

C_6H_4 .	Ratio $13\frac{1}{2} : 1$.	
$2(C_6H_4)O_2$ oil of cinnamon $C_{12}H_8O_2$.		
C_7H_8 .	Ratio $14 : 1$.	
$2(C_7H_8)+2HO$ creosote; uncertain $C_{14}H_{10}O_2$.		
$C_{12}H_6$ Phenyl.		
$(C_{12}H_6)NO_4$ artificial oil of almonds, or nitro benzole.		
C_6H_2 .	Ratio $15 : 1$.	
$4(C_6H_2)$ naphthalene.		
$C_{14}H_6$.	Ratio near $17 : 1$.	
$(C_{14}H_6)O_2$ benzyl.		
$(C_{14}H_6)O_3+HO$ benzoic acid (see also below).		
$(C_{14}H_6)O_4$ salicyl.		
$(C_{14}H_6)O_5+HO$ salicylic acid (see also below).		
C_3H .	Phenylen. Ratio $18 : 1$.	
$2(C_3H)+6HO$ glycerine..... $C_6H_5O_5$		
$4(C_3H)+2HO$ carbollic acid..... $12\ 6\ 2$		
or phenylic alcohol, phenol.		
$4(C_3H)+NH_3$ liquid anilin..... $12\ 7\ N$		
or ammoniated phenylen.		
C_7H_2 .	Ratio $21 : 1$.	
$2(C_7H_2)O_2+2HO$ benzoic acid (which see also above).		
$2(C_7H_2)O_4+2HO$ salicylic acid " "		
C_4H .	Ratio $24 : 1$.	
$(C_4H)O_2+2HO$ succinic acid (which see also above).		
$3(C_4H)O_3+3HO$ pyrogalllic acid " "		
$(C_4H)Cl_2O_2+2HO$ chloral hydrate.		
C_7H .	Ratio $42 : 1$.	
$(C_7H)O_3+2HO$ gallic acid (dried at 212°)..... $C_7H_5O_5$		
$2(C_7H)O_6+4HO$ gallic acid cryst..... $14\ 6\ 10$		
$4(C_7H)O_{12}+6HO$ tannic acid, tannin..... $28\ 10\ 18$		
Hydrated carbon series. Ratio of carbon : water.		
$C_{12}10HO$ wood, cotton, cellulose, starch, dextrine... $8 : 10$		
$C_{12}11HO$ cane sugar, pure gum arab., arabine... $8 : 11$		
$C_{12}12HO$ sugar of milk (see also lactic acid)... $8 : 12$		
$C_{12}14HO$ grape sugar, glucose..... $8 : 14$		

[SCHOOL OF MINES QUARTERLY.]

GOLD CHLORINATION IN CALIFORNIA.

By F. D. BROWNING, E. M.

GRASS VALLEY, California, has become famous as a gold quartz mining district. The country is composed of alternate belts of slate and granite. It is intersected in every direction by quartz veins, some of which cut across both the belts of slate and of granite, while others follow for some distance the dividing plane between the two formations and then strike off through either of them. A part of the gold found in these veins is free, and a part is contained in sulphurets. This is true of all the mines in the district, but the percentage of free gold and the character of the sulphurets vary greatly in different veins. The Idaho Mine, situated in the city of Grass Valley, is a good example of those carrying a large percentage of the gold in a free state; while the Providence Mine in Nevada City, four miles distant, exhibits the other extreme of heavily sulphureted ores. All the ores are worked by the same process, which is briefly as

The Providence mill and chlorination works illustrate the best practice in the district and, so far as I know, in the country. It is proposed, therefore, in the following article, to give a full description of them.*

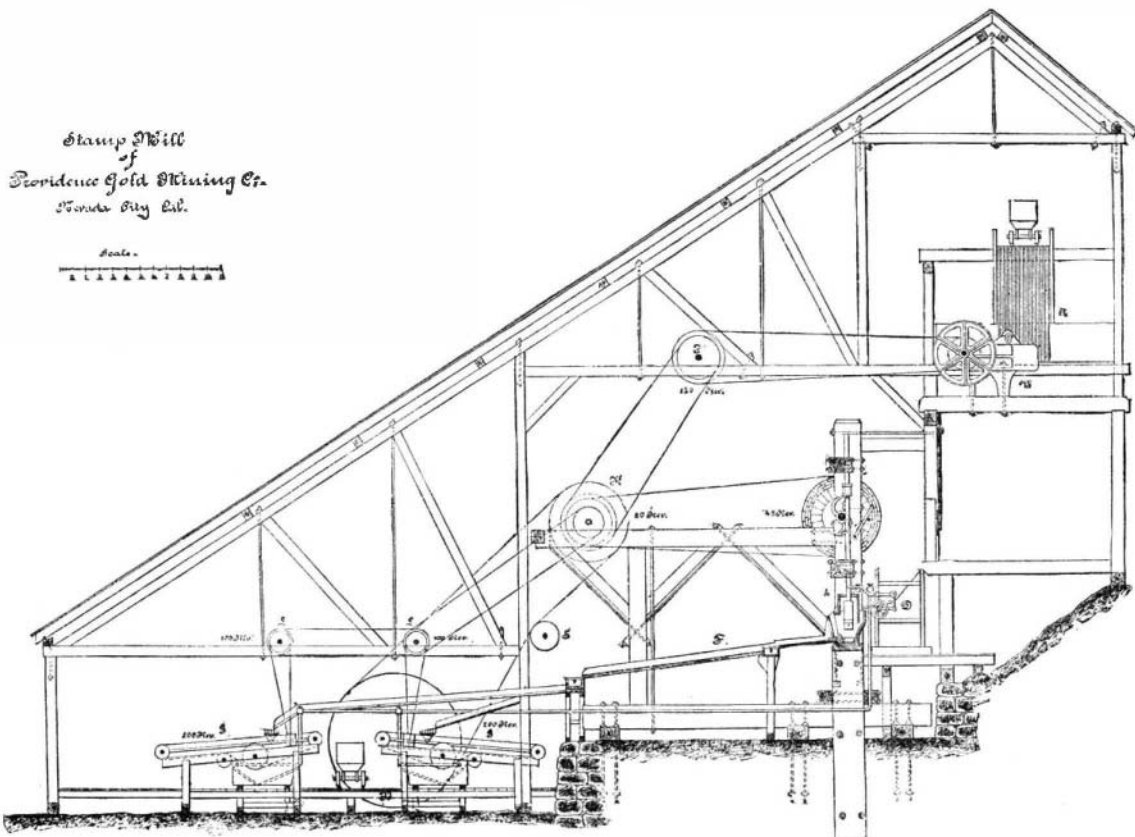
THE ORE AND ITS TREATMENT.

The Character of Ore.—The Providence gold ore is a heavily sulphureted quartz, which is hard and generally solid, though

reduced in the batteries till it passes through a No. 5 punched screen; then it runs as a slime over silver-plated copper plates to Frue concentrators.

The stamps are run with a 7 inch drop, and at a speed of 96 drops per minute. The screens are equivalent in fineness to a 30 to 40 mesh sieve, according to the length of time that they may have been in use. The stamping, therefore, is coarse, and especially so because of a low discharge and a

Stamp Mill
of
Providence Gold Mining Co.
Nevada City Cal.
Scale.

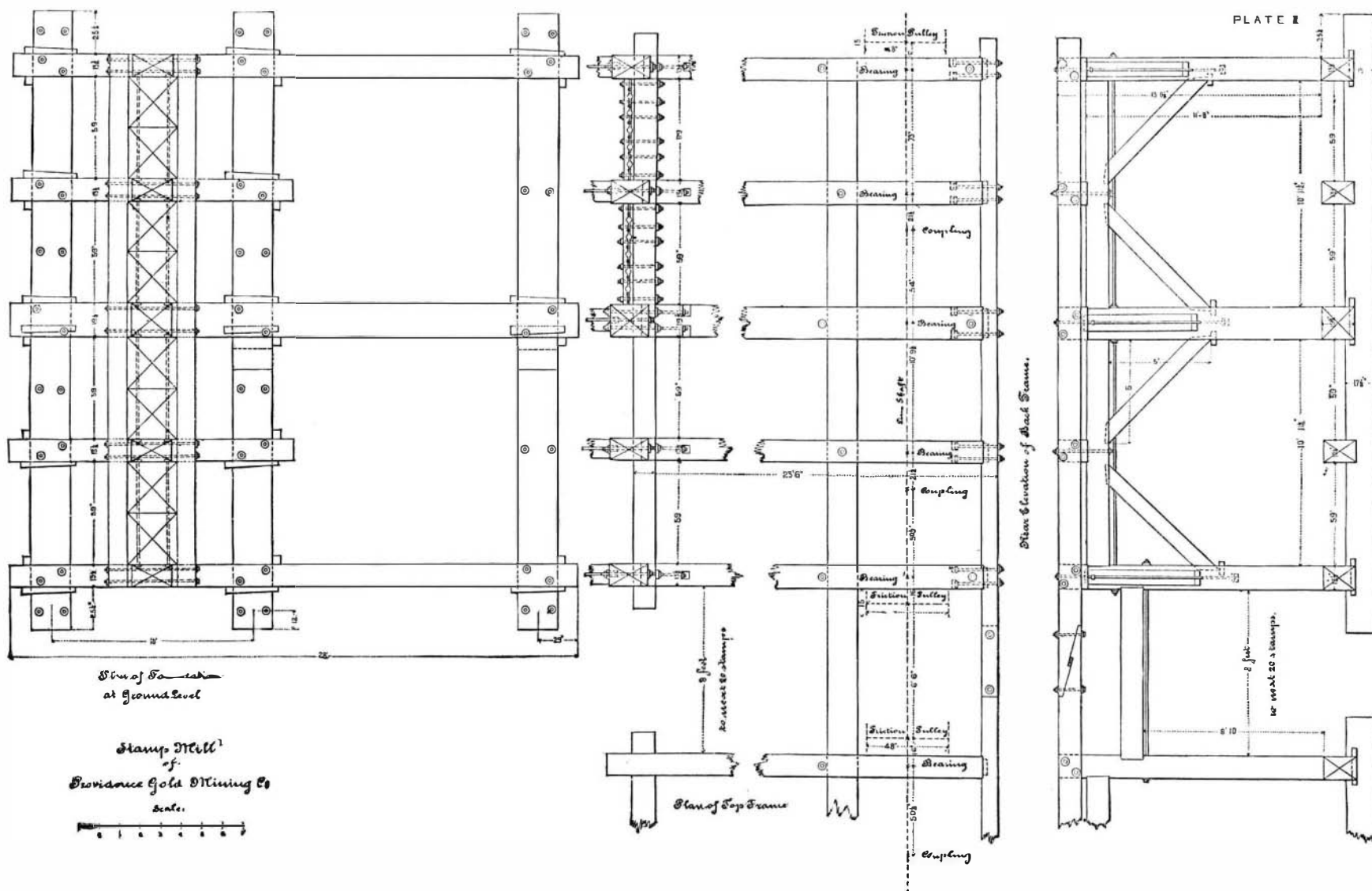


sometimes intersected by seams of chlorite. About seven per cent. of the total weight of ore are sulphurets, consisting mainly of pyrites with smaller quantities of galena, chalcopryite, arsenopyrite, and a very little zinc blende. The proportion of free gold to the total amount in the ore was not ascertained.

Milling.—Waste rock is separated from the ore in the mine, and is either filled into old stopes or sent to the surface during the night. All the ore is hoisted without sorting, and is sent over a tramway directly into a rock-house in the top of the mill. There it is dumped upon grizzlies through which the fine dirt falls into an ore bin, while the coarse rock passes over them and is delivered to rock breakers. In the coarse

high speed; but the free gold is effectually released and is caught in the battery and on the plates, while that contained in the sulphurets is recovered from the concentrates.

The amalgamating plates are inclined $1\frac{1}{4}$ inches in 1 foot. This rather steep pitch is employed in order to keep the plates clean and yet avoid the use of much water, which would flood the concentrators. Water is used in the batteries in quantities only barely sufficient to keep the plates clean at this inclination; if there is an occasional banking up of sulphurets on the plates, the latter are readily cleansed with a hose. On the washing field of each Frue vanner just enough clear water is used to prevent the gangue from being carried with the concentrate over the head of the machine.



follows: The ore is stamped wet; the free gold is amalgamated in the stamp battery and on plates set below it; the tailings flowing off the plates are concentrated; and the concentrates are treated by chlorination. The system of stamping is quite uniform throughout the district. The methods employed for concentrating the tailings, however, are various, including the use of different forms of buddles, settling tanks, blanket sluices, etc., but unquestionably the best system is that in which Frue vanners are employed.

ore there are some pieces of nearly pure sulphurets, which are thrown to one side and treated separately; the balance of the coarse stuff is fed into the rock breakers, and falls from these directly into the same bin that holds the fine dirt. From this bin all the ore passes down chutes to automatic feeders, which deliver it to the stamp batteries. The ore is

*I take this occasion to express my thanks to the Messrs. Walrath and to Mr. Hunter, owners and managers of this property, for the privilege of studying their operations and for the data furnished by them.

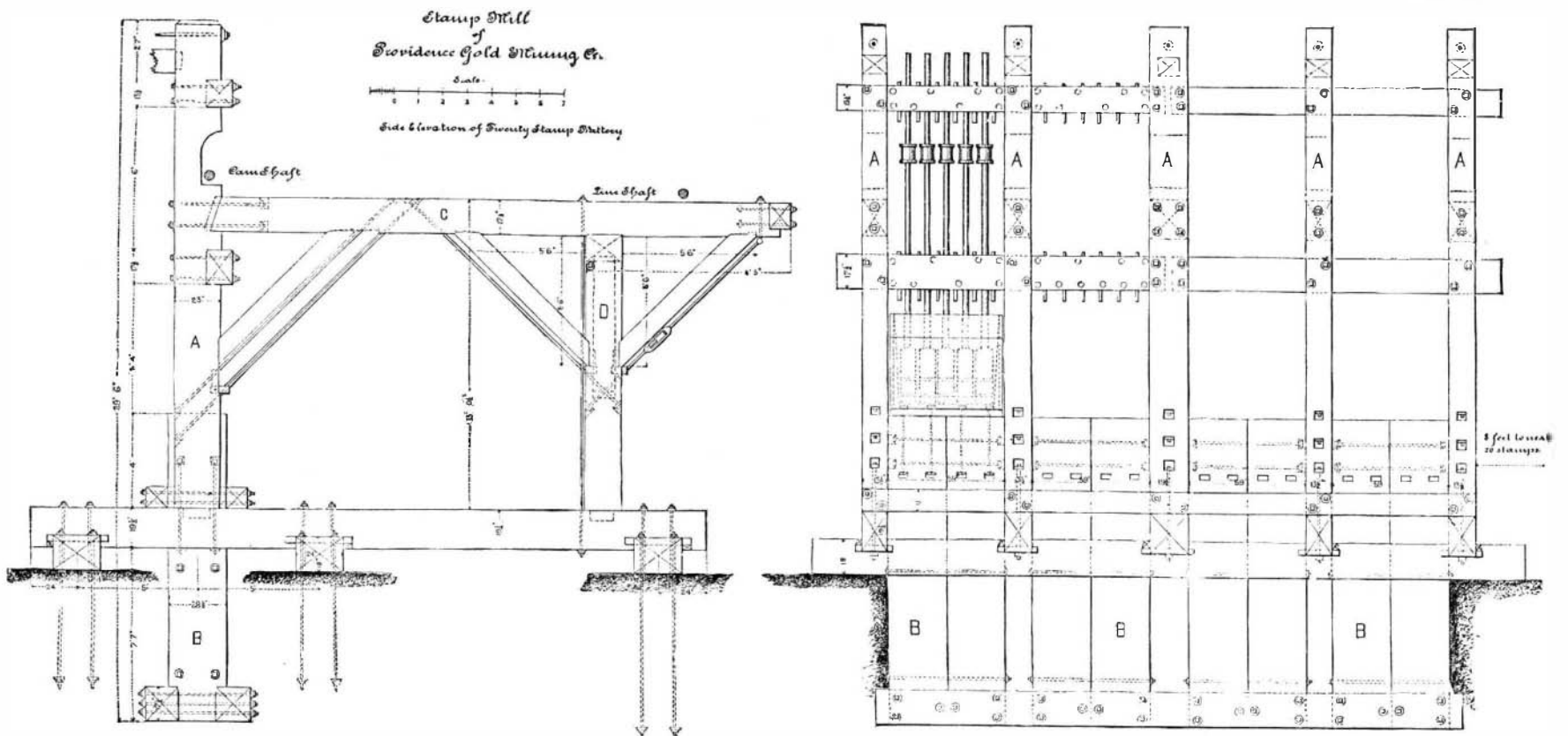
Great care is taken to have the concentrators perfectly level, and their lateral motion properly adjusted, to prevent the sand from banking on either side of the traveling belt.

The tailings from the concentrators, being practically barren,* are run into the river; the concentrates, which prove remarkably clean,† are spread on the floor of an adjoining room to dry.

* Stated to contain but one-twentieth of one per cent. of sulphurets.
† Containing as a maximum 10 per cent. of sand.

Side Elevation of Twenty Stamp Battery

PLATE I



Details of Stamp Mill of
Providence Gold Mining Co.

Nevada City, Nevada Co., California

SCALE: 1" = 1' FEET

When the coarse pieces of sulphurets, picked from the ore in the rock-house, have accumulated in sufficient quantity, they are put through a battery separately, and from the battery plates the rich sulphuret pulp is run directly into settling tanks, from which it is afterward shoveled, and mixed with the concentrates on the floor of the drying room.

The dried sulphurets* are taken to the Chlorination Works, where they are roasted, chlorinated, and leached.

Roasting.—The roasting is performed in a three story furnace of elliptical plan, the third floor being the top of the furnace and not covered.

The sulphurets (henceforth called *ore* for convenience) are dumped on a brick floor level with the top of the furnace. After all the lumps are broken by working the ore over with a shovel, a charge is spread over the top of the furnace, four or five tons of ore being kept continually drying and heating, but no stirring is required. Thence the thoroughly dried and heated ore passes to the middle or second hearth, in which likewise five tons are kept. Here the ore is thoroughly stirred over at intervals of ten or fifteen minutes, and a great part of the sulphur is burned off, the temperature being sufficient to keep the charge at a medium red

heat; any sulphur remaining in it can be detected by the smell when hot.

By this process of roasting the following effects are produced in the charge: Any arsenic or antimony present is oxidized and volatilized; the sulphides of iron, copper, zinc, and silver pass through stages of oxidation; and by the addition of salt most of the silver is converted into a chloride, and some chloride of copper is formed, while the balance of the base metals is completely oxidized. The gold is left in a free metallic state.

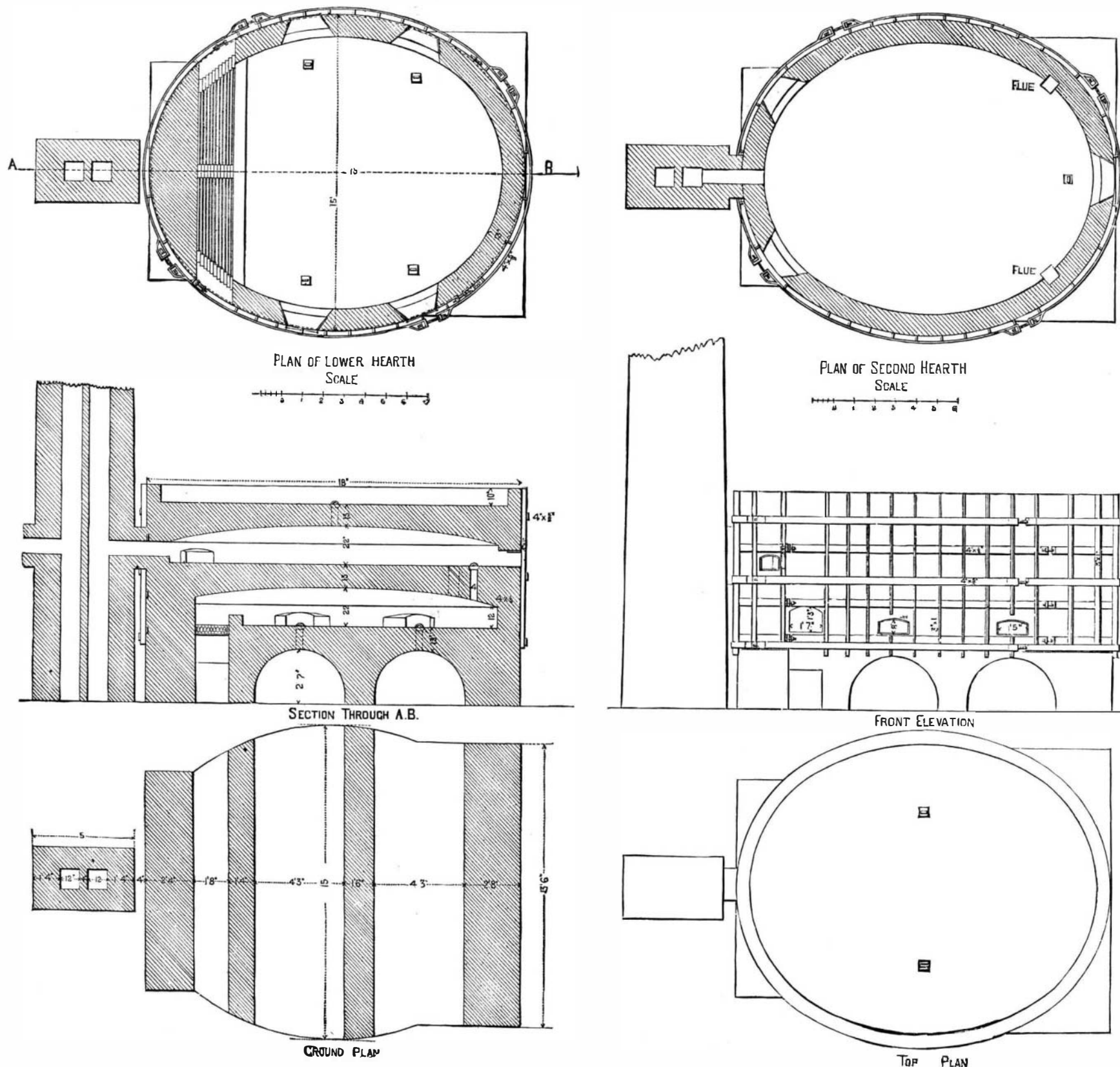
By conducting the process just as above described, except that the ore was discharged in one or two hours after adding the salt instead of in four to six hours, it was found that more silver was saved, but less of the gold. The reason for this is not far to seek. The more complete the roasting the more gold can be chlorinated, while some silver is carried off in form of a chloride by chloride of copper formed during the last stage of roasting, and is lost. The metallic gold is not thus carried off, and hence it is not lost by long continued roasting at a high temperature.*

The roasted ore is left in a pile under the furnace until partly cooled; then it is spread out on a brick floor in front

of manganese, 22 pounds of common salt, and 16 quarts of commercial sulphuric acid of 66° B. density. The ore is left in the tubs to digest and chlorinate for two, or preferably for three days. Chlorination should then be complete, which is tested by withdrawing a cork from the cover of the tub and holding an open bottle of ammonium hydrate over the hole; white fumes of ammonium chloride are seen if the chlorine has permeated the ore to the surface.

Leaching and Precipitating the Gold.—The gold having been converted into the tetrachloride by the action of the chlorine gas, is soluble in water and can be leached out of the mass. For this purpose a rubber hose is attached to a discharge faucet, the cover is raised, the ore flooded with water, and the solution of chloride of gold drawn into precipitating tanks. The ore is kept well covered with the leaching water, which continues to be supplied until the solution running into the precipitating tanks shows no trace of gold when tested with sulphate of iron.

The gold is precipitated in a fine metallic state by a dilute solution of sulphate of iron. An excess of the precipitant is added, and the solution well stirred and allowed to stand 24 hours for the gold to settle. The clear fluid is then drawn



ROASTING FURNACE OF PROVIDENCE CHLORINATION MILL.

heat. The ore is next drawn to the lowest hearth—two tons being moved every twelve hours, or, if it be necessary to force the work, one and a half tons every eight hours. As often as this charge is drawn to the lower hearth an equal quantity is drawn down on to the second hearth, and the same amount is added on top of the furnace, the ore being so manipulated that the portion which has been longest on each hearth is drawn to the one next below. After the charge has been in the last hearth four hours the fire is allowed to go down a little, and one per cent. of salt is spread evenly over the ore. The fire is then raised to the regular temperature, keeping the ore at a bright red heat, and this is maintained until the roasting is complete—or for four hours when treating a charge of a ton and a half, and six hours for one of two tons. On the lowest hearth the ore is well stirred every ten or fifteen minutes till within half an hour of the time for drawing, when it is raked into a pile and so left until discharged.

One man tends the whole furnace, dividing most of his time between the middle and the lowest hearths, where all the stirring is done. It is very essential that the ore be per-

fectly roasted; any sulphur remaining in it can be detected by the smell when hot. Just enough water is used to prevent any dust from rising when the ore is shoveled over; its consistency is such that it barely adheres when squeezed in the hand. The finer the ore the less water is required.

The ore is next passed through a six mesh sieve; all lumps hereby separated from the mass are ground in a small V mill and re-roasted.

Chlorinating.—The sieved ore is shoveled into boxes holding about 50 pounds each, and these are emptied into chlorination tubs. If shoveled directly into the tubs the ore would pack, and subsequently prevent chlorine gas from permeating it freely. The tubs are filled to within two inches of the cover, and it is then put on: a groove left around its edge is calked with rags, and the joints are wetted and luted with plenty of tough dough, which is kept moist by a covering of wet cloths. Chlorine gas is then passed for 12 hours into the tubs, being admitted into each through a false bottom. Every tub holds $2\frac{1}{2}$ tons of ore, and as much chlorine is used for it as can be produced from 8 pounds of black oxide

off, and is either run to waste or collected in a tank, where, if worth the operation, the copper it contains is precipitated on scrap iron. When sufficient gold has collected in the precipitating tanks to warrant a clean-up, it is dipped out into a cloth strainer; the water is drained off and the metal dried in a pan over a low fire; then it is melted in a graphite crucible in a small furnace, and run into bars.

Extraction of the Silver.—The silver, mainly converted in a chloride in the roasting furnace, and for the greater part preserved intact during the process of chlorinating and leaching the gold, now remains to be extracted from the ore pulp. The extraction is based on the reaction of calcium hyposulphite and silver chloride, which results in the formation of a soluble double hyposulphite of calcium and silver; the precious metal can be precipitated from this solution as a sulphide by soluble polysulphide of iron, and the simple calcium hyposulphide left in solution is used over and over again for leaching.*

* For a more detailed account of the reactions taking place in roasting, the reader is referred to *The Leaching of Ores of Gold and Silver*, Aaron, 1894.

* The reader is again referred to Aaron's work on leaching for a more detailed account of the reactions in lixiviation, but it must be admitted that many important questions as to solubilities and other points connected with leaching are not as yet answered in technical literature, and that much analytical investigation remains to be made.

* The value of these is said to be \$120 in gold and \$12 in silver per ton.

The ore, deprived of its gold, is left to drain for 24 hours in the chlorination tubs; then it is shoveled into another set of similar tubs, and pure water is run through the mass until the soluble salts of the base metals are well washed out, which is the case when the water coming from the ore gives but a slight precipitate on being tested with a solution of the polysulphide of lime. The ore is then allowed further time to drain thoroughly, and thereupon is leached with the solution of hyposulphite of calcium (or calcic thio-sulphate, CaS_2O_3).

If an excess is found, more of the silver solution must be run into the precipitating tank.

The heavy sulphide of silver settles in an hour or two, leaving a clear solution of calcium hyposulphite, which is drawn off into a well, and pumped from there up into a distributing tank for subsequent leaching. The sulphide of silver is cleaned out of the precipitated tanks as often as necessary, and is put into a cloth strainer from which the solution drains off. The sulphide, after drying, is burned in a small reverberatory furnace; the silver is then melted in

generator. The acid is placed in a convenient lead vessel above the generator, and by means of a faucet is allowed to pass drop by drop through the trapped lead pipe into the same. In this way the gas is slowly evolved, at about the rate that it can be absorbed by the ore in the tubs. From the generator the gas passes by one of the lead pipes through a pan of water into a glass bell-jar inverted in the water bath, and thence by a rubber hose, attached to a nipple on top of the bell-jar, to the chlorinating tubs. Two of these generators furnish in 12 hours enough gas for one tub, or for $2\frac{1}{2}$ tons of ore.

Sulphate of Iron.—This precipitant is made by dissolving iron scrap in very dilute sulphuric acid—30 gallons of water to 1 of sulphuric acid. An excess of iron is used.

Calcium Hyposulphite.—This solvent is not prepared directly; the solution for leaching chloride of silver is first made of sodium hyposulphite by dissolving the crystallized salt in water, making a solution of 8° B. density. By the leaching operation a soluble hyposulphite of silver and sodium is formed. When calcium polysulphide is added to this to precipitate the silver, calcium replaces silver in the solution. The double salt of calcium and sodium so formed is used as a solvent in the next leaching operation, and in the subsequent precipitation more calcium enters the solution. Thus the proportion of calcium to sodium increases until the solvent becomes practically the hyposulphite of calcium, which is equally effective in forming a soluble double salt with silver chloride.

The use of iron pipes or of an iron pump for this solution should be avoided, as iron is readily attacked by it. Brass should be used instead.

Calcium Polysulphide.—This is made by boiling powdered sulphur and quicklime in water. Into a 100-gallon tub are run 56 gallons of water; when boiling, 35 pounds of lime are added, and then 15 pounds of sulphur; the boiling is maintained for 5 hours with live steam, and the bath is kept well stirred.

THE MILL.

General Design.—The stamp mill is shown in sectional elevation on Plate I. Special attention is called to the framework of the building, and to the uses which it serves in supporting machinery and shafting. The ore bin, C, furnishes a foundation for the rock breakers, B, and grizzlies, A, as well as for the entire upper part of the building. The counter shaft, T, and the concentrator shafts, L, L, are supported on the roof trusses, while the main line shaft, K, rests on the battery frames.

Sizing Grates.—The mill is furnished with two sizing grates, or grizzlies, corresponding to two rock breakers. Each grizzly is 4 feet wide and 12 feet long, made of iron bars 4 inches deep and 1 inch wide, set $2\frac{1}{2}$ inches apart and held in place by five 1 inch rods passing through them horizontally, with ferrules on the rods between the bars. The rise of the grizzly is 6 feet 3 inches, which is not very great. The upper end is covered for a length of 4 feet with an iron plate upon which the ore is dumped.

Rock Breakers.—The two rock breakers are of the latest Blake patent, with 10 inch jaws. Each breaker can crush 50 tons of ore in twelve hours.

Ore Bin.—The ore bin is a plain rectangular chamber extending the whole length of the mill behind the batteries. It is 13 feet wide and 11 feet high, and is inclosed by a heavy frame lined with 2 inch planks. The typical inclined back is left out, and the ore is allowed to form its own slope on which it will run; thus the space which generally contains nothing but expensive framework and lumber in most mills is here occupied by a reserve pile of ore.

Automatic Feeders.—Each stamp battery is served by a Hendy automatic feeder, indicated at D. This apparatus is made by Joshua Hendy of San Francisco, and costs \$250.

Stamp Batteries.—The batteries have heavy square frames, which are the best form for this kind of mill. Being very rigid, they serve excellently for supporting the line shaft; they also form a most convenient platform upon which to roll the cam shafts when it becomes necessary to remove them; and, more important still, they leave the space about the mortars unobstructed. Complete working drawings of the battery frames are given on Plates II. and III.

The battery screens are No. 5, of the heaviest Russia iron that can be punched. They last about four weeks by reversing.

The mortars weigh 6,000 pounds each.

The weight of a stamp complete is...	750 pounds.
The weight of a shoe is...	125 "
The weight of a die is...	95 "
Shoes of chilled cast iron last...	30 to 35 days.
Dies of chilled cast iron last...	45 to 65 "
Steel shoes last...	90 "

As the steel shoes cost 11 cents per pound, and shoes of cast iron $4\frac{1}{2}$ cents, there is not much choice between the two kinds.

The battery blocks shown in the drawings are 10 feet long and set upon rock bottom. Dry blankets are spread on top of these blocks to form a cushion for the mortar.

Amalgamators.—The aprons in front of the batteries are the full width of the mortars and 4 feet long. They are covered with silvered copper plates, and incline $13\frac{1}{4}$ inches in 1 foot. Beyond each apron there are two sluices, shown at F; each is 16 inches wide and 14 feet long, covered in the same way as the aprons and having the same inclination. From these sluices the ore slime, or pulp, is carried through launders to the concentrators, G, G.

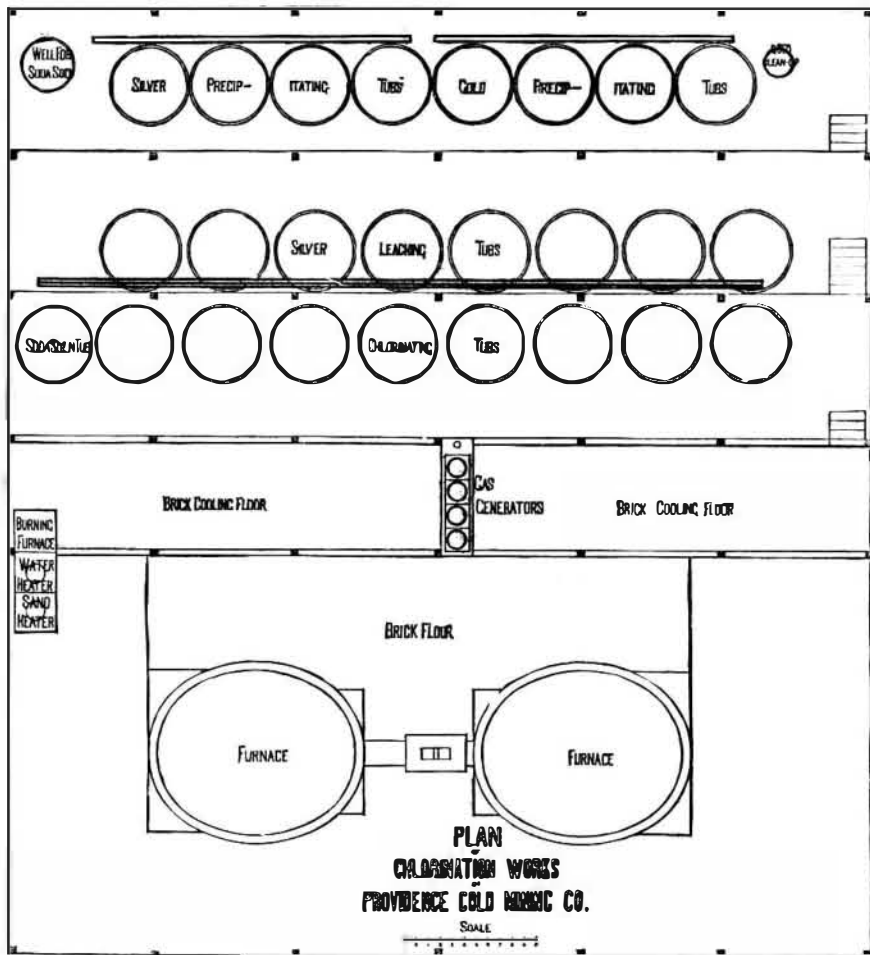
At the lower ends, or tails, both of the aprons and sluices, there are cross troughs, fitted, as shown, with longitudinal dividing boards, which extend to within two inches of the bottom. As the pulp runs into these troughs it has to pass under the dividing board, and in so doing drops the particles of mercury and amalgam which it carries in suspension.

Concentrators.—There are two concentrators for each battery of five stamps, or 16 in all for the 40 stamp mill. These machines are the latest form of Frue vanner, and cost \$750 each in San Francisco.

Motive Power and Water.—The whole mill is run by a six foot burly gurdy wheel, the invention of Pelton, of Nevada City. The wheel is driven with 104 inches of water* under a pressure due to a 390 foot head. The water costs 16 cents per inch, so that the motive power to run the mill for 24 hours costs \$16.64. It would require 12 cords of wood to furnish the same amount of power. In the batteries, on the concentrators, and in the chlorination works 5 inches of water are used and 1 inch is wasted, making altogether 110 inches which the company buys.

Shafting.—The main line shaft is driven by belting, with two pulleys interposed, from the water wheel. This shaft is supported on the square battery frames, as represented on

* A inch of water flowing 24 hours amounts to 17,000 gallons.



For this operation the leaching tubs should be kept full of the solution, and the outflow regulated to suit the capacity of the precipitating tanks, the solution pump, etc. The leaching is continued till the solution from the tubs gives but a trace of precipitated sulphide of silver, when a little calcium polysulphide is added to it in a test glass. This condition is reached in a few hours in treating this particular ore, but two or three days are required to leach some silver ores.

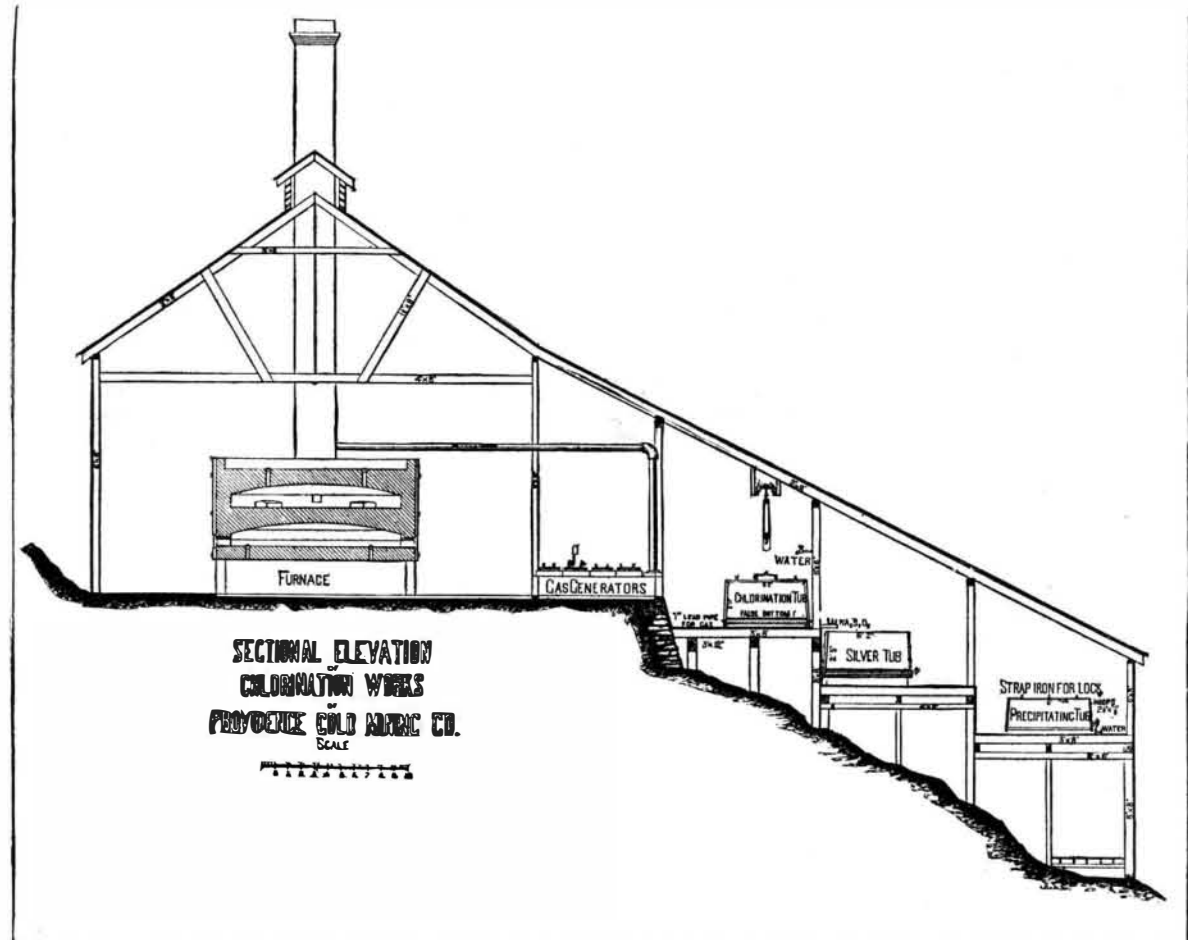
The silver solution having been run into tanks, is precipitated with a solution of calcium polysulphide. Great care is exercised in avoiding the use of an excess of the pre-

graphite crucibles, with scrap iron for a flux, and is finally run into bars.

The residue or tailings in the silver leaching tubs, after having been deprived of all mineral of economic value, are discarded. It is claimed that by this process 94 per cent. of the gold and 60 per cent. of the silver are saved.

PREPARATION OF REAGENTS.

Chlorine Gas.—This gas is generated in lead vats, 22 inches in diameter and 8 inches deep, set in brick work over a flue which is warmed to about 90° F. The vats are provided with lead covers having two openings, each 1 inch in



cipitant, for this would subsequently be carried back into the silver leaching tubs together with the solution of calcium hyposulphite, and would there precipitate silver as a sulphide, which would inevitably be lost. It is always safer to leave a little silver in the hyposulphite solution, for there it is not lost, while furnishing sure evidence that no excess of the precipitant has been used. To detect such excess, take in a test glass some of the clear solution, from which the sulphide of silver has settled, and add to it a little dilute acetate of lead. This reagent will produce a precipitate of sulphide of lead if a trace of calcium polysulphide is present.

diameter, into which lead pipes are luted with flour dough. One of these pipes serves for conducting off the gas; the other for introducing sulphuric acid. The second pipe is so bent as to form a trap just above the cover to prevent the escape of gas.

Into each generator are charged 9 pounds of black oxide of manganese and 11 pounds of common salt; then the cover is luted on with flour dough, and the sulphuric acid is run in. Commercial sulphuric acid of 66° B. density is diluted with water in the proportion of 16 measures of acid to three of water, and $9\frac{1}{2}$ quarts of this solution are used for each

"Plan of Top Frame," Plate III, and drives the whole mill, including 2 rock breakers, 40 stamps, and 16 concentrators. It is composed of five sections, as shown in Plate IV. in detail. Attention is directed to the form of coupling used, with a projecting collar on the one half fitting into a recess in the other. This device serves to keep the shaft in line if the bolts should not fit the holes in the coupling perfectly; but the same result can be secured by allowing one section of shaft to protrude half an inch, while the other is half an inch short in its part of the coupling, and this form is preferred by some.

Each coupling must be keyed solidly to its shaft, which is then put into a lathe and the coupling faced off perfectly true.

Each section of ten stamps is driven from a friction pulley on the line shaft. These are iron pulleys with a friction clutch, which serves to throw off any section of stamps at pleasure without stopping the balance of the mill.

The main driving pulley and the cam shaft pulleys are of wood. For pulleys of such large size they are cheaper than if made of iron, and they serve as well. The wooden pulleys are all turned up on the shaft in position.

There are four cam shafts, each driving ten stamps. They are 5 inches in diameter, and each is driven by a 14 inch rubber belt.

The rock breaker shaft, T, is 2½ inches in diameter, and is driven from the main line shaft by a 12 inch rubber belt. Each rock breaker is driven from this counter shaft by a 6 inch rubber belt.

There are two concentrator shafts running the whole length of the mill, each 1½ inches in diameter. The one nearest the main line shaft is driven from that shaft by a 6 inch rubber belt, and the two concentrator shafts are connected by a 6 inch rubber belt as shown in Plate I. Each concentrator is driven from its corresponding shaft by a 3 inch rubber belt.

The size of every pulley and its speed are indicated on the general drawing, Plate I.

Cost of Milling.—The mill is so arranged that hand labor is reduced to a minimum. Eight men suffice to run the mill day and night and keep it in repair. They are distributed as follows: two men by day, and one at night, spall the rock and feed the crushers; three men by day, and two at night, take care of the batteries, tend the concentrators, and deliver the concentrates into the drying room. The immediate daily running expense then would approximate the following:

3 Men at rock breakers @ \$2.25.....	\$6.75
3 " batteries @ 2.25.....	6.75
1 Man at concentrators @ 2.50.....	2.50
1 Foreman @ 3.50.....	3.50
110 Inches water @ 16.....	17.60
Wear on shoes.....	6.11
" dies.....	3.42
" screens.....	3.87
" rock breakers }	
" concentrators }	5.00
" copper plates }	
Illuminating.....	1.00
Lubricating.....	1.00
Total.....	\$57.50

The average quantity of ore milled per month is 1,850 tons, or 62 tons per day, which brings the cost for milling and concentrating to about 93 cents per ton.

THE CHLORINATION WORKS.

General Design.—The general plan and side elevation, Plate V., show the arrangement of the chlorination works, as well as the frame of the building itself. The floor upon which the sulphurets are dumped when first brought from the drying room of the stamp mill is not shown, but it is level with the top of the roasting furnaces.

Furnaces.—There are two roasting furnaces, placed as shown on the general plan, and provided with a double flue chimney. The details of their construction are shown in working drawings on Plate VI.*

These furnaces are built entirely of common red brick, and after two years' constant use they are in good condition. The "Plan of Top" shows the surface on which the ore is first spread to dry and heat. The walls of the furnace extend 10 inches above this level, forming a shallow basin. The ore is passed from one hearth to the next one below through ports four inches square, of which there are two in the upper floor, one in the second floor, and four for discharging the ore from the furnace. Each of these ports has a countersunk top, into which is set an iron plug, fitted with a handle for its ready removal. The lower hearth is supported on arches, as shown in "Section through A B." Under these arches the hot ore, as discharged from the furnace, is left to cool. The second hearth is provided with three working doors, and the lower one with four; all of these are arranged with a view to convenience in stirring the ore, and to reaching without difficulty every part of the hearths.

The flame spreads well over the lower hearth; the hot gases passing thence to the second hearth, by two flues shown on "Plan of Second Hearth," are turned in direction, and escape through the chimney.

The walls of the furnace are 13 inches thick, and are held securely in place by iron bands and staves. The brick wall is first encircled by three bands of 4×½ inch flat-iron, each band consisting of four sections, which are drawn together by ¾ inch bolts; then 32 vertical staves of 1×3 inch bar iron are set around the wall, as shown; and these are held in place by three outer bands of 4×½ inch iron. Each of these bands likewise consists of four sections, drawn together by 1½ inch bolts, which have a right-handed thread cut on one end and a left-handed one on the other, with a square section in the middle. The ends of the outer bands are bent to form rectangular loops, which are closed completely by welding, as seen in the drawings. The bolts are screwed into nuts placed in these loops.

The working doors are 17 inches wide and 8 inches high at the outside of the wall, but enlarged inward to allow a greater range for the hoe in stirring. In the doorway is set a cast iron frame ½ inch thick, to which the door is hung.

Chlorination Tubs.—These are of peculiar construction. Their capacity is 2½ tons each, and they have the following dimensions:

Diameter at top.....	5 feet 9 inches.
" " bottom.....	6 " 3 "
Depth to false bottom.....	3 " 6 "

The bottoms are made of 3 inch planks tongued together. The staves are of 2 inch stuff with plain joints, but there is

a batten ¾ by 2½ inches over each joint, and there are four iron hoops around all, driven hard. This construction gives a tight tub, and saves the iron hoops from being corroded by the chlorine, as would be the case if they fitted closely to the staves. The cover is made of 1½ inch stuff tongued together, and stiffened by four cleats screwed on top. A jog is cut all around the top of the tub 1½ inches deep and one inch from the inside of the staves; the cover fits into this jog, leaving a clearance of 1 inch for calking and luting. An iron bail is bolted to two cleats of the cover, to serve for raising it with the aid of a tackle, indicated on Plate V. The latter hangs from a small truck which travels on a suspended track extending over the whole row of tubs. The tubs are provided with false bottoms made of 1 inch boards perforated with inch holes, and covered with a double thickness of gunny sacks. They are supported two or three inches above the bottom by cross pieces.

Leaching and Precipitating Tubs.—The silver leaching tubs are of substantially the same construction as the tubs for chlorination, and the precipitating tanks differ only in being a little shallower, but there is no reason for having them so. All the tubs are painted inside and out with three coats of liquid asphaltum varnish, which should be renewed every year.

Output, Labor, Fuel, and Cost.—The maximum capacity of the two furnaces is 9 tons of sulphurets in 24 hours. Each furnace burns 1 cord of wood in 24 hours, and requires two Chinamen to work it during that time—the same man tending the whole furnace. Another Chinaman, one white man, and the foreman complete the force for the chlorination works.

The immediate daily expense then would be about as follows:

1 Foreman.....	\$3 00
1 White laborer.....	2 25
5 Chinamen, at \$1.50.....	7 50
2 Cords wood, at \$5.00.....	10 00
29 lb. binoxide manganese, at 2¾ cts.....	80
260 lb. salt, at 1 ct.....	2 60
216 lb. sulphuric acid, at 2 cts.....	4 32
Lime, sulphur, and calcium byposulphite....	30
Illuminating.....	20
Extras.....	1 00
Total.....	\$31 97

This outlay makes the cost of treatment per ton of sulphurets amount to \$3.55, when the works are run at full capacity.

But the ore contains, as has been stated, about 7 per cent. of sulphurets, or 4½ tons in the 62 tons milled daily. Though this quantity of sulphurets does not keep the two furnaces running at full capacity, yet both of them are maintained in continual operation. Most of the expenses remain the same, whether treating this smaller amount or running at a full 9 ton capacity; the actual cost, therefore, figured on a working basis of 4½ tons daily capacity, approximates as follows:

Labor.....	\$12 75
2 Cords wood at \$5.00.....	10 00
14 lb. binoxide manganese at 2¾ cts.....	38
126 lb. salt at 1 ct.....	1 26
104 lb. sulphuric acid at 2 cts.....	2 08
Lime, sulphur, and calcium byposulphite..	15
Illuminating.....	20
Extras.....	50

Total per day.....	\$27 32
Adding to this the cost for milling per day..	57 50

The total outlay per day equals.....\$84 82

or \$1.37 per ton for extracting the gold and silver from the ore. This estimate makes no allowance for the expenses of general supervision, interest on first cost, and gradual deterioration.

SCARLET FEVER IN NORWAY.

A VALUABLE contribution to epidemiological literature has been made by Dr. Axel Johannsen in his monograph on the "Epidemic Prevalence of Scarlet Fever in Norway" (Christiania, Jacob Dybwad, 1884), in which he has spared no pains to investigate the subject in a thorough manner. He has succeeded in obtaining records of epidemics which occurred so far back as 1817, and in each year from 1825 to 1878 inclusive, the latter years comprising naturally more full and exact details than the earlier ones. From the facts thus gathered he has compiled a series of statistical tables which tell of the great labor expended on his task. A number of diagrams are also appended, showing the relative distribution of the disease in proportion to the population in the different districts, and curves of the prevalence and mortality of scarlet fever as compared with those of other infectious diseases. It would be impossible to give here any but the barest review of some of the data which he has obtained. Among these may be mentioned the fact that 42 per cent. of the epidemics occur in the autumn months—September, October, and November—the smallest number of cases occurring in spring and summer. In the twelve years 1867 to 1878, there were attacked with scarlet fever 6,278 adults, or 9.8 per cent., and 57,982 children (under fifteen years of age), or 90.2 per cent., the cases being about equally distributed between the sexes. Speaking of the mortality from the disease, he points out that it is one of the main causes of death in the country, the rate varying from 2.12 per cent. to 12.5 per cent. of all persons attacked, epidemics varying much in their degree of severity. In children the mortality in the twelve years above mentioned was 16.6 per cent.; in adults 3.8 per cent.; among males 17.5 per cent.; among females 15.2 per cent. He compares the mortality in town and country districts, showing that it is proportionally higher in the latter. He discusses the question of incubation, of recurrences, and second attacks, and then deals in turn with each of the complications of the fever—angina, nephritis (extremely variable in different epidemics), phlegmonous inflammation of the neck, parotitis, arthritis, affections of the respiratory and digestive organs, of the sensory organs, of the brain, and pyæmia, gangrene, and noma. He states that Koren records in the Christiania epidemic of 1875-77 twenty-seven cases of scarlatinal arthritis out of 426 patients, the joints of the hand, fingers, and knee being most affected; it was invariably a simple serous synovitis. Pneumonia was not a frequent although an unfavorable complication. Meningitis was a frequent occurrence in the stage of evasion in the epidemic in Solor-Odalén in 1875-77. As to otitis, Koren found that in the Norwegian deaf and dumb institutes 12.38 per cent. of the deaf-mutes owed their defect to scarlet fever. Some doubt is thrown upon

the occurrence of true scarlet fever in puerperal women, but the author does not discuss this question at length. His statement that, out of 146 deaths in childhood in the years 1874-78, only three were due to scarlet fever seems to support his contention. The monograph, it may be added, is written in the German language. From the large mass of material which the author has collected the facts deduced are reliable, and will doubtless be utilized by subsequent writers on the subject. We should like to see a similar exhaustive study made of epidemic disease in this country; but we fear that until we have a thorough system of registration such a work could never be completed.—*Lancet*.

A RAMROD IN THE BRAIN.—RECOVERY.

By Geo. Fischer (*Deutsche Zeitschrift f. Chirurgie*) the following unparalleled case in surgical literature is related: At a shooting festival in Hanover, it occurred that a carbine was unexpectedly discharged, from which the ramrod had not been drawn. The ramrod struck a man in the back, was driven through the neck and head, from which it projected. The man reeled, staggered, but did not fall. He was laid down; he remained motionless and speechless. A comrade tried to draw the rod out, he used enough force to raise the body from the ground, but without success. Other attempts were made to that end, so much so as to drag the body over the ground, but failed. He had nausea and vomiting, but finally answered questions rationally.

Four hours later he was in the hospital. The obtuse end of an iron rod, thirty centm. long, projected on the left side, over the foreman supraorbital. The integuments grasped tightly the rod; not a drop of blood escaped. On the right side of the neck, below the angle of right submaxilla, was a great hard and painful swelling. Nothing abnormal could be felt in the throat. Between the right scapula and the vertebral column in the region of the fourth dorsal vertebra was a gunshot wound of the size of a five cent piece, with black edges; the patient could stand up, was weak, apathetic, but could give rational answers, and remembered distinctly the whole occurrence. The pupils were dilated, sight not very good, bleeding from right nostril, breathing normal, pulse rhythmic, sixty. The ramrods of carbines have a large button on one end; and as these rods are very short, the button end must necessarily be embedded in the neck. Without an anæsthetic, the wound was enlarged, and the button end of the rod was discovered up in the region of the sterno-cleido-mastoideus. The larger vessels were not seen. The rod was firmly wedged in the cranium, so that in order to loosen it the bones had to be chiseled away around it, and by many blows of a hammer it had to be driven downward before it could be extracted. No bleeding.

The patient was perfectly cognizant of what was going on, and made many sensible observations. He lay absolutely motionless, while, with a hammer, the rod was driven down. The operation lasted one hour. The rod was fifty centm. long, the lower end six mm., the upper seven mm. thick. The button had a circumference of four centm.

Cerebral symptoms were only trivial, first those of concussion, late of compression of the brain, memory little impaired. Escape of cerebro-spinal fluid in the right nostril. Amaurosis of right eye, suppuration of right ear, temperature a little higher, frequency of pulse, slow respiration, digestion, micturition not disturbed. The length of gun shot canal was thirty-five centm.

In order to ascertain the probable injury of the various organs and tissues, Prof. Henle of Göttingen imitated the canal on a cadaver. He found: The ramrod after penetrating the back between the M. splenius cervicis and M. levator scapulae without injuring the cavity of the chest, before the vena jugularis int. and art. carotis communis, near the bifurcation, behind the M. sterno-cleido mastoid, behind the belly of the M. stylo hyoid, and stylo-glossus; immediately behind the posterior margin of the median root of the pterygoid processes the ramrod entered the cranial cavity. It penetrated to the right sphenoid fossa, the lower floor of the orbital cavity, went through the right canalis opticus, lacerated the optic nerve. Here it struck the right gyrus, went then a distance between both hemispheres to the left side of the falx cerebri, then through both gyri fornicati up, three c.m. long through the left gyrus frontalis superior, and through the os frontalis ant.

After nine weeks patient left the hospital cured, after eleven months was perfectly well, attended to his very laborious duties, and dances all night as often as he can; amaurosis continues.—*St. Louis Med. and Surg. Journal*.

MOBILITY OF THE BRAIN.

THE paper recently read before the Académie de Médecine by M. Luys cannot fail to be of great interest to the physiologist.

The cerebral mass, he says, inclosed in the cranial cavity is surrounded by an empty space which permits its displacement in different attitudes of the body, and enables it to obey the laws of gravity. When a man is placed in an inverted position, the forehead being on a horizontal plane, the cerebrum glides from before backward; in the vertical position it always obeys the laws of its weight, recedes from the cranial vault, and leaves an unoccupied space at the vault. In a position of lateral decubitus the lower lobe sinks down and the upper presses upon it, slightly displacing the falx cerebri. In this position the vacant space is between the temporal lobes and the skull. Luys' experiments enable him to state that the gliding movement of the cerebral mass takes place in an automatic manner; that this movement does not take place suddenly, and that five or six minutes are required for the displaced part to regain its normal situation.

This mobility (or locomobility, as Luys terms it) of the brain should, from a physiological point of view, have a considerable influence in the phenomena of cerebral life. In the vertical position the brain, in pressing upon itself, causes a certain degree of folding in the compressed parts. Hence we notice various ischæmic troubles in debilitated subjects who have been confined in bed for some length of time; and that syncopal state known as sunstroke, which often takes place during a prolonged vertical position; and the various phenomena—vertigo, titubations, loss of consciousness, etc.—which depend upon arrest of the circulation in the basal capillaries. So true is this that the empirical remedy, horizontalizing the patient, is one which nature always employs in order that the pressure upon the capillaries may be removed and the circulation re-established.

It is very probable that this automatic displacement may have a large influence in the causation of sea-sickness. The rapid succession of tosses experienced by the cerebral mass should be expected to contribute largely to the development of that curious state of nausea and cerebral malaise; and it

* For these excellent drawings I am indebted to Mr. W. H. Englebright, Surveyor in Nevada City.