4 Sheets—Sheet 1.

F. L. CLERC.

PROCESS FOR EXTRACTING ZINC FROM ITS ORES.

No. 178,998. Patented June 20, 1876.

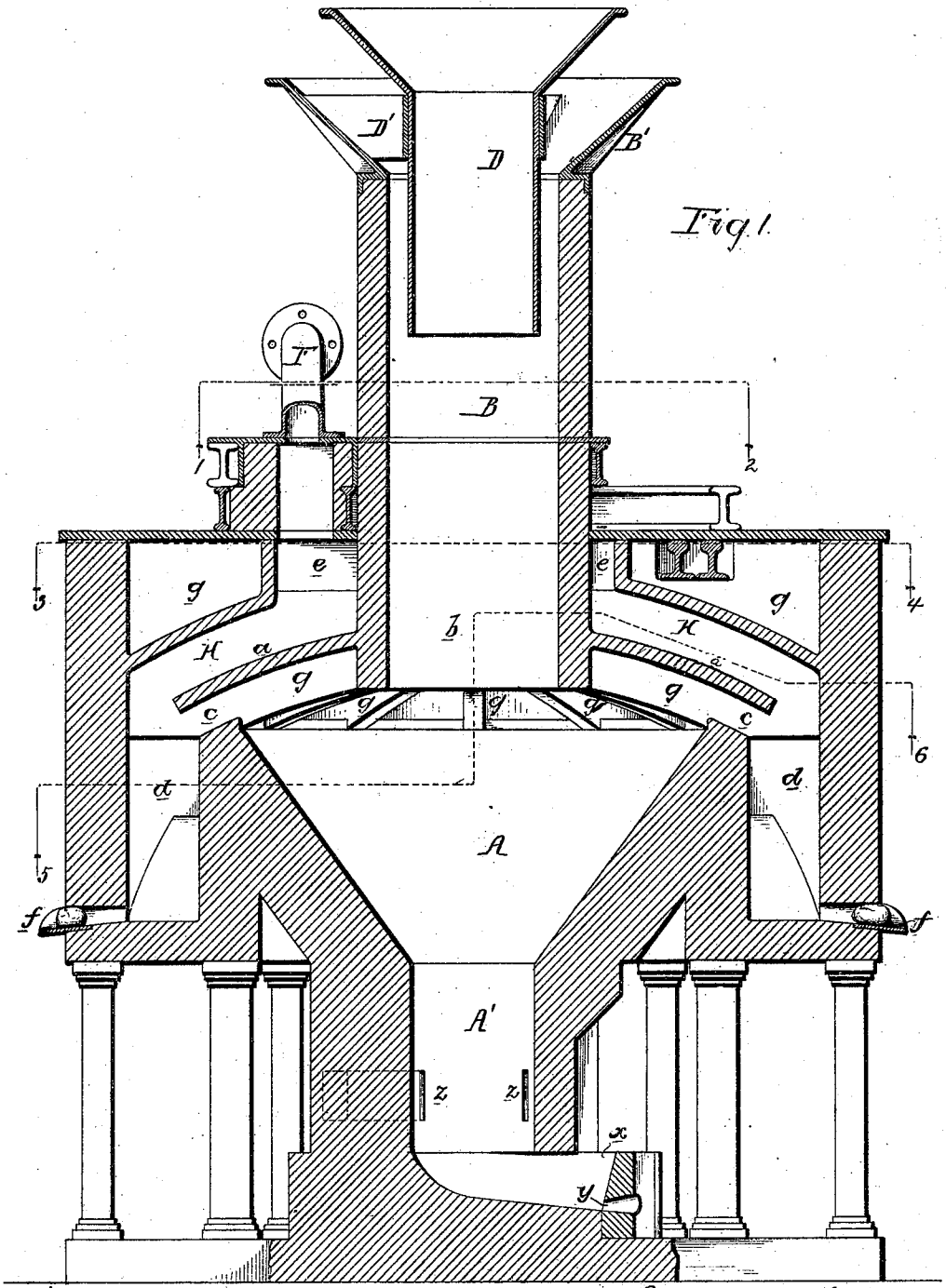

Fig. 1.

Witnesses
Harry Howson, Jr.
Harry Smith

Frank L. Clerc.
by his Attorneys,
Howson and Son

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Fig. 2.

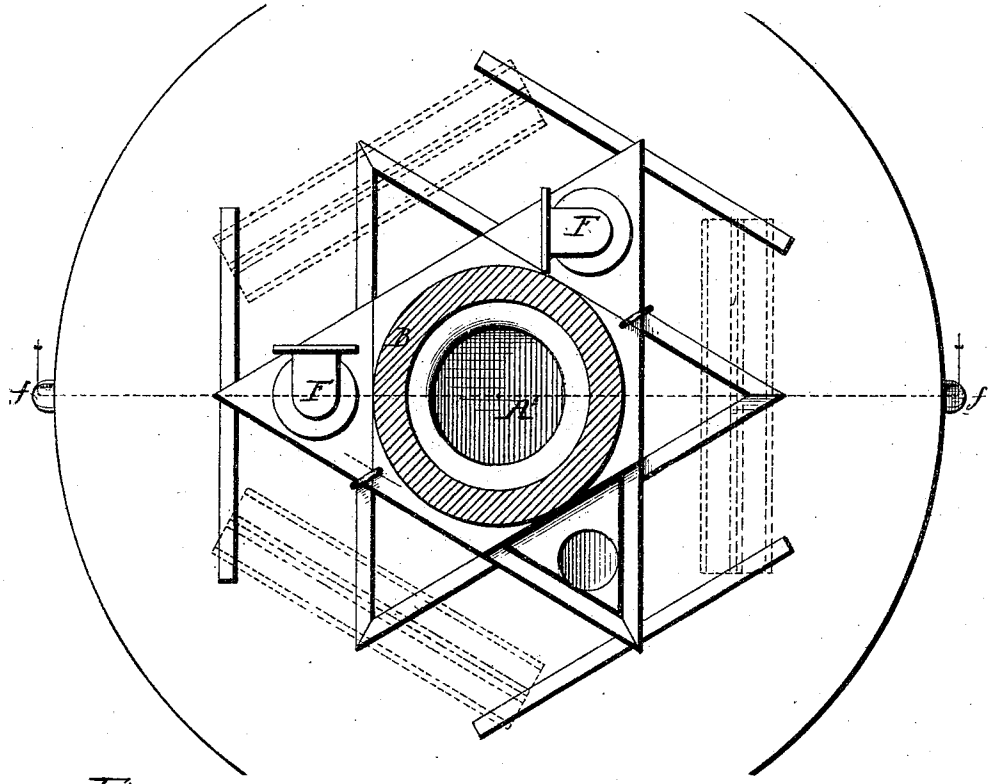
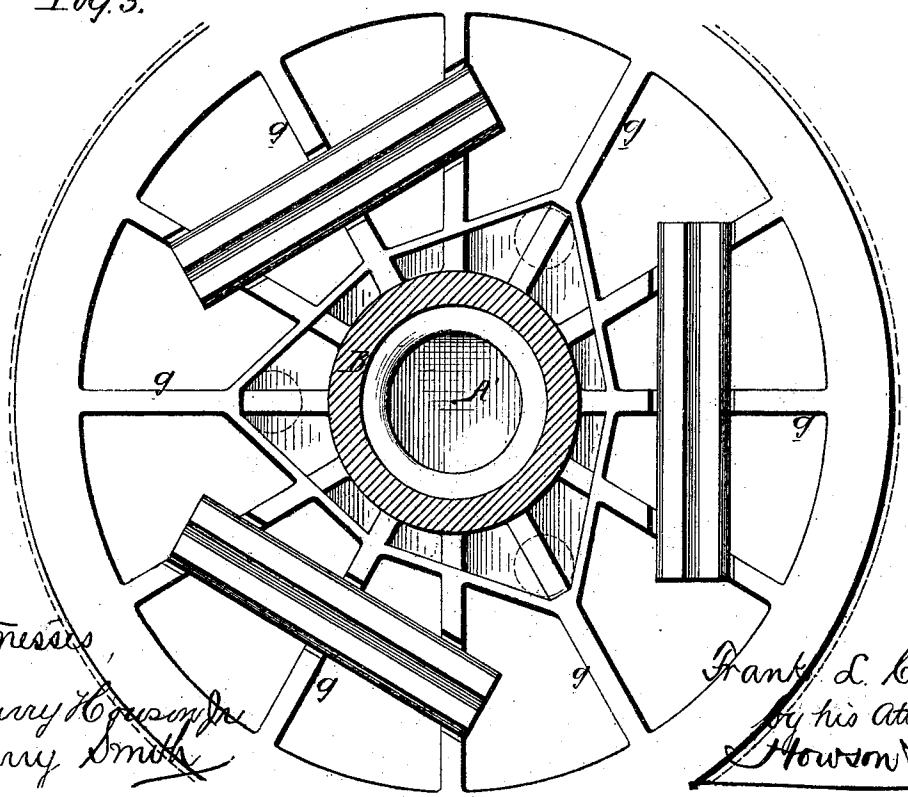


Fig. 3.



Witnesses,
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Harry Smith

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F. L. CLERC.

PROCESS FOR EXTRACTING ZINC FROM ITS ORES.

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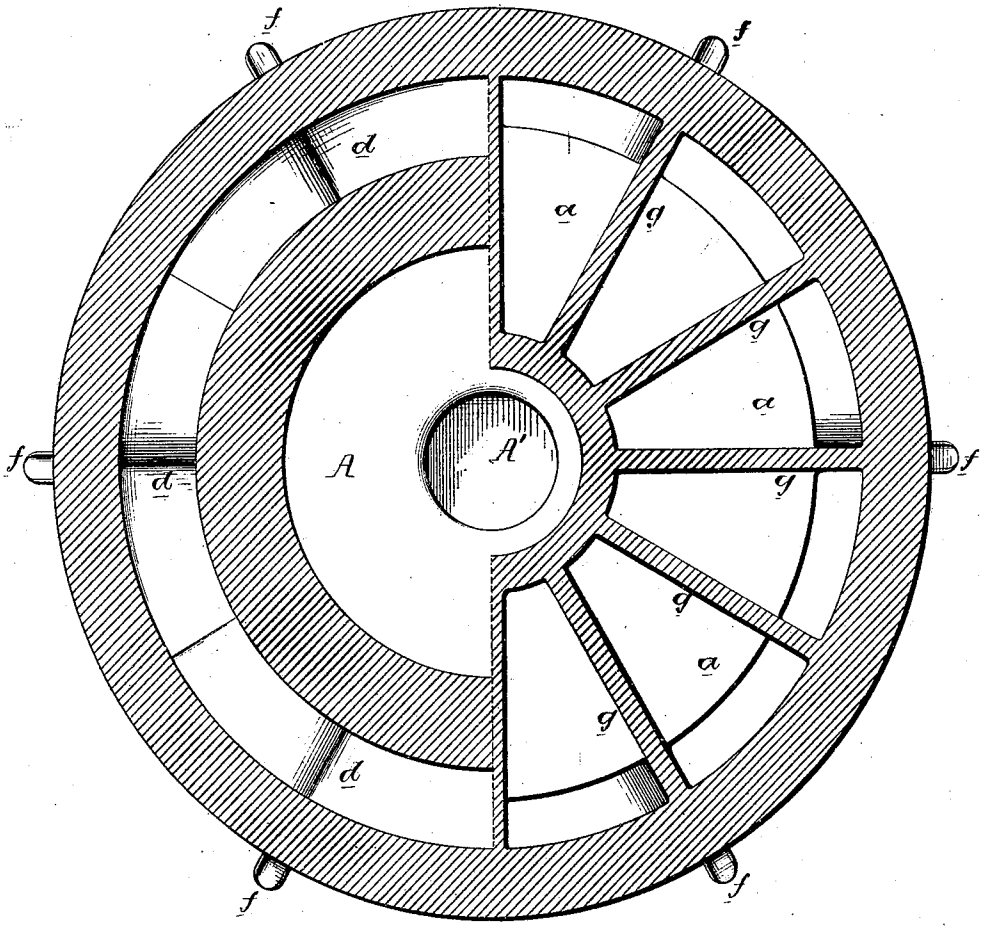
Fig. 4



Witnesses,
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Harry Smith

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by his Attorneys,
Howson and Son

4 Sheets—Sheet 4.

F. L. CLERC.

PROCESS FOR EXTRACTING ZINC FROM ITS ORES.

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Fig. 5.

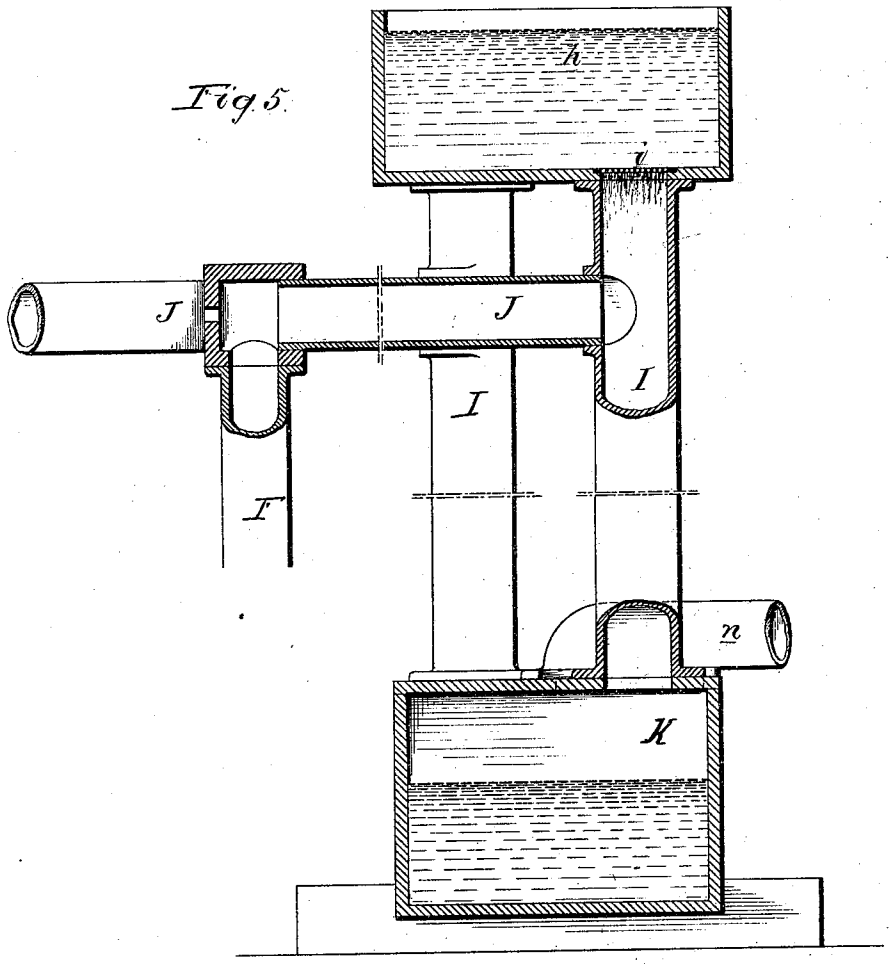
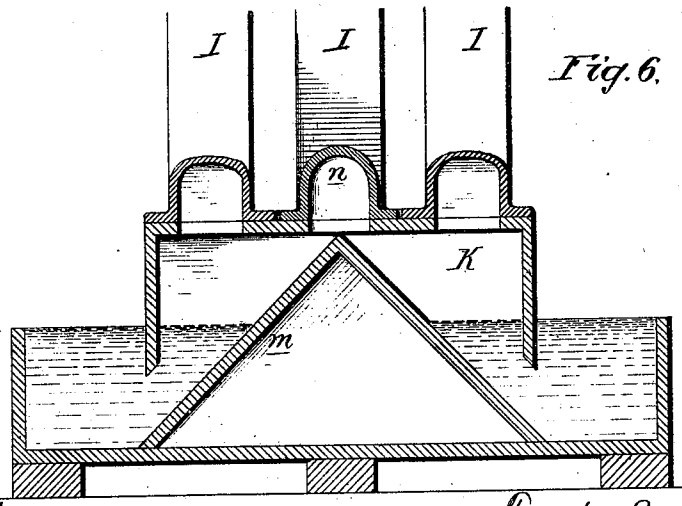


Fig. 6.



Witnesses
Harry Howson Jr
Harry Smith

Frank L. Clerc,
by his Attorneys, Howson and Son

UNITED STATES PATENT OFFICE.

FRANK L. CLERC, OF BETHLEHEM, PENNSYLVANIA.

IMPROVEMENT IN PROCESSES FOR EXTRACTING ZINC FROM ITS ORES.

Specification forming part of Letters Patent No. **178,998**, dated June 20, 1876; application filed March 29, 1876.

To all whom it may concern:

Be it known that I, FRANK LAURENT CLERC, of Bethlehem, Northampton county, Pennsylvania, have invented certain Improvements in the Extraction of Zinc, and in Apparatus Employed Therefor, of which the following is a specification:

The main object of my invention is to extract metallic zinc from its ores and oxide more economically and completely than by any process heretofore practiced.

My process is a continuous one, and consists of the following operations, namely: First, the reduction of the metal from its oxide in the form of a gas; second, the protection of the metallic vapor from reoxidation; third, the condensation of the metallic vapor to a liquid form; and, fourth, the disposal of the residues and the ashes of the coal.

The reduction is effected by carbonic oxide generated in the lower part of a furnace, by injecting a blast of superheated air, through tuyeres, into a mass of incandescent fuel. The metallic vapor is protected from oxidation by maintaining a layer of heated charcoal or soft coke on the top of the charge in the furnace, as described hereafter.

The zinc vapor is condensed to a liquid form out of the furnace-gases by passing them slowly, under pressure, through flues, preferably of fire-brick, in which the temperature is maintained above the melting-point of zinc. The gangue of the ore and the ashes of the fuel are melted together with a flux, and run out at the bottom of the furnace.

In working my process I prefer to use a furnace and apparatus essentially like that illustrated by the accompanying drawings, in which—

Figure 1, Sheet 1, is a vertical section of the furnace, condenser, and feeding-shaft; Fig. 2, Sheet 2, a sectional plan of the same on the line 1 2; Fig. 3, Sheet 2, a sectional plan on the line 3 4; Fig. 4, Sheet 3, a sectional plan on the line 5 6; and Figs. 5 and 6, Sheet 4, illustrate a washing apparatus connected with the furnace.

The furnace proper, A, is made in the form of an inverted frustum of a widely-flaring cone, on a cylindrical shaft, A′, called the hearth. The said furnace proper is arched over by a dome, *a*, having a large central opening, *b*, and lateral passage-ways *c*, as clearly shown in Fig. 1. In the hearth of the furnace are the openings *z*, for the insertion of tuyeres, the slag-eye *x*, and, in special cases, the additional tapping-hole *y*. The feeding apparatus B, Fig. 1, consists of a shaft of brick-work extending through the dome *a* into the furnace, and terminating at the top in a hopper, B′, through which descends, into the shaft B, an inner funnel-shaped hopper, D, supported by arms D′. The condenser is placed over and around the furnace proper, and consists of fire-brick flues, twelve in the present instance, passing over the dome of the furnace. These flues communicate with each other at the top in sets of four, through the transverse passages *e*, and lead into the three chimneys F. At the bottom the flues are connected together in sets of two, adjacent flues uniting at the bottom to form around the furnace the six receptacles *d*, for the collection of the condensed metal. The sides of these receptacles are inclined toward each other, and converge to the tapping-holes *f*. The sides of the flues are formed by the twelve arched radial walls *g*, extending over and across the furnace, but interrupted in the center to admit the feeding-shaft B. These walls also support the dome of the furnace and the lower portion of the feeding-shaft, and are continued above the flues to carry the superstructure of the furnace. The bottoms of all the flues are formed by the dome of the furnace. The condenser, carrying with it the dome of the furnace, feeding-shaft, &c., is built on an annular bed-plate, which is supported, in the present instance, by a double row of pillars, as shown in the figure.

The washing apparatus, shown in Figs. 5 and 6, Sheet 4, consists of a series of vertical pipes, I, connected near the top with the chimneys F by means of cooling-pipes J.

These vertical pipes communicate with the upper water-tank *h*, and each pipe is covered with a finely-perforated plate, *i*, the lower ends of the pipes entering the covered water-tank K, the bottom of which has an angular projection, *m*, the metallic blue powder, referred to hereafter, passing down the inclined sides of the projection into the bottom of the trough,

the water in which traps the gases, the latter passing off through the pipe *n*.

The operation of the process is as follows: The furnace is dried and lighted up in the same manner as a blast-furnace for smelting iron. The charge consists of an intimate mixture of calcined ore, crushed to about the size of a pea, or of oxide of zinc, artificially prepared, with proper proportions of fuel and flux, to which may be added the metallic blue powder, recovered in the washer from a previous charge. About one-half of the coal should be crushed as fine as the ore, and the remainder may be as coarse as egg-size. The proper proportions of coal and flux will vary in accordance with the character of the ore and fuel, temperature of blast, &c. They can be approximately determined in any case by a preliminary analysis of the fuel and ores, and accurately adjusted, so as to secure the best results, by a careful experimental working. For fluxes, quicklime, iron, or the oxides of manganese are generally applicable, and with rich ores, and with a fusible slag, and a highly-heated blast, a weight of coal equal to one-half the weight of the charge will be found sufficient. The charge is fed into the inner hopper as fast as it sinks in the shaft, and at the same time some charcoal or soft coke, easily acted on by carbonic acid, is fed into the exterior hopper. As they descend together they unite in a solid column, and are gradually heated before reaching the furnace, on entering which they spread outward, falling with a natural talus to the outer wall of the furnace. The charcoal, being on the outside, is thrust upward, forming a layer on the top of the charge, where, as it is gradually deposited, and in close proximity to the heated dome of the furnace, it is maintained at a sufficiently-high temperature to reduce the issuing gases. As the oxide of zinc descends in the furnace it encounters carbonic oxide sufficiently hot to reduce it. The reaction which takes place is as follows: $ZnO+CO=Zn$ (zinc vapor) $+CO_2$; but this is immediately followed by the action of the carbonic acid, so formed on the heated carbon of the fuel, namely, $CO_2+C=2CO-$. These two reactions may, in fact, be considered as taking place simultaneously, and may be written $ZnO+CO+C=Zn$ (zinc vapor) $+2CO$. The zinc vapor, so liberated, rises with the other gases, passes through the layer of heated charcoal, in which operation whatever carbonic acid there may be remaining in the accompanying gases is effectually reduced to carbonic oxide, and escaping from its free surface issues into the condenser through the passage-ways C. In passing through the condensing-conduits it parts slowly with its heat and condenses into drops, which gather on the sides of the conduits, run together, and trickle off the sloping bottom of the flues into the receptacles *d*, from which the metal is drawn off from time to time. After leaving the condenser the gases are still further cooled by passing them through the cooling-pipes J before they reach the washer, which they enter near the top of the vertical pipes I, and descend, along with a shower of water from the water-tank above, into the covered tank K, in which operation whatever zinc has escaped condensation in the condenser is washed out of the said gases in the form of a heavy metallic powder, known as blue powder, which settles quickly to the bottom of the tank, and is withdrawn therefrom to be dried and returned to the furnace. The washed gases are conducted from the top of the tank, to be burned as in the iron blast-furnace for heating the blast, or for other purposes.

It will be seen that in the operation of reduction the effect is the same as if the zinc were reduced by the direct action of the carbon in the fuel, and that the amount of coal which can be consumed in the upper part of the furnace is strictly limited by the amount which can be dissolved by the carbonic acid formed in reduction, or, what is the same thing, by the amount which can be burned by the oxygen combined with the zinc in the ore, and this amount is almost exactly three-sixteenths of the weight of the zinc in the charge. All the coal in excess of this amount, less the volatile constituents, which are as much as possible to be avoided, will descend with the flux and gangue into the lower portion of the furnace, where it encounters the free oxygen of the blast. Here it is rapidly burned to carbonic oxide with the generation of the heat necessary to melt the non-volatile elements of the charge, and to carry on the work of reduction in its upward passage through the furnace.

When the ore or the flux contains any metal, such as copper, manganese, or iron not volatile at the temperature obtained, and which does not flux with the gangue in the reducing-atmosphere to which it is exposed, it may be collected in a sump at the bottom of the furnace, and run out at a lower tap in the form of a metal, matt, or spiegeleisen.

General directions for working: To insure the satisfactory working of the furnace, it is essential that command should be had of a sufficient pressure and volume of blast to be able to regulate the rate of combustion and the temperature at different parts of the furnace, and to heat the blast as hot as is consistent with the durability of the furnace and blast apparatus, in order to compensate as much as possible for the heat withdrawn from the furnace by taking the gases out of the same at the required high temperature, and to counteract the cooling effect in the upper part of the furnace due to reduction, without unduly increasing the amount of fuel consumed, and consequently the volume of the gases with which the zinc vapor is diluted.

The temperature absolutely required in any case will depend upon the nature of the fuel. It will be less with charcoal and soft coke than with hard coke or anthracite coal. It must in any case be sufficient to kindle the fuel

wherever it comes in contact with it, and to insure a perfect conversion of its oxygen to carbonic oxide in passing through even a thin layer of the fuel. It is also essential that the ore, fuel, and flux should be thoroughly dry before entering the furnace, and free from volatile constituents capable of oxidizing the zinc vapor, if given off at the top of the furnace; for this reason, the ore and flux should be carefully calcined, and only such fuel as anthracite coke or charcoal containing but a small proportion of volatile matter can be employed.

The object in charging a portion of the coal and flux in lumps is to prevent the premature fluxing of the charge, or the smothering out of the furnace by the crushing down of the charge onto the tuyeres. Where the ore is very fusible, it may be necessary to charge in somewhat larger lumps than those given above. Even where anthracite or hard coke is used it would be well to mix with it a proportion of charcoal sufficient to effect reduction.

The satisfactory working of the washing apparatus will depend on the thoroughness with which the gases are deoxidized before leaving the furnace, since the presence of even a small proportion of oxide of zinc in the gases will suffice to choke up the pipes and obstruct the washing apparatus.

The cooling-pipes should be made as thin and light as possible, and should be so constructed that they may be replaced by duplicate pieces in case they become choked, as they are liable to do when the furnace is working irregularly. These pipes also serve to indicate the temperature at which the gases leave the furnaces. These gases should not remain in the condenser after they have cooled below the melting-point of zinc; otherwise the condensing-conduits may become filled with blue powder. Nor must the gases leave the condenser while condensation is still possible.

The height of the feeding-shaft will depend upon the pressure of the blast and the fineness of the charge. It must be sufficient to prevent the gases from escaping upward through it, instead of passing into the condenser.

The large open chambers in the condenser are constantly filled with a gas which will explode when mixed with air; hence the necessity of adopting precautions to prevent such a mixture.

So long as the blast is continued there is an outward pressure at all parts of the furnace, and no air can enter; but should the blast be suddenly interrupted the cooling of the gases in the furnace would be likely to induce air to enter the furnace, and this might cause an explosion; but this danger is greatly lessened by the intimate connection between the condenser and the washer, through which only the burnt gases and aqueous vapor could be drawn into the furnace, neither of which can cause an explosion with carbonic oxide.

The principal advantages claimed for my process over those heretofore used are, that it effects a great saving of fuel, avoids loss of metal by imperfect condensation, extracts almost the last traces of metal from the slags, requires no articles of fire-clay of special construction, demands the attendance of one-fourth the number of men, and less skilled labor can be employed to work ores containing other valuable constituents which cannot be worked directly in any other spelter-furnace, and upon ores too poor to be worked by other processes.

The furnace used costs less to build, requires fewer repairs, is continuous in its operation, instead of intermittent, and utilizes the carbonic oxide formed in reduction.

I claim as my invention—

1. The mode or process herein described of extracting metallic zinc from its ores and oxide—that is to say, by injecting a blast of superheated air into and through a charge of calcined ore, fuel, and flux, causing the gases evolved to pass trough heated charcoal or soft coke, and, finally, condensing the zinc vapor at a temperature above the melting-point of zinc, all substantially as set forth.

2. The herein-described process of preventing the oxidation of the distilling zinc vapors, and securing the deoxidation of the carbonic-acid gas, which consists in charging the furnace in such manner that a hot layer of superposed carbonaceous fuel is always presented to the outgoing gases and vapors at the time of their exit from under the furnace-dome, substantially as herein described.

3. The combination of the inlet-pipe J, downtake I, and water-reservoir *h*, with the water-seal tank K, having the inclined sides *m*, whereby the escaping zinc-dust is precipitated and readily collected, substantially as herein set forth.

4. A zinc-furnace in which are combined the following elements, namely, a hearth, A′, a furnace proper, A, made in the form of an inverted frustum of a cone, the dome *a*, central feeder B, and passages and flues, all substantially as set forth.

5. The combination of the vertical feeding-shaft B and its hopper B′, with the inner concentric shaft D, whereby the charge and fuel are distributed in the furnace in such manner as to present a hot superposed layer of fuel to the outgoing gases and vapors, substantially as herein described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

FRANK L. CLERC.

Witnesses:
HARRY HOWSON, Jr.,
HARRY SMITH.