No. 808,187. PATENTED DEC. 26, 1905.

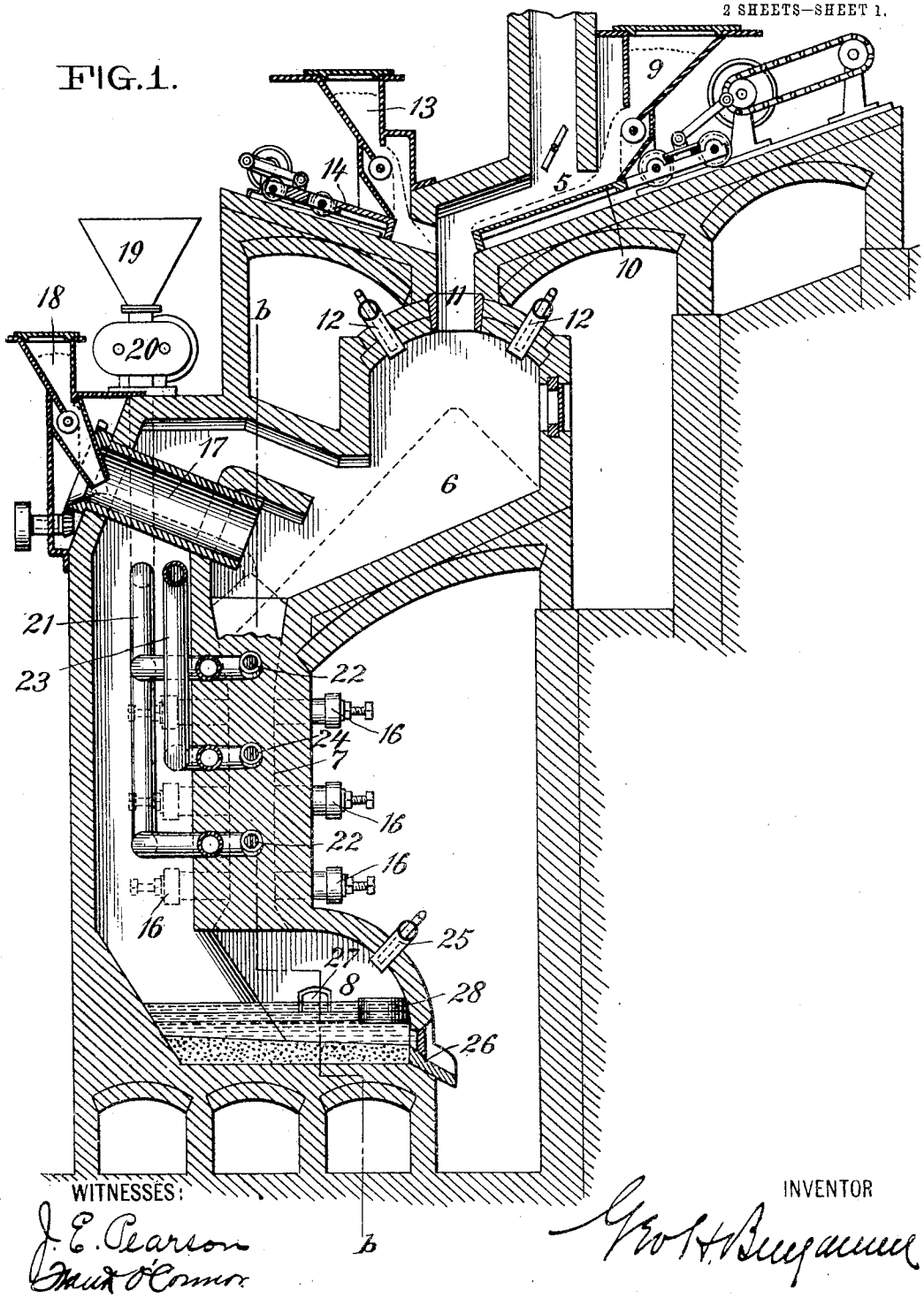
G. H. BENJAMIN.

METALLURGICAL FURNACE.

APPLICATION FILED APR. 27, 1903.

2 SHEETS—SHEET 1.

FIG. 1.



WITNESSES:

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Chas. O'Connor

INVENTOR

Geo. H. Benjamin

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2 SHEETS—SHEET 2.

FIG. 2.

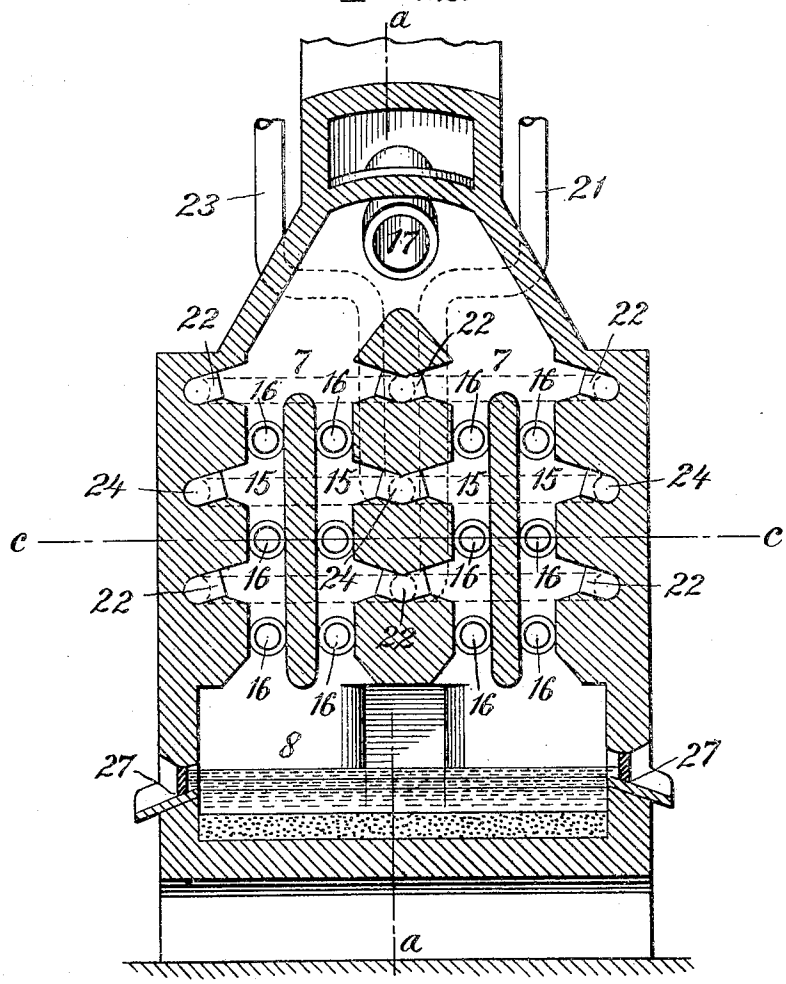
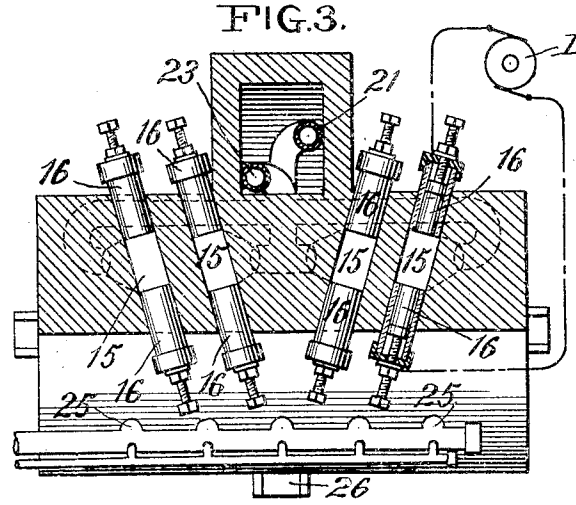


FIG. 3.



WITNESSES:

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UNITED STATES PATENT OFFICE.

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

METALLURGICAL FURNACE.

No. 808,187. Specification of Letters Patent. Patented Dec. 26, 1905.

Application filed April 27, 1903. Serial No. 154,590.

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, county and State of New York, have invented certain new and useful Improvements in Metallurgical Furnaces, of which the following is a specification.

My invention consists in a construction and method of operation of a furnace by means of which a metal may be rapidly separated from its ore.

The object of my invention is to decrease the cost of separation of a metal from its ore by decreasing the amount of the fuel, the fluxing materials, and the time required to effect the metallurgical operations.

My invention is based upon the following observed facts: To obtain a rapid separation of a metal from the bodies accompanying it, it is necessary that the ore body be subjected first, to a calcining temperature; second, to a reducing temperature; third, to the physical effects of a series of electric arcs while moving, said physical effects including that of a temperature in excess of that which can be obtained in any coal or gas heated furnace, as also that of electrolysis, mechanical agitation, &c.; fourth, to the action of a body which will combine with the metal of the ore or the bodies accompanying the metal, and thereby destroy the previously-existing bonds between such metal and its accompanying bodies; fifth, that the ore body and the introduced body be separately heated to a high temperature before being brought into contact and subjected to the physical effects of the electric arcs; sixth, that the introduced body be reduced to a fine state of division before being brought into intimate contact with the ore body in the presence of the electric arc.

The accompanying drawings will serve to illustrate my invention.

Figure 1 is a vertical section on the line *a a* of Fig. 2. Fig. 2 is a transverse section on the line *b b* of Fig. 1. Fig. 3 is a horizontal section on the line *c c* of Fig. 2.

The furnace as a whole is divided into four chambers, of which 5 is a calcining-chamber; 6, reducing-chamber; 7, electric combining-chamber; 8, receiving or oxidizing chamber. These chambers are connected together. Arranged over the calcining-chamber 5 is a hopper 9, through which the ore to be treated is introduced. 10 is a reciprocating rake arranged to move over the hearth of the calcining-chamber. In the drawings the calcining-chamber is shown as a short chamber. In practice this chamber would be of considerable length—*i. e.*, sufficient to effect the thorough calcining of the ore before it is introduced through the passage 11 into the reducing-chamber 6. The ore, it will be understood, is moved through the calcining-chamber by the reciprocations of the rake 10 and then drops into the reducing-chamber 6, where it is subjected to the reducing action of hydrocarbon flames introduced through the burners 12. Located over the hydrocarbon chamber is a second hopper 13, and under this hopper a reciprocating rake 14. Through the hopper 13 any suitable fluxing material may be introduced—such, for instance, as lime, carbon, a metal, or an ore body different from that under treatment. The materials introduced through the hoppers 9 and 13 fall upon the hearth of the reducing-chamber 6, as stated, and when sufficiently heated flow to the electric combining-chamber 7. The electric combining-chamber, as will be seen from an examination of Figs. 2 and 3, is divided into four passages 15, and arranged in pairs and opposite in these passages are electrodes 16. Three pairs of electrodes are shown in each passage. I do not limit myself in any wise to the number of pairs of electrodes.

The electrodes 16 may be connected to any suitable source of electric energy—as, for instance, a dynamo D. I do not limit myself in any wise to the particular kind of electric current which may be used. I may use a direct current, a direct current having its direction reversed at intervals, a pulsating current, or an alternating current. The character of the current used will in some respects depend upon the ore treated, as with a magnetic ore a direct current may be employed and with a non-magnetic ore a pulsating or alternating current. In practice I have observed the following facts: The current transmitted between the electrodes serves not only to form the arcs, thereby creating high-temperature effects, but also to produce electrolytic effects—*i. e.*, the separation or tearing apart of the materials where the materials acted upon form, so to speak, an "electrolyte." Such electrolyte may be formed from lime, carbon, or the various gases evolved from the decomposition of the ore body or the chemical reactions taking place between the ore body and the introduced body, and, further, that

the electric fields created between the electrodes act mechanically, especially where an alternating or pulsating current is used to agitate the falling metal and hold it suspended for an appreciable time in the arcs.

Located immediately over the orifice of the electric combining-chamber 7 is a rotating drum 17, and over the outer end of this drum is a hopper 18. Fluxes, a different ore or metal body, or carbon may be introduced through this hopper and delivered through the drum at the mouth of the combining-chamber 7. The drum 17, it will be observed, is so situated as to be heated by the gases within the furnace, and consequently to heat the material passing through the drum.

It will be observed from the description so far as given that fluxes, a different metal or ore body, or carbon may be introduced to the material upon the hearth of the reducing-chamber at two different points. I also provide for introducing the fluxes or carbon, or both, into the combining-chamber 7 in a finely-divided and highly-heated condition. Such means consists of the hopper 19, mounted over the blower 20, which communicates by pipe 21 with the delivery-orifices 22, which pipe 21, it will be observed, is situated within the combining-chamber. This hopper 19 may be used for the delivery of a flux, and a corresponding hopper and blower (not shown) connected to pipe 23 may be used for the delivery of carbon through the delivery-orifices 24. I prefer that the delivery-orifices from the two blowers 22 24 be disposed in staggered relation to each other. I do not limit myself, however, to the particular disposition of the delivery-orifices for lime and carbon, as they may be variously placed. Preferably, however, they should be so situated that the materials discharged from them will be projected in an upward direction and fall through the successive arcs in the passages 15, and thus be brought into intimate relation with the material to be acted upon, flowing through the passages 15.

The pipes 21 23 are shown as situated within the furnace in such position as to be heated by the gases of the furnace, thereby heating the material passing through them to a very high temperature.

Located under the electric combining-chamber 7 is a receiving or oxidizing chamber into which the materials delivered from the combining-chamber fall. This chamber is provided with hydrocarbon burners 25, which may be used to heat or to produce a reducing or oxidizing atmosphere, also a spout 26, through which the separated metal may be drawn, and slag-doors 27.

28 indicates a slag-ring arranged over the spout 26.

The operation of my improved furnace is as follows: Assuming that copper is to be the metal treated, the ore is dumped into the hopper 9, falls upon the hearth of the calcining-chamber 5, and is there calcined by the heat derived from the other chambers of the furnace and is then fed into the reducing-chamber 6. At the same time a certain amount of lime is charged through the hopper 13. As the ore is reduced it gravitates down the hearth of the chamber 6 into the passages 15 of the electric combining-chamber 7. If desired, further lime may be charged in through the hopper 18 and drum 17. As the material falls through the passage 15 it is subjected to the physical effects of the electric arcs 16 and also to the chemical action of the lime, carbon, or other combining bodies introduced through the pipes 21 23. The physical effects of the electric arcs, as previously stated, is to heat electrolytically, separate, and mechanically agitate the ore body and support the metal coming within its influence. The action of the introduced lime and carbon is to form, with the fluxed ore, a number of different bodies, among which the following have been observed: calcium carbid, silicon carbid, carbon oxid, carbon dioxid, hydrogen sulfid, ammonia, probably due to the separation of the nitrogen from the air, as well as various gases which have not been identified. These materials separate, the gases flowing in an upward direction and the liquid materials falling into the chamber 8, where they separate by gravity and can be drawn off. The mechanical agitation and supporting effect of the arcs, as described, materially aids in bringing about an intimate relation between the finely-divided introduced lime and other materials and the falling ore body.

In operating my improved furnace I may do away entirely with the hoppers 13 and 18 and introduce the fluxes, carbon, &c., through the blast-pipes 21 23.

It will be observed from the description, so far as given, that the material to be acted on are all in a highly-heated condition before being brought into contact in the presence of the electric arcs, which produce the combining temperature and other effects necessary to break the bond between the metal and the other bodies in the ore treated.

In this specification I have not entered into a detailed description of all of the parts of the furnace or of all of the metallurgical effects produced, as in my former applications, Serial No. 136,566, filed December 26, 1902, and Serial No. 150,427, filed March 31, 1903, I have given such full description as is necessary to an understanding of such matters.

In the claims I have used the expression "physical effects of an electric arc," and by this term I wish to have understood the temperature effect or action, the electrolytic effect or action, and the mechanical effect or action, singly or combined, of an electric arc

upon the ore body treated as differentiated from the mere temperature effect created by heat radiated by a resistant medium acted upon by a current of electricity.

I make no claim in this application for the general construction of the furnace shown and described, as the same has been made the subject of a separate application, Serial No. 150,427, filed March 21, 1903, the present application being limited to the mechanism employed for heating and discharging into the molten and reduced ore body, during the time it is passing the electric arcs, a combining body in a highly heated and divided condition.

Having thus described my invention, I claim—

1. A metallurgical furnace embodying in its construction, a series of arcs, means whereby a reduced ore body will flow within the zone of action of said arcs, and means for introducing a finely-divided combining body into said ore body while within the zone of action of said arcs.

2. A metallurgical furnace embodying in its construction, a series of electric arcs, means whereby a reduced ore body will flow within the zone of action of said arcs, and means for introducing a blast of air carrying a finely-divided combining body into said ore body while within the zone of action of said arcs.

3. A metallurgical furnace embodying in its construction, a series of electric arcs, means whereby a reduced ore body will flow within the zone of action of said arcs, means for introducing a highly-heated combining body into said reduced ore body before passing said arcs, and means for introducing a finely-divided combining body into said ore body while passing said arcs.

4. A metallurgical furnace embodying in its construction, a reducing-chamber, means for creating a reducing atmosphere therein, a heating-chamber adapted to discharge into the lower end of the reducing-chamber, a series of vertically-arranged arcs, a chamber in which these arcs are located situated below the reducing-chamber, and means for introducing a finely-divided combining body into the chamber in which the arcs are situated.

5. A metallurgical furnace embodying in its construction, means for reducing an ore body, means for introducing into said ore body at successive points in its line of travel through the furnace, charges of highly-heated combining material, and a series of electric arcs through which said reduced ore body and introduced material are moved and thereby subjected to the physical effects of said electric arcs.

6. A metallurgical furnace embodying in its construction, means for reducing an ore body, means for highly heating a combining body, means whereby these two bodies are brought together, a series of electric arcs through which the combined bodies are passed, and means for introducing into the combined bodies while passing through the electric arcs, a combining body in a finely-divided state.

7. A metallurgical furnace embodying in its construction, means for reducing an ore body, means for heating a combining body, a series of electric arcs, means for simultaneously causing the reduced ore body and the heated combining body to flow through said arcs, and means for introducing into said combined bodies while passing through the electric arcs, a finely-divided combining body.

8. A metallurgical furnace embodying in its construction, a reducing-chamber, means for creating a reducing atmosphere therein, a heating-chamber, means for heating said chamber, a vertically-disposed chamber under the reducing-chamber, a series of electric arcs in said chamber, means for introducing a finely-divided combining body into said last-named chamber around said arcs, and a receiving-chamber at the bottom of the furnace.

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

GEO. H. BENJAMIN.

Witnesses:
J. E. PEARSON,
FRANK O'CONNOR.