holding the charge in said second zone until the reducing metal has been converted to the fluid state, with-
 15 drawing the charge so treated from the second zone into a cooling zone, passing the charge through said cooling zone with successively decreasing temperatures until the metal solidifies, continuing the passage of
 20 said charge through said zone with decreasing temperatures until it has sufficiently cooled, then withdrawing the charge from said last named zone.

4. A process for the production of iron
 25 from its ores which comprises passing a charge of ore, together with an amount of reducing agent sufficient to completely reduce the metal from the ore, into a reduction zone in which the temperatures are maintained
 30 sufficiently elevated to effect reduction, holding the charge in said zone until the ore is sufficiently reduced, introducing the charge into a fusion zone in which the temperature is maintained higher than the fusion point
 35 of the reduced iron, but not greatly in excess thereof, holding the charge in said zone for a period sufficient to convert the reduced iron to a fluid state, then withdrawing the charge to a cooling zone in which the charge is main-
 40 tained at a temperature lower than the fusion point of iron for a period of time sufficient to effect the solidification of the metal.

5. A continuous process for the production
 45 of iron from its ores in which the ore to be treated is passed successively in the form of individual charges, together with a reducing agent sufficient in amount to cause complete reduction of the ore, into a reduction zone,
 50 retaining the individual charges in said zone until the ore is substantially reduced, successively passing the charges from the reduction zone into a fusion zone wherein they are retained sufficiently long to fuse the reduced
 55 metal, then introducing the charges successively into a cooling zone wherein the charge is retained for a period sufficient to cause solidification of the reduced metal, each charge which is removed from the exit of
 60 the cooling zone being replaced by a fresh charge of ore and reducing agent at the entrance of the reduction zone.

6. A continuous process for the production
 65 of iron from its ores which comprises successively passing individual charges of the

ore to be treated, together with an amount of reducing agent sufficient to effect complete reduction of the ore, into an initial heating zone, passing the individual charges through
 70 the initial heating zone with progressively rising temperature until a reduction temperature is reached, retaining the individual charges in the initial heating zone for a period of time to effect sufficient reduction of
 75 the ore, withdrawing the individual charges successively into a second heating zone having a temperature therein higher than the fusion point of the iron, retaining the charges in said second zone until the reduced iron is
 80 converted to the fluid state, successively withdrawing the charges into a cooling zone, passing the charges through said last named zone with progressively decreasing temperature until a temperature lower than the fusion
 85 point of the reduced iron is reached, holding the charges at temperatures lower than the fusion point until the metal solidifies, continuing the passage of the charges through said zone with progressively decreasing
 90 temperature for a period of time sufficient to cool the charges to the desired temperature, removing the individual charges successively from said last named zone, the charges so removed being replaced at the entrance end of the initial heating zone by
 95 charges of fresh ore and reducing agent.

7. A process for the production of iron
 100 from its ores which comprises passing successive unit charges of iron ore and a reducing agent through a longitudinal kiln, the maximum temperature of which is above the fusion point of the reduced iron, the entrance and exit temperatures of the kiln being main-
 105 tained at approximately room temperature, progressively increasing the temperature of the kiln from its entrance to a central heating zone at which the maximum temperature prevails, and progressively decreasing
 110 the temperature of the kiln from the central heating zone to the exit temperature.

8. A process for the production of iron
 115 from its ores which comprises passing successive unit charges of iron ore and a reducing agent through a longitudinal kiln, the maximum temperature of which is above the fusion point of the reduced iron, the entrance and exit temperatures of the kiln being main-
 120 tained at approximately room temperature, progressively increasing the temperature of the kiln from its entrance to a central heating zone at which the maximum temperature prevails, and progressively decreasing the temperature of the kiln from the central heating
 125 zone to the exit temperature, and maintaining the charges within the central heating zone for a sufficient period of time to completely fuse the reduced metal.

In testimony whereof I affix my signature.
 KENNETH M. SIMPSON.