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The Design for the Reconstruction of a Mill.

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THE DESIGN FOR THE RECONSTRUCTION OF A MILL

In this particular problem of the reconstruction of an old mill to make of it an economical,efficient, and modern mill three primary subjects must first be given serious consideration before the detailed plans of the mill can be entered upon. These three subjects are: 1st, the ore to be treated; 2nd.,the general method of treatment to be adopted to get the maximum economicaleextraction; 3rd.,the arrangement of the floors in the present mill building and the equipment therein with regard to their adaption to the new plans with the minimum alteration of the building and discarding of the present equipment.

The ore of the district has been formed by the silicification of the country rock outward from fractures or fissures.The milling ore varies from altered country rock through all stages of silicification to pure quartz. In this particular mine from which the mill will derive its ore the silicification has been very complete and extends out beyond the limits of milling ore so that the milling ore is almost wholly a dense jaspery quartz varying in color from white to gray and black. The ore is a silver ore carrying one part of gold for every one hundred parts of silver. Very little of the ore in this mine is oxidized consequently the silver values lie in sulphides. Argentite is the main silver mineral with pyrargyrite occassionally. In a certain mine in the district native silver is frequently found in the ore but it is entirely lacking in this mine. The silver sulphides are generally so finely disseminated in the ore as to have lost their crystal identity to the eye.

The only other mineral commonly obseved in the run of mine ore is a small amount of pyrite. The gold of the ore is never visible to the eye and is apparently included in the siver minerals. The ore contains zinc, lead, and copper minerals only in traces.

The general metallurgical treatment to be given the ore for a maximum economical extraction is not to be determined in this case by small metallurgical tests but by a careful study of the past and present mills of the district. The following chart gives the general construction features of all the mills in the district at the time of their erection ,which is followed by the changes in each mill which have since been adopted.

	MILL A	MILL B	MILL C
Mine Ore to Crusher	A single 10"X20" Blake	1 #7½ Gates Trommel 2 # 4 Gates	Same in all particulars as Mill B except it is a 60 stamp unit
Crusher to Battery Bins	Belt Conveyor 18½ degree slope	Belt Conveyor 21 degree slope	
Stamp Batteries	10 1300# Stamps 10 1100# " All Boss cantilever pattern. The ten 1300# stamps hame low double discharge mortars. Concretemortar blocks Driven in 10 stamp units. 50 H.P. motor for 20 stamps. Front drive.	100 1050#Stamps 10 stamp units. Concretemortar blocks 50 H.P. motor for 20 stamps . Wooden battery posts. Back drive.	
(Note on Mill A) Erected as an amalgamating mill. Crushing units followed by grinding amalgamating pans. Power - a 120 H.P. Deisel gas engine. Changed later to a cyanide plant as shown under "MILL A "			
-B- Other Crushing Units	3 5 ft. Hungtingtons Mills	5 5 ft. Huntington Mills	
Between -A- and-B- Classifiers	1 V Box , giving a Sands to -B- b Slime to -D-	10 20" Cones a Sands to -B- b Slime " -D-	
-C- Coarse Concentrators	4 #5 Wilfleys	20 #5 Wilfleys	

MILL D	MILL E
1 #5 Gates Trommels 2 #3 Gates	1 #4 Kennedy only
Belt Conveyor	Belt Conveyor
40 1050# Stamps 5 Stamp units Wooden mortar blocks " battery posts and back drive.	30 1050# Stamps 10 stamp units. Concrete mortar blocks. Wooden battery posts and back drive. 30 H.P. motor for 10 stamps.
2 5'x22' A. C. Tube Mills Belt driven from one countershaft driven in turn by a 150 H.P. motor.	2 5'x18' Traylor Tube Mills Driven in same manner as Mill D but by a 100 H.P. motor.
8 Small Cones	6 Small Cones
8 #5 Wilfleys	6 Deister Tables

-D-	MILL A	MILL B MILL C
Fine concentrators	None	None
Classifiers	3 3-ft.double cônes	10 24" cones followed by 10 35" cones.
Sand Treatment	6 16'x 6' collecting and leaching tanks Followed by 6 16'x 6' lower leaching tanks. Sand tailings shoveled to cars and trammet out. Transferred by hand.	4 33'x 8' collectors, Followed by 18 33'x 8' Leaching tanks. Sand transferred by Blaisdell excavator and distributor. Tailings by excavator and belt conveyors to tailings stacker.
Slime Treatment.		
Settlers or Collectors	See Below	See Below
Agitators	3 20'x12' combined settlers & agitators.	8 36'x20' combined settlers and agitators.
Filters	20 leaf Butters filter Plant	192 leaf Butters filter plan
Precipitation	Zinc Thread 5 22"x22" x 15' boxes Flat bottomed. Product shipped to smelter.	Zinc thread. 14 3'x3' x 22' boxes. Flat bottomed Product dried in muffle furnace and melted in coke. fired tilting furnaces.
Elevators	Bucket elevators	Bucket elevators and one 30-ft. and 1 54-ft.sand wheel.
Pumps	All centrifugal	All centrifugal
Agitation of slimes	By a crude form of the present Trent agitator	By mechanically operated arms, air pipes and centrifugals.
Site	Mild slope	Flat
Power	Electric in all mills	

Type of Mill Building: The crushing and concentrating part of Mill A is all steel and concrete, the rest like all the other mills being galvanized iron over wood, with part concrete floors.

MILL D	MILL E
16 4' Frue Vanners	12 Deister Slimers
Preceeding -D- 2 48" 50 degree cones at end of tube mills then 2 large cones for dewatering	Preceeding -D- 6 8' Callow Cones take the Dorr overflow and dewater for concentration.

No sand treatment being all-slime plants in both cases The sand being separated out in each case after -C- by two 5' Dorr Classifiers,each feeding the sand direct to a tube mill, the coarse from the tubes passing back through the tube mills via the Dorrs.

MILL D	MILL E
4 24'x16' 35 degree false bottom settlers.in Mill E	3 30'x10' 12 degree false bottom settlers in Mill D
6 17'x13' with a 45 degree hopper below this.	3 24'x16' flat bottomed tanks.
144 leaf Butters Filter	100 leaf Butters Filter
Zinc Dust 2 Merril Presses 48" 30 Frame	Zinc Thread 8 Sheet Steel,30",32",x26' with 45 degree hopper bottoms
Product shipped to the smelter	Product dried in a steam pan and melted in a Steel Harvey oil fired tilting furnace.
Bucket Elevator	Bucket Elevator
For solution-Triplex " pulp - Freniers&& Centrfugals	For solution -Triplex " pulp- Freniers & Triplex & Centrifugals
By Hendryx agitators,with no compressed air added.	By Trent agitators with compressed air added at the pump discharge.
Mild Slope	Almost Flat

The principal changes in the above mills today are as follows.

Mill A. This mill was closed down after one years operation. During this time it had to contend against high charges for water, a severe winter, a variable power supply, and the high prices and uncertain delivery of materials that mark a new camp. Its main defects was its limited capacity in certain departments; 1st, the failures of the Huntingtons through breakdowns and repairs to stand up to the work of taking a 12 mesh battery product to 30 mesh; 2nd., the small slime plant of 3 3,000 cu. ft. tanks used both as collectors and agitators. The sand plant required excessive labor, and the Butters filter required as much attention for its cycle as a unit many times its size. These facts coupled with poor classification and agitation made the best extraction of values impossible.

Mill B In this mill more Huntingtons were added. After five years the superintendent now recommends the substitution of Chileans. In the concentration department Johnson vanners were added to concentrate the finer material and to relieve the Wilfleys of this material. In the slimes department the using of the same tanks for both collecting and agitating was abandoned immediately. Three more tanks were added and the slime settled in seven of these units and transfered in charges with the addition of fresh solution to the others, used as agitators. This mill inaugurated the system of heating the solution during agitation which became an established custom in all the mills. Of recent date the suction of three of the settlers has been extended over the bottom of the tanks in two 6" pipes which have small pipes branching from them By this means the thickened slime is drawn from all over the bottom of the tanks , and the pipes are all free after 3 mo. operation. These three tanks now do all the settling for the mill.

Mill C This mill built simiiliar to Mill B also adopted the Johnson vanners but later discarded them. In the regrinding department the Huntingtons were discarded, and a tube mill substituted, and a second tube mill installed to regrind the middlings from the Wilfleys. In the slimes department the two combined settlers and agitators that were immediately used for settlers only, still continued to have their mechan -icalagitation ,and at alatter date after having been idle on account of riling the slime they were run at reduced speed with air lifts to raise the thickened slime to a single agitator. The one agitator feed by the settlers agitates the slime by arms, pumps, and air lifts until a charge accumalates when the charge is transfered to the regular agitators.In the filtering department the cocoa matting of the original Butters leaves which soon choked with slime and lime accretion crippling the plant, wa s discarded in favor of small parallel wooden slats stiched vertically in the canvass. About the same time the other plants adopted the same change.

Mill D. The changes in Mill D have been very slight. In the design of the mill especial attention was paid to obtaining close concentration and since there has been added several Deister slimers. In the Butters filter plant an auxilliary set of leaves installed to clarify the solution from the filtering leaves was discarded. In the zinc dust precipitation the traveling belt method of zinc dust feed which is controled by floats in the silver tanks,and requires more than one of these tanks,and is also irregular in its feed was replaced by anew feed,the design of B.Bosqui, which consists of a traveling worm in a V shaped zinc dust box,the worm being connected through a set of speed regulating pulleys to the pump line shaft. By this feed one tank is sufficient and the zinc is fed in according to the pump speed. It is independent of the flow of solution in the tank and since the triplex pump always pumps the same volume the zinc feed can be regulated to a nicety and acts steadily. In the precipitating department oil fired furnaces as used in Butters Virginia plant were installed in order to refine the precipitate.

MillE In this the latest designed mill there has been constant changes In the matter of pumping slime pulp the use of both Freniers and triplex pumps were discontinued in favor of centrifugal pumps. The first chain drive of milling machinery in the district was installed between the agitator motors and their centrifugal pumps. The mill was designed for close concentration. The first break away from this came with the discontinuing of the use of the troublisome Callow cones which allowed more of the fine slime to be washed over to the agitating department. No ill effects were noted or increased loss in tailings noted. As the agitating and filtering departments were doing excellent work the experiment was tried of discontinuing the slime ~~agitators~~ concentrators. After three months it was adopted as the regular practice with the addition of another agitator. Then the coarse concentrators were discontinued thus abandoning all concentration. This was soon adopted as regular practice.

A study of the chart and of the operating conditions in each mill and of other mills in near by districts,and of recent technical articles upon milling has led me to the following observations and conclusions concerning the redesign of Mill A to a 120 ton mill, being erected upon a site, having a drop of 30-ft. in 150-ft. horizontal.

Coarse Crushing Department

In all mills excepting A and E this department has been designed to crush to one inch or 1-1/2" size, in two stages, with two sizes of gyratory crushers, with trommels between the two units, in order to give only the oversize to the finer crushers. Mill A in District B, follows the same design. In Mill A, the single large Blake crusher was unable to crush from mine size to any size below two inches, without marked decrease in tonnage. Mill E installed a single gyratory, with the expectation of crushing to a 1-1/2" ring in a single crushing. The strain thrown upon the crusher, resulting in the breaking of two or more shafts and the present installation of a nickel steel shaft, indicates that the work required is too severe without obtaining as fine a product as Mills B, C, and D. Mill B, in District B, that has had but a single large gyratory, is about to install a small gyratory to follow, in order to cut down the size of battery feed and to obtain increased tonnage. Mill D's equipment is designed for a one inch sized product.

From the above examples and the proven fact that gyratory crushing is cheaper than battery crushing and that finer product to the batteries means in most cases greater tonnage per stamp, the best design of plant would be to crush to one inch or one and one-quarter inches in two stages. For the second crusher, the gyratory has no competitor in the Blake, since an even sized discharge is absolutely necessary. For the coarse crushing, the favorite is also the gyratory. For the 120-ton mill under consideration, the short head room beneath the ore bins makes a Blake crusher the most economical installation for the coarse crusher. It should be used to crush as fine as possible and its product should be fed to a trommel, the oversize from which should flow to a No.3 gyratory crusher, fitted with a short head and concaves and set as fine as possible. The design of the plant is such as to crush 120 tons of mine ore to one inch or three-quarter inch size in a shift of eight hours.

Battery Bins

The battery bins should be ample for two days' run. In the case of Mill A the bins are constructed to hold 200-tons.

Stamp Batteries

The common weight of the stamps in all the mills except Mill A is approximately 1050-lbs. In Mills A and B, of District B, this weight of stamp is also used. It is worthy of note that in most of these mills concentration follows the stamps, usually before regrinding takes place. In Mill A and Mills C and D, District B, 1350-lb. stamps were used. These stamps did very satisfactory work, but since they were followed directly by concentration and twenty mesh screens used on them, they did not show increased tonnage enough to gain them favor in the construction of later mills. On the Rand, in South Africa, where cyanidation without concentration is practiced, the weight of the stamp has been gradually increased from 1000-lbs. to 2000-lbs. The size of feed to the battery has not been materially increased, but the discharge is through coarse screens of four mesh, or less. The tonnage of the single stamp reaches ten tons in twenty four hours. This result is gained by the extra weight of stamp and by the fact that the stamp is no longer used to make a sweeping reduction from 1-1/2" down to a product below thirty mesh, which product means thirty per cent. of it will pass a 200 mesh screen. The South African metallurgist believes that the reduction from four mesh to two hundred mesh can be more economically carried out in tube mills.

The idea of a heavier stamp has not been adopted by American Engineers, but on account of concentration they have adopted stage crushing after stamp batteries. Mills A, B and C used Huntington Mills for final regrinding, while Mill A, in District B, after a few months' run, in which they did away with amalgamation of the battery pulp, installed a number of Chilean Mills and placed four mesh screens on their batteries. It is an open question if this had been foreseen before construction whether or not the heavy stamp, with greater tube mill capacity, would have been installed in the first instance. In the case of Mills D and E, the tube mills follow after the stamps, but coarse crushing in the batteries is not employed, as concentrators are placed in between the batteries and the tube mills. In Mill E, after close concentration at this point was not considered necessary, coarser screens were put on the batteries, until the twelve mesh screens gave a tonnage equal to the maximum sliming capacity of the tube mills.

If no concentration is to be practiced, as in Mill E, the question resolves itself into the most economical crushing of the ore from 1-1/4" size to a slime product, and the choice should lie between the three unit system of stamps, Chilean mills and tube mills, or stamps and tube mills alone in this problem of remodeling Mill A, where stamps are already installed. In a new installation there is the choice of the three unit system of rolls, Chileans and tube mills. In any case since the batteries will crush only to four mesh, it is my opinion that it would be advisable to use the heavy stamp, since it gives a smaller first installation and a stamp better fitted for rapid, coarse crushing. Where Chilean mills and tube mills follow the batteries, a partial de-watering of the pulp is first necessary for good results with the Chilean mill, and following them a close classification of the pulp, by cones or drag classifier, into a final very liquid slime product, and a thick sand product for the tube mills. By this method, the Chileans obtain the product from 1/4" to thirty mesh best suitable for them, and reduce it to an average 100 mesh product. The classification that follows gives the tube mills a very even, fine sand, product, which should result in a minimum return product, with less power and upkeep costs, since less grinding is required. It is evident that a tube mill, taking a product from 1" to 100 mesh, will give a large per cent. of return, or else do useless work, for if the 1/4" product must be slimed before discharge from the mill in one passage, the capacity of the mill will be greatly decreased and a constant load of slime ore retained in the mill, consuming power and occupying valuable space.

On the other hand with both Chilians and tube mills, two levels or floors are required if elevation of the pulp is to be avoided as it should be for this elevation would be a continuous mill charge, while if the site allows of two floors the first extra cost of construction would usually pay for itself many times over inthe saving of the elevating costs. Besides the greater first cost of installing the two seperate units there are other disadvantages in the operating of the two units instead of the single unit. In a 120 ton mill, since the number of machines in each unit is small, the shift man must tend to more than one unit in order to reduce labor costs. Of the three units the stamps will require the most care, then the Chilians, and finally the tube mills the very least. The shift man can make many repairs upon a battery, and can easily detect trouble and prevent serious damage. The battery needs constant attention to get the maximum tonnage, but its construction is such that it does not need constant attention lest it wreck itself. The tube mill likewise being very simple in mechanical details, and very slow speed, there is little chance of accident or breakage due to lack of vigilence in its care. The Chilian mill, while not an intricate machine has several rather heavy pieces in rapid rotation, that are very sensitive to both overload and underload resulting in serious injury unless quickly adjusted. If oil fails to reach the muller shafts either through lack of oil or choking of feed pipes the bearing will cut out on short notice. They require a more skilled and alert attendant than stamps or tubes, and the results from neglect are immediate and costly. In a 120 ton mill a shift man should be able to care for two such units as stamps and tube mills, but it would be a a very exceptional shift man who would be competent to understand fully and operate all three units of stamps, Chilians, and tube mills. though the number of each be much less, than with two units only. With the use of the three units a greater stock of repairsmust be kept on hand entailing a larger unprofitable outlay of money. From thex above consideration I would favor in the design of a mill of 120 tons capacity the installation of two units only, stamps and tube mills only, believing that if such an installation required greater power consumption to slime the ore than with the three units, that with only the two simple near fool proofunits, one shift man could tend both units satisfactorily, which would reduce the labor sliming costs to a minimum, and more than repay the greater power consumption. Repair and upkeep work for the mechanics crew would be less with the two simpler units. All the mills except mill D drive 10 stamps from each cam shaft or in other words they drive in ten st stamp units. In mill B the hanging up of a battery drive for repairs means the loss of one-tenth of the mill tonnage for the time. In Mill E with thirty stamps, it would mean one-third of the tonnage, which becomes a serious loss. In Mill A, it would mean one-half of the tonnage. Since in such a small mill there would be no repair crew on shifts afternoon and graveyard, such a shut-down would be serious. For this reason, in remodeling mill A, the battery drive should be changed tofive stamp units, to insure maximum tonnage, and to practically eliminate the chances of cam shaft breakage.

There is another three unit system of stamps, Huntington mills and tube mills. This system, although in use at Mill B, has shown excessive costs for maintenance and repairs. The Huntingtons power costs are against it, as is also its rapid rotation. The average mill man does not speak of the Huntington without a negative shake of the head, as he recalls the hours spent in repair work. The Chilean is rightfully replacing the Huntington, as an intermediate regrinder.

The method of separating the slimed ore from the sand content before tube-milling calls for a choice between gravity cones and mechanically operated classifiers. The gravity cones cannot make as sharp a separation, but they are simpler in design. Their product can be made thicker by the use of goose-necks or by diaphragms. Their cheapness is counterbalanced by the greater head room required and the constant danger of the restricted discharge becoming choked and the cones becoming packed with sand. Of the mechanically operated type there are two machines of proven merit. In each, the settling sand is scraped slowly upward along the bottom of the inclined tank, while the slime overflows the low end. In the Dorr classifiers, the tank is rectangular and flat bottomed and the sand is worked forward by cam mechanism and by closely spaced rakes that extent across the breadth of the tank and move forward along the bottom for a short distance, and on their backward trip are lifted free from the bottom. The Akins classifier is a half cylinder in shape and the scraping mechanism is a cylindrical screw that is constantly rotating in one direction, carrying the sand steadily to the head of the box. In comparison of the two, the simpler mechanism of the Akins is far superior to the jerky cycle of the Dorr, with its distinct forward drag, upward lift, back travel and drop. In the Akins, the back travel with its agitation is eliminated. Both are simple in repairs, which amount to almost nothing. The striking advantage of the Dorr is that the settling area is rectangular in shape, while in the Akins it is triangular, so that for a given width of tank the Dorr has three times the settling area. Since settling is directly proportional to area, this gives the Dorr a great advantage, which is only slightly offset by the agitation of the back stroke. The choice between them becomes, in my mind, simply one of relative cost for equal settling area. Delivered at the mill for the same outlay of money, you would obtain four times the settling area in the purchase of the Dorrs. In any case the mechanical separators are preferable to cones, if smoothness of operation and the small head room required are more important than the larger outlay. In the re-designing of Mill A, I favor the Dorrs. In Mills C,D and E, the Dorrs give entire satisfaction, and in Mill C, District B, an Akins is well liked. The gravity cone is not in use in the district to feed tube mills, but in Mill B, District B, their use is to be discontinued in favor of the Akins classifiers.

Tube Mills

The question of choice of tube mill design offers little difficulty. The tire type of mill has given away in general practice to the trunion type, due to the greater ~~friction~~ attention required by them. The conical tube mill, which appeared to have a very sound principle of graded grinding, produced simply by the conical form and the rotation, in which the pebbles diminished in size as the product decreased in size. However, in practice they have failed to show any advantage, and have the disadvantage of an odd form and limited volume. Their product contains much coarse sand, due perhaps to ~~no~~ the splash from the large center pebbles, carrying sand near to the outlet, and where the small pebbles cannot pulverize it, and to the fact that there is an incline all the way to the outlet, which allows sand to creep up and escape.

In tube mill construction of the trunion type, the various firms vary only in minor detail. The main point which is left open is the length of the shell, which commonly varies from 18 to 22-ft. in length, for the common diameter of 5-ft. There is little difference in cost, it being but the four feet of extra shell, as all of the remaining parts are the same. One company in Mexico, using a large number of mills of both lengths, has decided to use

18-ft. lengths only, claiming less power consumption per ton slimed, due, they claim, to the fact that in any greater length a larger quantity of slime is simply carried in the mill as a dead load until it can escape. The adherents of the 22-ft. mill claim that a shorter mill will not slime an ore without returning a larger percentage for regrinding. In my opinion, especially in a small mill, of 120-tons, the 18-ft. length will be the most satisfactory, as two units can handle the work, while a single 22-ft. mill will be too small, and two 22-ft. mills too large an installation. The 18-ft. mills have the advantage of less power to start, which means less strain on belts and friction clutches, and though a 22-ft. mill costs but little more, the larger clutches, belts and motors required and the heavier load, make them as expensive as the 18-ft. lengths, in proportion to their lengths. There is considerable difference as to the method of drive, the belt drive being commonly favored over the more compact, direct-connected drive. This is due mainly to the heavier first cost of the high torque motors required, and to the difficulty of eliminating jar and vibration from the motor. The method of belt drive takes much floor space, with an intermediate countershaft. There is a loss of nearly ten per cent. in transmission and a heavier wear on belts. I am convinced that the proper drive for a tube mill is a chain drive. This is not a new proposal, as it has been adopted in the East on cement mills with fair success, but it is unknown in metallurgical practice. Chain drives, from one horse power up to one thousand horse power, are rapidly supplanting belt drives, due to their high efficiency in transmission of power, to their compactness and to their wearing qualities. Dust is one of their worst enemies and that is what they have to contend with in cement tube mill work, but with metallurgical mill work, crushing in solution, this is eliminated. I propose to drive from the same pinion shaft, placing my tube mills end to end, the pinion of each mill to be connected to the pinion shaft by a 38" Imperial Friction Clutch, and the pinion shaft to be driven at its center by a large pulley. If this pinion shaft were to be driven by belting, it would require a countershaft with two 20" face pulleys, and 100-ft. of belting. Unless the countershaft is placed in a high, inaccessible position, this arrangement will require a floor space of over 100 square feet, in comparison the chain drive, would require to transmit the 100 H.P., a chain 15-ft. long and 12" wide, a four foot sprocket spring pulley on the pinion shaft, and a seven inch sprocket pulley on the motor, about five feet away. The chain drive will cost twice as much, but its compactness aids in lessening floor space required. Its life of years without renewal compares favorably with the yearly renewal of belting. If it saves but 5% in the transmission of 80 H.P. per month, or 4 H.P., @ $10.00 H.P.Month, it will pay for its greater cost in one year. The spring sprocket on the pinion shaft is used to take all vibration and jar from the chain and motor, due to the enmeshing of the coarser driving gears. In the district, Mills C and E have 18-ft. mills, and Mill D, a 22-ft. mill, and every case the drive is by belting through countershafts.

Collectors

To dewater and collect the slimed ore as it comes from the classifiers, both cone bottom tanks and flat bottom tanks, with mechanical operated mechanism, are in use. The cone bottom tank has been in use for years and the cone varies from twelve to forty five degrees. The flatter cones give greater capacity to the tanks, but invariably require sluicing at times, as the slime, left to itself, will form a natural cone exceeding fifty degrees. The steep forty five degree cone takes a conically constructed tank, with its high cost, or else leaves a very limited capacity in a flat bottom tank. The Flat bottom tank, with slow moving arms near the bottom, is comparatively of late adoption in settling, as the idea of moving arms in a settler was received with skepticism. It has been thoroughly demonstrated that those arms in no wise disturb the settling, but aid it by leveling the natural steep cone that the slime tends to build, and storing a thick, but liquid slime that by slanting paddles attached to the arms moves to the center discharge. The mechanism is of light construction and the power construction a small item. A 33-ft. x 10ft. tank, settling one ton of slime in a 1 to 2-1/3 pulp to every seven square feet of tank area, requires one-sixth horse power to run it. This use of wide, low tanks for settling often conforms to a mill site where its use would allow the slime to flow into them by gravity, thereby saving enough on power to operate them. As this type of thickener is of recent design, it is not found in the mills of the district, the type found in Mills D and E being tanks with a false cone bottom of about twenty degrees, and in Mill B flatbottom tanks which have the multiple pipes mentioned before. In every case an occasional sluicing out with solution is necessary to destroy the inclined cone of hardened slime. At Mill C, the two 36-ft. settling tanks were originally equipped with revolving arms for agitation, When the arms were stopped entirely, and with the mill at two-thirds capacity, there was constant trouble with slime overflow. With the arms revolving once in three minutes and the mill at full capacity, the slime hardly appears in sight. With this example of what a slow speed agitator has done in the district, and with the advantage of continous running , low head room , and the greater first cost of installation per unit balanced by the smaller number of units required it is in my opinion a better installation than cone bottomed tanks, especially in the case of only a moderate slope in the m mill site.

In the discussion of the sliming of the ore it was assumed that there was to be no concentration before sliming. This assumption simplified the sliming of the ore,by allowing the stamp to crush to a mesh too coarse for concentration of this particular ore and then reducimg the slime in one operation in the tube mill. With the example of mill E it is possible to leave out the concentration of the slime thus abandoning all concentration. The advisability of this step is one that requires considerable study in the cyanidation of silver ores. This new departure in silver matallurgy is not to be taken without serious consideration. It is to be noted that every mill in the district was designed with the idea of removing the silver sulphides as soon and as completely as possible. This was in line with all current practice. This fact is to be noted, that all sliming mills were unknown until silver cyaniding had been practiced many years, and silver sulphides in the leaching vats means long treatment and poor extraction. It is no wonder that the early metallurgical engineer strove to keep all sulphides from reaching the leaching vats. Experiments on cyaniding these concentration products gave a very high cyanide consumptionand a fouling of the solution which did not make it an attractive proposition over smelting rates. It seemed also that the presence of the concentrates in the slimed ore must have a similar effect of fouling the solutions. Consequently after all sliming was proven feasible, in that the extra cost of crushing was repaid in extraction, and that the filter leaf had made possible the filtering of the slime, we note that Mills D and E were erected in the district as all sliming mills, yet better equipped than the previous mills for concentration. In Mill D, 37-1/2% of the values are recovered by concentration and 52-1/2% by cyanide. The concentrating costs are not obtainable, but figuring from another mill the cost per ton of ore for Mill D is about 35¢. The annual report of the company shows that the gross value of metals recovered was 90-1/2%, but the total net receipts were only 85%, thus giving 5 -1/5% as the total cost of marketing the concentrates and bullion. An annual report of Mill C shows that it requires 2% of the gross value of the bullion to market it, while with concentrates it requires 10%. If the concentrates could have been shipped as bullion from Mill D, the saving would have been 8% on 37-1/2%, or 3% of the total value of the ore. This loss for freight and treatment was accepted as the best practice, even in all sliming mills, because concentration had always been considered necessary on silver ores, and no metallurgist, even though he doubted the necessity of it, cared to risk his reputation by building a mill without a concentrating floor. The success of the all slime treatment and the high cost for freight and treatment of the concentrated sulphides in districts far removed from smelters led to the experiment in certain Mexican districts and in Mill E of temporary suspending concentration to watch results. In certain Mexican mills, according to the Mexican Mining Journal, concentration was abandoned, because although the extraction dropped from 1 to 2%, the net returns, after marketing, were greater than before. In Mill E, by adding another agitator, giving one-third longer agitation, and by grinding to a slime, of which 90% passed through 200 mesh, the tailings remained the same.

After four months of operation the solutions showed no apparent fouling and the zinc boxes gave as good precipitation as before. At the time of the change in Mill E, I estimated the saving as follows. Each ton of concentrates shipped contained 400 ounces of bullion, of the gross value of 70¢ an ounce, or $280.00 per ton of concentrates. The consumption per ounce of bullion had been 21/100 -lbs. sodium cyanide and 6/100-lbs. zinc. This, at 26¢ for the sodium cyanide, and 12¢ for zinc shavings, amounted to 6.18¢ per ounce. If the 400 ounces in the concentrates took the same ratio per ounce, the cost for cyanide and zinc would be $24.72 per ton. The cost of marketing the 400 ounces of bullion at 1¼¢ per ounce gives $5.60. The pesent cost of marketing one ton of concentrates is $42.00. If we subtract the total chemical and marketing costs from the marketing of the concentrate cost, we have $9.28 per ton of concentrates in favor of the cyaniding of the concentrates, or as the concentrates amount to 2%, 18.6¢ per ton of ore. As to shifting of other costs within the mill, it will eliminate all concentration costs, it will increase the agitating, precipitating, and refining costs, while the settling and filtering costs will scarcely be affected. The agitation costs will be affected by the one-third longer agitation, with its power, heat and upkeep costs, but the labor costs remain the same, as the same shift man takes the additional labor involved. The precipitation costs will be increased by the additional labor involved. Since this mill saved 55% by cyanide and 35% by concentration, the labor of precipitation is increased in proportion to the ounces of bullion precipitated, then it will be increased 35/55, or 7/11. The refining costs should be increased 7/11 of its total cost. This mill does not sub-divide its mill costs, and to get the approximate costs we will take these costs from Mill C on about the same grade of ore, with just allowances for differences in the mills. The concentration costs should be 30¢ per ton of ore, or fifty times 30¢, giving $15.00 per ton of concentrates. The agitation costs, outside of labor and cyanide, should be about 20¢ per ton of ore, and increased one-third, would be 7¢, or $3.50 per ton of concentrates. The labor of precipitation amounts to 1/2¢ per ounce, or $2.00 per ton of concentrates. The total cost of refining is about 1¢ per ounce, or $4.00 per ton of concentrates. From the above the saving, in eliminating concentration, gives $15.00 per ton of concentrates, and the additional cost for agitating, precipitating and refining gives $9.50, ~~ex a saving of~~ plus 50¢ for small additional costs in settling and filtering, gives a saving of $5.00 per ton concentrates, or 10¢ per ton of ore. This, added to 18.6¢, gives 28.6¢ per ton of ore. On $14.00 ore this would mean a saving of 2%, or, allowing the extraction to decrease 2% and still be milling as economically as before. After four months in Mill E, the fact was established that the cyanide consumption per ounce of bullion, instead of increasing or remaining the same, was actually diminished. The same amount of cyanide as before nearly sufficed, which means with 63.6% more bullion, a lowering of 40% in the consumption of cyanide per ounce of bullion. Every mill man knows that the richer the ore, the less consumption per ounce of bullion. The explanation is that only a fraction of the cyanide is consumed in dissolving the precious metals, the remainder being consumed by cyanacides in the ore, by evaporation and leakage, by reaction with zinc and by discharge with filter tailings. It appears that the concentrates must be freed from cyanacides by the time they pass through in the batteries and tube mills so that when allowed after that to stay with the slime they consume only the cyanide necessary for dissolving the values. Since the cyanide consumption was figured on that added for four months, without figuring the actual amount in solution in the mill, at the beginning or end, there may be a decline here not taken in account that would increase the cyanide consumption a small percent, which would make it appear more reasonable. A reliable chemist at Mill B, after a series of tests on cyaniding the concentrates alone, gave the consumption of cyanide as 1-lb.potassium cyanide for each pound bullion, which here would be $15.00 per ton of concentrates. I, like many others, fail to realize the outside factors mentioned above and that, at the most, the extra cost for cyanide, at a wide margin, does not exceed $5.00. In precipitation likewise the extra cost is not proportional to the bullion content of the concentrate, as here also all the zinc is not consumed in precipitating the values, as part reacts with the cyanide, which depends on the strength of the cyanide in the solution and not upon its metallic value. The rest of the estimates remaining practically the same, the reduction in the cost of cyanide and zinc from $24.72 per ton to $7.22 per ton, gives a saving of $18.50 over the original estimate, or 35¢ per ton. This makes, based upon a four months' trial, a saving of approximately 28¢ plus 30¢, which, on $14.00 ore, means ~~4%~~. 4½%. There is still a question in my mind whether or not the total mill solution may not slowly become foul and reducing in its action, resulting in a gradual reduction in extraction, but since four months have not developed this result, the chances seem small that it will develop. It may ~~not~~ work successfully on low grade ore of $15.00 value, but when the value increases to $30.00, the solution may not keep as pure and the agitation might have to be continued to an extreme length, while concentration costs would be lowered on account of the greater tonnage of concentrates. If there is a metallic silver content in the ore, as with mill C, the concentration is absolutely necessary. In Mill D, the superintendent states that the concentrates are of such a nature that it is necessary to remove them before cyanidation, but since the ore of Mill E is of similar character and value to the ore in the proposed 120 ton mill, I believe the computed saving and the actual demonstration of it sufficient backing to eliminate the concentration floor, and in place add a third greater agitating capacity. The amount saved in construction costs would easily total ten thousand dollars, which in this case would mean 20% of the remodeling cost.

Agitation

The question of the method of agitating the slimes is of paramount importance, both from the standpoint of cost and extraction. Agitation by revolving wooden arms alone or by centrifugal pumps alone, it is sufficient to say, fail in the above essentials on silver ores. Aeration of the pulp is necessary and the combination of aeration and air lifts with either of the above, as in Mills B and C, gives good extraction, but at a high power cost. In Mill C, the Hendryx agitator is used with very satisfactory results, but with the power consumption of six horse power per tank in which 35 tons of slime are in agitation in a 1.30 pulp specific gravity. This is one horse power per 5.83 tons of slime.

In Mill E, Trent agitators are used, and compressed air admitted in the pump discharge. The charge per 24 x 16-ft. tank is approximately 80 tons of slime in a 1.25 pulp. The motor requiring 6.8 H.P. and the compressed air 2.2, or a total of 9 H.P., or 1 H.P. per 8.88 tons dry slime. In Mill A, of District B, Pachuca tanks of 15-ft. by 45-ft. are used, which contain 80 tons of slime in a 1.35 pulp, the motive power required for the compressed air being close to 6 H.P. or one horse power per 13.3 tons. The Hendryx agitator has a high power consumption, excellent agitation, depends for aeration only on the flow of the pulp in a thin stream over an apron, and has the disadvantage of a vertical shaft drive, with a step bearing in the tank. The Hendryx also requires a cone bottom, with its high cost, and a capacity of only one third the space occupied. Unlike the Pachuca, this fault is not over-shadowed by the great capacity of the cylinder above.

The Trent agitator has a fairly high power consumption, an excellent agitation, aeration sufficient but not excessive, a simple and effective mechanical drive, but one that has a steady wear on the centrifugal pump. The Pachuca has a low power consumption, excellent agitation, an aeration that is excessive and a drive that has no mechanical parts, and only one small wearing part.

From the above it is evident that the Trent and Pachucas are the leading agitators. They differ widely in construction, the Trent being used in flat bottom tanks, usually wodden, of large diameter, and a height of about three-fourths of the diameter, and besides the revolving arms and grit proof bearing of the agitator, the complete equipment requires a motor, a centrifugal pump and large pipe connection. The Pachuca tank is of sheet steel, of a height three times its diameter, usually 10 by 30-ft. or 15 x 45-ft., containing a steep 50 degree cone at its bottom. A central pipe, made 1" in diameter, for each foot in diameter of the tank, and an air pipe of small diameter completes the equipment. A Trent agitator 24-ft. x 16-ft. in height, with a capacity of 7000 cu.ft., capable of agitating 80 tons of slime in a 2-1/2 to 1 pulp, costs complete, including tank, agitator, motor, pump and piping, $1400.00. A Pachuca, 15 x 45-ft., with a capacity of 6800 cu.ft., capable of agitating the same charge of 80 tons of slime, weights 35,000-lbs., and at 5¢ per lb., plus 2.6¢ freight, the cost delivered becomes $2660.00. In addition, the cost of erection would be at least 25% in favor of the Trent.

The length of agitation to get the same extraction would be practically the same, yet upkeep of the Pachuca would be practically nothing, while the Trent would require $5.00 for pump liners, etc. per month. Both will start after a shut down of many hours without trouble. The Pachuca will agitate sandy material, while the Trent requires a fine slime. The excess air in the Pachuca certainly has the effect of increasing the cyanide and lime consumption by oxidation, while in the Trent, since agitation is by mechanical means, the air is added in the pump discharge just in the amount for best extraction results and appears as minute air bubbles slowly ascending through the charge.

The first cost of a tank for 80 tons of slime is $1260.00 in favor of the Trent, which with erection will amount to $1350.00. The Trent will require 3 H.P. per month more , which at $10.00 H.P. Month, plus $5.00 upkeep, amounts to $35.00. This excess of operating cost will balance first cost at the end of 38-4/7 months. After that the Trent will cost 3¢ per ton more for 48 hours agitation. The probable saving in chemicals is not considered in this estimate, but it is my personal opinion that it is a factor that on the high cyanide solutions used in silver ores will counterbalance the greater cost for power. The Trent has its best application to a mill site on a mild slope, where its low height may allow a gravity flow of pulp, and allow of symmetrical building construction. The Pachuca has its best application on a steep mill site where its height is convenient in the mill construction and can be charged with little pumping. In the case of remodeling Mill A to 130 ton mill, the features of the Trent make it especially applicable. The building for slime agitation is broad and low, allowing two 24-ft. Trents abreast, with plenty of head room and only a six foot difference in level between top of thickeners and top of agitators. With the Pachucas it would be necessary, even with the smaller sizes, to reconstruct the building, besides giving a 20-ft. difference in level between tops of thickeners and agitators. Forthese special reasons I believe the Trent the best installation to make. Another reason for the choice is that I wish the design of the mill to be such that after it is running smoothly it can be made to do continuous settling and agitation. Four Pachucas will not eliminate the chances of a small percentage of slime passing through the agitators without sufficient treatment, while I believe the form of agitation in Trent would eliminate this possibility.

Filtering

The method of slime filtering is one of the important problems in a mill site. Since every mill in the district is using Butters filters, it would seem that it has many advantages. At the time of its introduction, its only rival was the Moore filters. TheMoore people ask royalty, while the Butters Company sold the rights of use with the leaves. The centrifugal pump, with slime pulp and liquids to handle, appeals to the average mill man as a better unit than a heavy traveling crane, with its basket and solid slime cakes. The early installation of Butters leaves, with cocoa matting, were a source of great trouble and low capacity, but with the use of the modified leaf its efficiency and capacity made it a favorite. Of late years there has appeared, in the Oliver filter, a serious rival, its great advantage being in its continuous operation. My objection to it for use on slime pulp that contains a cyanide solution of both high metallic and chemical values is that it cannot wash its cake thoroughly enough in the limited arc of rotation given to washing. It is not flexible in its cycle. The price asked for a 100 tons filter is so nearly that of a Butters installation of 50% greater capacity that there is offered no incentive to attempt its adaptation to the conditions.

Another rival of the Butters is the Burt horizontal filter. It is, in my opinion, the best designed pressure filter on the market. It is simple in construction, simple in operation, requires no pumping back of pulp, weak solution or wash water, forms a thick cake under 40-lbs. pressure that should wash excellently, and discharges at one end a thick pulp only 20% moisture. This type of filter is new and its possible defects not common knowledge. The points I have against adopting it are first, Mr. Burt's wash curve shows that with one replacement of water in the final cake only percentage of the soluble values are removed. Second: The discharged material is so thick that on a slight grade to the tailings pont, as in the case of Mill A, water equivalent to that discharged by the Butters Filter must be added as the cheapest method of carrying it away. Third: The quotation made by Mr. Burt on two filters, necessary to filter 120 to 150 tons, is also 50% in excess of the Butters installation, without any positive assurance that it will save the difference in cost.

The Butters has its weak point in repairs to leaves, the gradual enriching of both weak solution and wash water, from contact with the slime cake, and in solution the values left in the cake, after an equal displacement of water in the final wash. It has the advantage of a simple unit, a leaf easily inspected and of a cycle that can be varied at the will of the operator, and of a solution treatment of the cake during the solution wash that can be prolonged as long as additional extraction warrants it. In the early installation the price of a single filter leaf being $80.00 to $100.00, the plants were inadequate and working under pressure. Now, with the price of $35.00 a leaf, it is the cheapest installation and should be installed in sufficient number of leaves to allow an easy cycle that can be prolonged if found benefichl to extraction, or if it interferes with other duties of the shift man at any time.

Stock Tank

The Butters filter stock tank, or the supply tank which takes the charges from the agitators and feeds to the Butters filter should have a capacity 1-1/2 times that of an agitator in order that unless there is a serious delay in the filters it will not be noted in the cycle of charges. This tank should also be provided with a method of agitation to keep the slime from banking up in the tank. In Mills B and D, arms are used. In Mill C, pumps are used. In Mill E, a Trent agitator. In all cases, the power consumption is high. I favor the use of a Dorr thickener for this purpose. If it were simply used in place of arms it would keep the pulp from packing, and the frequent pumping back of pulp would minimize the settling effect. Used this way, it would cut the power bill many times over the other method, however, there are other advantages to be gained.from its use as a settler by combining its use with that of a smaller tank, of somewhat less capacity than the Butters filter tank. The stock tank would receive the agitator charge of 1.25 specific gravity, and feed a pulp of 1.50 specific gravity to the smaller tank and deliver clear rich solution to the zinc boxes. This would also shorten the time of formation of the filter cake. In addition if the plant is to be run on continuous decantation and agitation as the plans for the remodeled mill makes easily possible, precipitated solution will be added to the pulp as it flows continuously to the stock tank. An equal volume of solution plus the volume gained by the thickening of the pulp will overflow the tank to the precipitating boxes, while the thickened pulp will contain solution of but one-half the value of the inflowing pulp. This will shorten the time of wash required in the filters or with equal time of wash will decrease the loss of soluble values in the tailings.

PRECIPITATION

In the precipitation of the silver bearing solutions the choice lies between the installation of zinc thread and zinc boxes or zinc dust and zinc dust presses. Mills B, C, and E use zinc thread. In mills B and C the boxes are flat bottomed and rest directly on the concrete floor that is the lowest level of the mill. In cleaning them all precipitate from these boxes must be raised out of them, which means additional labor costs and time consumed. In mill E each compartment of the zinc boxes has a hopper bottom, and all the hopper bottoms drain into the same vacuum sump tanks. From knowledge of labor costs in both mills B and E for cleaning up and redressing the boxes, I would place the labor costs at mill E at one-half that of mill B, the tonnage, values precipitated, and cubic feet of zinc the same.

At mill D the zinc dust is fed in the pump suction and is collected in the zinc presses. The installation has the distinct advantage of economy of space and security of product. However, in a silver mill the latter point is of little importance. Both methods precipitate equally as well, but the zinc dust method has a marked advantage, in that it allows a complete recovery of all the values precipitated up to the clean-up, while with the zinc thread there remains in the zinc boxes all the ~~boxes~~ values which lie in the partly consumed zinc. The regeneration of cyanide is evident in both cases, and if the adherents of the zinc dust method can claim regeneration, it is due to the gases formed remaining in the solution, the zinc box adherents can also claim that a large ~~form~~ part of the gases formed in the boxes are entrapped by the zinc filaments and remain in contact with the zinc as long as in the zinc dust method. As to the labor involved, the zinc dust method of Mill D takes the minimum labor. In Mill E, with boxes cleaned up bi-monthly, the clean-up can be made in equal hours of labor, but between clean-ups the presses require no labor, while the boxes require two hours a day, however, from a superintendent's report on Mill D, giving the cost of twill, for the presses for which there is no balancing ~~for the presses~~, cost in the zinc thread process at a figure that would more than balance this later.

As to the zinc consumed, a company superintendent's report of Mills B and D ~~were~~ where nearly equal percentages of solution were precipitated, 81,000 in one month and 95657 in eight months, giving nearly equal ounces of fine bullion, 294112 to approximately 325000, the ounces of zinc consumed per ounce of bullion were approximately .08-lbs. against .128-lbs. The thread, @ 10-1/2¢, and the dust @ 8.2¢, makes the cost per ounce of bullion .84¢ against 1.05¢, or 25% greater for zinc dust. The total cost in each place for the precipitation and clean-up checks very closely. In Mill E, which can clean up for one-half the labor cost of Mill B, the consumption of zinc per ounce of bullion is .06. In Mill B, the metal in precipitate is given as 71-1/2%, that in Mill D as 51.7%. This difference is due to the presses collecting all the fine silica that flows through the zinc boxes, as neither plant clarifies the silver bearing solutions. The free zinc in Mill D's product is 12 to 20%, which explains the higher zinc consumption.

From point ofcost of installation, the average price for the Merrill system of zinc dust precipitation is on the basis of $10.00 per daily tonnage precipitated, i.e., for 500 tons precipitated, the cost of installation would be $5,000.00. The cost of zinc boxes for an equal tonnage would be less than $1,000.00. The Bosqui zinc dust installation, in which the solution is automatically fed into, precipitated by zinc dust in, and pumped out of two small Trent agitators, alternately, and then pumped through presses to filter out the precipitate, is, in my opinion, a better system than the Merrill, and the price of installation is about the same as Merrill's in the above case.

Undoubtedly the high cost of zinc dust installation is due to patent rights, and to the actual cost of the heavy presses. I cannot see where the installation of the zinc dust precipitation, with its greater first cost, will repay for itself, and I believe the best installation for Mill A will be large zinc boxes, fitted with a hopper bottom to each compartment.

Refining

In drying the precipitate, Mills B and C use muffle furnaces, while Mills D and E use steam drying plants. The heavier cost of the furnaces, the maintenance cost for muffles, and the wasted heat, makes the furnace an unsatisfactory installation compared with the cheap, simple and economical steam drying plant.

For melting down the precipitate, mills B and C use coke furnaces, while mills D and E use oil. The coke furnaces are slow to heat, require an expensive fuel and are not easily regulated. The oil furnaces heat rapidly, use the same feed as the boilers, which is the cheapest fuel in the district, heat to a white heat if necessary and the heat can be regulated in a second by a twist of the wrist. If the operator understands the oil flame, his crucible will last as long as in the coke furnaces. For these reasons I favor the installation of a steam drying pan and an oil fired furnace.

Proposed Arrangement of the Units Chosen

The number of each units to be installed and their relative position in the remodeled mill, and the flow sheet of the mill is given in the following enclosures; that accompany this thesis and are my work:

No.1 A blue print showing location of mine and mill and proposed aerial tram to and tailings flume from the mill.

No.2. A blue print showing the arrangement in Mill "A before remodeling.

No.3. A blue line print of the floors and roof in the mill to aid in designing the new arrangement.

No.4. A blue print of the proposed remodeled mill.

No.5. A tenative flow sheet for the mill.

Jay A. Carpenter

Tonopah, Nevada, May 1, 1911.

FLOW SHEET

REMODELED MIDWAY MILL (I20 TONS A DAY)

IA, 2A,& 3A When 70 T. Mine Ore and 50 T. Tailings

IB,2B,&3B " I20 T. " " only.

IA 20 Stamps
Feed- Through I" Ring
Screens- 20 mesh — Ore 70 T.
6 T. Sol. to I T. Ore. — Sol. 420 T.

2A 2 Dorr Duplex Classifiers
Feed (I) From IA — Ore 70 T.
ALL below 20 mesh — Sol. 420 T.
25 % " 200 "
(2) Tailings — Ore 50 T.
All below 30 mesh — Sol. 300 T.
Sands 37% below 200 mesh
Slimes 69% " " "
(Screen test - Jan. I907)
Tailings- To be broken up by solution in an air agitator outside the mill and flow by gravity to #2

Discharge (I) To the Tube Mills(#3) — Ore 86 T.
ApproximatelyAll above 200 mesh. 54% Ore 46% Sol. — Sol. 73 T.
(2) To the Dorr Thickeners(#5)
Ore- Approximately 86% below 200 mesh — Ore I20 T.
— Sol. 720 T.

Total tonnage handled

From #I	(I) To #5	Ore	I20T.	Sol. 720T.
From #3	(2) (Return)	"	86	73
" "	(3) I0% 2nd Return		8.6	7.3
			2I4.6 T.	800.3 T.

Ratio 3.75 :I

3A. 2 Tube Mills (5 by I8)
Feed- As above
Mill-Discharge in one passage 90% slime product
I0% goes through a second time.

4A Bucket Elevator
Takes total discharge from #3 and delivers it to #2
Amount- Same as feed to #3 plus I0% return — Ore 94.6 T.
— Sol. 80.3 T

5 Dorr Thickeners 4 I6 by 8 Tanks
Feed- Total discharge from #2 by gravity — Ore I20.0T.
— Sol. 720. T.

Discharge - All the ore as a 2½:I Pulp
to the Agitators by #8 — Ore. I20 T.
— Sol. 300 T.

(2) Solution to the Circulating
Tank(#6) by gravity — Sol 420 T.

IB 20 Stamps
Feed- Thru I" Ring
Screens- 4 mesh — Ore I20 T.
6 T. Sol. to I T. Ore — Sol. 720 T.

2B 2 Dorr Duplex Classifiers
Feed- As above all below 4 mesh, by gravity — Ore I20 T.
I0% below 200 Mesh — Sol 720 T.
Discharge (I) To the Tube Mills
All above 200 mesh — Ore I08 T.
By gravity — Sol 92 T.
(2) To the Dorr Thickeners — Ore I20 T.
Approx. 86% below 200 mesh — Sol. 720 T.

Total tonnage handled

		Ore	Sol.
From #I	To #5	I20 T.	720 T.
" #3	Return	I08 T.	92 T.
" "	33% 2nd Return	36 T.	3I T.
		264 T.	843 T.

Ratio 3.2 : I

3B 2 Tube Mills (5 by I8)
Feed as above — Ore I08 T.
Discharge-In one passage 67% slime product — Sol. 92 T.
33% must be returned a second time

4B Bucket Elevator
Takes total discharge from #3 and elevates it to
#2 including the 33% return — Ore I44 T. / Sol I24 T.

5 4 Dorr Thickeners (I6 by 8) Settling area — Sq. Ft. 804
Same as given above under "A" series and the remaining units are the same in both cases

6 I Circulating Tank (20 by I2) I0 ft. used — Cu. Ft. 3I41.6
Sol 98.3 T.
" 420 T.
Feed - From #5
Holding Capacity 5 Hrs. 36 Min.
Discharge - To Battery Storage Tanks by #7

7 I Circulating Pump — Per Day 420 T.
Work I7.5 T. Sol. per Hr. against a 25-30ft. head. — " Min. 70 Gal

8 I Slime Pump
Pumping 420 T. 2½:I Pulp against a 22 ft. head
Continuous pumping- I7.5 T. per Hr. (462 Cu. Ft.) — " Min. 70 Cu Ft
(On approx assumption that a 2½:IPulp
I T.-26.4 Cu. Ft. and IT. Slime to this dilution - 90 Cu. Ft.)

9 3 Trent Agitators (24 by I6) Each - 7240 Cu. Ft. — Ore 80 T. / Sol 200 T.
Total holding capacity — Ore 240 T. / Sol 600 T.

This -48 Hrs. supply-Giving 48 Hrs Agitation when treated continuously.
#I Agitator 2 Ft. above #2, #2 2 Ft. above #3-With pulp flowing continuously through them.
By thinning the pulp- less hours of treatment
thickening " " - more " " "

10 I Butters Filter Stock Tank (28 by 22) 13,500 Cu. Ft.
Fitted with a Dorr Thickeners
Feed- Receives from #3 Agitator by #11 — 462 " " per Hr.
Holds- 29 Hrs. Supply
Discharge - To Butters Filter, by gravity — Per day Ore 120 T.
Thickened to a $1\frac{1}{2}$:1 Pulp — Sol 180 T.
-(#2) Overflow to Gold Tanks by gravity — " " Sol 120 T.

Size of tank allows #1 Large storage capacity in case of shut down in Butters Filters
#2 Gravity feed to Filters

Dorr Thickener allows
#1 For addition of precipitated solution to agitator pulp to reduce the value of the solution in the filter cake which shortens the time of necessary wash.
#2 For the thickening the pulp for the filters which saves power and shortens the time of forming the cake.

11 I Pump
For transfering pulp continuously from the last agitator to B. F. Stock Tank — Ore Per Day 120T.
Sol. 300 T
Pumping per min 77 CuFt

12 2 Emergency Tanks (28 by 5) Total 6,158 Cu. Ft.
Contain arms for agitation.
Connected by B. F. pump with any one agitator to empty it for repairs when necessary.
Can be used at any time for solution storage ~~.~~ as extra gold or precipitated solution tanks.

13 Butters Filter (100 leaves) With acid bath. Capac. Cu. Ft. 4436
Equipped with 6 in. Centrfugal Pump
and 10 in. by 10 in. Knowles vacuum pump
From experience of the camp, a 3/4 inch cake on the leaves ~~and~~ gives 20 T. of slime, and 6 4Hr cycles gives 120 T.
and to the gold tank Sol. 180 T.
IF Tonopah Extensionpractice is followed
$1\frac{1}{2}$ in. Cake - 40 T. 3 8 Hr. cycles This saves time required to tend to the filter
Computations-Volume of leaves 500 Cu. Ft. 4436 - 500= 3936
Charge of Pulp-3936 Cu. Ft.
Volume of $1\frac{1}{2}$ in.Cake at 160 Sq. Ft. per leaf — - 1000 Cu. Ft.
Volume of wash solution and wash water per charge — 2936 " "
to fill the filter tank.
Cake as formed and notair dried - 62% Ore and 38% Sol
$\frac{3}{4}$" Cake will contain 12.2 T. Sol.
Solution removed from the $1\frac{1}{2}$:1 pulp in forming the 20 T. cake - 30 - 12.2 or 17.8 T. or 570 Cu. Ft.or 11 in. on the Stock Tank to keep it full during the forming of the cake. ~~to kee-~~
The original charge of pulp requires 6 Ft. 5 In. from the Stock Tank, which makes a total of " 4 " required to flow in by gravity from #10.
If 2 T. wash solution are put through for each ton of slime in the cake = 40 T. Sol.= 1280Cu. Ft.
Volume of wash solution required 2936 plus 1280 - 4216 Cu. Ft.
If 1 T. wash water is used to replace each ton of wash solution in the cake - 12.2 T. = 390 Cu. Ft. Total volume of wash water required 2936 plus 360 =3296 Cu. Ft.

I3 B. F. Con.
Discharge- Slime, by gravity to waste
Solution by vacumm to #I6

~~I4~~
I4 3Wash Solution Tanks (I6 by 8) Capac. of each I608 Cu. Ft.
" " all 4824 " "

This gives 608 Cu. Ft. above that required as figured in #I3

I5 3 Wash Water Tanks (I6 by 8) TOtal Capac. 4824 " "
Thi s gives I528 Cu. Ft. over that required in #I3.

I6 2 Gold Tanks I (20 by I2) Capac. 3780
I (" 6) " -I890--
5670 Cu. Ft. or I77 T.

Probable amount of solution to be precipitated
3 T. of Sol. to I T. Ore 360 T.
to 4 T. 480 T.
Holding capacity I2 or 9 Hrs.

I7 Precipitating Boxes For 360 to 480 T. Solution

I8 Sump Tanks 2 (20 by 5) Total Capac. 3,I4I6 Cu. Ft.
or 98.5 T.

Holding capacity 6.5 to 5 Hrs.
Take precipitated solution from #I7

~~20~~
I9 Battery Storage Tanks 2 (20 by I2) Total Capac 6850 Cu. F t.
2I4 T.

Solution required for #I 720 T.
Holding capacity 7 Hrs.

20 Pump
Work 400T. from #I8 to #I9, #14 being against a 50 Ft. head.