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SMELTING PROCESSES FOR SILVER EXTRACTION Owen, J.R.D.

THESIS

Silver Extraction OWEN 1885

THESIS T 63



SMELTING PROCESS FOR SILVER EXTRACTION

J. R. D. Owen

1885

A Thesis for The degna of Mining Engineer by JAD. Own.

A Thesis for the degree of Mining Engineer by J. R. D. Owen.

The base metals used for The extraction of Silver From its one by smelting are lead and copper, and the defrient methods employed may be accordingly classified under the general headings of extraction by means of lead and "extraction by means of copper. A large portion of the mines now bring developted in The new mineral districts of our grat mineral bilt are Carrying a class of Carbonate and oxidized one that noun to by trated by the melting process. This interest including both gelena, Silver, and Copper, has alrady become one of such magnitude, That The guestion of the most thorough and economical tratment of These

The base metals used for the extraction of silver from its ores by smelting are lead and copper, and the different methods employed may be accordingly classified under the general headings of "extraction by means of lead" and "extraction by means of copper. A large portion of the mines now being developted in the new mineral districts of our great mineral belt are carrying a class of carbonate and oxidized ores that require to be treated by the smelting process. This interest including both gelena, silver and copper, has already become one of such magnitude, that the question of the most thorough and economical treatment of these

ons is one of the highest Silver extraction by means z leae Silver extraction by means of lead is classifiel according to the shape of the Jurnace used for the jurpone Thus we have ; I. Smelting in the open hearth. II. Melting in northeratory Jurnace III. Smelting in Shaft Junace. all these processes have one Comon purpose, The nduction of the lead to the metallic state and the concentration of the meta lie silver in it; but the chem ical mactions by which This is accomplished often deffec gratly, and the effi-ciency of each method voice with local circumstances, To Know Therefor the maction, and to wrigh the Circumstance in their economical brannys is The first duty of Those

ors is one of the highest importance.

Silver extraction by means of lead.

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Thus we have:

- Ι.
- II.
- III.

Smelting in the open hearth. Smelting in reverberatory furnaces. Smelting in shaft furnaces. All these processes have one common purpose, the reduction of the lead to the metallic state and the concentration of the metallic silver in it; but the chemical reactions by which this is accomplished often differ greatly, and the efficiency of each method varies with local circumstances. To know therefore the reactions, and to weigh the circumstances in their economical bearings is the first duty of those

who wish to selech a process An a particular locality. I. Smelting in the open hearth. This method is the oldest and simplest, and rep to the present time very few improvement have been made in its original features, This proceed as practiced in The american hearth is distinguish ed from the method followed in England and Scotland, chiefly by the cuployment of hoh black in Smelting very pun van one. The one smelled in the scotch hearth must like wise be fra from silica, not necessarily from other ganque. They are propored for smelling by roasting in numberatories, and the blast employed is cold. In both processes, infe sion Kinds of Juel, such as wood, peak, etc., can be used! The first condition of the con orical we of the hearth

who wish to select a process for a particular locality.

I. Smelting in the open hearth. This method is the oldest and simplest, and up to the present time very few improvement have been made in its original features. This process as practiced in the American-hearth is distinguished from the method followed in England and Scotland, chiefly by the employment of hot blast in smelting very pure raw ores. The ores smelted in the Scotch-hearth must like wise be free from silica, not necessarily from other gangue. They are prepared for smelting by roasting in reverberatories, and the blast employed is cold. In both processes, inferior kinds of fuel, such as wood, peat, etc., can be used. The first condition of the economical use of the hearth

in smelting lead one or a mixture of these with selver ones is Therefore purity of on, especially abscence of Silica and Jorign Sulphinetted metals. The in ought to be in the form of field not crushed. If brought to the works in the Caller Jonn, it ought to te agglomerated in a nurberatory before it is smelted in the hearth, but if this has to tr done, it would be more econ omical to Jinich the Smelting process in The nurberatory. The above conditions bring primanily requisite for the success. ful smelting in The hearth, and a large less of both level and selver by volatil ization tring Certain unless a very extension and costly system of condensing Chambers or carnuls is connected with The work, it is evident that for these masons alone This method cannot come into use conomically.

in smelting lead ores or a mixture of these with silver ores is therefore purity of ore, especially absence of silica and foreign sulphuretted metals. The ore ought to be in the form of pieces not crushed. If brought to the works in the latter form, it ought to be agglomerated in a reverberatory before it is smelted in the hearth, but if this has to be done it would be more economical to finish the smelting process in the reverberatory. The above conditions being primarily requisite for the successful smelting in the hearth, and a large loss of both lead and silver by volatilization being certain unless a very extensive and costly system of condensing chambers or carnals is connected with the work, it is evident that for these reasons alone this method cannot come into use economically.

The one though often nich in Silver, an vanly for from Siliceous gangue, Jorign sol phuets, antimonurets; and ansing is prevented in some localities by the scarcity of water and high price of labor in mining districts Desides it is extremely defficilt to down nich silver one without mairing a serious los of precious metal. It is Therefore meles at the Frisenh time to durl upon The proces of Amelting angetatif erous lead out in the open hearth. But for the pake of Composision I will give an illustration of This process as corried on at Vallecille, Mexico. The mx trated are nearly pure galena. The special nasons for adepting this process at Valleelle is that it n quines but little Jul, The hearthe are like a box about 24 mches Square, without a top and with one side laten away. The walls of the box

The ores though often rich in silver, are rarely free from siliceous gangue, foreign sulphurets, antimonurets; and dressing is prevented in some localities by the scarcity of water and high price of labor in mining districts. Besides it is extremely difficult to dress rich silver ores without incurring a serious loss of precious metal. It is therefore useless at the present time to dwell upon the process of smelting argentiferous lead ores in the open hearth. But for the sake of comparison I will give an illustration of this process as carried on at Vallecillo, Mexico. The ore treated are is nearly pure galena. The special reasons for adopting this process at Vallecillo is that it requires but little fuel.

The hearths are like a box about 24 inches square, without a top and with one side taken away. The walls of the box

are of half mak iron, maclosa hollow space, in which circuloto' air or water. The bottom of lock box is a lead-both holding goo to 1000 lbs. of melted lead, and over the top of each is a Can. Edek hearth has Three tuyeres, 2 makes in deaurter, flaced 6 inches about the lead both. Hoh blash is employed an a pressure of about 34 th a lb. In rooking this process it is easy to distinguish Thur be rode at which the charge indergoal notable changes, 1st the preliminary or heating up stage, in which the water goas off, The whole mas brand ndpot, and the sulphur Commences to burn, 2. The burning Sulphur raises The heat to the melting point flead the grater part give lead finds itself in a nducing almosphere, and news out in metallic zone, while

are of half inch iron, inclosing a hollow space, in which circulates air or water. The bottom of each box is a lead-bosh holding 900 to 1000 lbs. of melted lead, and over the top of each is a canopy leading to the stack. Each hearth has three tuyeres, 2 inches in diameter, placed 6 inches above the lead bosh. Hot blast is employed at a pressure of about $\frac{3}{4}$ of a lb. In working this process it is easy to distinguish three periods at which the charge undergoes notable changes. 1st. The preliminary or heating up stage, in which the water goes off, the whole mass becomes red-hot, and the sulphur commences to burn. 2. The burning sulphur raises the heat to the melting point

of lead; the greater part of the lead finds itself in a reducing atmosphere, and runs out in metallic form, while

the net is oxideged, curbonaled or volatilized with the remaining metals of that Kind, that are By This time passing off. 3.rd after the second stage has losted some time, the head of the mass has so menased That The ferriginous and earth. impunities of the or, combining with the litharge formed commence to sinter and agglomer. ate to a slog, inclosing the par tickles of lead as they new out charge to a mast which sticks to the walls of the hearth. Before this period Juirby sits in, The charge should to considerably reduced in bulk by the bur ving of the sulphur, melting of the level, etc., and its Justher. progres much to prevented by proper manipulations and by adding a new charge, The on Treated Centain's about 72 % of lead. Each heath produces about 2187 pounde of each, from 3500 pound gon

the rest is oxidized, carbonated or volatilized with the remaining metals of that kind, that are by this time passing off. 3rd. After the second stage has lasted some time, the heat of the mass has so increased that the ferruginous and earthy impurities of the ore, combining with the litharge formed commence to sinter and agglomerate to a slag, inclosing the particles of lead as they run out, and finally cementing the whole charge to a mass which sticks to the walls of the hearth. Before this period fairly sets in, the charge should be considerably reduced in bulk by the burning of the sulphur, melting of the lead, etc., and its further progress must be prevented by proper manipulations and by adding a new charge. The ore treated contains about 72% of lead. Each hearth produces about 2187 pounds of each, from 3500 pounds of ore

in 24 Louis. The cost of smelting 2187 lbs. in the hearth is estimated at \$6. The lead made by This process is of great Junity and very soft. The slogs centain a notable amount of iron, and an nich in lead in silver.

in 24 hours.

The cost of smelting 2187 lbs. in the hearth is estimated at \$6. The lead made by this process is of great purity and very soft.

The slags contain a notable amount of iron, and are rich in lead in silver.

11. Smelting in Reverbratory furnaces. The application of the norther-atory furnace to lead smelting is limited by many conditions similar to those enumerated in the use of the open hearth. There were two processes in use some ten years ago, which were executed in the northratory," The roasting and reducing; and the roasting and prospitating process. Formost a condition for the economical employment of the roasting and riducing process is the absence, to a certain extent, of siliceous or argillaceous ganque. Whenever the on contains mon than 4 90 of these substances, or less than 58% of lead this process cannot be executed satisfactorily any longer bacanse selicate of lead is formed, which is hard to nauce. Monover the process farmits The prisence of time, heavy

II. Smelting in Reverberatory Furnaces.

The application of the reverberatory furnace to lead smelting is limited by many conditions similar to those enumerated in the use of the open hearth. There were two processes in use some ten years ago, which were executed in the reverberatory; the roasting and reducing; and the roasting and precipitating process.

Foremost a condition for the economical employment of the roasting and reducing process is the absence, to a certain extent, of siliceous or argillaceous gangue. Whenever the ore contains more than 4% of these substances, or less than 58% of lead this process cannot be executed satisfactorily any longer because silicate of lead is formed, which is hard to reduce.

Moreover the process permits the presence of lime, heavy

spor, zincblend, and other forugn , Sulphurets in small guantates only. An important drawback m the employment of the reverbaratory process is also the proportionately large quantation of fuel required, and m This Country the item of labor, which is lorger in Froportion to the production than in shaft furnace Smelting. The loss of copper and the de tenoration of the lead by the some metal is another abjection as mentioned above, there were two reverberatory processes in use some ten years ago, the roasting and reducing, and the roasting and precipilating process. These were again corried out in various localities in a somewhat different manner, the deviations consist ing principally in a slower or quicked roasting and reduring, or the employment of a lower or higher tereperature.

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Roasting and reducing proces. As an example of this frees The English proces will be given. The English Process, The principal object of the Eng-lish modification of the nurberalong process is to most the grat est possible production; There for lorger Jurnaces with three working doors on each side, Stone doal as fuel, and higher temperature is suplayed. The furnace imployed for this process vones somewhate in its "Construction and demensions; the longth of the hearth is usually about 11 freeh, and its width gepach, it is supported on iron bars, on which is laid a course A flat tilter. On these is place ed a course of fin-bricks on edge, in which is arranged the usual plag ballom. The furnace has be working door and a fin door and has the tapping-part placed near the flue end, In general the one

Roasting and reducing process. As an example of this process, the English process will be given.

The English Process. The principal object of the English modification of the reverberatory process is to reach the greatest possible production; therefore larger furnaces with three working doors on each side, stone coal as fuel, and higher temperature is employed. The furnace employed for this process varies somewhat in its construction and dimensions; the length of the hearth is usually about 11 feet, and its width 9 feet, it is supported on iron bars, on which is laid a course of flat tiles. On these is placed a course of fire-bricks on edge, in which is arranged the usual slag bottom. The furnace has 6 working doors and a fire door and has the tapping-port placed near the flue end. In general the ores

trated on tolerably free from golena associated with carbonate and sulphate of lead and calcanous gangue, The cobbad and byon deliving to the fumace, on ground trans rollers and passed through siens of sheles to The linear inch, a charge of on weight 2970 lbs. Two men an supleyed at each furnace. In the tratment of nich ones, the ordinary method of working consist in roacting Them in buch a manner that reperards of one-half of the selphilos of lead present in the ore is concreted into a mixtun of oxide and sulphate. On raising the heat in the Jurnas to bright redness, the oxide and sulplate, formed in roasting, n ach on the undecomposed sulphide of lead present in the charge, and produce metallic lead, sulphur ous anhydride, and a visider of slog.

treated are tolerably free from impurities, being composed of galena associated with carbonate and sulphate of lead and calcareous gangue.

The cobbed ores before delivery to the furnace, are ground between rollers and passed through sieves of 8 holes to the linear inch, a charge of ore weighs 2970 lbs.

Two men are employed at each furnace. In the treatment of rich ores, the ordinary methods of working consist in roasting them in such a manner that upwards of one-half of the sulphides of lead present in the ore is converted into a mixture of oxide and sulphate. On raising the heat in the furnace to bright redness, the oxide and sulphate, formed in roasting, react on the undecomposed sulphide of lead present in the charge, and produce metallic lead, sulphurous anhydride, and a residue of slag.

alternate raking and poddling of the chorge is centinued at regular intervals, until, it is Thought to be desulphunged, which is generally the case at The end of fourthour. In smeeting the on it must on no account be allowed to lequely, and as often as it shows a tendency to fure, Some slaked line in Jonder is Thrown on the charge and will worked into it with a rake. The consumption of lime amounts, allegether, to about 2 go of on trated. The period of Amelting occu pies about 5 hours. The weight of Ceal Consumed is equal to 40% of the on Amelted. In trating 2970 lbs of are there is produced 1980 lbs A lead they of the of slog contain-ing 50% of lead. Hence the liss by volitilization is about 32 %. About sovo lbs. of on an smelted in 24 hours with a Consumption of 3 200 lbs. of Ceal and wish a

Alternate raking and paddling of the charge is continued at regular intervals, until it is thought to be desulphurized, which is generally the case at the end of four hours. In smelting the ore it must on no account be allowed to liquify, and as often as it shows a tendency to fuse, some slaked lime in powder is thrown on the charge and well worked into it with a rake. The consumption of lime amounts, altogether, to about 2% of ore treated. The period of smelting occupies about 5 hours. The weight of coal consumed is equal to 40% of the ore smelted. In treating 2970 lbs of ore there is produced 1980 lbs of lead & 640 lbs. of slag containing 50% of lead. Hence the loss by volatilization is about $3\frac{1}{2}$ %. About 8000 lbs of ore are smelted in 24 hours with a consumption of 3200 lbs. of coal and with a

production of Crude bullion of 4800 lbs. analysis of group lead Alag. Pho. 47.8790 Zno 7.52 7.52 12.68 Car All 3,01 De 03 2.86 Sion 12.52 01-50x 9.85 Roasting and Incepitaling Proced. The tratment of somewhate sili-Cevas ones by Jusion in the nurb-eratory furnace with either some iron or cashiron, was formerly corried on to a limited extent in Arance, but was ultimately discontinued, on account of the griat cost added to the unsatisfactory nature of the results ab tained. The furnace suployed sloptd from the finplace to The chinney placed at the pposite extrinity of the hearth, where then when as working down wish a topping hole breashit,

production of crude bullion of 4800 lbs.

Analysis of gray lead slag.

| PbO. | 47.87% |
|--------------------------------|--------|
| ZnO | 7.52 |
| CuO | 12.68 |
| Al ₂ O ₃ | 3.01 |
| Fe ₂ O ₃ | 2.86 |
| SiO ₂ | 12.52 |
| PbSO ₄ | 9.85 |

Roasting and precipitating process. The treatment of somewhat siliceous ores by fusion in the reverberatory furnace with either scrap iron or cast iron, was formerly carried on to a limited extent in France, but was ultimately discontinued, on account of the great cost added to the unsatisfactory nature of the results obtained. The furnace employed sloped from the fireplace to the chimney, placed at the opposite extremity of the hearth, where there was a working door with a tapping-hole beneath it,

in front of which was sitnated the usual nservoir for the neeption of the name ed metal. The charge consist ed of about 550 lbs. of galena, Containing nearly so 70 of lead mixed with from 220 to 260 lbs. of scrop or Cast- iron. When the temperature had been sufficiently elevated the charge was stimel at prequest interrals, and lead became reduced at the expense of the iron, which was conneted inte sulphiele. From galena containing 80% of lead from 67 to 70 % of metal was extracted, the mall contaming from 5 to 12 yo g lead 4 90 passed of by volitilization, and the plags retained from 4 to 5 yo. The process of smelt ing row over wich non m rearburatory furnaces is book wasteful and expension, and Therefor, practically, unsatisfactory,

in front of which was situated the usual reservoir for the reception of the reduced metal. The charge consisted of about 880 lbs. of galena, containing nearly 80% of lead, mixed with from 220 to 260 lbs. of scrap or cast iron. When the temperature had become sufficiently elevated the charge was stirred at frequent intervals, and lead became reduced at the expense of the iron, which was converted into sulphide.

From galena containing 80% of lead from 67 to 70% of metal was extracted, the matt containing from 5 to 12 % of lead; 4% passed off by volatilization, and the slags retained from 4 to 5%. The process of smelting raw ores with iron in reverberatory furnaces is both wasteful and expensive, and therefore, practically, unsatisfactory.

III. Smilting in shap furnaces. The black furnace is almost unvarsally adapted in all sparte of the world for the smil-ting of argentiferous lead only or a mixture of lead one with Silver one. There carry usually considerable quantaties of earthy matter and Silica, beider the various com binations of metals other than lead and silver. For this mason above they are not suited for any of the norrbaratory processes. Sup in addition the block Jumace nquine lies quel and labor in propertion to the yield. It is true the volalitization of the level is some what grater in the bloch jur. noce than in the reverberatory but this may be partly avoided by a proper shope and hight File furnace, and by for The largest percentage of lead volatilized and also silver can to caught in properly

III. Smelting in shaft furnaces. The blast furnace is almost universally adopted in all parts of the world for the smelting of argentiferous lead ores, or a mixture of lead ores with silver ores. These carry usually considerable quantities of earthy matter and silica, besides the various combinations of metals other than lead and silver. For this reason alone they are not suited for any of the reverberatory processes. But in addition the blast furnace requires less fuel and labor in proportion to the yield. It is true the volatilization of the lead is somewhat greater in the blast furnace than in the reverberatory, but this may be partly avoided by a proper shape and height of the furnace, and by far the largest percentage of lead volatilized and also silver

can be caught in properly

constructed system of con densing chambres, especially when showers of water and used to cool the Jumes. There an two processes in use, which an executed m The black furnace; The pricip itating, and the roasting and ridueing process. Galena one containing little silver, and no other gaugue are usual ly subjected to the prospitating process, those centaining much silver, and baside, the above pubstances a lorge percentage of forign sulphints, arsenin-rate, etc., to the roasting and reducing process. In the latter, a precipitating action is also often introduced by the oxides of iron calnady in the charge, or by a small addition of material's containing them The Incepitating process. This process is the simplish lead Amelting process in use It is based on the graler

constructed system of condensing chambers, especially when showers of water are used to cool the fumes. There are two processes in use, which are executed in the blast furnace; the precipitating, and the roasting and reducing process.

Galena ores containing little silver, and no other gangue are usually subjected to the precipitating process, those containing much silver, and besides the above substances a large percentage of foreign sulphurets, arseniurets, etc., to the roasting and reducing process. In the latter, a precipitating action is also often introduced by the oxides of iron already in the charge, or by a small addition of materials containing them

The precipitating process. This process is the simplest lead-smelting process in use It is based on the greater

abfinity of the sulphur for the iron than for the lead. and with one Containing only galera and quartzone or argillaceous ganque it can tr Carried out according to strict ly stoichiometrical principles. But when foregn sulphirets are present it becomes less advantageous. The presence J. Those of Cepper, antimony, arsenic, etc., is especially un desirable, breauxe these are also acled upon by the iron and The fortions induced to metal deteriorate the lead, while the sulphinets go into the malle, which basides much level carries the greater part of the silver, if silver be present with it, thus necessitating Juster processes for its extrac. tion. The Roasting and reducing process. This method is enrinently adopted to the tratment of one rich in silver, comporation

affinity of the sulphur for the iron than for the lead; and with ores containing only galena and quartzose or argillaceous gangue it can be carried out accordingly to strictly stoichiometrical principles. But when foreign sulphurets are present it becomes less advantageous. The presence of those of copper, antimony, arsenic, etc., is especially undesirable, because these are also acted upon by the iron and the portions reduced to metal deteriorate the lead, while the sulphurets go into the matte, which besides much lead carries the greater part of the silver, if silver be present with it, thus necessitating further processes for its extraction.

The Roasting and reducing process. This method is eminently adopted to the treatment of ores rich in silver, comparative

poor in lead, and containing various forign sulphurets, combinations of arsenic and antimony, and evoly and quartzore ganque. Its main advantage consist in a nearly parfect extraction of Delvan in the first smelting, breauxe meonsiderable quantations only of matte an Jorn ed; but considerable more fuel is needed, than in the fongoing process, on account of the roasting; the contents of silica cause often a loss of lood in the slog; and when Copper is present in The on it is lost of the roast ing has been carried out suf pliently to guard against a loss of silver by the Jomation of malle. The process consists in a roasting, (the purpose of which is to change the sulphile as much as prouble into ovides and to volatilize a part of such deterous substances als antimony, arsine,

poor in lead, and containing various foreign sulphurets, combinations of arsenic and antimony, and earthy and quartzose gangue. Its main advantage consist in a nearly perfect extraction of silver in the first smelting, because inconsiderable quantaties only of matte are formed; but considerable more fuel is needed than in the foregoing process, on account of the roasting; the contents of silica cause often a loss of lead in the slag; and when copper is present in the ore it is lost if the roasting has been carried out sufficiently to guard against a loss of silver by the formation of matte. The process consists in a roasting, (the purpose of which is to change the sulphides as much as possible into oxides and to volatilize a part of such deterious substances as antimony, arsenic,

and zine,) and a Rubsequent reducing Amelting. In the father it is inleveled to reduce The oxides of lead and Rilvin, to decompose, by means of iron, eisher added or nduced from the oxide in the charge, The sulphides of lead and silver, which may not have been ox-idized during the roasting, and to corry the earthy quartz-ose into the slog.

and zinc,) and a subsequent reducing smelting. In the latter it is intended to reduce the oxides of lead and silver; to decompose, by means of iron, either added or reduced from the oxide in the charge, the sulphides of lead and silver, which may not have been oxidized during the roasting, and to carry the earthy quartzose into the slag.

Roasting and reducing process. This process is divided into the following steps. 1. Onporation of the on for roas 2. Roosting the on in nurbrating furnates. 3. Smelting the roasted or in shaph furnaas for the produce tion of argentiferous lead. 1. Preparation of the my prost-Crushing the are so that is will pass through a sieve J. ob inch mech. The crushing is usually done by the Blake crusher and Cornish rolls, or by machine Similar in construction. 2. Roasting the on in norther-atory furnous. These furnices are be feeling and 12 Just wide, and an provided with eight doors on each side, sim of which

Roasting and reducing process.

This process is divided into the following steps:

- 1. Preparation of the ore for roasting.
- 2. Roasting the ore in reverberatory furnaces.
- 3. Smelting the roasted ore in shaft furnaces for the production of argentiferous lead.

1. Preparation of the ore for roasting. This consists simply in crushing the ore so that it will pass through a sieve of .06 inch mesh.

The crushing is usually done by the Blake Crusher and Cornish rolls, or by machines similar in construction.

2. Roasting the ore in reverberatory furnaces.

These furnaces are 60 feet long and 12 feet wide, and are provided with eight doors on each side, seven of which

an working doors, through which the on is moved forward toward the fin by means of long phovels, and the eight is used for firing. These doors an equidistant on each side, but an not opposite to each other, The fin bridge is Kept cool by a strace of water passing through it. The charge for roacting consist of 2000 lbs. of ore, and is introduced into the furnace by means of a hopper. The charge is allowed to remain in front of each work ing door to hours, it is then posed along to the next working door in the direction of the Jurplace, where it mains another 6 hours. This operation is continued every six hours until The charge naches the lash work ing door, thus requiring 42 hours for the roasting of a charge. The roosted charge is drawn as a pasty maxis

are working doors, through which the ore is moved forward toward the fire by means of long shovels, and the eighth is used for firing.

These doors are equidistant on each side, but are not opposite to each other.

The fire bridge is kept cool by a stream of water passing through it. The charge for roasting consists of 2000 lbs. of ore, and is introduced into the furnace by means of a hopper. The charge is allowed to remain in front of each working door 6 hours, it is then pased along to the next working door in the direction of the fireplace, where it remains another 6 hours. This operation is continued every six hours until the

This operation is continued every six hours until the charge reaches the last working door, thus requiring 42 hours for the roasting of a charge. The roasted charge is drawn as a pasty mass

from the Jurnace, through a slide-door situated in the hearth in Front of the last working door, into a Cart made Ly this method of roasting a charge of 2000 lbs. is with drawn every a hours, making The total amount roasted in 24 hours 8000 lbs. One of these Jurnael rigins The attendance of your men, who work in shifts of 12 hours each. When the amount of Julphur in the roosted oh exceeds 2% it is roosted. 3. Smelting the roasted on m Shaft Jurnace for the production of argentiferous lead. This operation is Cornel on in the water Jockeh blost Jurnace, with siphon top. The Jumace bring of the netangular partern, the ground plan of the base is that of a rectangle 9 by 72. Jean,

from the furnace, through a slide-door situated in the hearth in front of the last working door, into a cart made of boiler-plate.

By this method of roasting a charge of 2000 lbs. is withdrawn every 6 hours, making the total amount roasted in 24 hours 8000 lbs.

One of these furnaces requires the attendance of four men, who work in shifts of 12 hours each. When the amount of sulphur in the roasted ore exceeds 2% it is reroasted.

3.Smelting the roasted ore in shaft furnaces for the production of argentiferous lead.

This operation is carried on in the water jacket blast furnace, with siphon tap. The furnace being of the rectangular pattern, the ground plan of the base is that of a rectangle 9 by 7 ½ feet,

with the cerner's cut off, Thus allowing the uprights which support the deck plate to have foundation outside of the crucible bindus. These uprights an rolled brans. The deck plate is also made of rolled brains flaced pome distance apart, The pose between Them bring utilized as a condit for any vapers excaping from the jur nace. The crucible binders an made of nobrd wrought. iron. This substitution of wrought iron for Castiron exthroughout the whole structun. The water Jacket, which is in section, is made of steel in the following manner. The sheet forming the fin side of the jacket is shoped into a box over binches deep wishout cutting the corneis, so as not to have any niveted or welded joints ex Josed to the fire. The back plate is formed nito a shallow box felling

with the corner cut off, thus allowing the uprights which support the deck plate to have foundation outside of the crucible binders. These uprights are rolled beams. The deck plate is also made of rolled beams placed some distance apart, the space between them being utilized as a condit for any vapors escaping from the furnace. The crucible binders are made of rubbed wrought iron. This substitution of wrought-iron for cast iron ex throughout the whole structure. The water jacket, which is in sections, is made of steel in the following manner. The sheet forming the fire side of the jacket is shaped into a box oven 6 inches deep without cutting the corners, so as not to have any riveted or welded joints exposed to the fire. The back plate is formed into a shallow box fitting

noto The other, the concare side of both boxes facing outword, the outword edges of The two parts bring plush and in which position they an norted and calked, this leav ing the joint entirely on the outside. Attached to the out. side of the jacket an hopped open at the top and through which the cold water is sup. plied to Keep the Jackets cert and from which there is an outlen for the hot water. This your is known as the open topped jacket. The end jackets de not come down to the crucibles by about minches. The space so left is filled up with a small closed top jacket, which can br madily moved, This construction does away with the old-Zashioned trick brash, and in core of near sity enables the Jurnace man to sapiely open and close up the furnace at any

into the other, the concave side of both boxes facing outward, the outer edges of the two parts being flush and in which position they are riveted and calked, thus leaving the joint entirely on the outside. Attached to the outside of the jacket are hoppers open at the top and through which the cold water is supplied to keep the jackets cool, and from which there is an overflow for the hot water. This form is known as the open topped jacket. The end jackets do not come down to the crucibles by about 7 inches. The space so left is filled up with a small closed top jacket, which can be readily removed. This construction does away with the old-fashioned brick breast, and in case of necessity enables the furnace man to rapidly open and close up the furnace at any

time it becomes desirable Do to de: The shape of the Jumase internally is as fallout; From the tuyeres upwords The water jocket here a bosh on the pieles, thus incrasing The width to 52 Just; the ends ar perpendicular from the top of the jocket, the pidet an pupendicular to the feed door, making the shaft 5 by 52 Just. The hlight should the adapted to the character of The one to be worked. Knowing the composition of The roasted on, a Chorge is culculated, The play desirable bring brtween a sub and Singulo Silicate. One he kind of on depend the nation of the bases in the plag; Jerniginous one allowing of a sleg containing much iron. with non-firinginous ones a slog with a large percentage of time is more economical, as limestone

time it becomes desirable so to do.

The shape of the furnace internally is as follows: From the tuyeres upwards the water jacket has a bosh on the sides, thus increasing the width to 5 $\frac{1}{2}$ feet; the ends are perpendicular from the top of the jacket; the sides are perpendicular to the feed door, making the shaft 5 by 5 1/2 feet. The height should be adapted to the character of the ore to be worked. Knowing the composition of the roasted ore, a charge is calculated, the slag desirable being between a sub and singulo silicate.

On the kind of ore depends the relation of the bases in the slag; ferruginous ores allowing of a slag containing much iron. With non-ferruginous ores a slag with a large percentage of lime is more economical, as limestone

only costs 1/2 what won on dere. magnesia, manganese alumina, and zine, as high as The impurites, much be taken into consideration. The charge is given to the weigher, and the cons and pluces an wrighed accurate. ly in a whellowood, as a few pounds masoo-pound chorge make quite a defference in The slog. The charge is then dumped at the Jurnace door, finel is chorged at the geed door in alternate layers with the charget. Both cone and choreoal an used in varying proportions, The amount of fuel used vone from 12 to 1490. One Centaining only 6- 40 gled has been successfully smelted The resulting products of smelting an lead, containing silver and non or less impurities; malle, a sulphide of iron, and Aleg. The bullion is topped out by the siphon top and

only costs $\frac{1}{4}$ what iron ore does. Magnesia, manganese, alumina, and zinc, as well as the impurities, must be taken into consideration. The charge is given to the weigher, and the ores and fluxes are weighed accurately in a wheelbarrow, as a few pounds in a 500-pound charge make quite a difference in the slag. The charge is then dumped at the furnace door. Fuel is charged at the feed door in alternate layers with the charges. Both coke and charcoal are used in varying proportions.

The amount of fuel used varies from 12 to 14%.

Ores containing only 6 1/2 % of lead has been successfully smelted. The resulting products of smelting are lead, containing silver and more or less impurities; matte, a sulphide of iron, and slag. The bullion is tapped out by the siphon tap and

Coal into bars; matte coming Coming out with the slog' al the breash, plows into an Iron pat. 30 to 40 tons of on an Smeltel in 2x hours. at Inibran, Dohemia 40 to 45 tons of on and pluxes are Smelted in 24 hours. The slogs centain only . 0023 70 of silver and 1.5% of lead. The campaign loch 3 months the longest having been 158 days. at Railroad District, Nevela, 41 Tone of on and pluses was smelted in 2x hours, (28 tens of on and 13 tens of flux). The cost of smelting 1 ten of on is estimated at \$14.50.

cast into bars; matte coming coming out with the slag at the breast, flows into an iron pot.

30 to 40 tons of ore are smelted in 24 hours.

At Pribram, Bohemia 40 to 45 tons of ore and fluxes are smelted in 24 hours.

The slags contain only .0023% of silver and 1.5% of lead.

The campaign last 3 months the longest having been 158 days. At Railroad District, Nevada, 41 Tons of ore and fluxes are smelted in 24 hours. (28 tons of ore and 13 tons of flux). The cost of smelting 1 Ton of

ore is estimated at \$14.50.

Desilverization op The argentificat lead. Defon the discoury by The late Hugh the Pattison, of The pro-Cess by which the silver in argentif crows lead may be concentrated in a comparative small amount of That metal, the whole of the lead abtained by smelting was, when sufficiently rich, subjected to cupellation. This process is jounded on the arcumstance, first noticed by mr. Pattison, in The year 1829, That when lead containing silver is melled in a Duitable vessel, and afterwards suffered slowly to cool, with constant stirring at a temperature near the meeting point of lead, Small metallie crystals begin to form within the liquid alloy, which as rapidly as They are produced. sink to the bollow, and on bring moved are found to contain less silver than the lead originally operated on, The still fluid alloy from which The rystals have been reporated is at The same time undered proportionately richer in Silver.

Desilverization of the argentiferous Lead.

Before the discovery by the late Hugh Lee Pattison, of the process by which the silver in argentiferous lead may be concentrated in a comparative small amount of that metal, the whole of the lead obtained by smelting was, when sufficiently rich, subjected to cupellation. This process is founded on the circumstance, first noticed by Mr. Pattison, in the year 1829, that when lead containing silver is melted in a suitable vessel, and afterwards suffered slowly to cool, with constant stirring at a temperature near the melting point of lead, small metallic crystals begin to form within the liquid alloy, which as rapidly as they are produced sink to the bottom, and on being removed are found to contain less silver than the lead originally operated on, the still fluid alloy from which the crystals have been separated is at the same time rendered proportionately richer in Silver.

Modification of Pattison' Process. The arrangement eneployed for this process essentially consist of two costs iron vessels, the first which is called the meeting dot, and the other the crystalig-ing- pot, which much be placed at kuch a level that the metal from the melting-pot may be new directly inte it. Below the level of the crystalising gots much be one or mon need-ers you the neeption of the en iched lead. Instead of using machineny for stirring the level, The same object is mon simply and effectually accomplished by introducing a jet of high passur steam into he molten metal. This merhod is about 30 % cheaper than the Old Patti-Den nerheel, The Old Fattisen meshod is almost entirely out of use. Marselles modefication of the Pattison process is in use at Orbran tohemed,

Modification of Pattison's Process.

The arrangement employed for this process essentially consist of two cast iron vessels, the first which is called the melting pot, and the other the crystalizing pot, which must be placed at such a level that the metal from the melting pot may be run directly into it. Below the level of the crystalising pots must be one or more receivers for the reception of the enriched lead. Instead of using machinery for stirring the lead, the same object is more simply and effectively accomplished by introducing a jet of high pressure steam into the molten metal. This method is about 30% cheaper than the Old Pattison method.

The Old Pattison method is almost entirely out of use.

Marselle's Modification of the Pattison process is in use at Pribram Bohemia.

Desilvinsation by zine. Parkes Proces: When lead and zue an melted together and the fund mytime allowed to cool slowly, the zine solicifier first, foruing a loyer on The surface of the metallic bash which may be readily moved in the form of a cush cent-aining nearly the whole of the silver presed in the original lead. This process is operated as Jallout. A charge of y Tons of lead to be desilvenzed is fired in a large cast-iron pot, close to which is placed a small er one for the fusion of the ne As soon as the whole of he level has become melted it is made to boil, by the insertion of a grain pole, and the oxide which ed by a perforated skumer, The teleperature of the metal is now raised to the melting pomb of zine, and zine is added

Desilversation by zinc.

Parke's Process:

When lead and zinc are melted together and the fused mixture allowed to cool slowly, the zinc solidifies first, forming a layer on the surface of the metallic bosh which may be readily removed in the form of a crust containing nearly the whole of the silver present in the original lead. This process is operated as follows. A charge of 7 tons of lead to be desilverized is fused in a large cast iron pot, close to which is placed a smaller one for the fusion of the necessary zinc.

As soon as the whole of the lead has become melted it is made to boil, by the insertion of a green pole, and the oxides which rise to the surface are removed by a perforated skimmer. The temperature of the metal is now raised to the melting point of zinc, and zinc is added

in the Jused stale in the proper tim of about 1's lbs. for each ounce of pullor contained in the lead perated on. The mixtun is now well stime during about 2 hours, the fin subsequently wishdrown and the metal allend grodually to ceal; during the process of Cevling, duy of the zine alloy which may atthe, in the form of solid migs, to the sides of the poh much to moved by means of a piece surface has sufficiently hardand it is collected by skinung with a perforated lade. The alloy they abtained is a mixtun of lead and zine containing silver, and is subfeeled to a priver of liquation in an inclined retert, where it is heated somewhat above the melting point of lead, The zine, after bring as for as possible find from lead by liquation, is distilled in al Relgian Jumace in

in the fused state in the proportion of about 1 1/2 lbs. for each ounce of zine silver contained in the lead operated on. The mixture is now well stirred during about 2 hours, the fire subsequently withdrawn and the metal allowed gradually to cool; during the process of cooling, any of the zinc alloy which may adhere, in the form of solid rings, to the sides of the pot must be removed by means of a piece of wood, and as soon as the surface has sufficiently hardened it is collected by skimming with a perforated ladle. The alloy thus obtained is a mixture of lead and zinc containing silver, and is subjected to a process of liquation in an inclined retort, where it is heated somewhat above the melting point of lead. The zinc, after being as far as possible freed from lead by liquation, is distilled in a Belgian furnace in

admixture of live and ceal-dust,' the residue in the starts consist of level and pulverulent matter, The former is multed Skinned and cupelled, and The latter added to the charger of the ordinary lead Jumace. Modification & Parks Process. American method: Turnty tens of bars an meltel down slowly in a lorge murberatery jurhave. According to the amount of impunities In the lead the mollen meter mains her exposed to a low heat and plenty of air, for a shorter or lenger time, The arrage br. ing about 18 hours. After the first les Thour the covering of oxides, containing most of The Copper and antimeny and much lead is taken off. It amounts to from 1.5 to 2 % of the weight originally put into the furnace.

admixture of lime and coaldust; the residue in the retorts consist of lead and pulverulent matter. The former is remelted skimmed and cupelled, and the latter added to the charges of the ordinary lead furnace.

Modification of Park's Process.

American Method:

Twenty tons of bars are melted down slowly in a large reverberatory furnace. According to the amount of impurities in the lead the molten metal remains here exposed to a low heat and plenty of air, for a shorter or longer time, the average being about 18 hours. After the first 6 or 7 hours the covering of oxides, containing most of the copper and antimony and much lead is taken off. It amounts to from 1.5 to 2% of the weight originally put into the furnace.

The oxide forming after this are not taken off, but left in The Jurnace after topping The lead into the desilvensation Kettle. The drawing of from the for-noce into the desilversation Kettle is effected by means of a partly cered spout, There an fin desilvensation stelle The two large ones, the so called zine pots, fold 4 2 000 lbs. 7 metal even. They an walled in side by side, and immediately in Front of Them on the smaller lequation Kettle nos. 3 and 4, which hold 14 coolbo each. In printing There is The smallest Kettle, hodding 8000 lbs. which is used for liquation to drynes. The whole arrangement is in the shape of a triangle, nos, and 2 forming the base and no. 5 The apex. According to the richnew of the material to be trated There is deled from 1.8 to 2.6% The zine is added in three, and Sometimes four fortions.

The oxides forming after this are not taken off, but left in the furnace after tapping the lead into the desilverisation kettles. The drawing off from the furnace into the desilverisation kettles is effected by means of a partly covered spout. There are five desilverisation kettles. The two large ones, the so called zinc pots, hold 42000 lbs. of metal each. They are walled in side by side, and immediately in front of them are the smaller liquation kettles nos. 3 and 4, which hold 14000 lbs each. In front of these is the smallest kettle, holding 8000 lbs. which is used for liquation to dryness. The whole arrangement is in the shape of a triangle, nos. 1 and 2 forming the base and no. 5 the apex. According to the richness of the material to be treated, there is added from 1.8 to 2.6% of zinc, either in no. 1 or no. 2 kettle. The zinc is added in three, and sometimes four portions.

Each addition is with The lead for 's to 3/4 of an hour, the temp erature bring mantained abour The melting point of zinc. Then the fin is drawn and the Kettles an allound to stand long enough to permit the charge to Cool, and the zine-Silver alloy to rise to the surface, The lead The Accem is now taken off with perforated lodles and transfind to pot 3 or 4. If it is the secon resulting from the finch zine addition, it is after a gartial lequa tion, inmediately transfand to got no. 5 where the lequation is finished. The level nout ing your lequation is trans. fand from no. 3 or 4 book into no. 1 or 2 befor The second addition of give is introduced The peum resulting from The second, Third or fourth addition is not bynated, but used again in a subsequent operation; in place of a first zine

Each addition is with the lead for $\frac{1}{2}$ to $\frac{3}{4}$ of an hour, the temperature being maintained above the melting point of zinc. Then the fire is drawn and the kettles are allowed to stand long enough to permit the charge to cool, and the zinc-Silver alloy to rise to the surface, the lead below remaining liquid. The scum is now taken off with perforated ladles and transferred to pot 3 or 4. If it is the scum resulting from the first zinc addition it is after a partial liquation, immediately transfered to pot no. 5 where the liquation is finished. The lead resulting from liquation is transfered from no. 3 or 4 back into no. 1 or 2 before the second addition of zinc is introduced The scum resulting from the second, third or fourth addition is not liquated, but used again in a subsequent operation, in place of a first zinc

addition. In a lot of 40120 lbs of work-lead containing 0.19890 of silver the desilirnsation took glace as follows; 1. Added ; zine seum from for vious operation 3000lbs, Keft in lead after skinning Silver 0.11690. 2. Zinc leco lbs. Left in lead after skeining; Silver 0. 00390. 3. zine 125 lbs. Left in lead after skenning Silver 0. voole of Silver a. voole of In desilvising 287383 lbs. 1.870 zine was used ?

addition.

In a lot of 40120 lbs of worklead containing 0.198% of silver, the desilverisation took place as follows:

1. Added: zinc scum from previous operation: 3000 lbs.

> Left in lead after skimming: silver 0.116%.

- 2. Zinc 600 lbs. Left in lead after skimming: silver 0.003%.
- 3. Zinc 125 lbs. Left in lead after skimming, silver 0.0006% In desilverising 287383 lbs. 1.8% of zinc was used.

Distillation of the zine Riber allery. The rich give crust is lequated at some works in nurberatories, at other in stellies slanding for that perper near the longe desilunsation Kettler. It is, hours, always the aim not to produce any oxides, and for that mason the temperature is kept exceeding-ly low, excess of air is lindit-ed as much a possible. In this fact lies the fundament ican distillation and that at Tornowitz. The frocess of distillation is as falleros: Nev. A. Faber du Faurs tilting nort furnaces is jused. The stort furnace is healed gradually by means of coke until the ptort has become dork rad. Then it is charged by means of a small copper shoul with liqualed give crush, which has providely

Distillation of the zinc silver alloy.

The rich zinc crust is liquated at some works in reverberatories, at others in kettles standing for that purpose near the large desilverisation kettles. It is, however, always the aim not to produce any oxides, and for that reason the temperature is kept exceedingly low, excess of air is limited as much as possible. In this fact lies the fundamental difference between our American distillation and that at Tarnowitz.

The process of distillation is as follows:

Mr. A. Faber du Faur's tilting retort furnace is used.

The retort furnace is heated gradually by means of coke until the retort has become dark red. Then it is charged by means of a small copper shovel with liquated zinccrust, which has previously

bran cut into pieces about 1 to 1/2 Cubic inches. A charge filling the retort to the neck cowsish of From 250 to 400 lbs. of alloy with which from 3 to 5 lbs. of Amall chorceal, of been size has barn mixed, next the condent er is put on. The temperature is at once raised to a white heat, and Kept De until the distillation is complete. The operation last from 8 to 10 hours according to the percentage A zine in the alloy. When sufficient metallic zine has been collected, it is smelted in a Kelle under a cool Covering, The oxide and impavities an taken off, and the melal cash into plates, which on again used for desilionsation, trow 40 to 50% of the give ong-inally added to the work lead is required in the form of plates which centain only a trace of silver. The blue pender and oxide

been cut into pieces about 1 to $1\frac{1}{2}$ cubic inches.

A charge filling the retort to the neck consist of from 250 to 400 lbs. of alloy with which from 3 to 5 lbs. of small charcoal, of bean size has been mixed, next the condenser is put on. The temperature is at once raised to a white heat, and kept so until the distillation is complete.

The operation lasts from 8 to 10 hours according to the percentage of zinc in the alloy.

When sufficient metallic zinc has been collected, it is remelted in a kettle under a coal covering, the oxide and impurities are taken off, and the metal cast into plates, which are again used for desilverisation. From 40 to 50% of the zinc originally added to the work lead is regained in the form of plates which contain only a trace of silver.

The blue powder and oxide

containing no mon silver Than the metal, and comprising 10 to 20 go of the original zine, on pold to give works. When the distillation has been comiel on until There is only a troce of zine in the richt lead, the condenses is taken Ab and the fornace is left to itself for a Den minutes. Meanwhile a small wagon, corrying a castiron Joh, is brought in front of the stort, and by till mg the whole Jumace the rich lead is transferred in a straw to the after having cooled for awhile The metal is pound into lead mould.

containing no more silver than the metal, and comprising 10 to 20% of the original zinc, are sold to zinc works. When the distillation has been carried on until there is only a trace of zinc in the rich lead, the condenser is taken off, and the furnace is left to itself for a few minutes. Meanwhile a small wagon, carrying a cast iron pot, is brought in front of the retort, and by tilting the whole furnace the rich lead is transferred in a stream to the After having cooled for awhile the metal is poured into lead moulds.

Terman Cupellation Froces. The old German Cupelling Jurnace, which is still in use in many Centinental establish ments, transists of a Kind of reverberatory own, having a circulas hearth, and a lateral fireplace. The bottom which is regularly hollourd from the sides toward the middle, is composed of fire brick set on edge upon a shatum of firmile -compressed slog, and is again covered with a Coating of mart. This layer of marl arms pends to the test employed by English nfiners, and is cound by a dome of iron plastered over with mail. About ston of ordinary lead are usually supelled at one operation, and of This a little leas Than thur Jouths is introduced into The furnace before lighting up; The umainder is added at succession during the progress of cupellation, The operation is continued until the grader pertion of the lead has been unound in the

German Cupellation process. The Old German cupelling furnace, which is still in use in many Continental establishments, consists of a kind of reverberatory oven, having a circular hearth, and a lateral fireplace. The bottom which is regularly hollowed from the sides towards the middle, is composed of fire brick set on edge upon a stratum of firmly compressed slag, and is again covered with a coating of marl. This layer of marl corresponds to the test employed by English refiners, and is covered by a dome of iron plastered over with marl. About 5 tons of ordinary lead are usually cupelled at one operation, and of this a little less than three-fourths is introduced into the furnace before lighting up; the remainder is added at successive intervals during the progress of cupellation. The operation is continued until the greater portion of the lead has been removed in the

form of litharge, and a plate quearly fun silver remains. The average loss of lead during cupellation by the German fro-ces is about 8 %. about I tons are cupelled in 80 hours with a consumption g 12 cord g wood. The Glickeilur's obtained from This operation is mfined either in a movable test, like that em ployed in the English process, or in a fixed cupel forming the bottom of a nurberatory furnace

form of litharge, and a plate of nearly pure silver remains. The average loss of lead during cupellation by the German process is about 8%.

About 5 tons are cupelled in 80 hours with a consumption of $1\frac{1}{2}$ cord of wood.

The Blecksilver obtained from this operation is refined either in a movable test, like that employed in the English process, or in a fixed cupel forming the bottom of a reverberatory furnace.

Refining. English mestode. The cupellation of argentiferous lead is Conduc ted on a hearth composed of bone-ask, which forms the movable bollom of a nurberatory purnace. The cupel, or test, his Contained in an ellipticalizing, seldem less Than 52 or 6 inches in depth, usually about 4 fact in its grater and 3 grat in it lesser diameter, To support and stringthen the bottom of the test, This frame is provided with four parallel cross-bars, 4's inches wide, and, like the ring stelf, half an inch in thickness To propose a test the frame is filled with bone ash will braten in layers, after having been prover morslened with water. After the francing has, bren filled with bone ash, solidly traten down, a carity is scooked in its upper Aurspace. The test is healed Its nelness, and a charge

Refining. English Method.

The cupellation of argentiferous lead is conducted on a hearth composed of bone-ash, which forms the movable bottom of a reverberatory furnace. The cupel, or test, is contained in an elliptical iron ring, seldom less than 5 $\frac{1}{2}$ or 6 inches in depth, usually about 4 feet in its greater and 3 feet in its lesser diameter. To support and strengthen the bottom of the test, this frame is provided with four parallel cross-bars, 4 ¹/₂ inches wide, and, like the ring itself, half an inch in thickness. To prepare a test the frame is filled with bone-ash well beaten in layers, after having been previous moistened with water. After the framing has been filled with bone-ash, solidly beaten down, a cavity is scooped in its upper surface. The test is heated to redness, and a charge

of the neh level to be operated on is introduced. When fist introduced into the furnace, the liquid metal breemes cound by a grayish dross; but as soon as it has acquind the full temperature g the test, the surface of the both uncourse, and pused lithorge bigins to make its appearance. The blast is now turned on trough the nogle and the melted lishange is Thus driven from the book of the test up toward the broch where it glow out. The appearance of the surface indicates the precise period at which the operation is terminaled; "he block is turned Af, and the fin moved The plate of silver is Thus allourd to set, and as soon as it has done so the test grave together wish the silver is taken out and allowed to Gool. The silver is delached

of the rich lead to be operated on is introduced.

When first introduced into the furnace, the liquid metal becomes covered by a grayish dross; but as soon as it has acquired the full temperature of the test, the surface of the bosh uncovers, and fused litharge begins to make its appearance. The blast is now turned on through the nozzle and the melted litharge is thus driven from the back of the test up toward the breast where it flows out. The appearance of the surface indicates the precise period at which the operation is terminated; the blast is turned off, and the fire removed from the grate.

The plate of silver is thus allowed to set, and as soon as it has done so the test frame together with the silver is taken out and allowed to cool. The silver is detached

from the cupel, and any Sarticklis of lithorge, slogfor bone ash on moved by scroping with a win bruck. The plates atained vory in wight from 5000 & 1000 gs. and usually Contain Jonig 97 & 998 parts g silver in a thousand.

from the cupel, and any partickles of litharge, slag, or bone-ash are removed by scraping with a wire brush.

The plates atained vary in weight from 5000 to 10000 ozs. and usually contains from 997 to 998 parts of silver in a thousand.

Extraction of Silver by means 7 Copper. Silver extraction by means of copper is divided into the following steps: 1. Production of Cepper malle Containing the silver, 2. Extraction of the silver from the cepper matte. 3. Production of cepper from the cepper meriduer, after The silver has been extracted. 1. Production of Copper malle Centaining the Silver, This is accomplished by the norbiratory or blost Junace. Production of matter by the northinatory process. The production of matter as Corried on at the Boston and colorada Works will be given as an illustration The production of matter as follows;

Extraction of Silver by means of Copper.

Silver extraction

by means of copper is divided into the following steps:

- 1. Production of copper matte containing the silver.
- 2. Extraction of the silver from the copper matte.
- 3. Production of copper from the copper residues, after the silver has been extracted.
- 1. Production of copper matte containing the Silver.

This is accomplished by the reverberatory or blast furnace.

Production of matte by the reverberatory process The production of matte as carried on at the Boston and Colorado Works will be given as an illustration of the reverberatory process. The production of matte is as follows:

1. Sampling the on. all the over neural an pilled reparately on the pacepling grounds All the lorge pieces of gold on are roasted in heaps, and are then passed through a crusher and rolls, and afterwards through a perior with four to the inch mech. The tellurium on's an only crushed and passed through a ten to the inch mesh series, and are nady for smelting. The surface Silver on an Crushed and passed through a four to the inch mesh scoren, and then go to the furnace. The one rich in Sulphur are called heavy ons, and an crushed and roasted in large norberator funaces. 2. Roasting the one. a Roasting the one in heap The antiferous syntes is broken to 2 inches square in a crushe and roasted in heaps of about 50 tons each.

- 1. Sampling the ore. All the ores received are pilled separately on the sampling ground. All the large pieces of gold ore are roasted in heaps, and are then passed through a crusher and rolls, and afterwards through a screen with four to the inch mesh. The tellurium ores are only crushed and passed through a ten to the inch mesh screen, and are ready for smelting. The surface silver ores are
 - crushed and passed through a four to the inch mesh screen, and then go to the furnace. The ores rich in Sulphur are called heavy ores, and are crushed and roasted in large reverberatory furnaces.
- 2. Roasting the ores.
 - a. Roasting the ores in heaps. The auriferous pyrites is broken to 2 inches square in a crusher and roasted in heaps of about 50 tons each.

Two Cord of wood is consumed for roasting 50 tons. Three men does all the Dampling and unighing, and takes con of the piles. The roasted on is crushed and goes through a sien with a your to the inch mesh, and is then rady for the smelter. The roasting occupies about le make. The amount of sulphun remain ing in the on is about 4%. b. Roasting the on in a norteratory purnace. The one submitted to this process is paid to be calcined. The tailings and finely dividel copper ons an toastel in a nurberatory furnace, Called a calciner, till They Contain not mon Than '2 to 4 % of Sulphur, The total length of the furnace is 40 fret. the finplace, Each furnale has three step-hearth 10 Jech long. They an 11 juch wide, and have sie working doors,

Two cord of wood is consumed for roasting 50 tons. Three men does all the sampling and weighing, and take care of the piles. The roasted ore is crushed and goes through a sieve with a four to the inch mesh, and is then ready for the smelter. The roasting occupies about 6 weeks. The amount of sulphur remaining in the ore is about 4%. b. Roasting the ore in a reverberatory furnace. The ore submitted to this process is said to be calcined. The tailings and finely divided copper ores are roasted in a reverberatory furnace, called a calciner, till they contain not more than 1/2 to 4% of sulphur. The total length of the furnace is 40 feet on the outside, including the fireplace. Each furnace has three step-hearths 10 feet long. They are 11 feet wide, and have six working doors,

two door to each hearth. The peorths are i'r makes, one abour the other, and an equally divided in the length of the furnace. The fin place is arranged for wood, and has a door at the side, It is 5 frat long and 2 Just Sinche unde. The width of the bridge is 28 inches, the height of the roof abour the hearth is 28 inches and at the flue-end it is 18 inches. The funace is built of not brick, finbrick bring used only in the finplace and on the first hearth. A charge of one ton is introduced on the hearth nearest the plue, so that there are 3 tons in the fuinace at a time. As the charge is drawn drown once in Shows, it takes 24 hours to complete the roasting of one ton of the on. Two men work 3 tous in 24 hour 1/2 Cords of wood are consumed every schours. The Cost of roosting is \$4.45.

two doors to each hearth. The hearths are $4\frac{1}{2}$ inches, one above the other, and are equally divided in the length of the furnace. The fire place is arranged for wood, and has a door at the side. It is 5 feet long and 2 feet 8 inches wide. The width of the bridge is 28 inches, the height of the roof above the hearth is 28 inches, and at the flue-end it is 18 inches. The furnace is built of red brick, firebrick being used only in the fireplace and on the first hearth. A charge of one ton is introduced on the hearth nearest the flue, so that there are 3 tons in the furnace at a time. As the charge is drawn drawn once in 8 hours, it takes 24 hours to complete the roasting of one ton of the ore. Two men work 3 tons in 24 hours. $1\frac{1}{2}$ cords of wood are consumed every 24 hours. The cost of roasting

is \$4.45.

3. Fusion for malle. The roasted are is fused in a nurberatory furnace for matte, Phese furnaces an constructed to use wood, so that The finplace, which is 5 fect at the top of The bridge, is only 2 fact 6 makes at the grate; it is 5 fect long and 4% feet deep from the grate to the roof. The opening in the finplace for charging fuel is at the end of the funder, and not at the Lide as is usual. The bridge is 22 fact wide, The finplace side 22 Jach and The laboratory side 1% geet your Jeek 72 inches long, by 9 feet ginches wide, The working door is at the end, The hearth of the furnace is slightly inclined toward the working door, and also to one side. It is made of two layers of bricks, upon which fine quarty-sand is placed, which is mixed

3. Fusion for matte.

The roasted ore is fused in a reverberatory furnace for matte. These furnaces are constructed to use wood, so that the fireplace, which is 5 feet at the top of the bridge, is only 2 feet 6 inches at the grate; it is 5 feet long and 4 ¹/₂ feet deep from the grate to the roof. The opening in the fireplace for charging fuel is at the end of the furnace, and not at the side as is usual.

The bridge is 2 $\frac{1}{2}$ feet wide, the fireplace side 2 1/4 feet and the laboratory side 1 feet from the roof. The laboratory is 15 feet 7 ¹/₂ inches long, by 9 feet 9 inches wide. The working door is at the end.

The hearth of the furnace is slightly inclined toward the working door, and also to one side. It is made of two layers of bricks, upon which fine quartz-sand is placed, which is mixed

with a small quantaly of wood askes, and then agglomerated. When the heart is mæde the temperature is levend and the charges is introduced. The charge is made of Heap- vasted gold one, 2000 lbs. Roasted tailings, 2000 " Oxidized Silverores, 1500 " Roasted Silver ones, 1500 " Raw Ogrites, 800 . Flourspar, 250 " Rich Scorias, 500 " The charge is introduced with a short by a side dow, The on is introduced first and then the rich blags. The charas is so arranged That ten tons of mixed one will produce I ton of malle. The slog is carefully calculated basic, or othervise it would cut the finbrick to get silica. The charge is early distributed over the surface of the hearth which is almost at a cherry

with a small quantity of wood ashes, and then agglomerated. When the hearth is made the temperature is lowered and the charge is introduced. The charge is made of Heap-roasted gold ores, Roasted tailings, Oxidized silver ores, Roasted silver ores, Raw Pyrites, Flourspar, Rich Scorias, The charge is introduced with a shovel by a side door. The ore is introduced first and then the rich slags. The charge is so arranged that ten tons of mixed ores will produce 1 ton of matte. The slag is carefully calculated, so that it shall not be too basic, or otherwise it would cut the firebrick to get silica. The charge is evenly distributed over the surface of the hearth which is almost at a cherry



| 2000 | lbs. |
|------|------|
| 2000 | " |
| 1500 | " |
| 1500 | " |
| 800 | " |
| 250 | " |
| 500 | " |

nd heat. As soon as the Charge is made, The chorging door is built up and luted with pand. The priplace is thus charged and the Jurnace is left. The full pour of draft for 5 or 6 hours. At the end of This time they stir the jurnace carefully 5 or 6 minutes to bring up every thing from the bollow. The furnace is left for 20 minutes to effect the separation of the scome and malle. The plag is now drawn with a rabble into mouldo prepared for it. When all the slag is drawn off, a new charge of on is inhoduced. Four charges an made in 24 hours. While the slog is topped the malle is left to accum relate, and is lapped only once in 24 hours. The malle is topped and made into plale 3 Jack long, 14 inches wide, and 4 inches thick in the middle The bollow's bring rounded. 3 men per shift of 12 hours an

red heat. As soon as the charge is made, the charging door is built up and luted with sand. The fireplace is thus charged and the furnace is left the full power of draft for 5 or 6 hours. At the end of this time they stir the furnace carefully 5 or 6 minutes to bring up everything from the bottom. The furnace is left for 20 minutes to effect the separation of the scoria and matte. The slag is now drawn with a rabble into moulds prepared for it. When all the slag is drawn off, a new charge of ore is introduced. Four charges are made in 24 hours. While the slag is tapped the matte is left to accumulate, and is tapped only once in 24 hours. The matte is tapped and made into plates 3 feet long, 14 inches wide, and 4 inches thick in the middle, the bottom being rounded. 3 men per shift of 12 hours are

required to work two jumaces. 8 Cord of wood. on consumed in 24 hours. The plate slag cintain en an average 5% of Cepper, but is often poor energh to be thrown away with the other plage. It is generally a sili-cote of protoxide of iron, but is sometimes min basic. The priv slag centains younces of silver and a trace of gold. It is too poor to be treated and is thrown away. all the slags noter than this an put back into the Jurnace, The malle contains from 25 to 30 % of Cepper, 20 to 30 ouncer of gold, boo to 1000 ounces of Silvar, and some in, lead zine, and antimony. There an produced from this operation the copper malle, which posses to the next operation, The plate plag, which is unediately put back into the fumace, and the poor slag which is thrown away."

required to work two furnaces. 8 cord of wood are consumed in 24 hours. The plate slag contains on an average 5% of copper, but is often poor enough to be thrown away with the other slags. It is generally a silicate of protoxide of iron, but is sometimes mere basic. The poor slag contains 7 ounces of silver and a trace of gold. It is too poor to be treated and is thrown away. All the slags richer than this are put back into the furnace.

The matte contains from 25 to 30% of copper, 20 to 30 ounces of gold, 600 to 1000 ounces of silver, and some iron, lead, zinc, and antimony.

There are produced from this operation the copper matte, which passes to the next operation, the plate slag, which is immediately put back into the furnace, and the poor slag which is thrown away.

Production og malle by The block furnace process. As an illustration of this process the production of matte as corried on at Mansfield, Prussia, will be given. The Production of matter at manifield is divided into the following steps: 1. Burning the Schist. IT. Smelting burnt on with Slag for the production of Coarse-melal, III. Avasting the Course metal, IV, melting for fine-metal, 1. Surning the Schiet, This has you its object the Combustion or volatilization of a lorge portion of the bitumen, as well as the expulsion of water, assenie, etc.; a portion of the sulphur is also eliminated at the same time, but can much be laken to stain a sufficient quantity to form a good coarse metal

Production of matte by the blast furnace process. As an illustration of this process, the production of matte as carried on at Mansfield, Prussia, will be given.

The production of matte at Mansfield is divided into the following steps:

- Ι.
- Burning the Schist. П. Smelting burnt ore with slag for the production of coarse metal.
- III. Roasting the coarse metal. Melting for fine metal.
- IV.
 - Ι. Burning the Schist. This has for its object the combustion or volatilization of a large portion of the bitumen, as well as the expulsion of water, arsenic, etc.; a portion of the sulphur is also eliminated at the same time, but care must be taken to retain a sufficient quantity to form a good coarse-metal

with the Copper and a portion The iron. The schish is burnt in heaps 200 to 300 Jech long, 30 to 40 in width, 10 fact in height, and Containing 400 to goo ten, Ten pound of wood an con simed for each ton of schich burnt; and the reduction in fulk which takes place during The operation is about 10%, and The less of weight is 16 %. 11. Smelting burnt on with slag for the production of coarse melal The wasted on is taken from The pile in which it is furt directly to the Imelting Jumace, where it is gused with a mint un of slags and flour spar, the products abtained tring Coarametal and poor slags. This fusion takes place in a bloch Jurnace of which the lotal height is about 30 Jeeh. These furnaces are circular in form and on blown by

with the copper and a portion of the iron.

The Schist is burnt in heaps 200 to 300 feet long, 30 to 40 in width, 10 feet in height, and containing 400 to 900 tons. Ten pound of wood are consumed for each ton of Schist burnt; and the reduction in bulk which takes place during the operation is about 10%, and the loss of weight is 16%.

Smelting burnt ore with slag П. for the production of coarse metal.

The roasted ore is taken from the pile in which it is burnt directly to the smelting furnace, where it is fused with a mixture of slags and flour-spar, the products obtained being coarse metal and poor slags. This fusion takes place in a Blast furnace of which the total height is about 30 feet. These furnaces are circular in form and are blown by

Six tuyers. The purnace is Supported on eight Short Coshiron pilloux, corrying an iron ning, and is lined with fin brick. The block, which is headed to a temperature of 280°C., enter the furnace by six water tuyers, under a presure of 2 lbs. per squan inch, while The Froat, which is closed by The Cup-and-Cove orrangement, admits of the waste gasses bring Collected by means of openings. The materials to be charged on placed on a platform men the top, and usually consist of about 86.5 90 g wasted Schish from operation I., 6.5% of Fleur Spar and 7 90 of plag from operation IV. The fuel is introduced in alternale loyers with the on and yber, and a frish charge it added as som as flare makes its appearance at the lop. The slags flow of constantly and the course metal is from time to time topped off on the oppo site side of the furnace; this

six tuyeres. The furnace is supported on eight short castiron pillars, carrying an iron ring, and is lined with firebrick. The blast, which is heated to a temperature of 280°C., enters the furnace by six water tuyeres, under a pressure of 2 lbs. per square inch, while the throat, which is closed by the cup-and-cone arrangement, admits of the waste gasses being collected by means of openings. The materials to be charged are placed on a platform near the top, and usually consist of about 86.5% of roasted Schist from operation I., 6.5% of flour-spar and 7% of slag from operation IV. The fuel is introduced in alternate layers with the ore and flux, and a fresh charge is added as soon as flame makes its appearance at the top. The slags flow off constantly and the coarse metal is from time to time tapped off on the opposite side of the furnace; this

flews through an iron guller, from which it falls into a Cistern of water, where it is grandated. 120 to 135 tows of on are smelted in 24 hours , with a consump tim of soolbs of Coke per Ton, III. Roasting the Cense-metal, This is accomplished in rectangular stalls inclosed on three sides by permanent Stone walls, while the port is closed by a loose one of unce mented Stones, which is taken down whenever The roasted regular is required to be n mourd. Each stall is copable of centaining from 200 to 300 cubic part of cone-metal and Jul. The bottom of the ona is first cound with a leyer of wood, and upon this are pield from 20 to 25 tons of Coarse-melal This operation requires from 10 to 12 days The loss in weight is prove 12 to 15 90.

flows through an iron gutter, from which it falls into a cistern of water, where it is granulated. 120 to 135 tons of ore are smelted in 24 hours, with a consumption of 500 lbs of coke per Ton.

III. Roasting the coarse metal. This is accomplished in rectangular stalls inclosed on three sides by permanent stone walls, while the front is closed by a loose one of uncemented stones, which is taken down whenever the roasted regulus is required to be removed. Each stall is capable of containing from 200 to 300 cubic feet of coarse metal and fuel. The bottom of the ores is first covered with a layer of wood, and upon this are piled from 20 to 25 tons of course metal. This operation requires from 10 to 12 days. The loss in weight is from 12 to 15%.

IV, Melting for Jine-melal. The furnace suployed for This operation very closely remble that used in the re verbralon process for Amelting for course metal. The charge consist of 13 colbs. of a mixtur of once wasted boad twice wasted course-metal, 200 lbs. of Slag from operation II., and 250 lbs. of Siliceous sand. This mixture is charged into The furnace through a hopper in The usual way, and at the expiration of Shows, will have ban ndeaced to a perfectly lequid condition; he rigulus will have fallen to the bottom, and will be cound by a stralum of Siliceous plag. The slag is raked off and withdrown through The door, and a new charge let down into the hearth and smelted as before. Once in 24 hours, or oftener if required, The topping-hole is opened and the fine-melal which has accumulated in the bollow of

Melting for fine metal. The furnace employed for this operation very closely resembles that used in the reverberatory process for smelting for course metal. The charge consists of 1300 lbs. of a mixture of once roasted and twice roasted coarse metal, 200 lbs. of slag from operation II., and 250 lbs. of Siliceous sand. This mixture is charged into the furnace through a hopper in the usual way, and at the expiration of 8 hours, will have been reduced to a perfectly liquid condition; the regulus will have fallen to the bottom, and will be covered by a stratum of Siliceous slag. The slag is raked off and withdrawn through the door, and a new charge let down into the hearth and smelted as before. Once in 24 hours, or oftener if required, the tapping-hole is opened and the fine metal which has accumulated in the bottom of

IV.

The furnace is granulated by bring run into a tonk of toater. This granulated ngulus is subsequently dried, and is sent to the mill, in which it is nduced to a fine powder provously to bring triated for the extraction of suborr.

the furnace is granulated by being run into a tank of water; this granulated regulus is subsequently dried, and is sent to the mill, in which it is reduced to a fine powder previously to being treated for the extraction of silver.

Separation of films from copper. By taking advantage of the seculiarly strong affinity of copper for sulphin; the slight disposition it possesses when compand with other melal, to combine with oxygen, and its high specific gravity, that nost of the existing melallungi-cal processes for abtaining the pun metal have been arrived at. There are a number of plans for extracting silver from it or its compounds, which not on these and other important physical and Chemical peculianties. The extraction of Silver by liquation. This is one of the most ancient methods of extracting silver from copper. It is founded on the fact that when Cepper Containing Silver is alloyed with lead, and heated to a certain degna abour the

Separation of silver from copper.

By taking advantage of the peculiarly strong affinity of copper for sulphur; the slight disposition it possesses when compared with other metals, to combine with oxygen, and its high specific gravity, that most of the existing metallurgical processes for obtaining the pure metal have been arrived at. There are a number of plans for extracting silver from it or its compounds, which rest on these and other important physical and chemical peculiarities.

The extraction of silver by liquation.

This is one of the most ancient methods of extracting silver from copper. It is founded on the fact that when copper containing silver is alloyed with lead, and heated to a certain degree above the

melting point of lead, but below that of Copper, the lead will become pluid and drain or sweat out of the alloy, carnjing If most g the silver and leaving an impun copper. This method is out of use. Extraction of Silver by the analgamation of coarse copper. This process is based upon the circumstance that the silver which exists in Coarse Copper in a melallie state, when raised to a red heat, in connection with comen salt, is chang. ed to a chloride; and when queksilver is brought into intemate centack with this roasted mass, This chloride is decomposed, and an amalgan with filver and a small quantity of Copper and iron is produced. The amalgan thus Jomeel, when mond to cash iron storts and heated, is decomposed, the quicksilver destills gf, and the silver is refined.

melting point of lead, but below that of copper, the lead will become fluid and drain or sweat out of the alloy, carrying off most of the silver and leaving an impure copper. This method is out of use.

Extraction of silver by the amalgamation of coarse copper.

This process is based upon the circumstances that the silver which exists in coarse copper in a metallic state, when raised to a red heat, in connection with comon salt, is changed to a chloride; and when quicksilver is brought into intimate contact with this roasted mass, this chloride is decomposed, and an amalgam with silver and a small quantity of copper and iron is produced. The amalgam thus formed, when removed to cast iron retorts and heated, is decomposed, the quicksilver distills off, and the silver is refined.

Extraction of silver by the amalgamation of copper matte. This process which is very similar to that adapted in The usual amalgamation of silver one consist in roasting the mixtur of sulphides of Cepper, Silver, iron, etc., that form the matter, as it falls from the furnace, with a proper quantity of comm salt and lime, The first furnish es chlorine, by means of which The varous metals an turned into chlorides, while the live decomposes The chloreles of nor and copper, but leaves the silver to be dollated by The quick selver in the subsequent tratment. This system was once in use at mansfield, Prussia, but was replaced by Zeervogel's method.

Extraction of silver by the amalgamation of copper matte.

This process which is very similar to that adopted in the usual amalgamation of silver ores, consist in roasting the mixture of sulphides of copper, silver, iron, etc., that form the matte, as it falls from the furnace, with a proper quantity of common salt and lime. The first furnishes chlorine, by means of which the varous metals are turned into chlorides, while the lime decomposes the chlorides of iron and copper, but leaves the silver to be collected by the quicksilver in the subsequent treatment. This system was once in use at Mansfield, Prussia, but was replaced by Ziervogel's method.

Augustins method of extrac-ting silver from copper by means of a Solution of Sall! The circumstance long Known to chemists, that the chloriele of Silver is Somewhat Soluble in a cencentraled solution of Cenon Dalt, was taken advantage of by dugistin, in an ingenious plan you the separation of copper and selvir. Copper matter, yielding prom 50 to 70 g Copper, but Juce prom metallic granules, and Containing no lead, zine, antimony, or arsenie, apport the bish results when treated by augustin's process, The malle is powdered viry finaly, and roasted in a double hearth nurberatory Jurnose. The roasted poweler is ground and subjected to a second roasting, and near the end of the process, about 590 of salt is added, which change the silver into a chloride. This powder is now brought into lixiviating

Augustin's method of extracting silver from copper by means of a solution of salt. The circumstance long known to chemists, that the chloride of silver is somewhat soluble in a concentrated solution of common salt, was taken advantage of by Augustin, in an ingenious plan for the separation of copper and silver. Copper mattes, yielding from 50 to 70 of copper, but free from metallic granules, and containing no lead, zinc, antimony, or arsenic, afford the best results when treated by Augustin's process. The matte is powdered very finely, and roasted in a double-hearth reverberatory furnace. The roasted powder is ground and subjected to a second roasting, and near the end of the process, about 5% of salt is added, which changes the silver into a chloride. This powder is now brought into lixiviating

tubs and trated with hoh brine, which filtering through, comes with it the chloride of Silver, Jassing into precipita. tion tubs, it is brought in Contach with Copper, which Throws down the silver in the form of cement silver, This is collected, dried, and refined. The copper dissolud in the procepitation of the sil-ver is carried forward to other vissels and thrown down as cement copper with metallic iron. The lixiviated pouder is smelled in a nurberaleng furnace for coarse copper, which is named in the german peort

tubs and treated with hot brine, which filtering through, carries with it the chloride of silver. Passing into precipitation tubs, it is brought in contact with copper, which throws down the silver in the form of cement silver. This is collected, dried, and refined. The copper dissolved in the precipitation of the silver is carried forward to other vessels and thrown down as cement copper with metallic iron. The lixiviated powder is smelted in a reverberatory furnace for coarse copper, which is refined in the German hearth.

Lervogel's method of exhacting silver from Copper by mean of warm water, This method is founded on The circumstance, that when a mixtun of Cepper and in Sulphides, centaining silver is roasted in a state of fine division, in a nurberatory furnoce with certain perclution, ferrous Sulphate is first formed this by Justier voasting, becomes Jerric Sulphate, which is prally decomposed into farrie oxide, At This period sulphide of Cepper is trans formed into cupric sulph ate, and on the temperature bring further increased, cupie oxide is produced and sulphuric acid expelled, Anally, Silver Rulph ide is courted into sulphate of plur, a salt nadily dissolud in water, while nearly all The other inquidents of the wasted malle an insoluble in That menstrum. If the wasted matenal to now lixionaled with hob water, the silver will be

Ziervogel's method of extracting of warm water.

silver from copper by means This method is founded on the circumstance, that when a mixture of copper and iron sulphides, containing silver is roasted in a state of fine division, in a reverberatory furnace with certain percautions, ferrous sulphate is first formed, this by further roasting, becomes ferric sulphate, which is finally decomposed into ferric oxide. At this period sulphide of copper is transformed into cupric sulphate, and on the temperature being further increased, cupric oxide is produced and sulphuric acid expelled. Finally, silver sulphide is converted into sulphate of silver; a salt readily dissolved in water, while nearly all the other ingredients of the roasted matte are insoluble in that menstrum. If the roasted material be now lixiviated with hot water, the silver will be

obtained in a solution, from which it may to modely pro-cepitated as cement silver by metallie copper,

obtained in a solution, from which it may be readily precipitated as cement silver by metallic copper.

Production of Copper from The copper midues after The selior has bren extracted. As the Zierrogel Frocess is The one generally in use for the extraction of silver from Copper matte; the tratment of the Ziewogel tub noidues will be the only method considered under Thils head. The residues retained in The tubes in which the lixiviation for sulphate of selum has been Conducted Contain from 700 75 90 of Copper, chiefly as oxide, This is now converted into block Copper, by Jusing in a bloch Jumael. At Mans field the Copperoriele is mived with 8% of Clay, worked into balls and dhied; these balls have an addition made to them of about 10 90 of Siliceous sand, 590 of Syrites, and from 10 to 1590 of slog from the paule operation, or from the

Production of copper from the copper residues after the silver has been extracted.

As the Ziervogel process is the one generally in use for the extraction of silver from copper matte; the treatment of the Ziervogel tub residues will be the only method considered under this head.

The residues retained in the tubs in which the lixiviation for sulphate of silver has been conducted contain from 70 to 75% of copper, chiefly as oxide. This is now converted into black copper by fusing in a blast furnace.

At Mansfield the copper oxide is mixed with 8% of clay, worked into balls and dried; these balls have an addition made to them of about 10% of siliceous sand, 5% of pyrites, and from 10 to 15% of slag from the same operation, or from the

Process of refining. The mixtun is charged into. The jurnace alternately with layers of take. The nducing action of the Jurnace this counts The Jurnace this of the oxide into metallic copper while the sulphur in The Jyrite serves The surpose of cleansin The Alag. The black copper, which in ounts to 66% of the fall prove the furnace, contains 98.5% of Copper, and is mpined in the norsberatory furnace by polling. Rolla, Mr. Arspectfully Submitted, June 87/ 1885. June 1885.

process of refining.

The mixture is charged into the furnace alternately with layers of coke. The reducing action of the furnace thus converts the principal portion of the oxide into metallic copper while the Sulphur in the pyrites serves the purpose of cleansing the slag.

The black copper, which amounts to 66% of the fold from the furnace, contains 98.5% of copper, and is refined in the reverberatory furnace by polling.

Rolla, Mo. June 8th 1885. Respectfully Submitted, J. R. D. Owen