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Milling at Cananea

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MILLING AT CANANEA

by

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A

T H E S I S

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General Description of Plant:

The Concentrators are located at a point central with regard to the mines, and quite near the smelter. As there are no streams to furnish water no regard was given to this point in placing the mills. Photograph No. 1 gives an idea of the site. Advantage is taken of the steeply sloping side of a gulch. Two auxiliary vanner plants, top of one shown at 4 in the photograph, are located on the opposite side of the same gulch and low enough to be fed by gravity from the tailing-settling system of Concentrators 1 and 2. The crushing plant is separate from the Concentrators proper.

The older plant is No. 1, which has been in service 17 years. It is constructed of wood and covered with corrugated iron. It's two sections "A" and "B" are run independently. Their combined capacity is 1500 tons each 24 hours under favorable conditions.

Concentrator No. 2 is a steel building, covered with corrugated iron. It's two sections "C" and "D" are run independently; capacity, 1800 tons.

Power is furnished by a battery of Stirling boilers burning oil. Compound Corliss engines in "1" and"2" are belted to mill shafting. Electrical power, both direct and alternating current, is supplied by the main power station at the smelter. The crushing plant and mills 3 and 4 are run by motors, which are also used on the conveying system.

Kinds of Ore Treated.

Class I. Hard Ore. Analysis: Cu 2.50%, Si O_2 and Al_2O_3 82.8%, Fe 4.2% S 5.6% Ag 2.8 oz. Au 0.01 oz. Ore minerals: Chalcocite, pyrite, chalcopyrite. Gangue: Quartz, kaolin and clay, quartz predominating. Ratio of concentration 7 into 1. This ore is milled in one of the sections of No. 1, which is better able to handle the hard ore than Concentrator No. 2.

Class II. Medium Hard Ore. Analysis: Cu 2.60%, Si O_2 and Al_2O_3 76.4% Fe 5.6% S 4.4% Ag 1.2 oz. Au 0.01 Oz. Ore minerals: Chalcocite, pyrite, chalcopyrite and native copper. Gangue: quartz, kaolin, clay, talc, etc. Concentration ratio 6.5 into 1. This ore also is preferably treated in Concentrator No. 1.

Class III. Soft Ore. Analysis: Cu 3.08%, Si O_2 and Al_2O_3 62.6% Fe 13.4% S 12.7% Ag .11 oz. Ore minerals: Pyrite, chalcopyrite, chalcocite. Gangue: quartz, kaolin, talc, etc. This ore contains so much pyrite that its concentrate is lower in Cu and Si O_2 and higher in iron than the concentrates of ores of classes No. I and II. The concentration ratio is 3.5 into 1.

All these ores make large quantities of fine values and much slime. Ores II and III contain much talcose and clayey material. Lumps of this ore picked out in the crushing plant and rejected.

Crushing.

Crude Ore Bins.

The ore is brought from the mines over the Narrow Gauge Ry. in side-dump Ingolsby cars holding 25 tons each. It is dumped from the cars into the bins above the crushing plant. See Photograph No. 2.

From the hoppers of the bins the ore is fed onto a belt conveyor which discharges at the apex of two grizzlies making an undersize of one inch. Grizzlies are followed by two picking belts attended by six Mexican laborers. They pick out lumps of clay, talc, etc, pieces of rich ore, wood, steel, etc., throwing them into separate cars. The cars of "talc" are trammed to waste pile shown at W in Photograph No. 2. This waste pile does not grow for the material disintegrates under weathering action and is removed by a little stream. The picked ore is trammed to bin for shipment to smelter. The wood is also sent to bin for shipment. Large chunks of ore are removed from the belts and hand-cobbed to size which will enter the crushers. The picking belts discharge to crusher bins from which the ore is fed by plungers to five 10" x 20" Blake crushers.

The whole discharge of the crushers is fed to five 15" x 36" Allis Chalmers rolls set to crush through a one-inch ring.

The undersize of the grizzlies is conveyed on a belt marked U in the photograph to a long inclined conveyor O. The undersize of the rolls goes by conveyor R to O.

For wear of crusher parts and roll shells see table under "Crushing" below.

The crushing plant works one shift of ten hours per day, handling 2000 to 2200 tons, half of Classes I and II and half of III.

Cost of Picking.

Picked Ore	$00.1789	Gold, per ton picked out.
"Talc"	0.2572	" " " " "
Wood	1.2000	" " " " "

Cost of crushing and conveying to Mill Bins is 4 to 6 cents Gold per ton.

General Outline.

1. Conveyor. See photograph of Crushing Plant. To 2 and 3.

2. Sampling Plant. Sample. Reject by elevator to 3.

3. Bin conveyor with movable tripper discharge. To 4 and 5.

4. Concentrator bins, located at head of Mill No. 1. To 10, A and B.

5. Concentrator 2 Bins, 2800 tons capacity. These bins are shown at B in Photograph No. 1. To 6.

6. Conveyor marked C in Photograph No. 3. To 7.

7. Conveyor marked C. To 8C and 9. In an emergency the conveyors may discharge load to bin E. See photograph. From this emergency bin E, conveyor C' carries the ore back to 7.

8. C. & D. Concentrator 2, Sections C and D. Concentrates to concentrates bins. Tails to sand tanks 12.

9. The discharge of 7 is split, half going to Section C and half to 9 which is a conveyor marked 2, Photograph 3.

10. A.& B Concentrator 1. Sections A and B. Concentrates to bins. Tails to sand tanks (11).

11. Coarse and fine sand tanks. Coarse sand to 16 and fine sand to 14. Overflow slimes to 13.

12. Coarse and fine sand tanks. Coarse sand to 16, fine sand to 14. Overflow slimes to 13.

13. Settling tanks. Spigots to 14 and 15 and to 16. Clear water to Sump No. 1.

14. Mill No. 3. Concentrates to Bin. Tails to 16.

15. Mill No. 4. Same as 14.

16. Waste launder to dam (19).

17. Concentrates bins for 1 and 2. By narrow gauge to smelter.

18. Concentrates bins for 3 and 4. See B Photograph 5. By narrow gauge to smelter.

19. Tailings Dam. Clear water pumped to 20.

20. Precipitating Plant. See Photograph. Precipitate by Narrow Gauge to Smelter. Water to Sump No. 3.

Concentration, General.

The flow sheets afford a good general description of the process in use before present changes were instituted.

Mill One is the older plant so Number Two represents the more advanced practice.

The chief difference between the gneral schemes is in the regrinding arrangements. In both, the Bull and Coarse jig tails are recrushed in rolls. In Concentrator One, the 3/8" and fine jig tails are reground in fine rolls and passed through the 2mm trommel, and the 2mm sand jigs send their tails to the Bryan mills. Concentrator Two has 4 Bryan mills, to the section and regrinds in them both the 3/8" and 2mm tails. As a result of this arrangement it is found to be more economical to treat the ores of Class I and II, which are harder than Class III in Concentrator One. The fine rolls are positive machines, but it is found that the hard ores of Class I make considerable trouble in the Bryan mills, lowering the capacity. Little marbles of 3/8" hard quartz accumulate in the Bryan mills until they have to be removed by hand.

Concentrator Two has fine sand jigs on the table floor which handle the first spigots of the 1 1/2mm classifiers. Mill One depends upon Wilfley tables.

Study of the flow sheet shows that graded crushing and close sizing are practiced. No attempt was made to maintain a constant ratio between successive sizes. The 2mm and 1 1/2mm products are classified.

No tails are made by any apparatus treating material coarser than 1 1/2mm.

Harz jigs are used throughout . The classifiers are of the simplest type. Wilfley tables and Frue runners have held their own, though all standard machines have been tried out at the plant.

A notable feature of the practice is the extensive provision for the treatment of fine material. The following screen analyses of the products passing the 2mm trammels in the mills shows why this is necessary.

	Through 2 mm		(% Weight)
	Mill One		Mill Two
	Section A	Section B	Section C & D.
Character of ore	Class I.	II	III
On 20 mesh	23.8	15.5	19.3
40 "	24.8	17.8	11.7
60 "	14.6	11.9	11.1
80 "	3.0	2.6	3.6
100 "	4.5	4.0	4.4
150 "	5.6	7.0	5.7
200 "	1.6	2.2	3.2
Thru 200 "	9.0	2.3	3.2
Slimes,	16.5	36.6	38.0

The large quantities of slimes(product passing 200 mesh which will not settle out in 2 minutes quiet standing) makes it necessary to have a large number of vanners.

The slimes made in the overflows of dewatering boxes and classifiers are sent to pulp thickeners. Of these, two types are used: (1). Round California Tanks. (2) V - tanks. (1). These are wood stave tanks shown at P in Photograph 3. They are fed by an inlet extending 1/2 way down into tanks, discharging thickened slimes by spigots and making clear water or thin slimes around the upper edge. The V - tanks are fed at one end and discharge clear water at the other, making thickened slimes from spigots. Settling tests show that the slimes quickly settle to a density of 3 of water to 1 of dry slimes by volume--after this, very slowly. The round tanks have been found to have much less settling capacity than simple V tanks.

Details of Practice.

Crushing--

Rolls. All rolls are driven by belt to one drive pulley. On the coarse rolls the idle roll is driven by a crossed belt from the same shaft. All rolls are protested by springs and provided with removable pillow block bearings. Extra sets of shells mounted and assembled upon their shafts, bearings, etc., are kept on hand.

It is the custom to "set up" the rolls in each mill daily. End adjustment is made when grooves develop. When worn to a thickness of 3/8" or less the roll with its bearings is removed and replaced by a new one. The repair gang of Concentrator One changes rolls in 30 minutes.

Photograph No. 9 shows a worn roll shell. The old shell is lined with a cold chisel and then broken off. The new shell is set on and fixed in place by iron and wood wedges. Where the rolls run wet, the shells stay in place well. Where dry crushing is practiced (as in the crushing plant) the roll core is kept filled with water which has access to the wedges through holes in the periphery of the core.

Bryan Mills:

There are several patterns in use. Recently an improved form designed by Mr. Cole has been tried out. It is a 6 foot mill driven by pinion below the mill and having a long vertical shaft. It is heavier and has a greater capacity than the 5 foot regular Bryan mill. Mullers with tires wedged in place and die rings are kept on hand to replace worn parts.

The Bryan mills give a more uniform product than fine rolls. On hard ores the fine rolls have much greater capacity. The power required by the Bryan mills is more than twice that used by the fine rolls. The advantage in the use of the Bryan mills is that it is not necessary to send the product to screen for sizing. Generally this means, as it does here, that this does away with an elevator to send the undersize of the rolls back to the trammels.

All steel used at the Concentrators for wearing parts is Midvale Armour plate. It costs $.06 1/2 a pound and is cheaper than any other.

Below is a table giving the life and duty of steel in the crushing machines.

Department.	No. Pieces		Size	Wt Set	Wear lb/ton crushed	Size Feed	Pro. Disc
Blake Crushers Crushing Plant	Cheek Plates Back Plates Jaw Plates	10 5 5		6783	.022	Minerun	1 1/2"
"	Roll She~~et~~s	10	36x16	13615	.044	1 1/2	1"
Concentrator #1	Roll She~~et~~s	4	36x16	5444	.067	1"	3/8"
	Roll She~~et~~s	8	24x14	7256	.061	5/16"	2mm
	6' Cole Chilean Muller	3	5'6"x7"	7892	.224	1/4"	1 1/2 mm
	Cole Chilean Die Rings	2	5'x7"				
	5' Bryan		~~7"~~	6502	.304	1/4	1 1/2 mm
Concentrator #2	Roll Shells	4	36x16	5444	.210	1"	3/8
	5' Bryan		~~7"~~	6502	.093	~~1/4~~ 3/8"	1 1/2 mm

Screening.

All sizing is done by means of cylindrical trammels, inclined and driven by pinion gears from lower end. Screens are punched steel. The water used in the mill carries copper sulphate, and the iron in pipes, screens, etc. is rapidly replaced by copper, causing short life.

Table of Trammel Details.

No. Used	Size Hole	Size	Slope	Tons pr/day	Speed	gal wash water min.	Life days
2	5/8	48x60	3/4"/1ft	800	16 RPM	120	70
2	3/8	48x64	3/4	950	16	60	70
2	3/16	48x64	3/4	790	16	35	30
4	2mm	48x96	3/4	700	16	80	12

Jigging:

Bull Jigs. Feed ranging from 1" to 5/8". Concentrates by gate discharge. Hutch product to elevator and into system. Tails are reground in coarse rolls.

Coarse Jigs. Feed, through 5/8 on 3/8, Gate concentrates. Hutch to elevator. Tail reground.

Medium Jigs. Feed through 3/8 on 3/16". Gate and hutch concentrates. Tail reground in Bryan Mills in Mill Two, in rolls in Mill One.

Fine Jigs. Feed through 3/16 or 2mm. Hutch and gate concentrates. Tail reground in Bryan mills.

Sand Jigs. Feed from successive spigots of 2mm classifiers. Hutch concentrates. Tail reground in Bryan Mill.

Fine Sand Jigs. Feed from 1st spigot of 1 1/2mm classifiers. Hutch concentrates. Tails to waste. In the recent improvements more fine sand jigs have been added to Mill Two and Mill One will also have this equipment added.

Below is given a table showing the distances and speeds of plunger thrown in the various jigs.

Jigs Treating	Plunger Throw	Times per Minute
Oversize 5/8"	2 1/2 Inches	110
" 3/8"	2 1/2 Inches	140
" 3/16"	1 1/4 Inches	160
" 2mm	7/8 "	175
1st Spigot, 2mm Classifier	3/8 "	200
2nd & 3rd " 2mm "	3/8 "	222
1st " 1 1/2mm "	1/4 "	240

Wilfley Tables.

Tables are fed with classified products each spigot of the Hydraulic classifiers being sent to a separate set of tables. Concentrates to fine concentrates bins. Middlings of tables handling coarser material are elevated and reground in the Bryan mills. Middlings from tables treating the finer material are elevated and retreated on specially adjusted tables. With the excellent classification resulting from the new system using the drag-belt, the tables are making a good showing.

Card Tables.

Mill 3 has 6 Card tables which working at a disadvantage, make a poor saving.

The Wilfley Tables in Mill 2, which are fed from the spigots of the classifiers, following the drag-belts make a good saving as indicated by the following average analysis.

Feed	Cu, %	1.86	SiO_2 and Al_2O_3	---
Conc	"	6.44	"	17.2
Tail	"	0.51	"	---

Vanners.

Six foot Frue Vanners are used throughout the plant. Smooth belts are mostly used in the two main concentrators; though both No. 1 and No. 2 have a few corrugated belts. Mill 3 has smooth belts and Mill 4 has all corrugated belts. It has been found that the corrugated belts make a slightly better saving on an all slime feed than do the smooth.

Slope. In No. 1 and 2 smooth belt vanners have a slope of 3/8" per foot. Corrugated belts are given a slope of 9/16 " per foot. Pulp fed to vanners carries 12 to 16% dry solids.

In Mill 3 the vanners (smooth belt) have a slope of 1/4 inches per foot. In Mill 4 the vanners (corrugated belts) are given a slope of 9/16 inches per foot. Pulp carries 10 to 12% dry solids.

Because a large percentage of the values goes into the slimes, the vanners of the two large mills carry a good load of concentrates and the saving is high. Yet it is found possible to retreat the tailings from Mills 1 and 2 after removing the sands (See 11 and 12 in the General Outline above) and thickening the pulp in large settling tanks. (General outline No. 13).

The vanners fail to save the finest values as the following screen analysis of vanner tails will show.

	A			B		
	% wt.	% Cu	% Total Cu	% wt.	% Cu	% Tot Wt.
On 100 mesh	12.3	0.59	7.9	5.0	0.32	1.8
150 "	18.8	0.35	7.1	6.8	0.25	1.8
200 "	6.9	0.47	3.8	3.4	0.32	1.0
Thru 200 "	8.6	0.81	7.6	3.5	0.77	2.8
Slimes	54.1	1.25	73.6	81.2	1.08	92.5

The product denominated Slimes is that part of the material passing 200 mesh (wet screening) which will not settle out in two minutes. The settled product is called Thru 200 mesh.

A, is from the very hard ore of Class I. B, is from the Class II. It will be observed that in the first case the slime carries 73.6% of the total loss in the vanner tail, while in the second it holds 92.5% of the total loss. A note upon the physical condition of these fine values is given under the caption "Nature of Slimes" below.

The saving of these extreme fines is the problem at present.

Classifiers:

The simplest type of classifiers is in use. It consists of a trough with parallel sides and regularly spaced pockets. The hydraulic water is introduced into a pressure box in the bottom of the pocket with which it communicates by means of a slit. The spigot discharge is opposite the hydraulic jet. See photograph No. 12, (E - C). Hose connections are used. The hydraulic water is drawn from a box "L" in which a constant level is maintained by a butterfly valve.

The difficulty encountered in the classification here is the disposal of the slimes. The screen analysis given above show that the undersize of 2mm screens carries 16% Slimes on ore of Class I; 36% on ore of Class II and 38% on Class III. When this product is fed to the hydraulic classifiers the results are not satisfactory, for the spigot products, which are designed for jig and table feed are contaminated with slime and the overflow slimes are too dilute to be fed to the vanners direct. The following screen analysis of 2mm classifier shows the effect of the slimes.

2 mm Classifier. Section B. Conc. No. 1.

Treating Class II Ore.

	Feed	Spigot 1.	2	3	4	5	Overflow
On 20	10.6	29.0	23.2	16.4	10.2	5.2	
60	30.6	51.0	46.0	55.8	55.4	44.2	9.6
100	10.2	7.0	8.0	10.2	13.0	14.4	10.0
200	9.6	3.6	5.8	5.0	7.0	10.0	15.6
Thru 200	7.0	1.8	3.4	3.0	3.8	5.0	10.0
Slimes	32.0	7.6	13.6	9.6	10.6	21.2	54.8

Tables and jigs do not save any of the values in the slimes, and so it is a great disadvantage to send them slimes.

To remove this large percentage of slimes, a sand and slime separator has been designed at Cananes. It does very good work as will be shown.

Drag Belt. In the first place, there has long been in use at Cananes a device for transporting table and vanner concentrates. It is a rubber belt with lugs or plows made of small pieces of belting riveted to the belt. The belt travels in a horizontal launder, dragging along the fine concentrates to the desired point of discharge. Photograph number Eleven

The sand and slime separator was derived from this concentrates conveyor. Photograph Number Twelve shows the drag belt in place in Mill Two at D R S, where it is fed with the product from the Bryan Mills B,B,B,B, (1 1/2 mm). The feed is introduced at the right end of the trough and the belt, which is sixteen inches wide and equipped with iron plows bolted on, moves the material along the bottom in the direction S R D. From the roller R to D the trough is sloped and the sand is dragged up the incline and discharged into E. The suspended slime does not settle, and overflows at S, from where it is sent to feed vanners. A spray washes the upper side of the belt at a point above the sand discharge. E is a revolving cylindrical tub, with a hole in the bottom, it's purpose being to distribute the product equally to four hydraulic classifiers, C C. See description of classifiers above.

The first spigots of the classifiers are sent to fine sand jigs, each of the following spigots to separate sets of tables. The overflow from hydraulic classifiers enters the V boxes at the ends of the classifiers proper. Diving boards force the feed downward and the spigots are placed on the outer side of the V boxes. These spigots also feed tables. The final overflow joins the slime from the Drag Belt going to the vanners. Below is given screen analysis of Drag Belt products.

	Per Cent Weight.		
	Feed	Slime Discharge	Sand Discharge.
On 20 mesh	1.6		11.2
" 40 "	5.0		21.2
" 60 "	7.2		23.2
" 80 "	4.5		9.0
" 100 "	5.8	3.9	10.6
" 150 "	9.5	8.4	11.2
" 200 "	5.2	5.1	3.4
Thru 200 "	9.0	11.3	5.7
Slimes	51.4	70.4	4.3

The Drag-Belt solves the problem of separating the fine sands from the slime.

As shown in the photograph, the sand discharge of the drag belt goes to four hydraulic classifiers.

Screen Analysis of Classified Products.

	Feed	Spigots 1.	2.	3.	4.	5.	6.	Overflow.
On 20 mesh	9.5	9.5		2.0	23.4	9.1		
60 "	42.6	58.4	30.2	51.3	30.1	21.7	4.2	
100 "	18.8	17.2	59.1	25.2	27.5	22.6	18.3	9.0
150 "	14.2	7.9	7.7	12.8	5.0	7.0	27.0	10.6
200 "	2.2	1.9	2.7	2.6	7.3		10.1	9.0
Thru 200 "	4.4	1.5	.5	2.4	11.0	11.9	14.6	7.8
Slimes	8.2	3.5	.4	4.7		27.5	25.6	63.6

The classifier requires little attention.

Richards Pulsator Classifier.

A two inch Richards Classifier was set up in Section A for trial. It was fed with undersize from the 2 millimeter trammel. Rated capacity 40 tons per 24 hours. Actual capacity doing good work: with feed containing 6 water and 1 ore by weight - 20 tons 24 hours; with feed containing 3 water and 1 ore by weight, 40 tons per 24 hours. A change in the ratio of ~~ware to~~ water to ore in the feed requires change in adjustment. A change in the quantity of feed necessitates readjustment. Adjustment is accomplished by changing the heights of the gates and regulating each compartment valve. Generally any readjustment involves making all the changes mentioned. As to capacity it may be stated that the apparatus was fed at the rate of 80 tons per 24 hours (double capacity) but the resulting products were not good.

When working at normal capacity the apparatus gave products which were as good as those shown by screen analysis of classifier in use. It was essential, however, that the feed be thick (not more than 3 of water and 1 of ore by weight). The manufacturers recommend even less water in the feed, but it was not possible to run the 2mm trammels with less water than was used.

It was concluded that the apparatus required more and more intelligent attention than the simple classifier in use in order to give equally good results. For use at Cananea the apparatus would have to be made of material which would not be attacked by the copper in solution in mill water.

Water Supply.

Primarily water is conveyed in pipes and launders from five of the mines to the concentrator sumps, from which it is sent to the mills direct or to the tanks above Mill 2 shown at the extreme left in Photograph No. 4. These waters contain from six tenths pound per thousand gallons to nil Copper.

Water for boilers etc., is taken from the general water supply mains which originate at the ~~Rio de Agna~~ Ojo de Agua east of Cananes.

Secondarily, the slimes of Concentrators 1 and 2 tails are settled in large V tanks shown at T in Photograph No. 4. The clear water made by these tanks goes to main sump and is pumped to tanks to go into circulation. The tails from Mills 3 and 4 and the sands from 1 and 2 tails are sent to the dam. (See photographs). Two barges equipped with centrifugal pumps, shown in Photograph No. 13, send the water from the pond to launder which delivers it to precipitating plant, from where it flows to sumps.

A number of centrifugal pumps are in use; but the larger units are Aldrich Triplex pumps. These have replaced centrifugal and other pumps, for it is found that the Aldrich are much more economical in repairs and power. A specific instance is the installation of two Aldrich pumps of 5000 gal. per min. combined capacity at the main sump. Formerly there were two stage worthingtons pumping 3300 gal. per minure, and using 280 horse-power. The Aldrich pumps use only 175 horse-power pumping 4000 gal. per minute, and cost much less for repairs, and lose less time.

The Sand Dam. It is situated near Mill 4, as shown in several of the photographs. The sand and slime tailings are sent to the dam in one launder. Opposite the boots of the four elevators are four packets in this launder. Sand with enough water and slime to make it flow in the distributing launders above is drawn from the packets into the boats and elevated. The slime free from sand flows on past the elevator boats and is sent to the upstream side of the dam, where the slime settles out leaving the water clear.

The elevators discharge into distributing launders. These launders are provided at regular intervals with pockets having spigot and hose discharges. The sand settles into the pockets and is distributed on the dam by means of the hose. The slime flows on and is sent upstream to make clear water.

The dam was built up from the bottom of the arrayo in the manner described. Elevators were necessary only at the last. Some of the buried trestle work may be seen sticking out of the dam.

This dam is almost finished and another larger one is being started. During the brief rainy season much water will flow in the arrayo and to dispose of this excess, a tunnel has been driven through the hill to the next arrayo.

The Precipitating Plant.

As the water received at the Concentrator contains some copper and dissolves some during the process, a plant has been put in to recover it. This is shown in Photograph No. 7, and at P in No. 5. From the lowest box the water goes to sump underneath Mill 3.

Under average conditions the water entering the plant from the pond carries .6 to .7 lb. copper per 1000 gallons. The outflow carries less than .1 lb. per 1000 gallons. The precipitate contains 40% copper, 20% Iron, 6% Silica, etc.

Scrap iron is piled into the boxes which are run full of water. A clean-up is made once or twice a month, the old iron scraped free from precipitate and enough fresh scrap added to fill the boxes. One lb. of Fe added in the scrap iron produces .7 to .8 lb. Copper.

Pipe.

The presence of Cu in the water in circulation results in a very short life for iron pipe. So wood stave pipe is used for all mains, etc., and rubber hose is used for many purposes for which iron pipe is employed in most mills.

Transportation of Materials.

Ore is brought from the mines and concentrates are shipped to the smelter by the narrow-gauge railway operated by the Company. For both purposes Ingolsby side-dump cars are used. The cars hold about 25 tons of crude ore or 35 of concentrate.

Launders.

All launders are of wood built rectangular in shape, with no constant ratio of width to depth. Steeply sloping launders are lined with thick glass or cast iron liners in sections 2 and 3 feet long. Other launders are lined with wooden slabs held in place by triangular beading.

For conveying concentrates in the mills shaking launders are used. The head motion consists of a toggle and spring and the launder is swung by flexible boards attached to the framing overhead. The slope varies with size of product, etc.

Concentrates.

The bins are set high enough to discharge by gravity into the railway cars. The overflow water from the concentrates bins is settled in flat bottomed mud tanks. The mud produced carries 5 to 6% Copper and is also sent to the smelter. The overflow from the mud tanks goes to the settling tank system to make feed for Mill 4.

The heavy concentrates stick in the bins, and a man is kept busy with a long iron pipe forcing the discharge. The pipe is connected with compressed air line and thus forms a very effective instrument for cleaning the bins.

Sampling.

Crude Ore. In the top of Concentrator No. 1 the long conveyor marked O in Photograph No. 2 discharges to a horizontal conveyor. At this point the crude ore is sampled. Deep rectangular buckets are attached to two chains which run on sprocket wheels at right angles to the stream of ore. The buckets pass under the discharge of Conveyer O, cutting the stream of ore at the rate of 8 buckets per minute. The chains carry the buckets out over a hopper into which they discharge when they turn upside down ~~from~~ for the return. The buckets take out one thirty-ninth of the total ore.

The sample mill consists of 5 sets of rolls and 3 Snyder samplers. The last set of rolls is set close. The sampler following the last rolls sends it's product to a coffee mill pulverizer. The undersize of the coffee mill passes through a stationary splitter from which the sample is taken. The final sample amounts to one fourteen-thousandth of the total ore. It is sent to sample rooms, bucked, and parted for assay.

Tailings. Photograph No. 10 shows the Scoby samplers used for tailings. The mechanism, not shown, is driven by belt from the mill shafting. Once every eight minutes the scoops are pulled quickly through the stream of tailings.

At present concentrates are not automatically sampled. As the cars are loaded from the bins, a dipper with a six-foot handle is swung back and forth through the stream of concentrates. From the 25 pounds taken from each carload, a moisture and an assay sample are taken.

Within the mills, sand jigs, feed, concentrates, and tails are sampled every half-hour by hand. This serves the purpose of keeping check on the work of the part of the mill above the sand jigs as well as the jigs themselves.

In Mill 2, the drag-belt products are sampled every half hour by hand. As the vanner tail and table and fine sand jig tail are automatically sampled ~~repeatedly~~ separately, the work of the lower division of the mill is easily observed.

Hand sampling is practiced for regularly studying the work of the various divisions which the daily routine does not include.

The samples are taken for the 3 daily shifts separately. The results of the assays for the 3 shifts of the preceeding day are posted daily in each section. This results in a rivalry among the shifts. When the tailings are high in copper, or the concentrate too high in silica, the shift boss is held responsible.

The Sampler makes a daily report of all assays to Mill Superintendent, a copy going to each foreman that he may have a record of what he is doing.

Testing and Experimenting.

New apparatus placed on the marker, which is likely to prove valuable, is purchased and carefully tried out. Most forms of slime tables and so forth have thus been experimented with. It is worthy of note that the present equippment for treating fines consists of fine jigs, Wilfley tables, and 6 foot Frue Vanners.

Deister slime tables gave results as good as the vanners, but the Deister motion was troublesome.

Experiments with canvas tables have shown that, while a low grade concentrate can be saved from the slimes, the plant necessary would be a large one, and would require a great deal of labor. The low grade concentrate would have to be retreated.

For each machine in use, careful tests are made to determine the best, adjustments under certain conditions of feed and so forth, and then the adjustments are uniformly maintained until changed condition require new investigation.

Monthly concentration tests are made on composite samples of the ore fed to each section. A Wilfley table and a vanner are utilized and the products are kept as close as possible to those made in the mills. The object of these tests is to check the saving made in the mills and to determine the distribution of the losses.

Composites of the daily tailings samples are made monthly. Screen analyses of these composites are made and samples for assay taken from each screen. This determines the distribution of the losses. Reference to the screen analysis of vanner tails under the subject of "Vanners", above, is an example of this. All similar analyses of vanner tails show, as do those quoted, that the principal losses are in the slimes. See note of microscopic study under "Slimes" below. The losses in the table and jig tails are partly due to fine free sulphides and partly due to included grains, as brought out by microscopic study. However, the vanner tails are responsible for a much larger part of the total loss than the table and jig tails. The vanner tails average less than .9% while the table and jig tails are below .6% Copper.

Nature of the Slime.

The Analyses of the ores and the notes on the mineralogical composition indicate what is to be expected in the way of slime. The clay and talcose material form impalpable grains and flakes which are readily suspended in water which has the least bit of motion. And the finely divided sulphides are so persistently associated with this slime that 75 to 80 % of the total loss is accounted for by the slimes.

The term "Slimes" is restricted to material passing 200 mesh, which will not settle out in two minutes quiet standing. The fine stuff which does settle is denominated "Thru 200 Mesh", in the screen analyses given in this paper.

A series of tests were made to determine the possibility of inducing the rapid settling of the slimes by adding some electrolyte to the water. In the first place, a chemical analysis of the water showed very large quantities of salts present in solution.

Analysis of Water in General Circulation.

			Parts 1 Million.
CaO		387	" "
MgO		90	" "
FeO		192	" "
Fe_2O_3		35	" "
MnO		58	" "
ZnO		65	" "
CuO		35	" "
Al_2O_3		15	" "
SiO_2		20	" "
SO_3	combined	1110	" "
Free H_2SO_4		nil	" "

Beakers were used in the settling tests.

When nothing was added to the slime, after 15 minutes quiet standing it had settled to a density of 3 of water to 1 of dry slimes; after 24 hours the liquid was slightly opalescent and the settled product 2 1/2 water to 1 of dry slime.

Sodium Chloride, Sulphuric Acid, Alum, and Lime in varying quantities were successively tried. No practical effect on the rate of settling of the slime or density after 24 hours was observed. Alum cleared the supernatant liquid.

A microscopic examination of the slime shows that the slime flakes are made up of material in a very fine state of subdivision, .01 mm and less in diameter up to .1 mm. The grains of sulphide have a range from .05 mm down. The fine grains exhibited a strong tendency to associate in more or less persistent groups, making the "flakes". The particles of sulphide are of normal shape, not flaky, and are quite pure mineral. Under the micros-cope they look like the clean concentrates from the coarse jigs.

Conclusion.

The most ~~important~~ noteworthy feature in the milling at Cananea is the use of the Drag Belt and the treatment of fine material. The introduction of the drag-belt resulted in a more effective treatment of this fine material.

The drag-belt was introduced to take the discharge from the Bryan mills in both sections of Mill 2. The classifiers following the drag-belt were equipped with rubber hose connections and means for maintaining a constant hydraulic head.

The dewatering boxes No. 33 (Flor sheet No. Two) and the large cylindrical pulp thickeners No. 44. were done away with. In the space occupied by the latter another jig No. 47 was installed and also 3 tables in each section.

The result of this change was an important improvement in the classification which resulted in better results on the tables, jigs, and vanners.

The slimes were removed from the table and jig feeds, and the sands removed from the vanner feed. See screen analysis of drag-belt products above. The large pulp thickeners were done away with, for the slimes are not diluted by treatment in hydraulic classifiers.

In the treatment of fines, the tables are fed with material coarser than 150 mesh, and the vanners with material finer than 150 mesh, and the line is quite sharply drawn. A long series of experiments has shown that tables handle all material coarser than 150 mesh to good advantage - that is with proper classification. Vanners are widely used on material carrying a large percentage of grains coarser than 100 mesh; but at Cananea the vanners are given only the finer material.

Recently improvements designed for Section B, Mill 1, involve a more extensive use of the drag-belt device.

Both 2mm and 1 1/2mm products will be sent to drag-belts making slimes for Vanner feed and sand discharges for classification. An additional drag-belt will be used for conveying and dewatering the Bryan mill feed.

This drag-belt device will surely fine application in other plants working under similar conditions. It is a flexible instrument.

I suggest that it may also find a useful place in certain cyanide mills as a conveyor and dewaterer for tube mill feed. Under certain conditions it may be a more valuable apparatus than the Dorr classifier in common use.

The officials of Cananea Consolidated Copper Company, S.A. are very courteous to visiting engineers.