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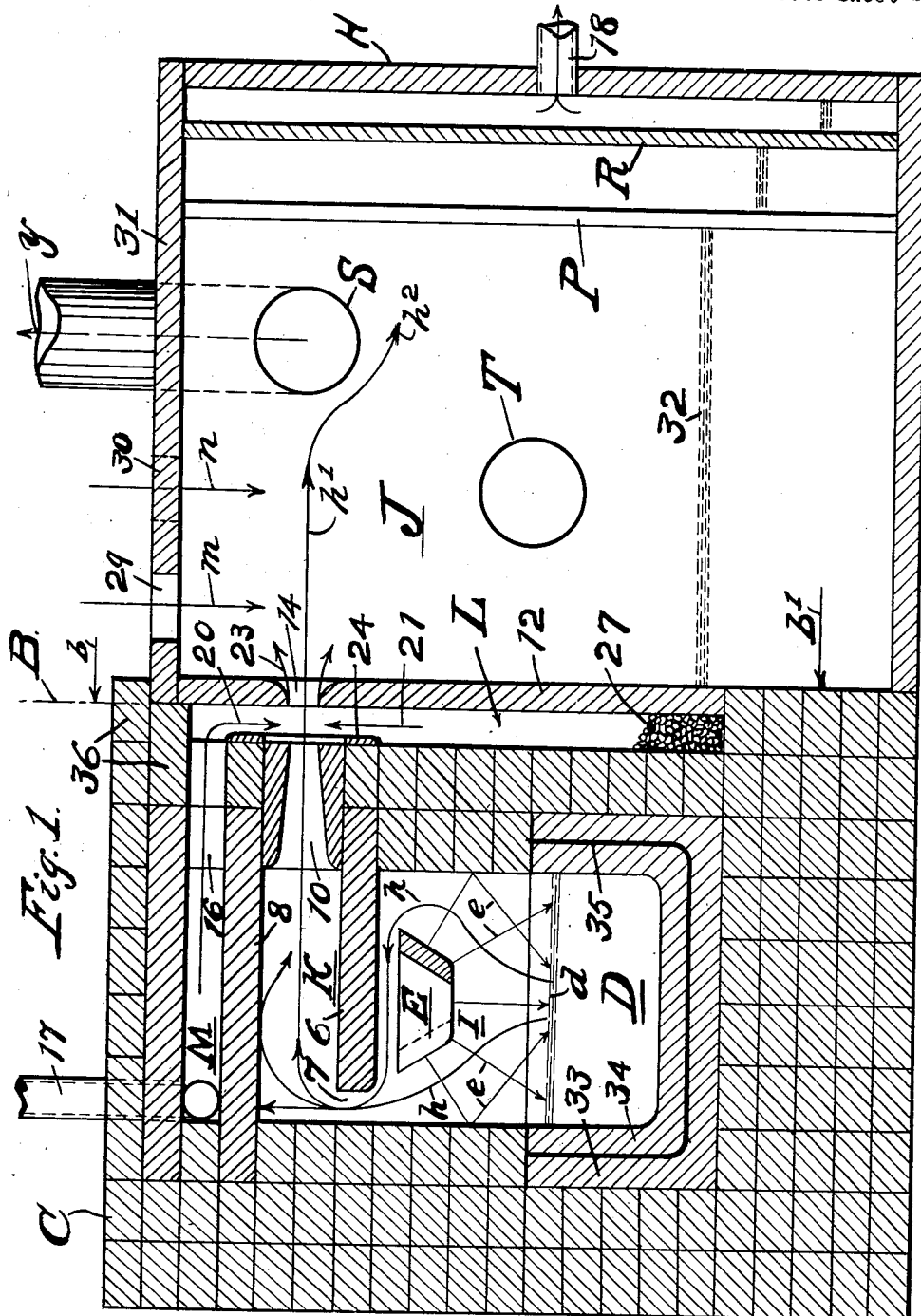
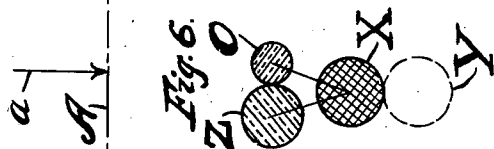
J. THOMSON ET AL

1,503,564

ELECTRIC FURNACE AND PRECIPITATOR FOR PRODUCING OXIDE OF ZINC

Filed Aug. 21, 1922

3 Sheets-Sheet 1



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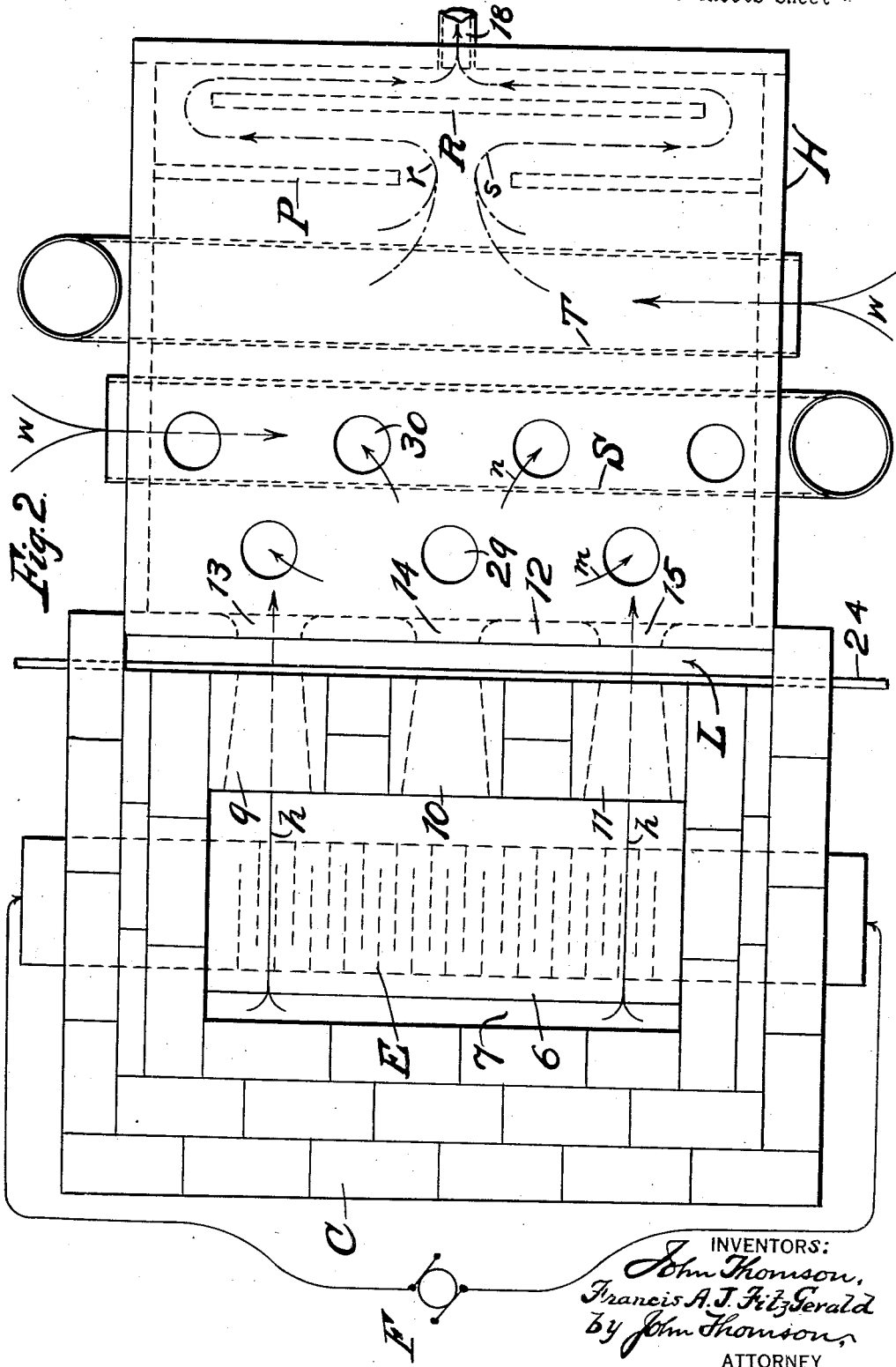
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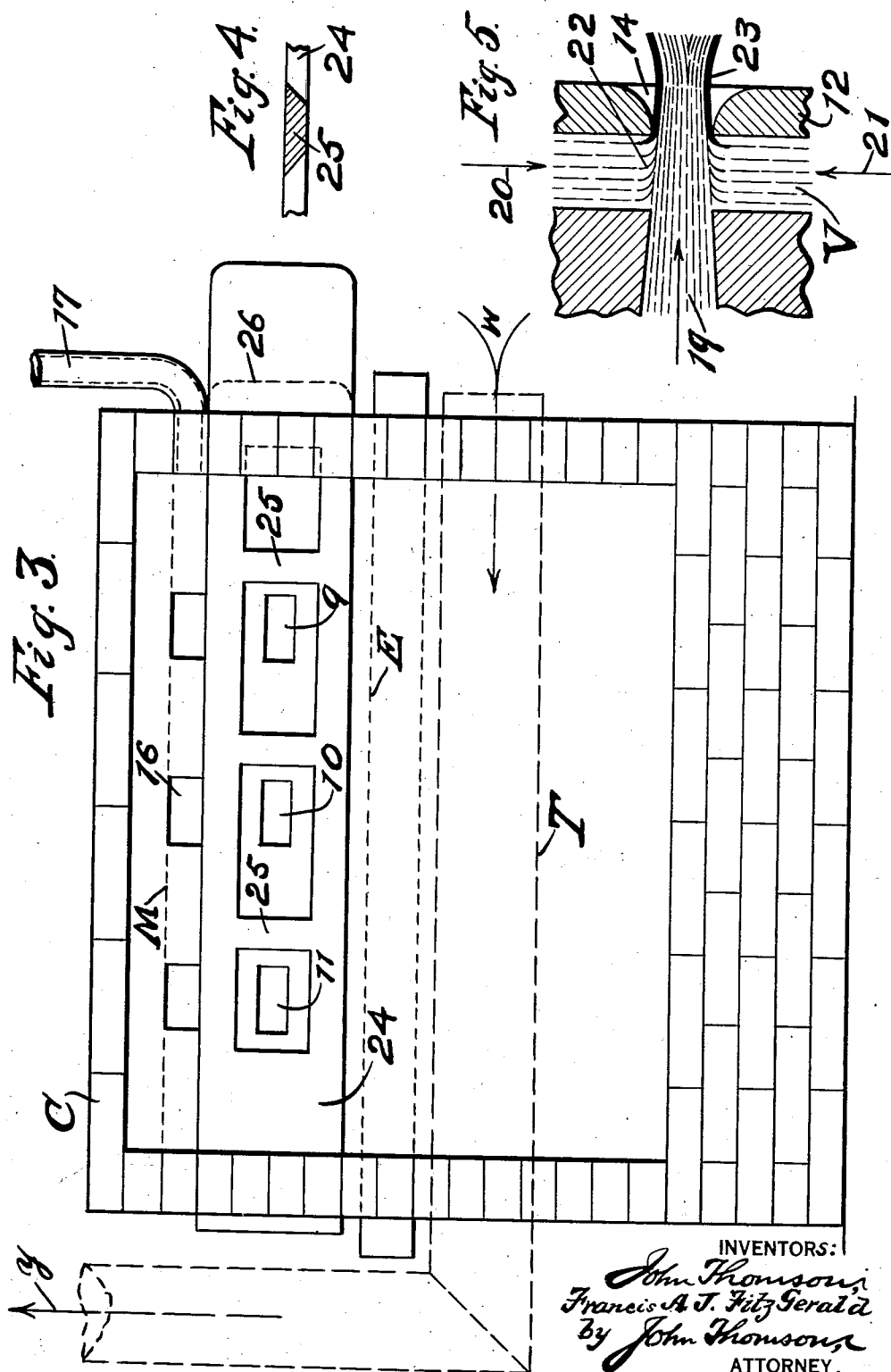
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3 Sheets--Sheet 3



UNITED STATES PATENT OFFICE.

JOHN THOMSON, OF BROOKLYN, AND FRANCIS A. J. FITZGERALD, OF NIAGARA FALLS, NEW YORK.

ELECTRIC FURNACE AND PRECIPITATOR FOR PRODUCING OXIDE OF ZINC.

Application filed August 21, 1922. Serial No. 583,388.

To all whom it may concern:

Be it known that we, JOHN THOMSON and FRANCIS A. J. FITZGERALD, citizens of the United States, and residents, respectively, of the borough of Brooklyn, city and State of New York, and of the city of Niagara Falls, State of New York, have jointly invented an Electric Furnace and Precipitator for Producing Oxide of Zinc, of which the following is a specification.

This is an invention in electric furnaces and precipitators for producing oxide-of-zinc (ZnO) by the oxidization of redistilled zinc. The summated objects hereof are to enhance the quantity and quality of the merchantable product; and, relative to prior practice, to diminish the difficulties of operation; and to control the physical characteristics of the derived oxide.

Zinc-oxide, is suitable for pigment purposes and for incorporation with vulcanized rubber, may have a structure which is commonly, but perhaps inexactly, characterized as "amorphous," and it may also have a structure which, with exactness, is definable as "crystalline." The difference in structure is deemed to be a function of temperature; for, at all thermic ranges at which vaporized zinc will "burn" to its oxide (that is above the critical point at which zinc-fume condenses to liquid metal) the resulting product may be either amorphous or crystalline in structure, depending upon certain conditions.

In the time-honored "French-process," (whereby zinc is vaporized in retorts by fuel-heat externally applied) the fume may not acquire but a moderate, if any, super-heat, that is heat imparted to the fume after it leaves the surface of the bath. In an electric furnace, however, the fume can be super-heated to any desired extent. Hence, one of the co-ordinating features of this invention is to provide conditions, particularly in an electric furnace, whereby all of the evolved fume can be fully burned to its oxide and to also produce either amorphous oxide or crystalline oxide at will.

When zinc-fume flows from a furnace-port into an oxidizing atmosphere, the inner surface of the outlet portion of the mouth of the port, and thereafter the face of the port contiguous to the bore, gathers an accretion of what is commonly termed "crust," which may also contain more or

less of condensed metal and blue-powder. This crust, or sinter, is not remuneratively marketable, except it is subsequently reduced according to the classical equation ($ZnO + C = Zn + CO$); moreover, it must be occasionally removed, to avoid clogging of the outflowing aperture. The obviation of this difficulty is a co-ordinating feature hereof.

In prior practice, it has been customary, and even necessary, to supply a volume of air far in excess of what is actually required to furnish the oxygen for burning a given quantity of zinc-fume to its oxide. Among the objections to this practice, the following are selected for specific mention: An excessive volume of spent and semi-spent residual gases have then to be dealt with; and portions of the fume may be "burned" at a considerably lesser temperature, or a higher temperature, than other portions thereof, resulting in the precipitation of an oxide having various degrees of comminution and of crystallization. The obviation of these objections is a concrete feature hereof.

Other allied features, not deemed necessary to prefatorily mention, will hereinafter duly appear.

In the drawings, which constitute an integral part of this specification,

Figure 1 is a vertical, transverse center section of an electric zinc-fuming furnace, whilst contiguous thereto, on the right hand side of the drawing, is a vertical, longitudinal section of the co-ordinating precipitator in which the zinc-fume is reduced to its oxide; but is here shown of a lesser relative length than would be the case in practice;

Figure 2 illustrates the furnace in horizontal section, along the plane A of Figure 1, viewed as arrow *a*, the contiguous precipitator being shown in plan;

Figure 3 is a longitudinal elevation of the furnace, along the plane B of Figure 1, viewed as arrows *b*, *b'*;

Figure 4 is an enlarged detached sectional view of a structural detail;

Figure 5 is an enlarged diagrammatic illustration of the gaseous flows from the furnace to its precipitator; and

Figure 6, sheet No. 1, is a diagram to visualize a conceived theory of crust-formation.

C is the furnace; D is the zinc-tank reservoir, containing a molten bath, as *d*; E is a typical zig-zag, carbon resistor, connected to a source of power, as conventionally shown by F; the heat-flow from the resistor to the bath is denoted by arrows *e, e*; and H is the precipitator, contiguous to, or formed as an integral extension of the furnace.

It has not been deemed necessary to encumber the drawings with means for charging the furnace; which may be presumed to be supplied by pouring pre-melted metal through a suitable sluice or funnel.

Above the resistor is a septum, 6, formed by fixing a plate, preferably formed of carbon, in the right hand side of the furnace, but leaving a lengthy port-opening, as 7, at the left hand side of the fuming chamber, I. The object of this septum is to baffle a free flow of heat upwardly from the resistor, thereby preventing its direct impingement upon the roof of the furnace; also to cause all of the rising zinc-fume, denoted by arrows *h, h*, to flow through the aforesaid opening, causing the fume to impinge upon the roof-plate, effecting an even diffusion of temperature, whence it thereafter flows towards and through the furnace ports, 9, 10, 11, and finally into the precipitating chamber J, as see arrow *h*¹. The cubical capacity of this furnace sub-chamber, K, may be such that the rate of flow therethrough may be quite slow; whereby, provided the heat-conducting conditions above the roof-plate 8, are adequate, the temperature of the up-flowing fume, from the opening 7, will be considerably diminished. The foregoing feature is here presented as a complementary combination, with other co-ordinating features yet to be pointed out, which appears in United States patents to John Thomson, one of the present applicants, Nos. 1,193,633 and 1,214,842, respectively dated August 8, 1916, and February 6, 1917. As disclosed in these patents, this septum-system may be variously arranged in single or compound series, or in parallel, which can be here utilized, if or when such should be desirable.

Extending along the right hand side of the furnace, intermediate of the precipitator, is a relatively narrow, vertical chamber, L, formed by a bridge-wall, 12, in which are three openings, 13, 14, 15, in axial alignment with the bores of the furnace zinc-fume ports. In the roof of the furnace, above the lower roof-plate, is a horizontal chamber, M, having a port, 16, or a plurality of ports as shown in Figure 3, which connects this chamber with the vertical chamber, L; and leading into chamber M is a supply pipe, as 17. It will thus be perceived that chamber L encompasses all of the ports leading from the sub-chamber and the roof-chamber.

It has already been briefly alluded to but will now be further amplified that, when

zinc-fume passes through a port and thence directly enters an oxidizing atmosphere, the bore of the port and thenafter its outer surface becomes coated with "crust"—a sort of clinker—as if the oxide were fused, appearing like a honey-combed structure; which, if the temperature of the contiguous port-surfaces is below the condensing point, may contain imprisoned metallic zinc and "blue-powder." If the reaction proceeds in clear space, even with super-heated zinc-fume and pure oxygen, none of the resulting oxide will be sintered. It is conjectured that the reason thereof is probably because the reaction, although considerably exothermic, may be characterized as molecularly isolated, one particle being out of contact with another of them.

But when the initial reaction takes place at or near to a surface, particles of oxide can then collect, whereby the intensely focalized heat, as in, to again so express it, a contiguous molecule in process of transformation, heat is transferred by conduction to the aforesaid collected particles, whence it is quite conceivable that the temperature is sufficient to fuse or semi-fuse the oxide, thereby sintering the particles together. This hypothesis seems substantiated by ocular observation; for incrustation begins slowly; but, after the initial deposition of crust, it thenafter builds-up, with cumulative rapidity, as in the familiar case of a rolling snow-ball.

The foregoing concept is visualized in Figure 6, wherein Z is a gaseous "molecule" of zinc-fume; O is its complementary "molecule" of oxygen and X is the resulting ZnO. At this stage, although the focalized heat is doubtless very intense, the produced particle of oxide remains, so to express it, distinctly isolated. If, however, this particle, at the instant of its transformation, and when its temperature is a maximum, impinges upon another particle, as indicated by the dotted circle Y, or numerous particles forming a collected fringe thereof at the port-face, the heat is, or may be, so intense and so adequately transferred, by direct conduction from one to the other of them, as to sinter the particles together, forming the so-called "crust."

The generic remedy for the difficulty just described has already been signalized by Francis A. J. Fitzgerald, one of the present applicants, as see his United States patent entitled "Method of protecting resistors of electric furnaces," dated March 1, 1910, No. 950,905. In that instance, the resistor, formed of carbon, is suspended in a chamber filled with inert gas, whereby, as the aforesaid patent expresses it, the inert gas is "around the resistor" thereby "actively checking the entrance of air" to the said resistor. The present pertinency of the

foregoing citation will now be made apparent.

By completely embedding the zinc-fume, as it issues from its port, or ports, within inert gas, such as nitrogen, or monoxide of carbon, or even producer gases, "the entrance of air" to the zinc-fume, is "actively" checked. Moreover, if the embedding inert gas is itself pre-heated, the temperature of the outer portion of the furnace fume-port can thus be maintained above the critical condensation point of zinc and a lesser volume thereof will serve the benign purpose.

The foregoing desirable conditions may be effectively realized as follows: By keeping the chamber M filled with inert gas it will rapidly absorb heat from the relatively thin underlying roof-plate, thus serving the desirable purposes of abstracting heat from the zinc-fume, contained in chamber K, and itself absorbing the heat given up by the fume. The inert gas then flows out, through port 16, into chamber L, completely filling it, as in the nature of an equalizing reservoir, that is this condition ensues when a normal flow of zinc-fume is being delivered from the furnace-ports and thence passes on through their co-ordinating port-openings in the bridge-wall. The consequence thereof is that air in chamber L is wholly displaced by inert gas; which, so to speak, forms a dense fog-cloud, or gas-bank, between the furnace and the bridge-wall, whereby the fume-jets, before their entrance to the precipitator can be effected, must first pierce the said gas-bank. And one should here bear in mind that the inert gas would normally be under pressure, slightly above atmosphere; that the zinc-fume is impelled by slight pressure from the furnace chamber; and that a moderate degree of suction is contemplated within the precipitator, derived from a pump, not shown, attached to the end-pipe, 18.

As a concomitant of the piercing action of a zinc-fume jet, as 19, Figure 5, this produces attrition upon the inert gas, V, supplied under slight pressure as arrows 20, 21, which will therefore be stripped or peeled off, by the flowing fume, somewhat as is indicated at 22. The stripped gas will thence pass through the bridge-wall opening, 14, around the fume-core, in the form of a mantle or band, as 23. This inert-gas-mantle will effectively baffle an impingement of the air in the precipitator upon the on-flowing fume-jet, and so delays or impedes the reaction, until the fume has advanced into space entirely clear of wall-surfaces, that the formation of a sintered substance is wholly avoided. If the fume-jet, as it leaves its port, converges towards its axis, as depicted, whereby it would normally slightly clear the inner sharp edges of the bridge-wall openings, of indrawn inert gas

will then be a minimum. Moreover, the mode of supplying the inert gas is uniquely efficient, in that it approaches the fume-jet at a right angle thereto and at a low rate of flow; consequently, the rate of its extrusion is governed by and corresponds to the velocity of the fume. The bridge-wall ports 14, need not necessarily be rounded outwardly, but may be reversed, curving inwardly towards the furnace.

When a furnace-unit is being brought up to working temperature, or during a short run, or if the supply of inert gas should fail, to avoid the usual inefficient method of keeping the fume-ports free of crust, as by poking with a rod or the like, through a wall-opening, a relatively thin plate, 24 is suitably mounted to lie across the faces of the ports, its ends protruding, having formed therein vertical sharp-edge strips, as 25, Figure 3, of which an enlarged cross-section is shown in Figure 4. The arrangement and disposal should be such, somewhat as is depicted, that when the plate is slid forward, as to the dotted position, 26, these strips will pass across and in close-contact with the faces of the ports, and when again pulled outwardly the same effect will ensue. Any initial deposition of crust will then be shaved off and fall into the bottom of the chamber, as 27, Figure 1, whereby it will not become mixed with the oxide in the precipitating compartment. This shaving action can be readily, frequently and rapidly effected, either manually or mechanically; and, as crusting begins slowly, it is thus feasible to prevent its accretion and to operate the furnace with but a nominal production of unmarketable material. So, too, it is entirely feasible, if or when desired, to situate this shaving-plate to act upon the bridge-wall ports, 13, 14, 15; or two of these plates can be used, one within the bridge-wall as shown, and the other without, as just described.

It might seem, at first blush, as if it would make but little difference, in the results, as to the way and manner that the oxidizing medium is introduced into the precipitator; but such, definitely, is not the case. On the contrary, it has been demonstrated, whereby the moving theory was proven to be well founded, that if the oxidizing agent, be it generated oxygen or atmospheric air, be introduced vertically to impinge upon an underlying, horizontally flowing stream or streams of zinc-fume, as through a plurality of openings 29, 30, in the precipitator roof-plate, 31, Figures 1 and 2, a more rapid and complete commingling of the reacting gases ensue. This is due to the facts that the right angle impingement thus effected produces attrition, and also that either oxygen or atmospheric air, at normal temperature, has a greater density than zinc-fume when

it is heated to the high temperature necessary for being "burned" to ZnO. The advantage of inducting the oxidizing medium from above, flowing vertically downward, as arrows *m*, *n*, Figure 1, is that it, being of the greater density, gravitates into the gaseous fume-bath, as arrow *h*¹, of lesser density, the merged gases moving along and downwardly, as arrow *h*², whereby the admixture is probably as perfect as it is possible to attain. The reaction necessarily proceeds rapidly and uniformly, besides which the derived oxide is given an initial impetus towards the bottom of the precipitator, thereby deriving a more compact deposition thereof, as 32, in the forward portion of the precipitator, than could otherwise be attained. Furthermore, less oxide is floated rearwardly; and, when bags are used, their duty is diminished.

It thus becomes a matter of fundamental simplicity to regulate the supply of air; which is controlled by increasing or decreasing the area of the roof-openings, or by varying the intensity of the suction, or both.

The rearward flow through the precipitator, may be around suitable baffle-partitions, as P, R, denoted by arrows *r*, *s*, Figure 2, and conventional blankets or bags may be provided, beyond the suction tube, 18, for regaining such oxide as may float out with the residual gases.

When it is required to produce an amorphous oxide, if the stored heat in the out-flowing residual gases is greater than is desired, for example, adequate to produce a crystalline oxide, this condition can be well controlled by mounting open-ended tubes, such as S, T, to pass through the precipitator horizontally, one portion of each projecting upwardly, whereby cooling air is caused to circulate therethrough, by natural draft, as is indicated by arrows W, Y.

When it is required to deliver the zinc-gas with a lesser degree of super-heat, the septum may be omitted, as also the horizontal chamber, M, and the enmantling inert-gas would then be otherwise introduced; for example, directly into the vertical chamber, L, through the end-walls of the furnace, or firstly into a pre-heating sub-chamber, or chambers, located along the sides or beneath the bath-tank.

When the bath-tank of an electric zinc-fuming furnace is brim-full, the relatively moderate temperature imparted thereto is about equal to that of the molten metal and the heat is quite uniformly distributed; but, as the depth of the bath is diminished, the inner vertical surfaces are thereby exposed and a much higher temperature is then directly imparted thereto by the resistor. In these circumstances, portions of the inner wall-surfaces are exposed to peri-

odic expansions and contraction; and, if a so-called "crazy-crack" is started its tendency is to progress until a complete cross-fracture is produced, when metal leaks into the surrounding brick-work. As see Figure 1, this objection is obviated by forming the bath-tank of nested pans, or tanks, an outer, as 33, and an inner, as 34, but preferably having narrow, free spaces between them, as denoted by the heavy line, 35, which may be filled with oxide of zinc, which is an excellent non-conductor of heat, or with granular iron, or with a mixture of both. As is well established, any joint disposed transversely to heat-flow, serves to baffle and sensibly diminish thermic transfer from one member to another. Also, molten zinc, particularly when at a relatively high temperature, is an active dissolvent of iron; the resulting product being a viscous, pasty conglomerate. Thus, utilizing the foregoing conditions, if the inner pan of the described bath-tank is fractured upon its inner surface, the progress thereof ceases at the intervening space; and the transfer of heat into the outer pan is substantially less than if both were merged into an integral unit. Moreover, if molten zinc enters the aforesaid space, it having previously been charged with granulated iron, such as filings, the latter will be dissolved and a self-filling, metallic, putty-like paste will be produced. Hence, should the outer pan itself be eventually fractured this viscous material will be displaced and forced therein, whereby free leakage from the path is prevented. But it is important to observe that the quantity of iron shall be so limited as not to produce, when dissolved, an objectionable pressure upon the walls of the nested pans.

It is deemed to have been adequately shown and elucidated that the maneuver of this furnace-unit is under complete control, whereby any desired operative condition, or set of operative conditions, can be realized at will, as the following brief recapitulation substantiates.

If highly super-heated zinc-fume is desirable within the precipitator, it can be had; if, per contra, a moderately super-heated zinc-fume is desirable, it can be had; if it is desired to wholly prevent the formation of crusts, this is readily and inexpensively realizable; yet, if it will serve to permit a slight initial formation of crusts, but to periodically arrest an objectionable accretion thereof, this practice may be followed; by utilizing the described difference in gaseous densities, the speed and uniformity of the reaction is controllable, a desirable accumulation of the oxide is confined to the forward portion of the precipitator, the volume of spent, or semi-spent, gases to be dealt with becomes a minimum, and the tempera-

ture may be so determined as to produce either amorphous or crystalline oxide.

Various detail modifications can be made and yet be bounden within the purview of the ensuing claims. For example, the inert gas can be pre-heated, outside of the furnace, prior to its introduction into the roof-chamber; and the sliding shaving plate may be substituted by separate, fulcrumed blades to be operated in unison and pass across the port-faces with a sickle-like motion. So, too, the top of the vertical, inert gas-chamber may be enclosed with mica, or glass, whereby the condition of the parts may be under convenient and continuous visual inspection, to augment which the interior of this chamber may be electrically illuminated. It will also be perceived that, by simply removing the overlying bricks, as 36 Figure 1, plugs or blocks can readily be inserted, whereby to close-off the various port-openings until a free evolution of zinc-fume will have been established.

What we claim is:

1. An electric fuming furnace and a co-ordinating oxide precipitator between which is a chamber adapted to receive inert gas, such as nitrogen, the construction and disposal being such that the zinc-fume, in its transverse traverse from the furnace towards the precipitator, must pierce the said inert gas.

2. An electric furnace and co-ordinating precipitator for producing oxide of zinc from re-distilled zinc, having a cloud-bank of inert gas, such as nitrogen, in a chamber intermediate of the furnace ports and the precipitator ports, whereby the transversely flowing zinc-fume pierces the said cloud-bank, strips off an enmantling band of the said inert gas and conveys it into the precipitator.

3. In an electric furnace and a co-ordinating precipitator for producing oxide of zinc from re-distilled zinc, a chamber intermediate of the furnace ports and the precipitator ports which is kept filled with pre-heated inert-gas, such as nitrogen, and functions as a conveyor of heat to the contiguous port-surfaces.

4. In an electric furnace and a co-ordinating precipitator for producing oxide of zinc from re-distilled zinc, a cloud-bank of inert-gas, such as nitrogen, maintained in a chamber intermediate of the furnace and the precipitator, the construction and disposals being such that the transversely flowing zinc-fume extrudes a mantle or band of the inert gas, around the zinc-fume, as and when the latter enters the precipitator.

5. The combination, with the zinc-bath and fuming chamber the resistor side-ported septum and the co-ordinating precipitator, of the zinc-fume chamber and the inert gas roof chamber, whereby the inert gas serves

to abstract heat from the zinc-fume and itself absorbs the said extracted heat.

6. The combination, with the zinc-fume ports and an inert gas port or ports in the furnace, of an encompassing frontal chamber formed by a bridge-wall having openings or ports in axial alignment with the furnace zinc-fume ports which lead to the oxidizing compartment of the precipitator.

7. In an electric furnace and a co-ordinating precipitator for producing oxide of zinc from re-distilled zinc, means for mechanically shaving these faces of the fume-ports from which the zinc-fume passes into the precipitator.

8. In an electric furnace and a co-ordinating precipitator for producing oxide of zinc from re-distilled zinc, a slidable plate having formed therein sharp-edged strips whose construction and disposal are such that a longitudinally movement thereof causes the said strips to pass across the faces of the fume-ports and to simultaneously impart a shaving action thereto, as and for the purpose set forth.

9. An electric zinc-fuming furnace and a co-ordinating oxide precipitator, the zinc-fume flowing into the precipitator towards the upper zone thereof and along a general horizontal plane, in which the oxidizing medium, such as generated oxygen or air, is passed into the burning chamber through its roof, thence flowing vertically downward and impinging upon the horizontally moving zinc-fume.

10. An electric zinc-fuming furnace and a co-ordinating oxide precipitator in which the oxidizing medium, such as produced oxygen or air, at its normal temperature, is so introduced into the burning compartment that it gravitates into the hot zinc-fume of lesser density.

11. In an electric furnace, a reservoir for molten metal formed from pans nested together.

12. In an electric furnace, a reservoir for molten zinc formed from nested pans separated by intervening spaces which are filled with granulated iron.

13. In an electric furnace, a reservoir for molten zinc formed by a plurality of pans, or tanks, having intervening spaces filled with granulated iron: whereby, if the inner pan is fractured, zinc will reach and dissolve the iron, as and for the purpose set forth.

14. In an electric furnace and a co-ordinating furnace for producing oxide of zinc from re-distilled zinc, open-ended tubes passing through the precipitator horizontally, one extension of each being thence deflected upwardly, whereby natural draft is created therein, as and for the purpose set forth.

15. An electric zinc fuming furnace and

a co-ordinating oxide precipitator having means in the furnace for so controlling the temperature of the zinc-fume, prior to its introduction into the precipitator, that the
5 characteristic structure of the produced oxide shall either be wholly amorphous or wholly crystalline.

16. An electric zinc fuming furnace and
10 a co-ordinating oxide precipitator having means in the precipitator for so controlling the burning temperature that the characteristic structure of the produced oxide shall either be wholly amorphous or wholly crystalline.

17. An electric zinc fuming furnace and 15
a co-ordinating oxide precipitator having means in the furnace and also in the precipitator, operative either severally or jointly, for so controlling the temperature of the reaction that the characteristic structure 20
of the produced oxide shall correspondingly be either wholly amorphous or wholly crystalline.

This specification signed as of the 8th day of August, A. D. 1922.

JOHN THOMSON.
FRANCIS A. J. FITZGERALD.