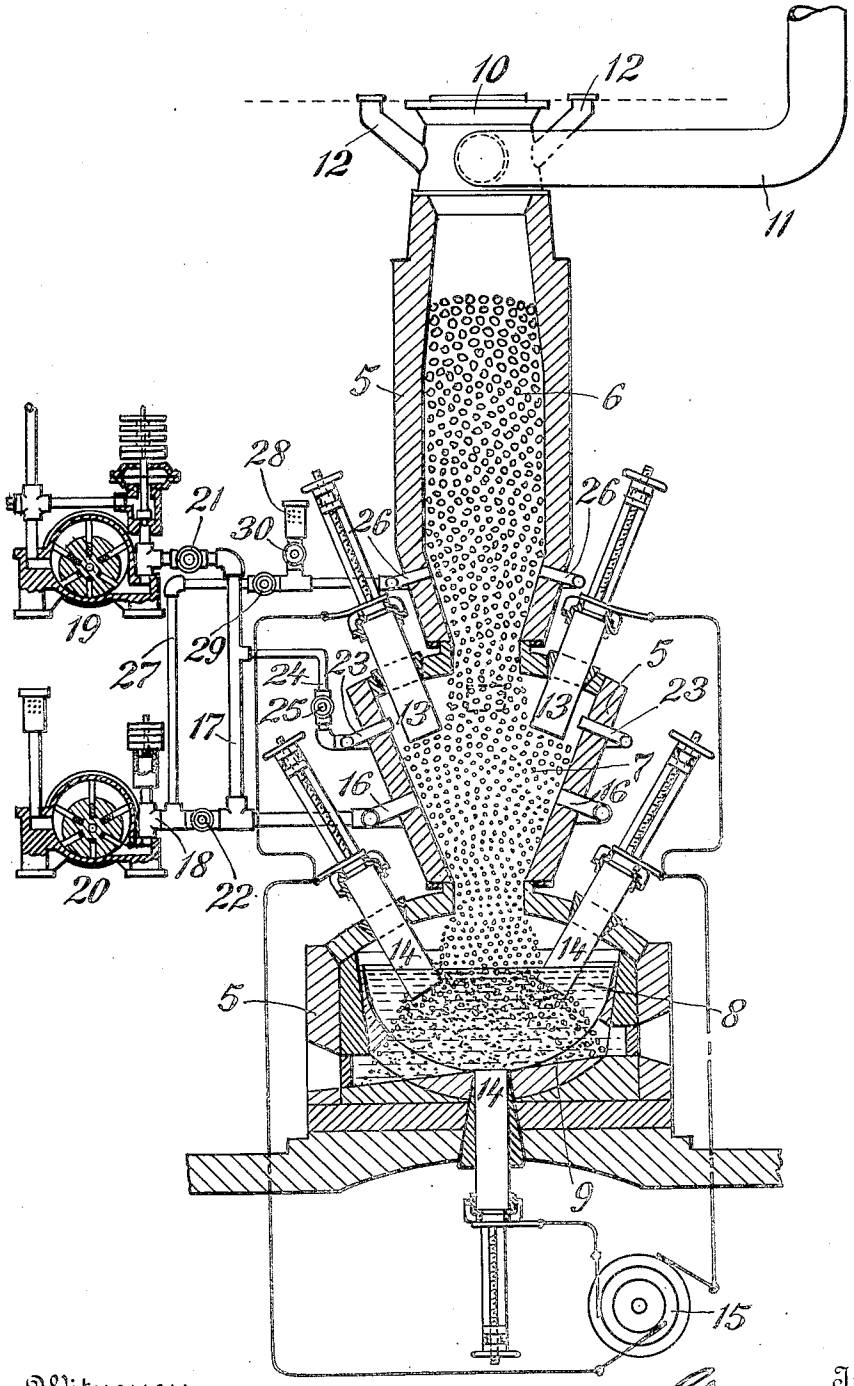
G. H. BENJAMIN.

ELECTRIC FURNACE AND METHOD OF OPERATING SAME.

APPLICATION FILED APR. 9, 1912.

1,057,213. Patented Mar. 25, 1913.



Witnesses:
Helen E. Dolloch
Eli S. Weill

Inventor,
Geo. H. Benjamin

UNITED STATES PATENT OFFICE.

GEORGE HILLARD BENJAMIN, OF NEW YORK, N. Y.

ELECTRIC FURNACE AND METHOD OF OPERATING SAME.

1,057,213. Specification of Letters Patent. Patented Mar. 25, 1913.

Application filed April 9, 1912. Serial No. 689,503.

To all whom it may concern:

Be it known that I, GEORGE HILLARD BENJAMIN, a citizen of the United States, residing at New York city, in the county and State of New York, have invented certain new and useful Improvements in Electric Furnaces and Methods of Operating Same, of which the following is a specification.

My invention relates to furnaces especially adapted for the reduction of iron ore.

The object of my invention is to effect the reduction of iron ore by reducing the amount of carbon and flux employed and the time required in reduction, thus lessening the cost.

The accompanying drawing, which is in a sense diagrammatic, will serve to illustrate my invention.

The drawing illustrates a furnace and other parts to be used in connection therewith, in vertical section.

I wish it understood that the drawing is diagrammatic and only intended to convey an idea of such a construction as may be used to carry the invention into effect, and is not intended to illustrate details of construction.

Referring to the drawing: 5 indicates the furnace structure, which is divided into three chambers—6, heating chamber; 7, reducing chamber; 8, refining chamber, these chambers being superposed one upon the other. The chambers are shown as circular in horizontal section and increasing in diameter from above downward. The heating chamber 6 has its interior cavity increasing in diameter from the top to a point near the bottom, and then decreasing in diameter from such point to the point where the lower end of this chamber communicates with the top of the reducing chamber. The reducing chamber 7 has its interior decreasing in diameter from the top to the bottom, and the refining chamber 8 has its interior decreasing in diameter from above downward, the bottom or hearth 9 being substantially concave.

The purpose of arranging the interiors of the furnace as described is to provide that the material fed into the furnace shall move freely downward, through the heating chamber 6, and through the reducing chamber 7 on to the hearth of the refining chamber 8, without exerting any appreciable pressure upon the electrodes.

10 represents an opening through which the charge may be introduced into the furnace, and 11 a flue through which the gases rising through the chamber 6 may be conveyed away from the furnace.

12 indicates gas testing openings.

Arranged in the reducing chamber 7, are electrodes 13. But two electrodes are shown. Manifestly more than two may be employed; that is, I may use two electrodes in series and transmit through them a direct current; or three electrodes, and transmit a three phase current. I do not limit myself in any wise to the arrangement or number or character of electrodes or the nature of the current transmitted. The arrangement of the electrodes relative to the material acted upon in the chambers 7 and 8 I prefer to be such that the heating and other effects will be due not only to the resistance of the material acted upon, situated between the electrodes, but to arcs formed between the several electrodes and the material acted upon.

In practice I have found that so far as heating effects are concerned, the temperature due to resistance is satisfactory, but to effect volatilization, as for instance volatilization of sulfur, the best results are obtained through the use of arcs. Such arcs may be formed between the individual electrodes and the material acted upon, or between the electrodes and the overlying fluxes. Arranged in the refining chamber 8, are electrodes 14. Three electrodes are shown, connected to a three phase generator 15. I do not limit myslf to the arrangement of electrodes as shown, as any known arrangement may be employed. Arranged in the sides of the reducing chamber 7 are burners 16. These burners are connected through pipes 17 and 18, with gas and air pumps 19 and 20. Valve 21 controls the gas and valve 22 the air. Located also in the reducing chamber 7, are burners 23 connected to any suitable source of gas through pipe 24.

25 is a valve which controls the gas fed to the burners 23. Situated in the bottom of the heating chamber 6 are air pipes 26. These pipes are connected through a pipe 27, to air pump 20, also to an air strainer 28. Valve 29 controls the air from pump 20, and the valve 30 the air from the strainer 28.

The general mode of operation of my improved furnace is as follows: A charge consisting of ore, a small amount of coke and a flux, is introduced through the opening 10

into the heating chamber 6, from which it gravitates to the reducing chamber 7 and refining chamber 8. When the furnace is started, the gas burners 16 in reducing chambers 7 are lighted. The gas and air fed to the burners 16, which is delivered in the ratio of gas one pound, air one and one quarter pounds, produces an intensely high temperature at the burner orifices, which temperature is due to the instantaneous combustion of the transmitted gas and air. The effect of this temperature is to heat the air in the chamber 7, and as the gas and air flame is a reducing flame, reduce the ore. The products of combustion (CO_2) rise through the material in the chamber 7, thence (as CO) through the material in the chamber 6, to the flue 11, highly heating both of these materials. Prior to this time, current from any suitable source has been transmitted through the material in the reducing chamber 7, by reason of the electrodes 13, the material acting as a resistance medium and being raised to a high temperature; arcs are also formed.

The effect of the transmitted electric current is to bring about certain combinations, *i. e.:* (*a*) To cause the introduced lime to combine with the carbon to produce calcium carbid. (*b*) To cause the introduced lime to combine with the free silica to form calcium silicid. (*c*) To cause the free lime to combine with the free phosphorus to form calcium phosphid. (*d*) To cause the magnesia or potash in the flux to combine with nitrogen to form a nitrite or nitrid to effect separation of sulfur, as well as other chemical combinations due to the presence of fluxes and materials which will combine therewith, set free or rendered active by the high temperature, and possibly the high temperature, electrolytic and vibratory effects of the transmitted electric current. Further, to act as a means for splitting up CO_2 due to the combustion of the gas and air introduced through the burners 16, into C and O, and the combination with carbon to form 2CO. CO_2 in breaking up into CO, exerts an endothermic action, and will draw heat from the high temperature zone between the electrodes 13, but not sufficient in amount to effect the chemical reactions taking place in this zone as described.

It will be understood that CO_2 passing through the zone, is split up into C and O and combines with free carbon to form 2CO, so that the gas, passing upward through the heating chamber 6 is not only a high temperature gas, but a gas which, upon being burned, will exert an exothermic action. To burn the CO gas in chamber 6, air is introduced through the air pipes 26 which air may be derived from the air pump 20 and therefore under pressure in excess of that of the atmosphere, in which case the valve 29 is opened and the valve 30 closed, or drawn through a strainer 28 at atmospheric pressure, in which case the valve 30 is opened and the valve 29 closed, which will combine with the CO and ignite to heat the charge in the chamber 6. The charge as it passes downward, is practically heated in the chamber 6 to a high temperature, and then reduced in the chamber 7 until it is in a condition of slag and reduced iron. If desired, further fluxing materials and carbon may be introduced when the material is in the chamber 7, so that when the material passes into the chamber 8, it is in condition to be acted upon by the high temperature effects of the electric current transmitted between the electrodes 14, the material acting as a resistance body. In the chamber 8, the practical refining operation to convert the iron into steel is conducted. Chemical combinations similar to those which take place in chamber 7 may be effected, or other combinations, depending upon the character of the flux introduced, temperature of the current, vibratory effects of the current transmitted, etc.

I wish it understood that I understand and believe that the current transmitted in chamber 8 acts not merely by reason of the high temperature produced, but by reason of the vibration imparted to the atoms or molecules of the bodies within the sphere of influence of such current.

It will be seen from the above statement that all of the temperatures created within the furnace give rise to gases or heated vapors, which move upward from the bottom of the furnace toward the top, heating the material acted upon in their passage, and that means are situated immediately below the heating chamber for converting all carbonic dioxid, which contains but few heat units, into carbon monoxid, which contains a large number of heat units, and in order that such heat units may be utilized in the preliminary heating of the material in the heating chamber. It will further be apparent to those skilled in the art to which this invention belongs, that by reason of the heat due to the introduced gas and air, the materials which are to be acted upon by the electric current to effect chemical combinations are brought into the best condition to be so acted upon and to require the least expenditure of electrical energy. It will be further seen that in my improved furnace the reduction chamber in effect serves the purpose of a gas producer to produce fuel to effect heating in the heating chamber, in that the CO_2 gas introduced under the heated zone formed by the electrodes 13 is converted into a combustible gas by the action of said heated zone and the addition of carbon to be subsequently burned within the heating chamber, or in other words,

that the furnace is so designed as to utilize all the units of heat originally created, either by the introduced gas and air, or the electric current; and further, to revivify the gas and air which has been burned to CO_2 to produce a combustible gas, which may be subsequently burned to heat the charge in the heating chamber. It will also be observed that by increasing the percentage of air introduced into the heating chamber in connection with the CO gas, that this chamber may serve not only as a heating chamber, but as an oxidizing chamber, and that if the proportion of air introduced by the pump 20 be regulated, the effect of the introduced gas and air into the chamber 7 will be not only to heat but to act as a reducing or oxidizing agent, depending upon the percentage of air transmitted. It will further be understood, that, due to the cooling or endothermic effect of CO_2 in its conversion into CO, the temperature of the heated zone between the electrodes 13 may be increased or diminished in proportion to the amount of CO_2 transmitted; thus the temperature in the heated zone in the chamber 7 may be greater or less than that of the heated zone between the electrodes 14 in the heated zone of chamber 8. The purpose of the burners 25 is to provide for a constant ignition of such gas as may accumulate around the electrodes 13 and which, if not ignited or drawn off, will frequently expode and destroy the furnace.

Generally, I wish it understood that I believe I am the first to disclose a furnace in which all of the heat units are employed in the heating of the charge, and where the zone of high temperature due to a transmitted electric current is employed to convert a non-combustible gas into a combustible gas to aid in the heating of the charge.

Having thus described my invention, I claim:

1. An electric furnace, comprising a heating chamber, a reducing chamber, a refining chamber, means in the reducing chamber for creating a temperature due to the combustion of gas and air, means in such chamber for creating a temperature greater than can be obtained by the combustion of gas and air, and means in the refining chamber for creating temperature and other effects due to the passage of an electric current through the material contained in the chamber as a resistant medium and to the production of electric arcs.

2. An electric furnace, comprising a heating chamber, a reducing chamber, a refining chamber, such chambers located at successively lower levels, means in the lower part of the reducing chamber for creating a temperature due to the combustion of gas and air, means in the upper part of said chamber which will create a temperature sufficient to convert CO_2 due to the combustion of such gas and air, into CO, and means for introducing air into the heating chamber to effect combustion of the CO gas flowing to said chamber from the reducing chamber.

3. An electric furnace, comprising a heating chamber, means in said chamber for creating a temperature by the combustion of CO gas and air; a reducing chamber, means in the lower part of said chamber for creating a temperature by the combustion of CO gas, means in the upper part of said chamber for creating a temperature higher than that produced by the combustion of CO gas and sufficient to convert CO_2 into CO; a refining chamber, and means in said refining chamber adapted to produce chemical combinations between materials introduced into such chamber and the volatilization of bodies carried by such introduced materials.

4. In an electric furnace, a chamber, means in the lower part of said chamber for producing by combustion a CO_2 gas, and means in the upper part of said chamber whereby CO_2 gas will be converted into a CO gas.

5. In an electric furnace, a chamber adapted to contain a body of carbonaceous fuel and metalliferous ore, means in the lower part of said chamber for introducing a CO gas and burning the same therein, and means in the upper part of said chamber whereby the CO_2 gas produced will be reconverted into CO gas.

6. An electric furnace having a plurality of chambers one of said chambers provided with means for converting an incombustible gas created in the lower part of said chamber during the act of heating said chamber, into a gas which when combined with air, may be burned to heat another chamber of said furnace.

7. The herein described method of reducing ore, which consists in first subjecting it to the temperature effects due to the combustion of a CO gas and air; second to the temperature effects due to the combustion of a CO gas and air and the temperature and other physical effects due to the transmission of an electric current where such current acts through a resistant medium and in the production of arcs, and third to the temperature and other physical effects due to the transmission of an electric current where such current acts through a resistant medium and in the production of arcs.

8. An electric furnace in which the physical and chemical effects are primarily due to the heat transmitted by the passage of CO gas, the secondary effects to the passage of an electric current through a resistance medium, and the tertiary effects to the combustion of gas and air and the formation of a reducing gas.

9. An electric furnace in which the mate-

rial treated is first subjected to the heat effects of a CO gas transmitted through it, second to the heat and vibratory effects of an alternating electric current where the material acts as a resistance medium, third to the heat effects and reducing action due to the combustion of gas and air, and fourth to the heat and vibratory effects of a transmitted alternating electric current, where the material serves as a resistance medium.

In testimony whereof, I affix my signature, in the presence of two witnesses.

GEORGE HILLARD BENJAMIN.

Witnesses:

HELEN E. KOELSCH,

ELI L. WEILL.