

[Note: this description of Langley Mill is from the Mulcaster papers in the care of Wigan Archive Services (Ref D/DZA/264). The Wigan document is another copy of Mulcaster's account of smelting which was delivered to the Literary and Philosophical Society of Newcastle in 1795 and which is in the Society's collections (also in Dukesfield Documents). However the Newcastle version does not include these pages which must have been written later as they are signed and dated 1806.]

Description of the Works at Langley Mill

At Langley Mill there are three Smelting or Ore Hearths, one Slag Hearth, two Refining Furnaces, one Reducing Furnace, and one Roasting Furnace; their different descriptions and particular operations will be given afterwards.

The Ore is distinguished at the Mill under three Heads Vizt. First Bouse Ore, or that which is in the largest pieces and is the best part of it; Second Cutting Ore which is obtained from the refuse or Tails left after washing the Bouse Ore; and Third Slime Ore which is procured two ways, the one is from the Stone or Matrix of the Vein called by the Miners Pikestones indicating that the Ore is picked out from them. These Stones are generally covered with a thin coating of Ore on the side which adjoined the Vein, and after as much of the Stone is struck off with a Hammer as can be without wasting any of the Ore, they are then reduced to a Powder, which entirely detaches the Ore from the Stone, so that they may be easily separated by washing; the Ore got by this method is sometimes called Stamp Mill Ore, on account of the Pikestones being pounded in a Stamp Mill, this Machine consists of three strong Wooden Posts placed perpendicularly, to the lower end of each of which is affixed about One Cwt. of Cast Iron, they are lifted one after another about twelve Inches high by a Water Wheel with other Machinery fall down again by their own weight, and crush any thing that is put under them. The other mode of obtaining Slime Ore, is by making small Reservoirs below the washing places which receive all the Water that comes from them, and the fine particles of Ore that have been carried away with it subside in these Reservoirs, and it is then taken out and after being properly washed yields fine Slime Ore.

The above divisions of Ore into Bouse, Cutting and Slime, are only Mechanical varieties, because in fact they only relate to the size of the Pieces or Particles, and the different methods by which they respectively are procured, tho' on that account there will always be a difference in the proportion of extraneous matter they contain, even when they are taken from the same Vein, for it will seldom happen that either the Cutting or Slime will yield so much Lead as the Bouse.

The principal part of the Ore in Alston Moor and I suppose in most other places, is the Blue ore of Lead generally called Galena; when pure it is Lead Mineralised with Sulphur, and for that reason called in Chemistry a Sulphuret of Lead, but in reality there are no absolute pure specimens, and when taken in a quantity is greatly contaminated with Stoney, Earthy and Sparry matter, and some of it with the Ores of other Metals, particularly with Blende or Black Jack and Calamine, both Ores of Zinc,

the Iron Pyrites frequently accompanies Galena, and also very minute portions of Copper, none of which excepting the latter unite with Lead in any sensible quantity, but Lead that contains the least Copper is rendered unfit for converting into White Lead because the Copper is formed into the green Oxide or Verdigris by the process of making White Lead which destroys the beauty of its colour; but the worst thing for hurting the purity of Lead is Antimony, which makes it extremely hard and brittle if it only contains five per Cent of it; our Slag Lead is of this description, besides Galena or Sulphuret of Lead, Alston Moor furnishes a good deal (particularly Fairhill Flow Edge Mine) of the Earthy Ore of Lead, it is of a grey colour and constitutes nearly half the Ore of that Mine in weight, tho' not in produce of Lead, it consists of the Oxide of Lead intermixed with Earthy substances, and we sometimes meet with small Chrystals of the white Spar of Lead, which are mostly very pure, it is Lead combined with the Carbonic Acid or fixed Air, in Mineralogy called a Carbonate of Lead.

The preceding three sorts of Lead Ore are all that occur in Alston Moor, but owing to the different proportions of the extraneous Matter before pointed out that they are intermixed with the treatment in Smelting must be adapted to each particular variety, but as Lead in the whole of them is perhaps only in an intimate state of combination with the Mineralizing substances vizt. with Sulphur in Galena or Blue Ore of Lead, Oxygen in the Earthy Ore of Lead, and Carbonic Acid in the white Spar of Lead (the other substances are only supposed to be in a state of mixture) it is clear before Lead can be extricated from them, that something must be presented to these substances; to which they have a greater tendency to unite than they have with Lead: Oxygen with the aid of Heat decomposes Galena by uniting to the Sulphur and forming the Sulphurous Acid, which flies off in a gaseous state; any Combustible will abstract the Oxygen from the Earthy Ore of Lead, and Heat alone will expell the Carbonic Acid from the white Spar of Lead; Lime is used to protract the fusion of the extraneous matter, in the Language of Smelting, to dry it up, but where the Ore contains a great deal of Argill or Clay, Lime is the most necessary: hence the principle of the Smelting Hearth which I shall next endeavour to describe.

The Smelting or Ore Hearth

is of a rectangular form about twenty four Inches long by eighteen Broad inside measure, it is entirely lined with Cast Iron, and the Bellows acts the longer way, adjoining the fore part of the Hearth is placed the Work Stone (which is also of Cast Iron) in an inclined position, with a groove or gutter in it to convey the Lead from the Bottom or Pan of the Hearth, into a Cast Iron Pot that is placed to receive it, from whence it is cast into Pieces or Pigs; the Pan of the Hearth is about five Inches deeper than this groove, in order that there may be a constant Reservoir of five or six Cwts. of Lead in it to cool the Lead as it is liberated from the Ore, the height of the Hearth from the Bottom of the Pan is near twenty one Inches and it is entirely open in the fore part excepting a piece of Cast Iron that goes across the top, the under part of which is about eleven Inches above the top of the Work Stone.

At the termination of every Smelting Shift there is a part of the Ore left in a half Manufactured state (by the Smelters called Brouse) it is found to answer a better purpose than to have always to begin with the Ore itself, at the commencement of Smelting the Hearth is filled with Peats (a kind of decayed vegetable substance cut about three Inches square and fourteen long) one of which is set fire to and placed before the muzzle of the Bellows Pipe, the Bellows are then set a blowing which communicates the Fire to every part of the Hearth, some Coals and a little of the Brouse are occasionally added, as the Workmen see it proper, after the Brouse is all got into the Hearth in this manner, and sometimes before, the greatest part of its Contents is brought upon the Work Stone before described by the help of a large Iron Poker, the refuse part of the Ore called grey Slags, known to the Smelter by their superior brightness to the Brouse, are then picked out with a Shovel and thrown aside, the Brouse is then returned back into the Hearth with the addition of a little Coal if heat be wanting and a little Lime, if too great a tendency to fusion be apprehended a small charging of Ore is then spread over the top of it, but previous to the Brouse being returned into the Hearth again after taking out the grey Slag, there is always about half a Peat (as described above) put before the Muzzle of the Bellows, it is of the most essential service being extremely porous and combustible, not only preventing any thing from getting into the Pipe of the Bellows, but partially retarding the Blast yet suffering it to pass, and by that means it is forced to find its way through every part of the Hearth; the Muzzle of the Bellows Pipe is not quite two Inches diameter, of course without something of this kind, the Blast would pass too much in a stream through the Hearth; this being done in about ten or fifteen Minutes the Contents of the Hearth is again brought upon the Work - Stone, the grey Slag is picked out, the Peat put before the Muzzle of the Bellows, Coal and Lime in the proportions necessary used, the Brouse returned back into the Hearth, and a fresh supply of Ore thrown over it, this constitutes the Manual of Ore Hearth Smelting, and it is to be repeated at the above Intervals. In this manner the best of the Lead with the Silver is as it were sweated out, without ever bringing the Ore to fusion, the Blast of the Bellows pervading every part of the Hearth, presenting Oxygen to the Sulphur of the Galena, or bringing the Contents of the Hearth to a proper temperature for the combustible matter in it, to abstract the Oxygen from the grey or Earthy Ore of Lead or to expel the Carbon from the white Spar of Lead, conformable to the Principle before laid down.

Remarks

Though very little of the Alston Moor Lead Ore is quite clear of the Ores of Zinc, and some of it contains a good deal of that Metal, yet the Lead from the Smelting Hearth is very little or perhaps not at all injured by it, on account no doubt of the small tendency these Metals have to form a combination, and the great affinity Zinc has to Oxygen; for the moment a particle of Reguline Zinc is formed in the Smelting Hearth, it is beset on every side with Oxygen, they immediately unite and are volatilized together, forming a sublimate of the white Oxide of Zinc, but at the temperature of the

Smelting Hearth, not much of this Metal will be extracted from its Ore, and will therefore be left mostly in the Grey Slags. But Antimony is more inclineable to unite with Lead and not so tenacious of Oxygen, and therefore not so readily volatilized, but its point of fusion is higher than Zinc, and on that account if Ore Hearth Smelting is carefully conducted at a low heat, there won't be much of it found in the Lead, at least it is the case here, and like the Zinc will be chiefly left in the grey Slags; but on the contrary where the Lead is extracted from the Ore by reducing the whole Mass into a Fluid, it must be greatly adulterated with this Metal provided it is either connected with the Lead Ore, or in a state of combination with it, and what is still worse, when Lead is extracted from Galena by fusion with the help of no other Agent than Oxygen, it will seldom be completely free from Sulphur, these two substances must render the Lead extremely hard and impure, but if it is refined a considerable part of them will be dissipated forming the white Oxide of Antimony and Sulphurous Acid. The Grey Slags or refuse of the Ore Hearth are manufactured in the Slag Hearth to obtain what is called Slag Lead the description of this process is as follows.

The Slag Hearth

Its horizontal Section is an oblong Rectangle, being about twenty eight Inches long by eighteen broad, the Depth is near thirty six Inches, it is all made of Free Stone but the fore part which is of Cast iron, excepting about ten Inches high from the bottom of the Hearth that is left open, the blast issues from the middle of the back part of the Hearth, and previous to its being set to work, this Hearth is beat nearly half full of small Cinders, the reason for which will be shewn afterwards: the Fuel used is Cinders or Coal Coke, they are preferred to Coal not only by their producing a greater Heat, but being freed from Bitumen are not so liable to Cake – Peats are used at the beginning to facilitate their burning, and when they have arrived to a proper Heat, the Grey Slag is put upon them, and during the operation from time to time there is added a stratum of Cinder and another of Grey Slag: In this process the Slag is completely fused and the Lead is separated from them by the same Agents as in the Ore Hearth Vizt. Oxygen and Combustible matter (because Lead and whatever other Metals these Slags may contain, are chiefly in a kind of semi-Ore state) the moment this separation takes place, the Lead filters through the small Cinders already mentioned beat into the bottom of the Hearth and is received into a Cast Iron Pot, the top of which is on a level with the Bottom of the Hearth, and at near two feet distance from it, this Pot is covered with small Cinders and also the space between it and the Hearth, the melted Slag cannot find its way through the said filter of Cinders, but in the opening of the Fore part of the Hearth, before described, a hole of about an Inch diameter is made through this filter by a bent Iron Rod, the Slag then comes pouring out in a red hot stream and flows upon the Cinders that cover the Pot where it very soon fixes in a flat Cake and is thrown off occasionally, this is called Black Slag the process it undergoes will be explained further hereafter.

Remarks

The Lead or rather Slag Lead obtained at the Slag Hearth is vastly different from the Ore Hearth Lead, it has already been noticed that where Lead Ore is either intermixed or combined with the Ores of Zinc and Antimony, that the greatest part of these Metals in their Ore state will be left in the Grey Slag, on account of the low heat (and other reasons there given) used in the Ore Hearth, but the Heat employed here, must either entirely dissipate them in the state of Oxides and Carbonates, or they must come off with the Lead, the case appears to be from Dr. Thomsons Analysis of a specimen of Slag Lead, and of a sublimed White Powder that is found attached to the outside of the fore part of the Slag Hearth, that the whole of the Zinc is volatilized, and also part of the Antimony, the other part unites with the Lead, and is one of the causes of the granular fracture and brittleness of Slag Lead*, perhaps in some of it there may be other substances besides Antimony, tho' in that examined by Dr. Thomson there was not, but there ought to be several specimens analyzed to enable a Person to speak with confidence, because it is certain that there may be an alloy formed of Lead and Zinc, and as it might easily happen that the above Slag Lead was from an Ore that did not contain Zinc, this single Analysis will not decide the point.

*The other cause of the hardness of Slag Lead, is no doubt owing to a doze of Carbonic Acid, which it imbides, formed by the combustions of the Cinders in the Hearth

The Smoke from the Slag Hearth at a neighbouring Mill has been conveyed in Horizontal Chimnies (tho' it is not done here) and it is said that nothing could be got from it, which if really the case; the sublimed Oxides of Zinc and Antimony must be the only cause of giving this Smoke its very Metallic appearance, and by any method practised in the Lead Works, these Metals would in a great measure be revolatilized, especially Zinc, which should be mingled with some Combustible and distilled in a close Vessel, connected with a Tube to conduct its Regulus into Water, and the Regulus of Antimony I presume would be got easiest by the same method. If a small wooden Trough lined with Plaster or made of Tin was placed over the Slag Hearth Chimney (it might do if it only took in part of the Smoke) a little of this Smoke might be collected and examined, but nothing can be inferred from the Dust or Fume that falls down in ascending the Chimney, because it is little more than the small parts of the Grey Slag that are blown up by the Bellows.

The refuse of the Slag hearth is called Black Slag on account of its colour, which is owing to its containing near twenty per Cent of the brown Oxide of Iron, the Lead it contains is either in small Globules wrapped up in the Slags or in thin plates adhering to them which are got by the same means as are used at the Mines to separate the Ore from the Pike Stones as already described, see Page first that is by washing and Stamping.

The following Calculations will show the Expençe of obtaining Lead at the Ore and Slag Hearths both from medium Fusible, and medium Refractory Ore, and they are founded upon actual admeasurements.

First Calculation for medium fusible Ore which will take about 4 Bings 2 Cwts or thirty four Cwts. to produce a Newcastle Fodder of 21 Cwts. of Lead which is near 62 per Cent Lead.

Coals used in the Ore Hearth 12 Winchester Bushels at 4d	4		
Cinder or Coal Coke used at the Slag Hearth 6 Winr. Do. at 6 ¼ d	3	1 ½	
Lime for Ore Hearth Smelting 6 Winchester Bushels at 3 ½ d	1	9	
Peat or Turf 3/4ths of a Cart Load at 2/-s	1	6	
Weighing 4 Bings 2 Cwts. of Ore at 1d p[er] Bing		4 ¼	
Peats getting in for the Smelters for 1 Fodder of Lead		2	
Ore Smelters Wages if 1/21 part be Slag Lead, 20 Cwts at 8/-s p[er]	7	7 ¼	
Fodder			
Slag Smelters Wages, 1 Cwt. at 12/- s p[er] Fodder		7	
Wear of Machinery, Bellows, Hearths, Tools &c. say	5	6	
Carriage of 4 Bings 2 Cwts. of Ore at 6s/6d p[er]Bing taken on an average	1	7	7 ½
Carriage of Lead to Newcastle, 1 Fodder	1	1	
Total Cost p[er] Fodder	3	13	2 ½

Which divided by 4 Bings 2 Cwts. or 4 ¼ Bings is £- .. 17 .. 2 ¼ p[er] Bing

Second Calculation of medium refractory Ore which will take about 5 Bings 4 Cwts. or 44 Cwts. of Ore to produce a Fodder of Lead which is near 48 p[er] Cent Lead.

Coals used in the Ore Hearth 21 Winchester Bushels at 4d	7		
Cinder used at the Slag Hearth 12 Winr. Do. at 6 ¼ d	6	3	
Lime for Ore Hearth Smelting 12 Do at 3 ½ d	3	6	
Weighing 5 Bings 4 Cwts. of Ore at 1d p[er] Bing		5 ½	
Peat or Turf 3/4ths of a Cart Load at 2/-s	1	6	
Ore Smelters Wages if 2/21 part be Slag Lead, 19 Cwts at 12/-s p[er]	10	10 ¼	
Fodder			
Slag Smelters Wages, 2 Cwt. at 12/- s p[er] Fodder	1	1 ¾	
Peats getting in for 1 Fodder of Lead		2	
Carriage of 5 ½ Bings of Ore at 6s/6d p[er]Bing taken on an average	1	15	9
Carriage of Lead to Newcastle, 1 Fodder	1	1	
Wear of Machinery, Bellows, Hearths, Tools &c. say		7	
Total Cost p[er] Fodder	4	14	7 ½

This divided by 5 ½ Bings gives £ ..17..2 ¼ p[er] Bing the same as before

From the preceeding Calculations it appears that the Expencc of Smelting Ores of different qualities may be considered, as nearly the same per Bing, and therefore from

the average here made out the Cost of manufacturing the Lead from any quantity of Ore may pretty nearly be known provided its produce of Lead does not fall much under forty eight per Cent, or much exceed sixty two, which is the general limit of the Alston Moor Ores, tho' there have been instances of its Ore producing seventy two per Cent of Lead on an Average of Five Hundred Bings.

The Silver sometimes does not exceed one or two Ounces in a Fodder of Lead, but it frequently produces twenty, and sometimes thirty Ounces from that quantity, and it always happens that the Lead obtained from the Ore at the Smelting Hearth contains a little more Silver than the Slag Lead from the Slags of the same Ore at the Slag Hearth. This is undoubtedly owing to the Calx of Iron that in every instance exists in our purest Black Slag, this Calx has a great affinity to Silver and unavoidably robs us of a little of it. Silver cannot be extracted with out a considerable quantity of the Lead being carried off in the Smoke, on that account and also the value of the substances used in Refining and Reducing, as well as Workmens Wages, no Lead can be refined with Profit, unless it contains more Silver than will cover these expences, but before this is taken into consideration it may be as well to describe the Operation of Refining.

Refining

Is performed in a reverberating Furnace, the Fire Place of which is about twenty two Inches square separated from the Furnace by a Partition about fourteen Inches broad called the Fire Bridge, so that nothing but Flame can pass over it into the Furnace, the Flame then ascends an upright Chimney of perhaps forty feet high by two Flues that communicate with the Furnace: The Cupel or Vessel called a Test that the operation is performed in, consists of an Oval Iron Frame, its greater diameter is four feet and the lesser two and an half feet, and it is about four Inches deep, this Frame is beat full of a mixture of Bone and Fern Ashes in the proportion of eight of the former to one of the latter, being previously moistened with Water to make them adhere together, then with a Shovel and other Instruments they are scooped out into a proper form, and placed in the Furnace to dry, which must be done with great care, for if too much heat is applied the Water with which the Ashes were moistened, will be too quickly evaporated and occasion the Test to fly in pieces. After it is got dried and brought to a proper heat it is nearly filled with melted Lead previously fused in a Cast Iron Pot. It takes about five Cwts. for that purpose, but at the temperature the Lead is put into the test, it only takes a small doze of Oxygen which converts it into the Grey Oxide or Dross as it is called by the Refiners but after increasing the Fire in the Furnace untill the Lead becomes red hot, in a little time it becomes charged with an additional doze of Oxygen upon the surface in the form of a yellow Pellicle called Litharge, this Oxide is very fluid and upon the Blast of the Bellows placed at one end of the Test beginning to blow; it is skimmed off at the other end over a Gutter or Channel cut in the Ashes on a level with the surface of the Lead, it falls down upon a Cast Iron plate and very soon fixes in clods; upon the Lead in the Test being forced over and oxidated to the level of this Channel a little more melted Lead is put into the Test, which makes

the Litharge regain this Channel and pass over it as before, the Refiner taking care to keep the Lead in the Test sufficiently heated to form Litharge, in this manner the operation is continued until Eighty four Cwts. or four Fodders of Lead is introduced into the Test; but as this is insufficient to produce a Cake of Silver of the common size (which is generally from eight hundred to one Thousand Ounces) there is from two to three Cwts. of Lead in the reguline state, left at the end of every Test unconverted into Litharge, this is called rich Lead, because it contains all the Silver in Eighty four Cwts. of Lead. After so many Tests are worked as will furnish a sufficient quantity of this rich Lead as will make a Cake of Silver of the above weight (which may be known very nearly by Assay) it is melted down and refined in the same manner as the Lead already described with this difference, that the operation is continued until the whole of the Lead is made into Litharge, and nothing but the Silver remains. The Litharge from the Refining Furnace is then converted into Lead by the operation called Reducing, the description of which is as follows.

Reducing

The Process called Reducing is directly opposite to Refining, since it is restoring Litharge to its reguline state, or converting it into Lead, this as well as Refining is done in a Reverberating Furnace which is a great deal larger than for Refining being about six feet long and near four feet broad inside measure, the Fire place is twenty five Inches square divided from the Furnace by a Partition or Fire Bridge and it sometimes has only one and sometimes two Flues, through which the Flame ascends the upright Chimney.

In the Refining Furnace as has been observed nothing but the Flames is permitted to Act upon the Lead, because any Combustible in a state of Ignition suffered to come in contact with that Metal would not only by its superior affinity for Oxygen prevent the conversion of Lead into Litharge but would abstract the Oxygen from the Litharge that had been formed. Upon this account the Litharge for the Reducing Furnace is carefully mingled with small Coal and the bottom of the Furnace being previously covered about two Inches thick with Coals, the flame from the Fire place very soon sets the Coals on Fire and in a little time they are burnt to red hot Cinders. The above mixture of Litharge and Coal is then thrown upon them, and by the proper management of the heat or Flame in the Fire Place the necessary temperature is kept in the Furnace to enable the Combustible matter to take the Oxygen from the Litharge, and to set the Lead at liberty, which as that is done is received into a Cast Iron Pot, and is cast into Pieces of one and an half Cwt and is called Refined Lead, it is superior to other Lead and gives the highest Price in the Market.

Remarks

The reason of the superior quality of Lead that has been Refined and Reduced is very clear, for should it contain Antimony or in its Smelting not be entirely freed from

Sulphur, a great deal if not all of these substances would be volatilized in the state of Oxides, at the Heat employed in Refining, but this must depend upon their quantity.

It is evident from the principle of the Reducing Furnace; that the combustible mingled with the Litharge, ought to pervade every part of it, otherwise the Oxygen cannot be abstracted from it, the Litharge therefore will be vitrified or converted into a kind of Glass, but whatever care is taken to mingle these substances with each other, I apprehend were it not for the Bitumen of the Coal, that they never could be mixed to answer a good purpose at the low heat used in the Reducing Furnace, because they would come too seldom in contact, but the Bitumen upon being volatilized, takes away this difficulty as its Smoke must find its way into every part of the Litharge and reduce it into Lead, this is a decided advantage that Coal possesses over Charcoal, tho' in other respects a more impure Combustible, if the Lead was obtained from Litharge by reducing it to a Fluid in a Furnace something like the Smelting Furnace, there is little doubt but Charcoal would be found more advantageous than Common Coal, if it does not at that greater heat partly Carbonate the Lead and make it harder.

The following is the Expence of Refining and Reducing a Newcastle Fodder of Twenty one Cwt of Lead.

Coal 20 Winchester Bushels (Refining 7, Reducing..13)	at 4d	6	8
Cinders for Litharge Slag Smelting 3 Win Bush	at 6 ¼	1	6 ¾
Bone Ashes for Refiners Tests ½ Bushel	at 6/-s	3	
Fern Ashes for Refiners Tests 4 Bushel	at 8d		2
Peat or Turf 1/10th of a Cart Load	at 1s/8d		2
Refiners Wages			3
Reducers Wages estimating the loss of Lead by Refining and Reducing at 1/14 – 19 ½ Cwts. at 2/-s p[er] Fodder		1	10 ¼
Litharge Slag Smelters ¼ Cwt. of Slag Lead at 21/s p[er] Fodr.			3
Wear of Furnaces and Tools			1
Loss of 1 ½ Cwt of Common Lead at £38 p[er] Fodder		2	14 3
Total Expence		3	11 11
Slag Lead from Litharge Slags from the reducing Furnace and Test Bottoms from the Refining Furnaces ¼ Cwt. at £37..15.- per Fodder		8	11 ½
Advanced price of £1 p[er] Fodder on 19 ½ Cwts.		18	6 ½
Carriage saved of 1 ½ Cwt of common Lead to Newcastle		1	6
Total saving except the Value of the Silver		1	9
Difference to be repaid by Silver		2	2 11

Which will take seven Ounces of Silver at 6s/1 ½ d p[er] Ounce to make that Money; so that whatever number of Ounces of Silver Lead contains more than seven Ounces, the value of it will be clear profit.

The Roasting Furnace

Remains now to be describes, it is nearly the same in form and dimensions as the reducing Furnace, excepting, the Fire place being about half as large again, because a greater Heat is sometimes wanted than is necessary for Reducing Litharge and the Reducing Furnace has only two Doors opposite each other. On each side of the Roasting Furnace there are three Doors for the more particular stirring of the Ore to be Roasted. The chief uses of this Furnace is to concentrate or bake the small particles of Ore such as Slime Ore, and the Fume from the Horizontal Chimnies, which would otherwise by the Blast be again forced up the Chimney; it also dissipates a considerable part of the Mineralizing substances of the Ore, such as Sulphur and the Carbonic Acid, and must therefore partially manufacture the Ore: From six to twelve Cwt of Ore is put into this Furnace at a charging which must be frequently stirred, to present fresh Surfaces to come in contact with the Air to Oxidate the Sulphur which flies off in Smoke as in the Smelting Hearth; if these frequent stirrings were not resorted to the consequence would be, that the Ore and Sulphur would become vitrified, even at the proper Heat for Roasting and a more intimate union would take place than at first; of course the Lead would be more difficult to separate and never could be so completely effected as if this had not happened. After the Ore has been properly Roasted it is taken to the Smelting Hearth to extract the Lead which is done in the same manner as other Ore that has not undergone the operation of Roasting.

Horizontal Chimnies

Have been lately erected here, and last year the profit from them was nearly Seventy per Cent on the original cost; there are four of them one to each of three Smelting Hearths, and the Smoke of the two Refining Furnaces is carried in the fourth.

These Chimnies are taken nearly in a Horizontal position, they are about one hundred yards, and the perpendicular section of each of them is five feet by three. This is about three times the Area the Smoke would require to pass in, but provided it will pass, they cannot be too large, because a greater quantity of cool Air is admitted which will condense more of the Smoke, it scarce need be observed that the Fume from the Smelting Hearth Horizontal Chimnies is mostly a sublimate of Ore intermixed with a more considerable proportion of extraneous matter than the Original Ore contained, and in addition to which a good deal of Lime is mixed with it that is blown by the Bellows up the Chimney from the Lime used in Smelting. The Fume from the Refining Horizontal Chimnies, is chiefly a sublimated Oxide of Lead and Antimony, it is tinged with a minute portion of the green Oxide of Copper, which is the cause of its blue colour, for if Copper was absent this Fume would be of a dull white.

The whole of the Refining Fume is baked in the Roasting Furnace, in the state it is got from the Chimnies, the Lead is extracted at the Slag Hearth and it sells as Slag Lead. That part of the Smelting Fume nighest the Hearth consists of considerable

particles of Ore, and contains the most impurities, it is washed and Roasted and the Lead is obtained at the Smelting Hearth and the other parts of the Fume from the Smelting Horizontal Chimnies is only Roasted and the Lead is got at the Slag Hearth. All the Lead got from this Fume pays extremely well for Refining last year it contained near fourteen Ounces of Silver per Fodder.

I have now described in the best manner I can the several operations at Langley Mill in manufacturing Lead and Silver, but what has been said, perhaps will be better understood by shewing the different processes the Ore and other Substances resulting from it undergo in the order in which they are practised.

A certain weight of Ore is delivered to the Smelters from which to extract the Lead and Silver, if the Silver is not sufficient to redeem the Value of the Lead wasted in Refining and Reducing which is from one twelfth to one fifteenth of the quantity Refined, together with Workmens Wages &c. The Lead is cast into pieces of one and an half Cwt and is marked with an **O**. to shew that it is made immediately from Ore, and in that state it is sent to Market; but if the Silver will repay the above expences which is known by Assay, the Lead is made into pieces of one Cwt. to be Refined, and is called refineable Lead from Ore, which after being refined and reduced is called refined Lead and is made into one and an half Cwt Pieces and marked with an **L** signifying it to be Litharge Lead and in this state is fit for Market.

The grey Slags or refuse from the Smelting Hearth are of two sorts and are kept separate. If they are obtained in Smelting Lead that won't pay Refining they are called Unrefineable Grey Slags, if from the Smelting of Refineable Lead, Refineable Grey Slags. The Lead from both is got at the Slag Hearth, that from the former is made into Pieces of one and an half Cwt, and is marked with **S**. and in that state is sent to Market and is called Unrefineable Slag Lead. The Lead from the refineable grey Slags, after being refined and reduced, is made into Pieces of one and a half Cwt and is marked with **S**. and called refined Slag Lead. The Black Slags see Page after being stamped and washed to obtain the Lead, which as they are from the Grey Slags of unrefineable or Refineable Ore is unrefineable or refineable black Slag Lead, if from the former it is cast into Pieces of one and an half Cwt and marked **S**. but if from the latter is made into Pieces of one Cwt and refined along with the refineable Grey Slag Lead.

At the end of every charging of Litharge in the Reducing Furnace there is a part of the Cinder or Cake of the Coal left unconsumed which is intermixed with small Particles of Lead and Litharge, and is in some degree incorporated with the latter, they are called Litharge Slags, and are smelted in the Slag Hearth along with the worn out refining Tests called Test Bottoms, which are very much impregnated with Litharge, to these are added a mixture of Black Slags to promote their fusion, and the Lead so procured is called unrefineable Slag Lead from Litharge Slag, black Slag and Test Bottoms, it is marked **S** and made into Pieces of one and an half Cwt as is all our Lead sent to Market.

In Refining there is always a small portion of Silver brought off with the Litharge, which is proportionable to the quantity of Silver in the Lead Refined, but if

the Workmen do their Work properly, they will seldom leave more than a quarter of an Ounce of Silver in one Fodder of Lead provided the Refineable Lead be under twenty Ounces per Fodder; for the above reason the Litharge obtained in extracting a Cake of Silver from the rich Lead saved at the end of every Test (see Refining) is always after being reduced worth Refining over again, at least where the average produce of Silver in refineable Lead exceeds twelve Ounces to the Fodder, the Litharge Slags made in Reducing the above rich Litharge together with the Silver Test Bottoms, after having their Lead extracted at the Slag Hearth is also Refineable both of which are Refined and Reduced together the Lead is then made into Pieces of one and an half Cwt. marked with L and sent to Market, and is called Refined Lead, as well as that obtained from Refineable Ore Lead.

Note. Lead marked L. sells twenty Shillings per Fodder higher than that marked O, and twenty five Shillings higher than Lead marked S.

Memorandums

In 1802 which is thought to be a proper year to found a calculation upon there were four Hundred and ninety three Fodders of Lead Refined at Langley Mill, and the Silver produced therefrom was Six Thousand three Hundred and fifty four Ounces which is nearly thirteen Ounces for each Fodder of Lead. Now by the calculation at Page there should be seven Ounces of Silver deducted from the Expences of Refining and Reducing, which will leave six Ounces the Value of which at six Shillings will produce a gain of £1..16.- per Fodder, and this multiplied by the quantity of Lead Refined four hundred and ninety three Fodders gives £887..8.- for Profit by Refining in 1802.

This is the Profit as near as can be calculated for as there is always a stock of the different Materials in Hand, such as Coal, Lime, Cinders &c., the quantity used in each particular year cannot be exactly determined.

The number of Workmen employed at Langley Mill are as follows Vizt. Ten Ore Hearth Smelters, two of which are occasionally employed at the Roasting Furnace Two Slag Hearth Smelters, Three Refiners, Two Reducers, a washer and Assistant, and a Labourer to weigh the Ore to the Smelters, in all Twenty, there are the same Works at Blagill Mill, and the same number of Workmen. There are always two Men at a Smelting Hearth, they begin Work at two o'clock on Monday morning, and continue untill six or seven at Night they do the same on Tuesday and begin at the same Hour on Wednesday but give over generally before twelve o'clock, another set of Men then take the Hearth on Thursday morning, and Work the remainder of the Week in the same manner, so that Ore Hearth Smelters work is at least forty two Hours in a Week; (in that time they make from two to upwards of three Fodders of Lead I mean each two Men) and are paid by the Fodder of twenty one Cwt the price last year was for fusible Ore seven Shillings and Six Pence per Fodder and for Refractory Ore Ten Shillings and Six Pence but owing to the advance of all sorts of Wages on account of the high price of living, these prices are now augmented to eight shillings for the former and twelve

Shillings for the latter, however Ore Hearth Smelters seldom make more than Twenty six Pounds a year, but as they are only at the Mill one half of the week, in the other part of it they sometimes get work in the Country especially in Summer.

The Slag Hearth Smelters begin work at the same time as the Ore Hearth Smelters, and Work from three to four Shifts of thirteen or fourteen Hours each, their Wages run upon an Average to upwards of Thirty Pounds a Year.

The Refiners work from two to six Tests in a Week, they have two Tests going on at the same time, a Man at each, the third Man that is off Work changes the others at stated Intervals, on an Average each Man Works about Thirty five Hours in a Week, they have three Shillings a Fodder for Refining and make thirty four or thirty five Pounds a year.

At the Reducing Furnace only one Man is employed at a time, they change every twelve Hours, their Wages have been lately advanced to two Shillings a Fodder from One Shilling and ten Pence they work near Thirty Hours a week and make about Twenty five Pounds a year.

The washer has three Shillings a day but he sometimes Works by the Bargain, and the Labourer or Ore weigher has two Shillings a Day.

All the Workmen employed here who wish to have Money on Account are paid Twenty Shillings a Month and the remainder is paid off twice a year.

Langley Mill, 27th January 1806
James Mulcaster