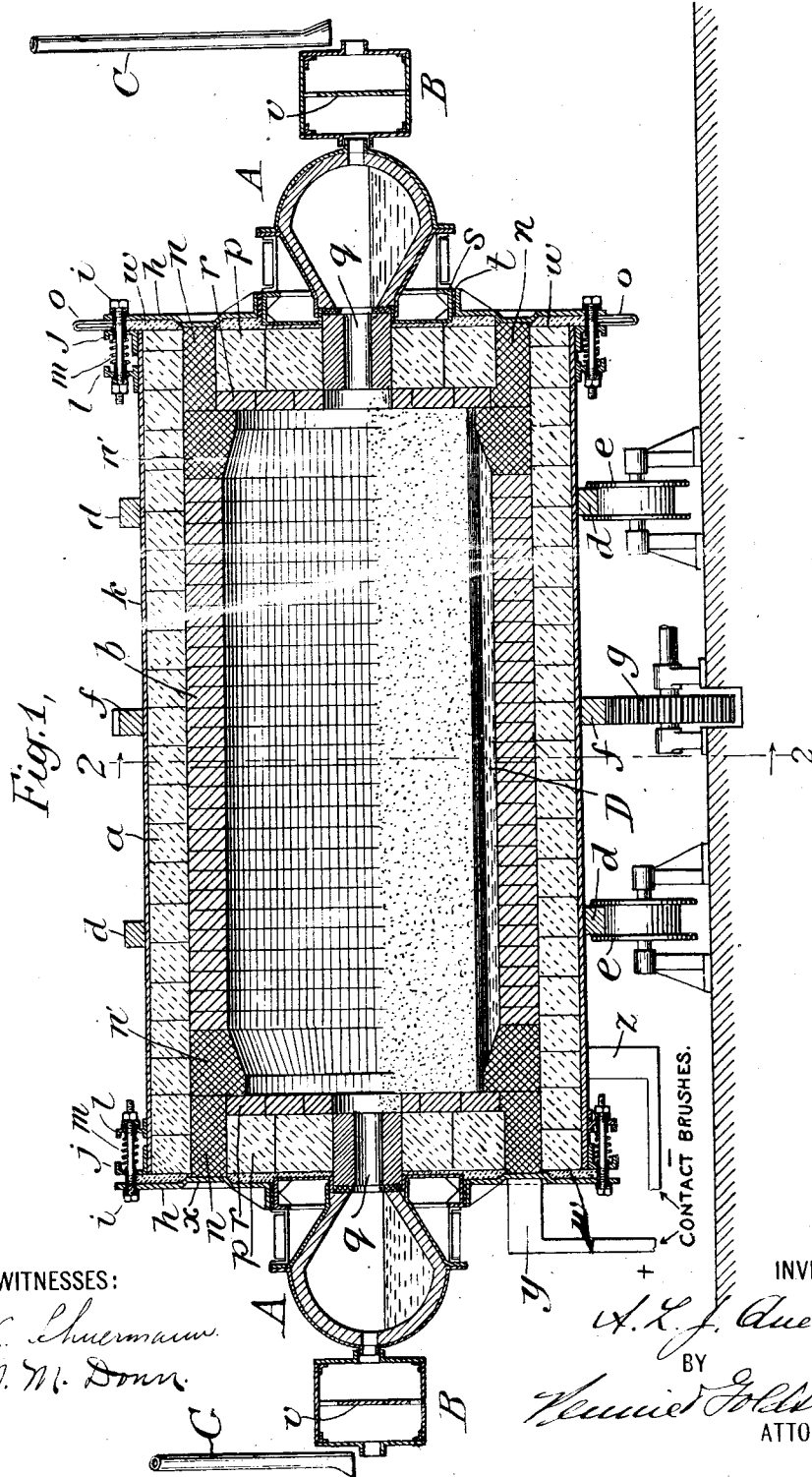


APPLICATION FILED APR. 7, 1909.

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3 SHEETS—SHEET 1.

1,064,992.



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1,064,992.

Fig. 3,

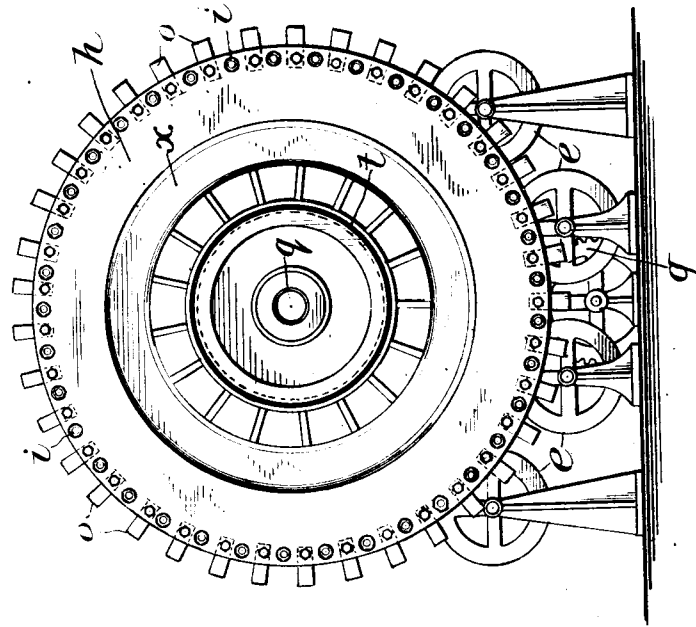
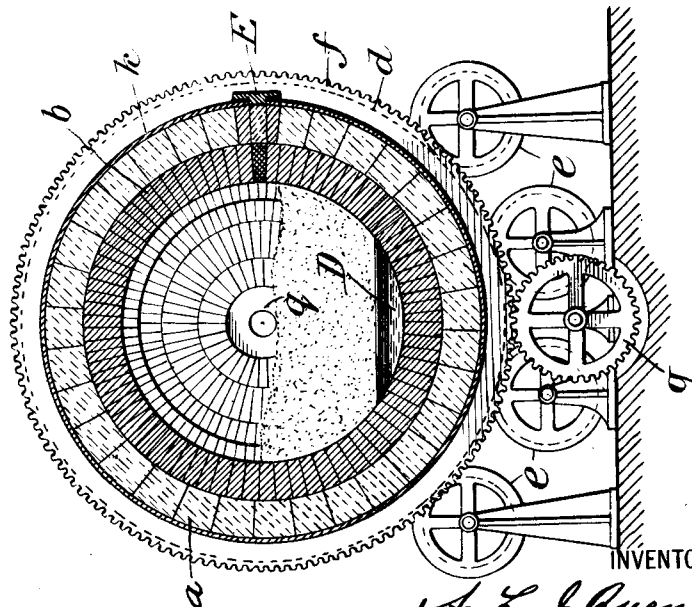


Fig. 2



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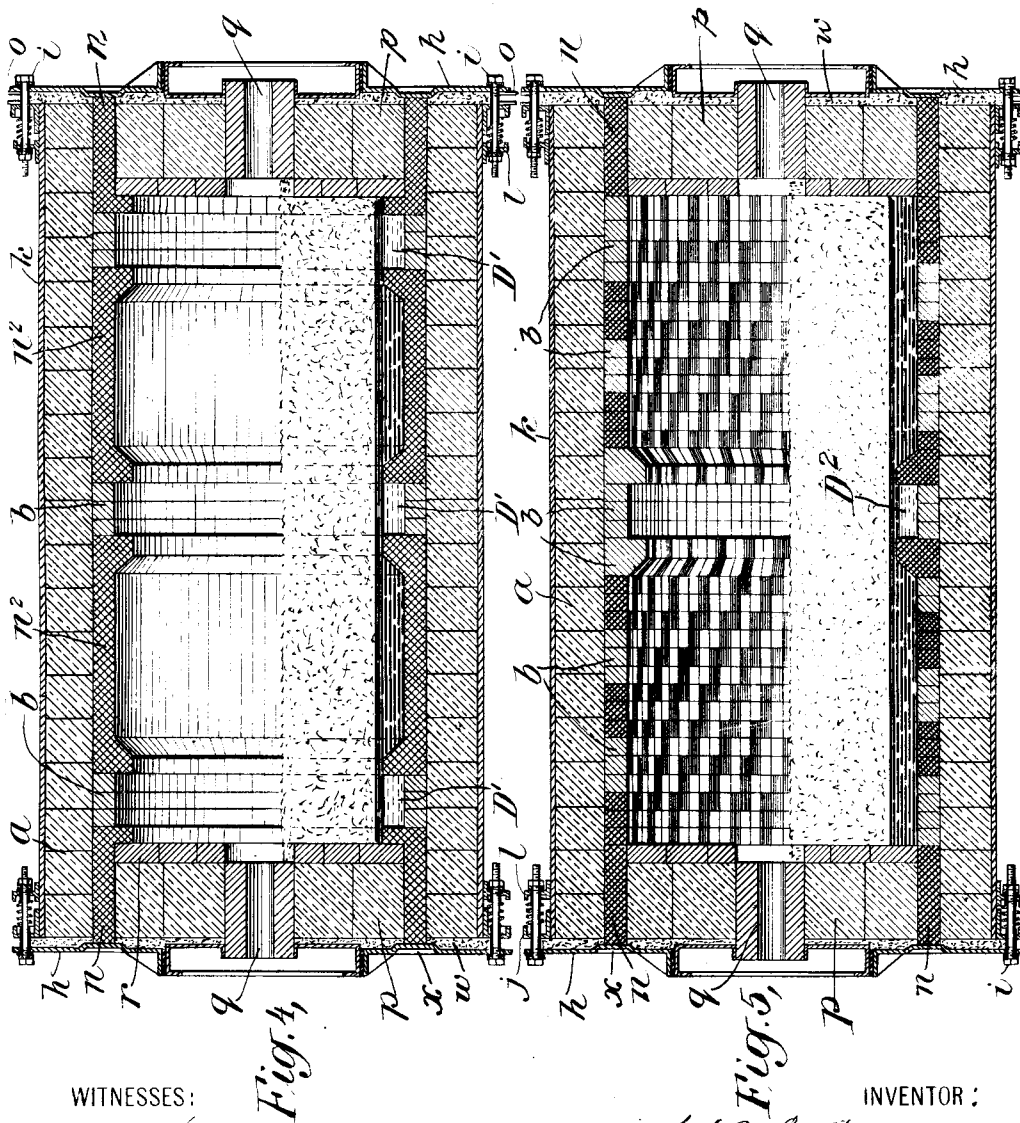
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METALLURGY OF ZINC.

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1,064,992.



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METALLURGY OF ZINC.

1,064,992.

Specification of Letters Patent.

Patented June 17, 1913.

Application filed April 7, 1909. Serial No. 488,399.

To all whom it may concern:

Be it known that I, AUGUSTIN LEON JEAN QUENEAU, a citizen of the Republic of France, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in the Metallurgy of Zinc; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

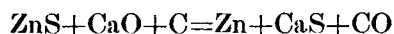
The standard practice of today in the smelting of zinc ores is to roast the ores to remove the sulfur from the sulfid ores or the carbon dioxid from the carbonates. The resulting zinc oxid mixed with finely divided coal is reduced in small fire clay retorts (holding from 50 to 150 pounds of charge) fitted up in tiers within a heated furnace, the heat passing through the wall of the retorts. The zinc vapors issue into short fire clay receivers where they condense into molten metal. That this process is an extremely inefficient one has long been recognized, but the many attempts to supplant it have heretofore been unsuccessful. The inefficiency of the process arises from the fact that the ore mixture must be heated to about 1200 degrees C. Consequently, the retorts must have thin walls, in order to transmit to the charge the heat required, and must be made of fire clay which alone possesses the necessary plasticity for the purpose. The fire clay retorts are difficult to make, fragile, readily attacked by slag, and absorb considerable quantities of zinc, which is lost when the retorts are destroyed. The heat efficiency is very low and the average life of the retorts hardly more than thirty days. The condensation of the zinc vapor also presents difficulties, and much of it is collected as a metallic powder which must be re-distilled in order to be condensed to the liquid state.

In contrast to the standard practice above indicated, the present invention permits the treatment of the ores in receptacles of large size, adapted to contain a correspondingly large charge. Furthermore, it permits the thickness of the walls of the containing vessel to be greatly increased and permits them to be made of a material more resistant to

the action of slag than fire clay. Moreover, in the treatment of zinc ores containing sulfur it is not necessary, in order to adapt them to the uses of the invention, that they should first be brought to a sweet roast, inasmuch as the reduction of the ores by means of iron, or by means of lime and carbon, according to the formulæ



and



can be readily effected, particularly in view of the fact that during the reducing operation, the reducing agents are brought into intimate contact with the ore. It is, therefore, desirable merely to roast the zinc sulfid ores to a sulfur content of five or six per cent., which can be brought about with a small expenditure of coal, and, in fact, zinc ores in the new or unroasted condition may be treated in accordance with the invention. Furthermore, in the practice of the invention, zinc ores carrying copper, lead, iron, gold or silver can be commercially treated, and to particular advantage if to the zinc ores carrying gold or silver, some copper ore is added to form a copper matte to take up the precious metals.

In the prevailing practice, the employment of ores high in slag-forming elements corrosive to the fire clay walls of the retorts is avoided, as it is necessary to have the reduction residues present in a dry pulverulent condition in order to allow of their easy removal from the retorts, and for this reason a large excess of reducing material is used to act as a sponge, holding apart any slag-forming material. In the present invention, on the other hand, as will appear from the description of the furnace, it is necessary to have the residual products of the treated charge in a highly fluid state and of a chemical composition having the minimum dissolving power for zinc compounds. It follows, therefore, that ores that are of an objectionable chemical composition for the prevailing practice but which are of low cost are highly desirable for the practice of the present invention. In the practice of the present invention it is also feasible to pre-heat the ore to a high temperature before admitting it into the reduction furnace, for

instance, to pre-heat it to a temperature of say 1000° C. This pre-heating of the ore may be attained in the ordinary roasting kilns, and is incident to the roasting of the ores in such kilns; so that the ore, after its sulfur content is reduced to the low limit incident to the roasting operation, and is discharged from the kiln, may be discharged directly into the zinc-reducing furnace, or may be temporarily stored in a receptacle which will conserve or substantially conserve the high heat of the ore until the zinc-reducing furnace is ready to receive it. Whether the high preliminary heat of the ore is an incident of the roasting operation or is otherwise imparted to it, such temperature is higher than the temperature at which the coal or other reducing agent would burn in the air. For this reason, the mixing of the reducing agent with the ore should preferably take place within the furnace itself. Nevertheless, it will be found of advantage to also pre-heat the reducing agent, but at a temperature lower than that at which it would burn in the air, the ore and the reducing agent being charged separately into the reducing furnace and mixed therein by revolving the latter.

In carrying out the invention, it will be desirable to heat the interior of the rotatory reduction furnace to a high temperature, (preferably by the electric current) before admitting the furnace charge. To then maintain the reducing temperature during the subsequent reduction of the ore and distillation of the zinc therefrom a molten fluid resistor is employed, which is introduced into the furnace chamber, in such manner as to form a path for an electric current of such a character as to maintain the fluidity of the resistor and the high temperature necessary to carry on and complete the reducing operation, the surfaces of contact between the charge and the fluid resistor being constantly renewed by reason of the rotative movement of the furnace chamber, thereby increasing the speed of the reaction. The zinc vapors given off by the charge are received in condensers of such construction and arrangement that the vapors are condensed therein to the metallic liquid state.

In the accompanying drawings, Figure 1 represents a longitudinal central section, partly in elevation, of a furnace and its condensers adapted for the practice of the invention. Fig. 2 represents a section thereof taken on a plane indicated by the line 2—2 of Fig. 1. Fig. 3 represents, an end view of the furnace, with the corresponding condenser removed. Figs. 4 and 5 represent central longitudinal sectional views showing modifications of the furnace structure.

Referring to the drawings, it will be noted that the furnace, which is of the rotary type, is provided with a shell *k*, preferably of low

carbon steel, lined interiorly with refractory material of suitable physical characteristics. In the modification shown in Figs. 1, 2 and 3, the outer blocks *a* proximate to the steel shell, are of good heat insulating fire brick, whereas the inner blocks *b* are preferably of chrome bricks, inert to slags and zinc vapors.

The metal shell of the furnace as illustrated in the drawings, is preferably cylindrical in shape, and is supported upon bands or tires *d*, resting on rollers *e*, the axis of the furnace being preferably horizontal. The shell is also provided with a band gear *f*, driven through the intermediacy of a gear *g*, which constitutes an element of a variable speed drive, adapted to be actuated from a variable speed electric motor, so that the number of revolutions per minute of the furnace may be readily varied.

Each end of the furnace is faced with an annular metallic plate *h*, preferably of low carbon steel or other like appropriate conducting metal, which plate is provided with an annular series of apertures near its outer edge or border, through which apertures pass a corresponding series of headed bolts *i*, which bolts likewise pass through the rings *j*, *l*, and are provided at their inner ends with screw-threads having adjusting and locking nuts, as shown. Springs *m* are interposed between the rings *j* and *l* and encompass the shanks of the bolts, so that by means of the said nuts, the plates *h* may have a capacity for independent movement, to correspond to the effects of heat expansion in the furnace, but will nevertheless be held in strong elastic, adjustable contact with the furnace ends. The bolts *i* are held out of electrical contact with the plates and rings through which they pass by means of insulating sleeves, as shown, and the springs *m* rest against the ends of these sleeves and are out of electrical contact with the rings *j*, *l*, so that no electric current shall pass through the springs to affect their temper or resiliency.

The end lining of the furnace is made up of a circular course of graphite blocks *n*, making good electric contact with each other, and also of courses of fire brick *p* and chrome bricks *r*. A casting *s*, insulated from the plate *h* serves to sustain by suitable brackets the condenser A (one on each end of the furnace), which condenser and its prolong B revolve with the furnace structure and communicate with the interior thereof by means of the refractory connection *q*. Between the plate *h* and the end lining of the furnace may be interposed any suitable packing, for instance, asbestos, as indicated at *w*. The non-condensable gases escaping from the prolongs B may conveniently be led away through suitable stacks C, and the prolongs themselves may

be provided with interior partitions *v* to lessen the liability of small explosions therein.

The plates *h* are provided with an annular recess or depression *w*, which makes reliable electric contact with the outer ends of the courses of carbon blocks *n* at the two ends of the furnace, and these depressed portions *x* are held in such contact, by means of the springs *m*. At one end of the furnace, the depressed portion *x* forms a path for a carbon or metallic brush *y* constituting one of the terminals of an electric circuit, so that, during the revolution of the furnace, the electric current will be transmitted with certainty to that end of the furnace and to the circular course of carbon bricks, whatever longitudinal expansion may take place. The other carbon or metallic brush *z* constituting the opposite terminal of the current employed makes contact with the metallic shell *a* of the furnace. The ring *j* at said opposite end is in electric contact with the shell *a* and is likewise in electric contact with the corresponding plate *h*, through the intermediacy of the spring metal plates *o*.

In all three modifications of the furnace illustrated in the drawings, the arrangement of parts, hereinbefore specifically described, is preserved. In the modification shown in Figs. 1 and 2, however, the inner lining of chrome bricks *b* occupies substantially the entire length of the furnace, opening at its ends against the courses of carbon blocks *n*. In the modification shown in Fig. 4, the lining of chrome bricks *b* is not continuous, but is interrupted by intermediate sectional linings *n*² of graphite blocks. Finally, in the modification shown in Fig. 5, the inner lining is made up of chrome bricks or blocks and graphite bricks or blocks arranged in a particular sequence, whose function will be hereinafter more fully set forth.

In all of the modifications, the metal plates *h* at one end of the furnace are out of direct electric connection with the metal plates at the other end of the furnace, and are intended to be electrically connected, during the operation of the furnace, through the intermediacy of a molten fluid resistor, which is adapted to extend longitudinally, either from end to end of the interior chamber of the furnace, or, so as to span any non-conducting areas that may exist therein. This fluid resistor is indicated by the letter *D* in Fig. 1, by *D'* in Fig. 4, and by *D*² in Fig. 5. It may consist of a metal, a salt, or a slag, adapted to maintain fluidity during the passage of an electric current of suitable voltage and amperage, which current may either be direct or alternating.

In most instances, I prefer to employ cast iron as the material of the molten fluid resistor, and to give it such a chemical compo-

sition as to obtain not only high specific electric resistance, but also high fluidity at relatively low temperatures, say about 1200° C. Such an alloy may be obtained, for instance, by adding various proportions of phosphorus, nickel and chromium to cast iron, the proportions of the metallic elements being such as to form an alloy of iron, phosphorus, nickel, chromium and carbon of the minimum melting temperature, that is to say, the minimum eutectic for these five elements. The percentage of carbon present in solution in the alloy is automatically regulated by the equilibrium law of solution for a given temperature, there being always present an available excess of readily soluble carbon. The elements phosphorus, nickel and chromium are recommended because they have the property of giving high electrical resistance, while phosphorus gives high fluidity, and because these elements have a lower chemical affinity for sulfur than has iron. There is always present in the zinc ore charge a large excess of iron to always satisfy whatever sulfur has remained in the roasted zinc ore. It follows, therefore, that the quantities of phosphorus, nickel and chromium originally present in the molten cast iron resistor, will be practically maintained constant, except for the mechanical losses, such as metallic shot, entrapped by the slag or mattes. It will be, of course, apparent that the advantage of high fluidity of the molten resistor is to permit it to quickly adjust its level during the rotation of the furnace, and that the advantage of high specific electrical resistance is that, for the depth of resistor necessary, a high electrical efficiency is nevertheless secured, *i. e.*, that the ratio of the ohmic resistance of the molten resistor to the total of the electrical resistances between the molten resistor and the brushes is at a maximum.

In the modification shown in Fig. 4, the molten fluid resistor is illustrated as bridging portions of the inner lining, in such manner that the passage of the electric current will take place in part through molten resistor and in part through solid resistor. The number of bridges of molten resistor *D'* and of intervening solid resistor of graphite *n*² may vary in accordance with the particular thermal effects desired. Thus, in Fig. 4, there are shown three bridges *D'* of molten resistor and two intervening lining sections *n*² of graphite resistor, but I do not confine myself to this particular number, as it is evident that one or more of the bridges may be suppressed and their places substituted by graphite resistor, or that their number may be increased, if desired.

In the modification shown in Fig. 5, the interior lining is likewise made composite, that is, consisting in part of a molten re-

sistor and of a solid graphite resistor, so as to correspondingly increase the resistance within the furnace and obtain higher heating effects. In this instance, I have shown a single bridge of molten resistor D^2 occupying a position midway of the furnace lining, but it is, of course, evident that this bridge may be supplemented by others, as in the instance illustrated in Fig. 4. A particular feature of the arrangement shown in Fig. 5 is that in order to permit uniform linear expansion throughout all of the longitudinal rows of the interior lining, I have so disposed the bricks or blocks that in each longitudinal row there will be the same number of bricks or blocks, although each row is made up in part of chrome bricks and in part of graphite bricks. In this Fig. 5, the chrome bricks are indicated by the white rectangles and the graphite bricks by the black ones, and it will be noted that the graphite bricks of one longitudinal course overlap the graphite bricks of the courses on each side thereof. It, therefore, results that there is continuity of electrical connection, in a zigzag or oblique line from each annular course of graphite bricks n at the ends of the furnace to the middle well occupied by the molten resistor, and furthermore, that each of the longitudinal courses is made up of the same number of chrome bricks or graphite bricks; for instance, in the example shown in Fig. 5, each longitudinal course of the internal lining is made up of fifteen (15) graphite bricks or blocks and eighteen (18) chrome bricks or blocks (including the three chrome bricks at the central well or bridge) and it will be equally apparent that this arrangement provides an equal coefficient of expansion for all of the longitudinal courses.

Condensation of the zinc vapor to the liquid condition will take place in the zinc chamber or chambers A, which rotate with the furnace, and these condensers may be cooled, in addition to the cooling which they experience from rotating in the open air, by a jet or jets of air, directed upon them. Any condensable matter carried off from the condensers A into the prolong B are recovered therein and the productions of combustion are collected and carried off through the stack or stacks C.

In the practice of the invention, the furnace may be charged in any suitable manner, either by removing one or the other of the condensers, or by admitting the charge through an aperture in the shell and lining, which aperture is normally closed by a plug E (see Fig. 2) and the removable brick sections thereunder. Before admitting the charge, however, the furnace is heated preliminarily. This heating is effected either by a gas or oil flame, but preferably by admitting into the furnace, a body of molten

lead, or other metal of low melting point, and passing the electric current through the furnace, while subjecting it to a slow movement of rotation. When the furnace lining has attained the necessary temperature, the furnace is stopped and the lead or other like metal is tapped off. A known amount of resistor, preferably melted before it is inserted in the furnace, is then introduced, sufficient to reach the level desired. The furnace is then charged, preferably with roasted ore direct from the roasting furnace, and at the high temperature incident to such roasting, and also with the necessary amount of carbon, also preferably pre-heated. The furnace is then again set in rotation, and the reducing and condensing operation proceeds, the electrical current maintaining the necessary thermal conditions. When the reduction of the charge is completed, the contents of the furnace may be tapped, through the same aperture that had served for charging it, it being understood that the capacity of the furnace to rotate permits the slag to be tapped off separately from the metal remaining in the furnace. It has already been indicated that where the zinc ores treated contain any of the precious metals, it will be desirable to add enough copper ore to the charge to form a copper matte, to insure their recovery.

Speaking further of the general operation of the invention, it will be noted that the agitation of the contents of the furnace, due to the rotation, results in close and intimate contact between the constituents of the furnace charge, thereby shortening the time required for the complete chemical action, and not only increasing the daily furnace capacity, but also increasing the heat efficiency of the furnace, as heat is radiated, for a given charge, during a shorter space of time, so that the loss of radiated heat is correspondingly less. Furthermore, the rotation and agitation of the contents of the furnace result in the rapid attainment of an equilibrium of temperature throughout the mass of the charge, and the rotation of the furnace, by constantly renewing the surface of the lining in contact with the heating medium, keeps the whole furnace at a high heat. Evidently, however, the upper part of the furnace will be at all times to some extent cooler than the lower part which contains the molten resistor. This is a desirable feature, in that it keeps at a minimum the temperature of the issuing gases and vapors, thus facilitating the condensation of the latter while keeping at a minimum the number of heat units carried away by the gases.

What I claim is:—

1. An electric furnace, having an interior lining made up of longitudinal courses consisting of the same number of conducting

and non-conducting blocks, so as to equalize expansion, the conducting blocks of the adjacent courses overlapping so as to conduct the electric current from one to the other.

- 5 2. An electric furnace, having a rotatory main body chamber, provided with an interior peripheral lining having a series of longitudinal courses of solid peripheral conductors forming a part of said lining and
10 separated from each other by longitudinal courses of solid peripheral non-conductors, said conductors having a break in their electric conductivity and being bridged successively at the bottom of the chamber and
15 across said break by molten resisting material.

3. An electric furnace, having a rotatory main body chamber, provided with an interior peripheral lining, having solid peripheral conductors forming a part of said lining, said conductors having a break in their electric continuity, across which break they are bridged at the bottom of the chamber by molten resisting material.

In testimony whereof I affix my signature, 25
in presence of two witnesses.

AUGUSTIN LEON JEAN QUENEAU.

Witnesses:

JOHN C. PENNIE,
LAURA B. PENFIELD.