E. A. MATHERS.

SMELTING PROCESS AND APPARATUS.

APPLICATION FILED DEC. 20, 1911.

1,242,833.

Patented Oct. 9, 1917.

3 SHEETS—SHEET 1.

Fig. 1.

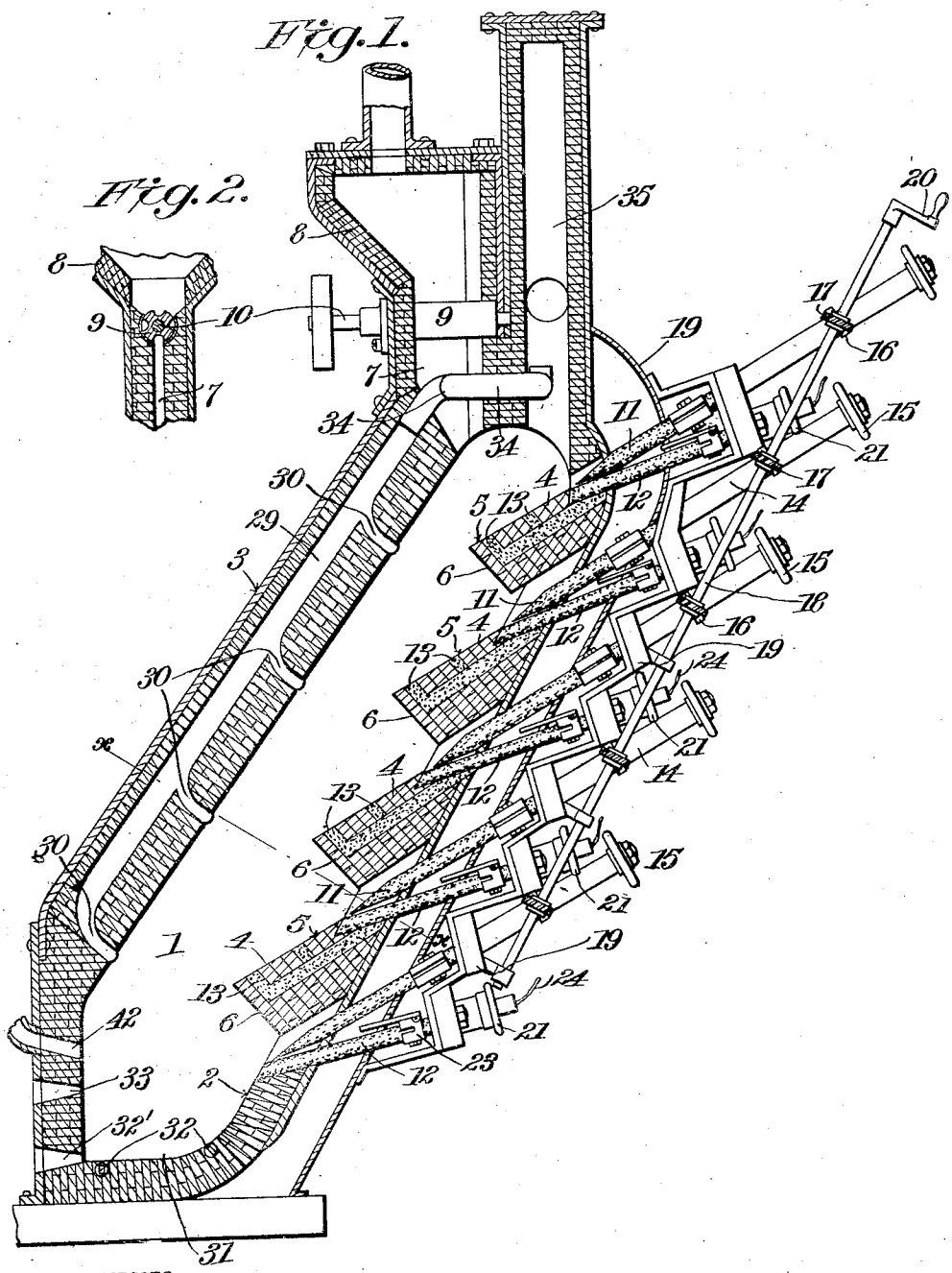


Fig. 2.

WITNESSES

M. E. Jones Jr.

Frank E. Rapp

INVENTOR

Ezra A. Mathers,

BY

E. W. Bradford

ATTORNEY

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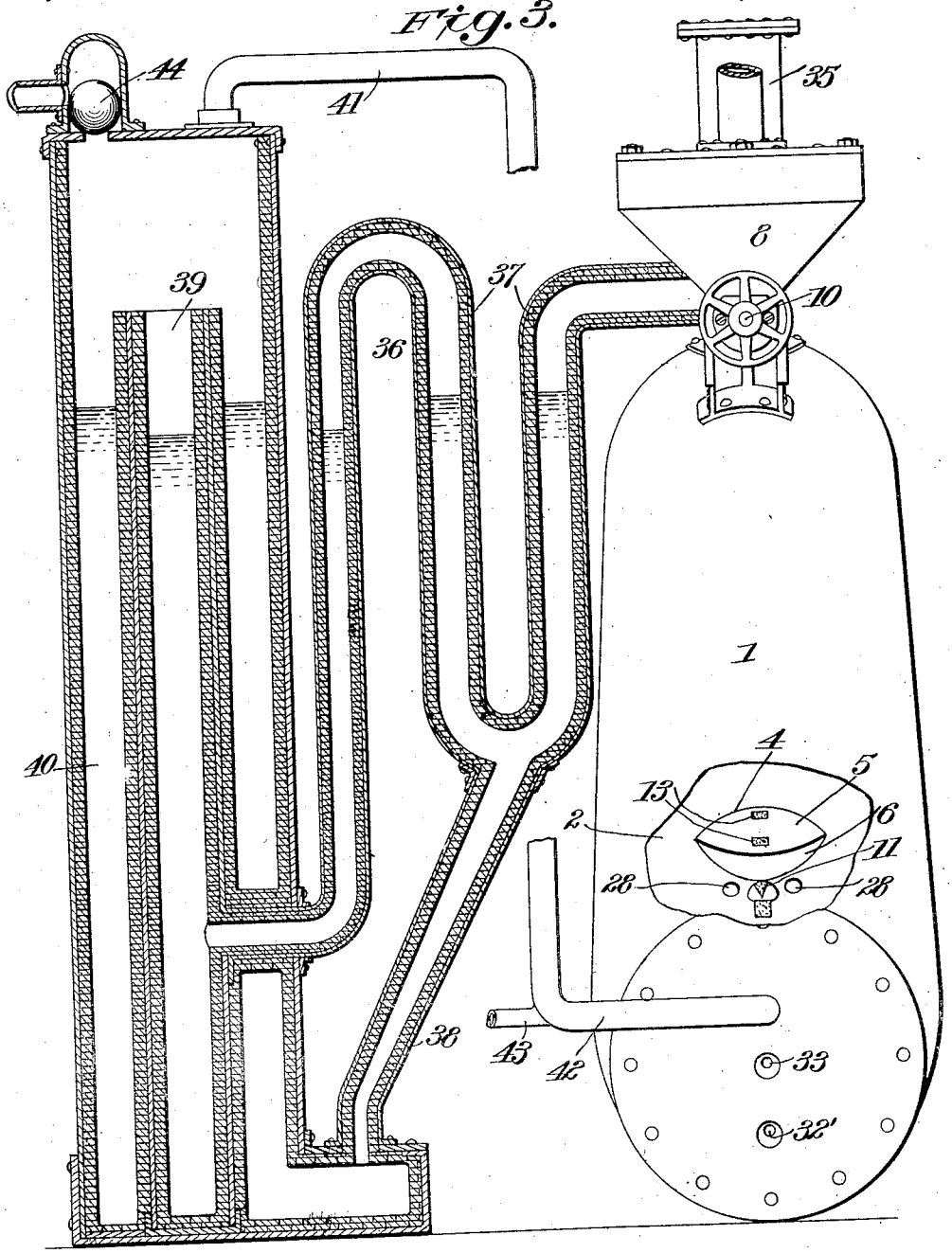
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Fig. 3.



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3 SHEETS—SHEET 3.

Fig. 5.

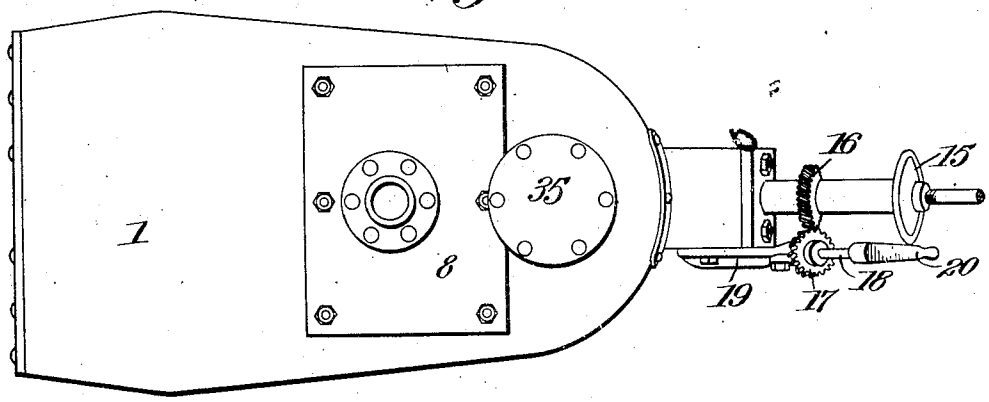


Fig. 4.

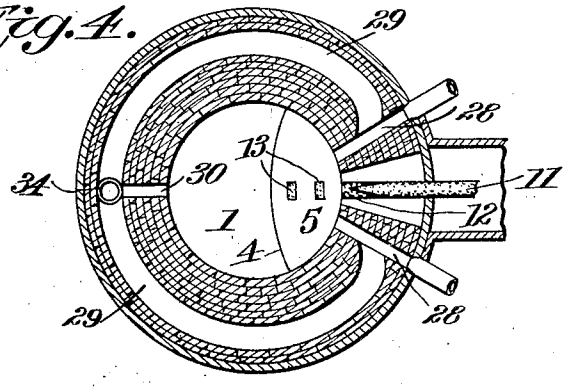


Fig. 6.

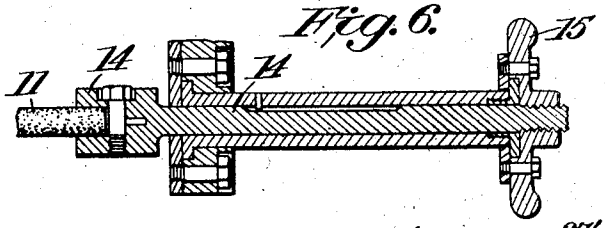


Fig. 8.

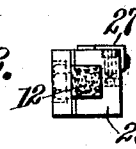
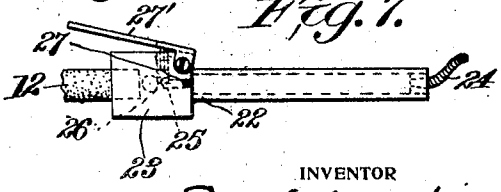


Fig. 7.



WITNESSES

M. L. Jones Jr.

Frank E. Rapp

INVENTOR

Ezra A. Mathers,

By E. W. Bradford

ATTORNEY

UNITED STATES PATENT OFFICE.

EZRA A. MATHERS, OF NEW YORK, N. Y.

SMELTING PROCESS AND APPARATUS.

1,242,833. Specification of Letters Patent. Patented Oct. 9, 1917.

Application filed December 20, 1911. Serial No. 666,930.

To all whom it may concern:

Be it known that I, EZRA A. MATHERS, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Smelting Processes and Apparatus, of which the following is a specification.

My invention relates to a process of and apparatus for electrically treating ores, *e. g.*, electric smelting.

The objects of the invention are to provide means for facilitating the rapid and cheap treatment of highly refractory ores, for treating the material in a substantially continuous operation, thereby reducing the cost of treatment and obtaining a greater productive capacity of apparatus, to provide means whereby the gases resulting from the combustion and smelting after purifying are returned to the smelter and utilized therein in a continuous cycle, and to provide means whereby said gaseous products may be revivified by the addition of air, for the purpose of enabling such gaseous products to be re-utilized in the furnace.

With these ends and others in view my invention consists of the apparatus hereinafter described and claimed.

In the accompanying drawings Figure 1 is a vertical section of a preferred form of apparatus in accordance with my invention,

Fig. 2 a detail cross section at right angles to Fig. 1, of the regulable controlling gate for the ore hopper,

Fig. 3 an end elevation of the apparatus partly in section,

Fig. 4 a cross section on the line *x*—*x* of Fig. 1,

Fig. 5 a detail side elevation showing the electrode adjusting means,

Fig. 6 a longitudinal section of one of the electrode carrying members,

Fig. 7 a detail side elevation of mechanism for resetting one of the electrodes in arcing position, and

Fig. 8 a detail cross section at right angles to Fig. 7.

In carrying out my process the ore or other material to be smelted is first preferably pulverized, by suitable crushing means, not shown, and is then introduced into a suitable hopper from which it is fed by gravity into the furnace in a quantity and at a rate controlled by a suitable gate, or similar means, the speed of operation of which may be regulated to accord with varied conditions of the ore and the capacity of the furnace. The pulverized ore thus fed from the hopper is dropped directly upon an inclined ore way from the surface of which are projected flaming electric arcs so controlled as to be directed into intimate contact with and through the stream of descending ore in a manner to obtain the greatest surface contact therewith and thus fully utilize the heat of the arcs. During this treating with the arcs, the air introduced through the twyers (to be later described), as well as the other air in the furnace, will act upon the ore to perform oxidation of sulfur, etc., as is well understood in electric smelting. The resulting products accumulate in the bottom of the furnace and are there maintained in a heated state by suitable electric resistance means in order to maintain the same in a fluent condition and the fused mass and slag are then led therefrom through separate openings for utilization or further treatment. The process is a closed furnace method operating under pressure and to this end and also in order to supply oxygen for oxidation of oxidizable constituents of the ore, air under pressure may be admitted adjacent to each arc but in such a manner as not to destroy the formation and desired direction of projection of said arcs. Instead of operating under air pressure it may be found desirable in some cases to operate in a partial vacuum, in which instance only sufficient oxygen will be supplied for carrying out the smelting reactions. In this modification, a vacuum pump will be substituted for the gas washer, and the oxygen will be admitted as described below.

The fumes and the gaseous products of combustion resulting from the smelting operation are prevented from escaping and are carried out of the furnace and, after the addition of air thereto, are again introduced into the furnace for the purpose of again subjecting the ore to treatment therewith while the surplus gases in excess of those that may be utilized merely by the addition of air thereto are permitted to accumulate in a suitable chamber until of sufficient volume and pressure to be forced out through a suitable circulation system provided with means to revivify the said gaseous products. To this end the said accumulated over-flow of gaseous products are led through a suit-

able washer, such as a trap containing water, by which the absorbable impurities may be collected and drawn off and this washer also preferably communicates with a suitable water-jacketed container, after which the gases again enter the furnace by a suitable flue leading to the lower part thereof. The flaming arc referred to herein is disclosed in my United States Patent No. 1,002,721, and dated September 5, 1911.

Referring to the drawings, 1 is the smelting chamber of the furnace structure proper which is built of suitable material provided with a refractory lining. This chamber has opposite sloping walls preferably inclined at an angle approximating 60 degrees to the horizontal and one of said walls 2 constitutes an inclined ore way for the pulverized ore which may be fed into the furnace at the upper end of the chamber. The opposite wall 3 of the chamber is preferably in substantial parallelism with the ore way 1 for the purpose of properly guiding and directing the gases and fumes resulting from the smelting operation. The inclined ore way 2 is provided with a series of steps 4. These steps have their upper surfaces 5 also inclined downwardly from the surface of the ore way and the risers 6 of these steps meet the outer ends of the upper surfaces at an acute angle. The steps are spaced from one another for a sufficient distance to permit the pulverized stream of ore to be thoroughly disintegrated by the heat and chemical action, as the ore falls from one step to another and to permit the projection of the flaming arcs against and through the flowing body of ore, from the surface of the ore way between the steps.

The pulverized ore is fed upon the upper step from the chute 7 of a feeding hopper 8 within which chute at the lower end thereof is mounted a rotatable feed controlling gate 9 consisting of a longitudinally grooved wheel and acting in conjunction with the body of pulverized ore above the wall in the hopper to keep the opening of the hopper sealed against the upward escape of gases or fumes and serving to permit the feed of the ore from the hopper only when and so fast as the gate is turned by suitable means outside of the furnace. The gate 9 is mounted on a shaft 10 journaled in the walls of the hopper and carrying at its outer end a suitable drive wheel consisting either of a pulley or a gear which may be connected to any suitable driving mechanism capable of being regulated by an operator for the purpose of changing the speed of the shaft and the consequent rapidity of feeding movement of the gate whereby the rate of feed of the ore to the furnace may be regulated.

Adapted to project through the wall 2 of the smelting chamber above each step 3 is a negative electrode 11 of a pair of arc producing electrodes. This negative electrode is adapted to be fed by suitable manually controlled operating means as the same is consumed and is also adapted to be adjusted axially to present new surfaces to the complementary electrode. The complementary positive electrode 12 is also adapted to project through the wall of the ore way and is adapted to extend substantially flush with the inner inclined surface of such ore way, the action of each pair of electrodes being to project a flaming and pear shaped arc into the interior of the smelting chamber. The positive electrode 12 is electrically connected with auxiliary electrode members 13 projecting through the upper surface of each step and adapted to attract and draw downwardly into approximate parallelism with the downwardly inclined direction of the ore way, the arc produced by the negative and positive electrodes, thereby drawing against and confining to the body of ore the flaming arc and obtaining to the full the utilization of the heat units.

Each negative electrode is clamped within a suitable supporting sleeve 14 mounted in the wall of the smelting chamber and provided at its outer end with a suitable hand wheel 15 whereby the electrode may be fed inwardly by hand as same is consumed in the action of the furnace. Each sleeve is also provided with a suitable helicon gear 16 adapted to mesh with a similar gear 17 carried by a common shaft 18 extending substantially parallel to the inclined outer surface of the ore way and journaled in a suitable support 19 fixed to the furnace wall. Such shaft is provided with a crank handle 20 at the upper end thereof for the purpose of enabling the shaft to be rotated by hand whereby all of the negative electrodes may be rotated on their longitudinal axes so as to present new surfaces relative to the opposing positive electrodes. Each main positive electrode is also provided with a hand feed wheel 21, on supporting sleeve 22 in the inner end of which is mounted an electrode clamp 23. The sleeve 22 is made hollow and is adapted to receive the flexible tube 24 through which air is conducted from a suitable source of compressed air. The inner end of the tube 24 terminates in a diaphragm chamber 25 within which is mounted a small diaphragm 26 having fixed thereto a stem 27 the upper end of which is adapted to contact with a pivotal contact finger 27^1 of electrical conducting material. The above arrangement is adapted to be employed to reëstablish the arcing space between the electrodes when the circuit has become dead from any reason. The contact finger is suitably connected electrically with the main positive electrode and if for some reason the current is not working properly in the electrodes so that no arc is being pro-

duced compressed air is directed through the tube 24 thereby raising the diaphragm and throwing the electric contact finger into contact with the negative electrode which establishes a circuit through the electrodes and contact finger and reëstablishes the sparking action between the electrodes.

On each side of each negative electrode of each pair is an inlet 28 for air or other gas located slightly above the plane of the electrode so as not to interfere with the projection of the arc thereof and also having the inlet so formed as to direct the current of air or other gas upwardly for the same purpose. These inlets are preferably in communication with a source of compressed air outside the furnace, not shown, and they serve to supply the oxygen necessary for the oxidation of the ore and also to produce a forced draft throughout the furnace and its connected parts for the purpose of establishing a circulation of the gaseous products of combustion and fumes. The radial flues constituting the air inlet means are respectively in communication with the opposite ends of a vertical circumferential flue 29 formed in the wall of the furnace chamber and extending around said chamber from one air inlet flue to the other, circumferentially and from near the bottom of the chamber to the upper end thereof, vertically. This flue 29 constitutes part of a circulation system and adapted to communicate with the same are outlet means 30 consisting of short passages formed in the wall of the chamber substantially opposite to the respective air jet openings in the inclined ore way which outlet means permit the escape of the fumes and gaseous products of the smelting from the chamber into the vertical and circumferential flue. The air inlet means 28 acting as an injector upon the gases within the flue 29 and thus draw said gases from the chamber through the flue and back into the chamber again with the addition thereto of fresh air under pressure thus utilizing the gases again in the process of combustion and serving to more effectually burn off combustible matter in the ore.

The pulverized ore as it passes down from the upper end of the chamber over the stepped and inclined ore way is brought into successive contact with the separated and downwardly inclined flaming electric arcs. The ore upon its first contact with the ore way is roasted and then as it travels along said way is rapidly and effectively smelted in the successive arcs, the steps serving to break up the stream and afford more intimate contact of the arcs therewith. The mixture of molten matter and slag, produced by the smelting operation, then descends and collects in the settling basin 31 when it is maintained in its molten condition by means of electric resistance members 32 projecting into the bottom of the settling basin. From the settling basin the matter and slag are drawn off through their respective openings 32^1 and 33.

The fumes and other gaseous products from the circumferential flue 29 in excess of those consumed in the furnace will pass through branch pipes 34 leading from the top of said flue around the chute of the feeding hopper into an accumulator chamber 35 provided with a refractory lining. This chamber communicates with a water trap system 36 comprising an upper pipe 37 and a lower settling pipe 38. The gases are drawn through the water in the upper pipe and any foreign impurities carried by the gases will be collected therein. The gases thus washed are then drawn through a suitable container 39 further washing the gases, and thus revivifying the gases and enabling them to be employed again in the process. This container is surrounded by a water jacket 40 and from the container a return pipe 41 is adapted to conduct the revivified gases back to an entrance 42 leading into the lower part of the furnace. Joining this return pipe at its entrance into the furnace is a suitable air pipe 43 adapted to admit air to the furnace with the returned gases. At the upper end of the cylinder 40 there is an escape opening controlled by a suitable valve 44 whereby when the pressure of the gases passes a predetermined point they will be permitted to escape to the atmosphere to relieve such pressure.

The process, as above described, may be employed in the smelting of highly refractory sulfid ores, but I do not limit myself to the treatment of such ores.

It is clear that changes in the details of the steps of the process and of the features of construction of the apparatus may be made without departing from the principle of the invention. The term "ore" as used in the specification and claims will be understood to include any material which the apparatus may be found adapted to operate upon.

Having thus described my invention, what I claim is:

1. The process of smelting ores which consists in feeding a substantially continuous stream of ore against a series of separated heating bodies and projecting the heat of said bodies downwardly in a line approximating parallelism with the flow of ore, substantially as set forth.

2. The process of smelting ores which consists in feeding a substantially continuous stream of pulverized ore against a series of separated heating bodies and projecting the heat of said bodies downwardly in a line approximating parallelism with the flow of ore, substantially as set forth.

3. The process of smelting ores which consists in feeding the same by gravity against an interrupting and distributing surface and projecting bodies of heating medium into said stream of ore at the points of interruption of the flow, substantially as set forth.

4. The process of smelting ores which consists in pulverizing the ore and feeding the same by gravity against an interrupting and distributing surface and projecting bodies of heating medium into said stream of ore at the points of interruption of the flow, substantially as set forth.

5. The process of smelting ores which consists in introducing the ore into a closed electric furnace, forcing air under pressure into said furnace and maintaining a constant circulation throughout said closed furnace and the parts communicating therewith of the air and gaseous products of combustion, substantially as set forth.

6. The process of smelting ores which consists in introducing the ore into a closed electric furnace and subjecting said ore to the action of flaming electric arcs, introducing air under pressure to said chambers and leading the gaseous products of combustion from said chambers and through a purifying agent and back to the furnace in a continuous cycle, substantially as set forth.

7. The process of smelting ores which consists in introducing the ore in a pulverized state into a closed electric furnace and subjecting said ore to the action of flaming electric arcs, introducing air under pressure to said chambers and leading the gaseous products of combustion from said chambers and through a purifying agent and back to the furnace in a continuous cycle, substantially as set forth.

8. The process of smelting ores which consists in introducing the ore into an electric furnace closed against escape of the products of combustion to the atmosphere, introducing air under pressure to said furnace, leading the gaseous products of combustion from the combustion chamber to a point of re-commingling with freshly admitted air and leading the excess gaseous products of combustion through a suitable washer and returning such gases to the combustion chamber, substantially as set forth.

9. The process of smelting ores which consists of introducing the ores by means of electric arcs in a furnace apparatus closed against escape of the fumes or gaseous products to the atmosphere and comprising the feeding of the ore in a substantially continuous stream to flaming electric arcs, introducing air under pressure to the combustion chamber of said apparatus, leading the gaseous products of combustion in a continuous cycle from said combustion chamber and back thereto, introducing in conjunction with the return gases a continuous supply of fresh air, leading the accumulated excess gaseous products from the combustion chamber through a suitable washer and then through a suitable fuel supplying medium and returning said gases to the combustion chamber, substantially as set forth.

10. In a smelting furnace the combination with an inclined feed way, means for feeding ore to the upper end thereof, members projecting into the furnace chamber from said feed way at intervals and electric arc-producing means mounted between said members, substantially as set forth.

11. A smelting furnace comprising an inclined ore way leading downwardly from the upper end of the furnace chamber, members projecting from the surface of said ore way and each having a downwardly inclined upper surface at an angle to the ore way surface and a lower inclined surface, said members being spaced apart vertically and heating means between the adjoining members, substantially as set forth.

12. In a smelting furnace, comprising an inclined gravity feed ore way therein, step members projecting from the surface of said ore way, an electrode between adjacent step members, and a complementary electrode, substantially as set forth.

13. In a smelting furnace, the combination with means providing a smelting chamber, means to feed material to the upper end of said chamber, a downwardly extending inclined ore way in said chamber having openings therethrough, and electric arc producing means in a plane inclined downwardly from the surface of said ore way and operable to project an arc against the ore passing over said ore way, substantially as set forth.

14. In a smelting furnace, the combination with means providing a smelting chamber, an inclined ore way in said chamber, inclined steps projecting electrodes mounted in openings in said ore way, and means operable to draw said arcs downwardly, substantially as set forth.

15. In a smelting furnace, the combination with means providing a smelting chamber, of means for feeding ore by gravity over a surface in said chamber, an electric arc electrode projecting into said chamber and operable to produce an arc acting against the ore passing over said surface, means outside the chamber for feeding said electrode and means for adjusting the same circumferentially to present new surfaces, and complementary electrode means, substantially as set forth.

16. In a smelting furnace, the combination with means providing a smelting chamber of a series of pairs of electrodes for producing arcs in said chamber, and means op-

erable outside the chamber for simultaneously adjusting one electrode of each pair to present new surfaces to the opposing electrodes.

17. In a smelting furnace, the combination with means providing a smelting chamber of a series of pairs of arc producing electrodes, means for rotating simultaneously the corresponding electrodes of all the pairs and individual means for feeding said electrodes longitudinally.

18. In a smelting furnace, the combination with a smelting chamber, means to close the furnace against the escape of gaseous products of smelting, heating means within the chamber, means to admit air under pressure to said chamber, gas purifying means, and means to provide a continuous circulation of gaseous products from said chamber through the purifying means and back to the chamber, substantially as set forth.

19. In a smelting furnace, the combination with a chamber of downwardly directed heat bodies and adjacent compressed air admitting means directed across the direction of the heat bodies, substantially as set forth.

20. In a smelting furnace, the combination with a chamber, of flaming electric arc means in said chamber, means to admit compressed air to said chamber adjacent to said arcs, outlet means for gaseous matter leading from said chamber opposite said air inlets and a circulation flue leading from said outlet means back to the furnace and communicating with the air inlets, substantially as set forth.

21. In a smelting furnace, the combination with a chamber, smelting means therein, a source of compressed air, air inlet means in said chamber, gas outlet means from said chamber, gas washing means communicating with said outlet means and means of return communication between said washing means and the furnace chamber, substantially as set forth.

22. A smelting furnace comprising a chamber, downwardly directed heat bodies therein, and adjacent fuel supplying means, substantially as set forth.

23. A smelting furnace comprising a chamber, means for supplying heat bodies therein, and means for supplying fuel, said sets of means being arranged to project the heat bodies and fuel to intersect, substantially as set forth.

24. In a smelting furnace, the combination with a smelting chamber structure, heating means therein, a source of compressed air in communication with the chamber, gas accumulating means in communication with the chamber, a gas washer in communication with the accumulator and means of return communication between the washer and smelting chamber, substantially as set forth.

25. In a smelting furnace, the combination with a smelting chamber, means for introducing air under pressure communicating with said chamber, a gas accumulator, a gas washer, fuel adding means in communication with said washer and means of communication between said means and the smelting chamber, substantially as set forth.

26. In a smelting furnace, the combination with a smelting chamber, means to feed pulverized ore in a substantially continuous stream to said chamber, means to prevent the escape of the gaseous products from said furnace, a water trap device communicating with the furnace chamber, at two points, to establish a circulation and a source of air under pressure communicating with said chamber, substantially as set forth

27. In combination with a smelting furnace means for producing a complete cycle of circulation of gaseous products from the furnace and back again, a washer interposed in said circulation means, and a fuel compound container also interposed in said circulation means, substantially as set forth.

28. In a smelting furnace, the combination with a smelting chamber structure, of flaming electric arc means in the chamber, a source of air under pressure communicating with said chamber, means to revivify gaseous products of combustion, and to lead said products in a continuous cycle from the chamber through said revivifying means and back to the chamber, substantially as set forth.

In witness whereof, I have hereunto set my hand and seal at Philadelphia, Penna. this fourteenth day of December, A. D. nineteen hundred and eleven.

EZRA A. MATHERS. [L. S.]

Witnesses:
E. W. BRADFORD,
S. C. MILLWARD.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."