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XXXII. *Memoir on the Refining of Lead; with some Reflections on the Inconvenience of Ash Cupells; and the Description of a new and economical Method of constructing Cupells or Refining Vessels: read in the French National Institute.* By C. DUHAMEL, Member of the Institute and Inspector of Mines*.

IT is well known, that to separate silver from lead, a metallurgic process called refining or cupellation, performed in a vessel called a cupell, has been employed: it is known also that this vessel is composed either of the ashes of the bones of animals, or of those of vegetables, after they have been lixiviated, to free them from the saline matters which they may contain.

The great quantity of wood-ashes which must be employed in the construction of cupells, and the difficulty of obtaining them, long ago induced me to endeavour to discover a simpler and less expensive method of constructing the vessels in question. The old chemists having observed that lead becomes oxidated, or reduced into what is called *litharge*, when exposed to heat, or the contact of the atmospheric air, while the silver united to it retains its metallic form, nothing seemed necessary but to find the means of separating these two metals. They were conducted to the method of accomplishing this by observing that the oxide of lead, in its state of liquefaction, easily penetrates the substances which are in contact with it, and especially bone-ashes, without deforming the vessels which are formed of them. No matter, indeed, is more proper than the latter for constructing small refining cupells.

The difficulty, and often even the impossibility, of obtaining about 160 English gallons of ashes for each operation of refining on a large scale in the German furnaces, made the proprietors have recourse to wood-ashes; but, besides that these ashes are expensive, it often happens that they cannot be procured in sufficient quantity. They are even attended with one inconvenience, which is, that they come off, and float on the fused lead; the refining then fails: and this takes place every time that the ashes are badly prepared, that the cupell is insufficiently or not uniformly beat, or when the canals destined for the evaporation of the moisture are neither in sufficient number, nor properly arranged, nor covered with a stratum of scoriæ, on which is established the bottom, that receives the ashes, and which ought to be con-

* From the *Journal des Mines*, No. 64.

fructed of the most porous bricks, in order that the water, with which it is necessary to moisten the ashes, may penetrate them in evaporating, may proceed to the bed of scoriæ, and escape by the spiracles which are at the base of the furnace.

To ascertain the proportion of lead in silver, it is sufficient to put some pennyweights into a small cupell of bone-ashes placed under the muffle of an assaying furnace. In proportion as the lead becomes oxidated, it insinuates itself into the cupell, and the silver at last assumes that vivid appearance which announces that the whole lead is dissipated, that the silver it contained is refined, and has attained to its *maximum* of purity.

In refining on a large scale, the object also is to separate the silver from the lead, but not to make the whole of the latter penetrate into the cupell, which is even impossible; for in that case it would be necessary to have a much larger quantity of ashes for the total absorption of the metal: besides, the operation would require a period ten times as long as that used in general for refining, and would occasion ten times the expense in fuel, and a much greater loss of the metals than by the usual process, where the greater part of the lead is obtained in litharge, while a portion penetrates into the cupell for about two inches of its thickness, which must be fused to revive the lead. This reduction is also more expensive, and experiences a greater loss than the litharge, which is easily fused, and which, without passing through the furnace, may be employed as an article in commerce.

Lead ore and litharge may be fused as in England, and the department of the ci-devant Brittany, in a reverberating furnace the soles or basons of which are formed of pounded and moistened clay. These soles can stand the action of heat and of the oxide of lead for six or eight months of uninterrupted labour.

The durability of these earthen soles gave me the first idea of the method, which I shall hereafter propose, for refining-furnaces, where the only thing required is to oxidate the lead to obtain it in litharge, and not to cause the cupells to imbibe the whole of it, as is done when the object is to assay the metal in order to know whether it contains silver. In operating on a large scale, the cupell, though of ashes, absorbs only a part of the lead, as I have already said, observing at the same time that it would be much more advantageous to obtain the whole transformed into litharge, the reduction of which into lead is much easier than that of the

oxide contained in the ashes, which oppose fusion, and the scoræ of which always carry with them some of the metal.

In a cupell of ashes beat into an oval circle of iron, the greater diameter of which is only five or six feet and the less one yard, the English refine from a ton to 23 cwt. of lead, which is converted into beautiful litharge, except the small portion which penetrates into the cupell, the thickness of which is only about $2\frac{1}{4}$ inches, and which is supported under the arch of the furnace by two bars of iron. A pair of leather bellows drive the litharge towards the anterior part of the furnace, from which it falls, without interruption, on the floor of the foundry, while, to fill up the vacuity left by the oxide running off, an ingot of lead placed close to the base of the bellows is made to advance gradually into the interior part of the furnace. This lead, by fusing, keeps the cupell full till towards the end of the operation.

If I have here given a short view of the process of the English, it is only to show that it is possible to perform operations of refining by employing only a small quantity of ashes for the construction of cupells. Those in question do not absorb 90 pounds of oxide in the large quantity of lead which is refined.

It is then proved that metallurgists have always endeavoured to obtain the greatest quantity possible of litharge, and little ashes impregnated with oxide; but as they thought that they ought not to deviate from the docimastic process, they have always constructed their cupells of ashes.

It has been seen that in cupellation on a small scale, lead, in proportion to its oxidation, penetrates the ashes. When no more is left, the small button of silver remains pure at the bottom of the basin under a spherical form. This operation takes place with the more celerity, as the surface of the mass is always convex in these small vessels; which allows the oxide to flow as on an inclined plane, towards the edges of the cupell, where it is immediately imbibed.

The case is not the same with cupells on a large scale, which are several yards in diameter: bellows must be applied, the wind of which serves not only for accelerating the oxidation, but also for driving the litharge towards the gutter formed for its escape.

We have remarked the inconveniences and even the impossibility of making the whole lead penetrate into the ashes of large cupells: oxidation, indeed, is not effected but in the parts of the mass exposed to the contact of the air or to the wind of the bellows; but as litharge, towards the middle of the basin, could not reach its edges, it would remain there

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in a state of stagnation, and would necessarily oppose the formation of a new stratum of oxide. This has induced metallurgists to expel the litharge by the wind of a pair of bellows in proportion as it is formed, and to make it flow from the furnace.

Oxidation then takes place only at the surface of the mass, and not at its lower part: if the case were otherwise, the ashes of cupells would be penetrated by the oxide to a thickness the more unequal, as the operation is longer; but I have always remarked, that the *test*, or the part of the ashes impregnated with litharge, in refining on a large scale, is not thicker in the centre of the basin than towards its circumference, though the lead remains thirty or forty times as long in the bottom as on the edges; since the mass continually decreases till the whole lead is reduced to litharge, and till nothing remains but a cake of silver at the bottom of the cupell.

If the whole lead is imbibed by the assaying cupell, it is because this small vessel is exposed to a heat uniform in all its parts. As the cupell, in operations on a large scale, presents to the action of the caloric only its upper surface, the oxide imbibed ceases to penetrate it at the place where the temperature is no longer high enough to keep that oxide in a state of fusion. For this reason, the thickness impregnated is equal throughout the whole extent of the cupell; and this prevents the possibility of making the whole lead penetrate into the ashes.

From the above observations it may easily be conceived, that if the assaying of lead ought to be performed in small cupells of bone-ashes, in order that the oxidated metal may penetrate them, and be in part evaporated, the case is different with refining on a large scale, where it is necessary to accelerate the operation, and to obtain as much litharge as possible.

I have already said, that the wood-ashes of which cupells are made for refining on a large scale are expensive; that very often a sufficient quantity cannot be procured; and that besides this, part of the ashes, and sometimes the whole, separate themselves entirely from the sole; which occasion a considerable loss. I shall add, that to give more weight and consistence to the cupells, it is often necessary to mix with the ashes a large quantity of sand; especially if the lead contains foreign substances, such as arsenic, cobalt, antimony, tin, &c. If the lead be only arsenical, after having separated the first scum, a quarter of a hundred weight of iron filings or cast iron turnings are now and then thrown over the whole

surface of the mafs. This iron, being lighter than lead, floats over it and abforbs the arfenic, after which the mafs muft be fcummed: foon after, the litharge is formed without any obftacle. This method is employed in Saxony.

The neceffity of adding fand to the afhes of cupells muft have conducted to the difcovery of the following means, which I fhall here propofe.

New Method of conftructing Bafons for Refining.

Without making any change in the mafon-work of the refining furnace, called the German, care only muft be taken to form at the bottom a fufficient number of canals for the evaporation of the moiſture, and to arrange them in the manner beſt calculated to produce that effect. Theſe canals or ſpiracles muft be covered with a bed of ſcoriæ, over which a pavement is to be made of one layer of the moſt porous bricks.

On this area, which muft be concave like the ſole on which the afhes of common cupells are beat, place founders' ſand a little moiſtened; to which may be added a fifteenth part of argil, if it is not ſufficiently earthy, in order to give it the requiſite ſolidity; and the whole muft be carefully mixed. This ſand muft be rammed in the ſame manner as for consolidating afhes; and a refining baſon is to be formed in like manner, uniformly beat in all its parts. The thickneſs of this cupell muft be fix or ſeven inches: it may be formed of two ſtrata, as will be ſeen hereafter.

After the baſon has been uniformly beat in every part, about a gallon of lixiviated wood-aſhes may be ſifted over its whole ſurface, and rendered adherent with beaters.

When the cupell is thus prepared, let down the head on the furnace and make a moderate fire in the fire-hole; which muft be maintained for ſeveral hours, in order to cauſe a part of the water, with which the ſand has been moiſtened, to evaporate. The ſurplus will be diffipated during the operation, without any inconvenience, by canals of evaporation.

After a ſufficient deſiccation, raiſe the head and ſuffer the cupell to cool a little; ſpread out ſtraw or hay over it, and arrange the ingots of lead, placing them gently on it that their weight may not derange the ſand: it is to prevent ſuch derangement that ſtraw is employed, as is done in regard to cupells of bone-aſhes*. When the quantity of lead neceſſary for filling the cupell is arranged in the furnace, let down

* Inſtead of prifmatic ingots it will be better to caſt the lead in hemiſpherical iron moulds. Pieces of that form are leſs liable to damage the cupell.

the head, and, having luted it round with soft clay, make fire in the fire-hole as for the common operations of refining.

When the lead is in complete fusion, and the mass is covered with scum and charred straw, make the scum or dross run off by the gutter for the litharge with a bit of board about a foot in length, in the middle of which is fastened a rod of iron of sufficient length to traverse the furnace and about a yard more.

When the lead has been well scummed several times, and begins to be red, make the bellows act, but at first gently; arrange the nozzles of them in such a manner, that the wind issuing from both may be directed to the centre of the cupell; and in order that the wind may be always reverberated on the mass, adapt to the extremity of each nozzle a small round piece of iron plate. This kind of valves, which the French refiners call *papillons*, is employed for refining according to the German method. They are suspended by hinges at their upper part: at each stroke of the bellows they are half raised, and they reverberate the wind on the lead, which accelerates its oxidation.

After all the dross or scum is removed, and when the lead has become exceedingly red, and covered with a stratum of litharge, form, with a small iron hook destined for that purpose, a small gutter in the sand of the cupell, which must be dug deeper, gradually and with caution, until the bottom of it be on a level with the mass. The litharge then, driven by the wind of the bellows towards the anterior part of the furnace, will run by this gutter and fall on the floor of the foundry, as is the case in the common operations of refining.

When the refiner observes that no more litharge remains in the neighbourhood of the gutter, he will stop the flowing off with a small quantity of moistened ashes: but as soon as the lead again becomes covered with oxide, the gutter must be opened, and must be dug in proportion to the diminution of the mass, taking care that no lead escapes, and particularly towards the end of the operation; for it would carry with it a great deal of silver, which would be lost. You must proceed in this manner, till the silver has acquired its vivid colour; taking care to increase the fire in proportion to the diminution of the mass; especially when the operation is nearly terminated, because the silver then is collected together: and, as it is much more difficult to be kept in fusion than the small quantity of lead which remains united with it, it could be refined only in an imperfect manner at an insufficient temperature; and instead of about a twentieth of lead, which the silver generally contains in the German refining-

houses, it would remain charged with a great deal more, which would render it more difficult to proceed to a second operation, called the *refining of silver*, by which it is carried to the required degree of purity. The Germans call this second process *silber brennen*, burning silver.

Those accustomed to the refining of lead according to the German method, will be able to perform that which I here propose; for, though the cupell be of sand instead of ashes, the operation must be conducted in the same manner.

It has been seen that the English refine a large quantity of lead in a small cupell: in the like manner, a great deal of metal may be made to pass by that which I propose, if care be taken to add more metal as that which is oxidated escapes. If we suppose that the cupell is capable of containing four or five tons of lead, above sixteen may be refined at one operation; which will not be attended with the inconveniences of the English process.

I have reason to think that a cupell of sand well constructed may serve for several operations without the necessity of re-constructing it each time, as is the case with those of ashes; but in this case, and before the lead is introduced, you must fill up the gutter which has been made for the litharge to run off, after having removed with a chisel the kind of varnish which the oxide of lead has left on the sides of it, in order that the new sand, somewhat moistened, may form an intimate connection with the old sand, which must also be watered in that part before the new sand is deposited.

The long duration of earthen soles in reverberating furnaces, where lead ore and even litharge are fused, as I have already mentioned, leaves no room for apprehension in regard to the action of the oxide of lead, which will act only at the surface of the cupell, and will penetrate only a very small part of its thickness.

After one or more operations of refining, this crust must be removed, and fused in a furnace in contact with fuel, in order to obtain the lead. This process will be as easy as the reduction of that metal contained in the ashes of common cupells, and in a much smaller quantity. More litharge then will be obtained by the new method than the old; which is an advantage, as I have already observed. I shall here add, that as the sole of sand does not absorb so much oxide of lead as that of ashes, it will not carry with it so much silver; for it is well known that lead revived from its ashes always contains more than that which arises from the reduction of litharge.

Instead of sand, argillaceous earth might be employed for
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the construction of cupells, as is the case in regard to the soles of the reverberating furnaces in the ci-devant Brittany; but it would be necessary to ram this earth repeatedly for several days; otherwise it would split, and these cracks would increase by the shrinking which must result from the heat, and lead would insinuate itself into these fissures: an inconvenience which cannot take place with sand even a little earthy. I shall observe also, that a sole of earth would harden too much to allow a gutter to be dug for the passage of the litharge: in this case it would be necessary that the place destined for the oxide to run off should be constructed with sand or lixiviated ashes.

I shall add also, that it will be advantageous to employ two kinds of sand in the formation of the basin of the cupell; one kind fine like that used by founders, and the other coarser and not earthy: the latter will form the first stratum, which, after being beat with rammers destined for that purpose, ought to be about three inches and a half in thickness. The fine sand, a little earthy, must then be applied over this first stratum to form a second, which is to be rammed like the former. Both these kinds of sand must be somewhat moistened before they are introduced into the furnace, in order that they may be better heaped up, and be consolidated by the rammers.

The sand of the lower stratum, being coarser than that of the upper, will absorb the moisture of the latter in proportion as it evaporates; and it will pass without any obstacle through the canals disposed for that purpose.

The lower stratum of sand may remain in its place when a new cupell is to be constructed with fine sand, and the part of the latter, which has not been impregnated with oxide, must be mixed with new sand to form a cupell. Care must be taken in raising this sand not to touch the lower stratum; for the sand of the latter, which is coarse, must not be mixed with the other. This inconvenience may be avoided by beating over the bed of coarse sand a thin stratum of ashes, at which you must stop in removing the fine sand of the upper stratum.

It has been said that the founders' sand must be somewhat earthy, and that, if it is not, a little argil must be added to give it cohesion: but, as it is necessary that this argil should be uniformly diffused through all the parts of the sand, it must be diluted in the water with which the sand is moistened, and the whole must be carefully mixed.

It may be objected, that as cupells of sand do not absorb so much litharge as those of ashes, more time will be required to terminate the operation of refining; since, in the new process,

cess, the oxide, instead of being absorbed, ought to flow from the furnace. This circumstance needs excite no uneasiness; for the wind of the bellows, if well directed, will make the litharge flow along the gutter more abundantly than if there had been an absorption.

I have seen refiners in Germany, who, in constructing their cupells of ashes, formed in the middle of it a small circular depression the diameter of which was proportioned to the quantity of the silver which they knew to be contained in the lead subjected to the operation. By this excellent disposition no grains of that valuable metal remain insulated from the cake; the whole runs into the central basin, and forms a cake perfectly round. I would recommend this practice.

I am certain that the cupells here proposed, if carefully and properly constructed, will be attended with complete success; will be free from the inconveniences of those of ashes, and at the same time will be economical. I am desirous, for the benefit of metallurgy, that the method here pointed out may be put in practice: it will prove that we ought not to be too tenacious in adhering servilely to ancient usages or to the common routine of workmen.

XXXIII. *On Painting.* By Mr. E. DAVES, Painter *.

I THINK it right again to repeat, that I have not observed any order in the production of these Essays. They were written as the subjects arose in my mind, and the present paper should be considered rather as an introductory address than otherwise. My motive in writing the present essay was to endeavour to remove the prejudice of those who consider the arts as a useless study, and their produce as things merely ornamental. But who, in a state of civil society, would be content with the useful or necessary? Who is he whose soul seeks not after perfection?

The motions of his spirit are dull as night,
And his affections dark as Erebus:
Let no such man be trusted.

The subject of the following essay had long engaged my attention; but I had dropped the idea of writing on it, in consequence of some intelligent friends observing it would be useless, as no one could be so stupid as not to see the usefulness and influence of the arts on society. Experience,

* Communicated by the Author.

however,