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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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MINES BRANCH INVESTIGATION REPORT IR 70-72

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A SYSTEMATIC EVALUATION OF FLOTATION SCHEMES FOR THE TREATMENT OF A COMPLEX BASE-METAL ORE FROM CHESTER MINES LIMITED, NEW BRUNSWICK

by

T. F. BERRY AND R. W. BRUCE

MINERAL PROCESSING DIVISION

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A SYSTEMATIC EVALUATION OF FLOTATION SCHEMES FOR THE TREATMENT OF A COMPLEX BASE-METAL ORE FROM CHESTER MINES LIMITED, NEW BRUNSWICK

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SUMMARY OF RESULTS

The average head assay of the Chester Mines ore was about 2.50% Cu, 0.50% Pb and 1.80% Zn.

The best overall results were obtained in Test No. 20 in which the copper-lead cleaner concentrate was deleaded to produce a final copper concentrate assaying 26.50% Cu with a recovery of 80.1% and a final lead concentrate assaying 43.0% Pb with a recovery of 75.6%. The zinc concentrate in this test, assaying 40.7% Zn with a recovery of 60.3%, was lower than expected but the investigation showed that grades in excess of 50% Zn with high recoveries can be obtained.

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INTRODUCTION

Early in 1970, Mr. E.W.J. Thorton, Chief Metallurgist of the Sullivan Mining Group Limited, asked the Mines Branch to undertake a pilot plant investigation of an ore from Chester Mines Limited, which is a company controlled by the Sullivan Group.

At the property, development work indicates that this Cu-Pb-Zn prospect at Clearwater Stream, Newcastle, New Brunswick, has an underground copper zone estimated at 3.8 million tons assaying 1.58% Cu before dilution. In addition, a second deposit suitable for open-pit mining contains an estimated 400,000 tons of ore assaying 0.75% Cu, 0.36% Pb, and 0.89% Zn before dilution.

In April, a 60-ton shipment of lump, mine-grade ore was received at the Mines Branch and pilot plant testing commenced on April 6 and continued until May 15. During this time twenty-two tests, differing in such variables as grind, flotation cell arrangement, and reagent additions, were evaluated.

The authors acted as liaison officers between the Mines and Mr. Thorton, who assumed responsibility for the test work.

CONCLUSIONS AND DISCUSSION

As the type of grinding was considered to have an effect on the flotation characteristics, the pilot plant work commenced, using mild steel grinding media which was later exchanged for high-density alumina pebbles. These grinding techniques later gave way to autogenous grinding.

With conventional grinding, it was not possible to produce a talc concentrate low in sulphides. In Tests No. 1 and No. 5 the results shown are typical of those obtained using mild steel grinding media. The final copper results, both grade and recovery were higher than anticipated, a fact that may be attributed to the amount of copper mineral in the ore and to that mineral's rather coarse crystalline structure. During rougher copper flotation, optimum recovery was achieved by increasing the amount of Z-200 and Z-6 reagents. The increased amount of these reagents caused more insoluble material and zinc to float with the copper, and thus lowered the grade of the copper rougher concentrate. This low-grade concentrate placed a heavy load on the cells in the copper cleaner circuit, such that more cleaner capacity will have to be provided than was originally intended. Test No. 14 illustrates the value of greater copper cleaning capacity.

Zinc recoveries and grades were as expected. With properly operated copper and zinc rougher and cleaner circuits, it should be possible to discard the cleaner tailings rather than recirculate them.

Lead results were poorer than expected and non-sulphide lead assays showed that a large percentage of the lead existed in a form other than galena. Previous work has been done in which it was found that a considerable proportion of the galena was present with oxide coatings.

Grinding with high-density alumina pebbles gave results similar to those achieved with mild steel balls.

It was decided to try autogenous grinding using a 44-in. by 38-in. long (inside dimensions) Dominion ball mill. A previous investigation on ore from Mattagami Mines showed that autogenous grinding of their sulphide ore in this mill at a feed rate of 1.0 ton per hour resulted in a pebble consumption of 14% of the mill feed. In the current pilot plant test, a feed rate of 1.0 ton per hour was impractical because of the limited capacity of the flotation circuit. A feed rate of 500 lb per hour was maintained but with this large mill it was impossible to keep a pebble load in the mill. As a result, a smaller grate discharge mill was used and, at a feed rate of 500 lb per hour of pebbles, the ball mill load remained constant during the next five tests. Some difficulty was experienced, however, in maintaining the classifier overflow at a constant density.

Immediately noticeable in the flotation circuit was the purity of the talc concentrate and the tendency for lead to float with the copper even at high pH values. Because of this, the MIBC was increased to float more of the talc and the pH was lowered to allow more lead to float with the copper.

The next step was the deleading of the copper concentrate, a process which had not worked well in bench-scale tests but which proved very efficient in the pilot plant. The amount of cyanide used in deleading the copper-lead concentrate depended to a large extent on the amount of Z-200 which had been added in the copper rougher circuit.

The flotation of a copper-lead concentrate eliminated the need for a lead circuit with its cyanide additions. This decrease in cyanide was accompanied by a decrease in the amount of copper sulphate needed for good zinc flotation.

ACKNOWLEDGEMENTS

The chemical analysis of all test products in this investigation was done under the direction of Mr. Ulrich Dienstbach, Chief Chemist, Bondar-Clegg & Company Ltd., Ottawa, Ontario.

The authors also wish to acknowledge the assistance of Mr. A.J. Boisonnault, mill Foreman, Mineral Processing Division, who directed the personnel of the metallic minerals mill in the setting up and the operation of the pilot-plant equipment used in this investigation.

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APPENDIX

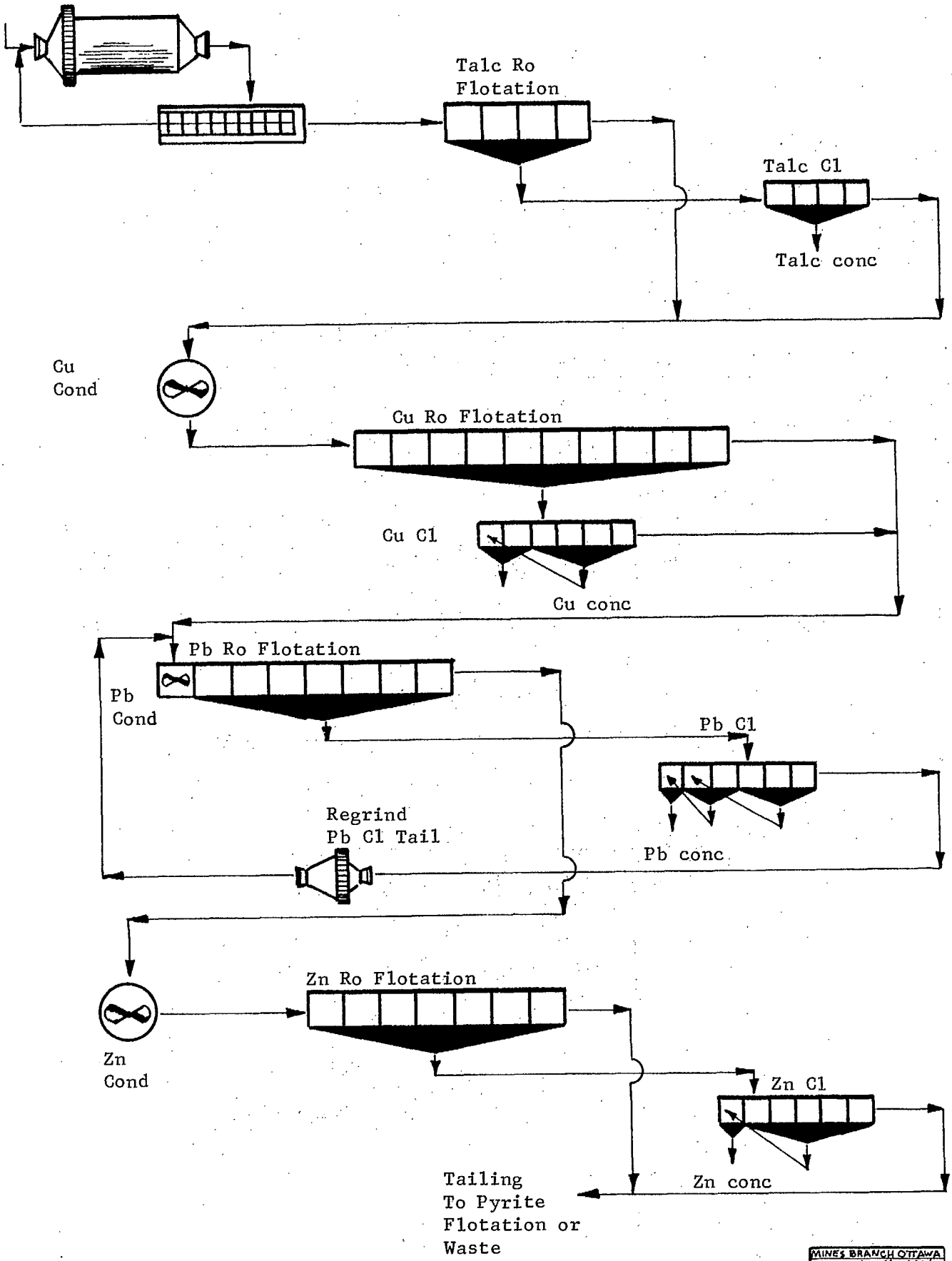
PILOT PLANT TEST NO. 1

In this preliminary test the lime additions were made to regulate the pH. The feed rate was 480 lb/hr into a 2' x 4' diameter overflow type ball mill containing 1600 lb of mild steel balls.

Point of Addition	pH	Reagent Consumption lb/ton Lime	MIBC	Z-200	Z-6	NaCN	$CuSO_4$
Grind	9.1	3.3					
Talc rougher			.001				
Cu "	8.6			0.022	0.028		
" cleaner	9.0			0.041			
Pb conditioner	9.0				0.019	0.11	
" cleaner	8.8					0.055	
" cleaner						0.055	
Zn rougher	9.5	2.75		0.044			1.92
" cleaner				0.019			

Screen Analysis

Mesh	Class O'flow	Pb Cleaner Tailing
+48 mesh	0.2 %	-
+65 "	0.5	-
+100 "	1.4	0.4 %
+150 "	1.9	0.4
+200 "	3.6	0.9
+270 "	5.5	1.3
+325 "	7.8	2.4
-325 "	79.1	94.6


Talc Ro
Flotation
Talc Cl
Talc conc
Cu
Cond
Cu Ro Flotation
Cu Cl
Cu conc
Pb Ro Flotation
Pb
Cond
Pb Cl
Pb conc
Regrind
Pb Cl Tail
Zn Ro Flotation
Zn
Cond
Zn Cl
Zn conc
Tailing
To Pyrite
Flotation or
Waste
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Pilot Plant Test No. 1

Product	Assays % Cu	Pb	Zn
Classifier o'flow	2.00	0.68	2.34
Talc cleaner concentrate	13.60	0.88	1.32
" " tailing	2.76	0.71	2.40
Cu rougher tailing	0.15	0.42	2.43
" cleaner concentrate	22.80	4.42	1.98
" " tailing	1.24	1.43	3.89
Pb rougher "	0.20	0.29	2.52
" recleaner concentrate	0.45	18.20	4.21
" cleaner tailing	1.03	0.45	2.99
Zn " concentrate	0.47	1.70	53.50
Flotation tailing	0.29	0.32	0.37

Metallurgical Balance

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Class o'flow	100.0	2.00	0.68	2.34	100.0	100.0	100.0
Talc cl concentrate	2.6	13.60	0.88	1.32	17.7	3.4	1.5
Cu ro feed	97.4	1.69	0.67	2.37	82.3	96.6	98.5
Cu cl concentrate	6.02	22.8	4.42	1.98	68.7	39.1	5.1
Pb recl "	0.25	0.45	18.20	4.21	0.1	6.9	0.4
Zn cl "	3.47	0.47	1.70	53.5	0.8	8.7	79.1
Flotation tailing	87.66	0.29	0.32	0.37	12.7	41.9	13.9
Talc + Cu conc	8.62	20.05	3.35	1.78	86.4	42.5	6.6

Pilot Plant Test No. 2

The talc circuit was discontinued. Lime was increased to obtain a higher pH. The last cell of each rougher circuit was sampled to determine whether the retention time was sufficient.

Point of Addition	Reagent Consumption lb/ton					
	pH	Lime	Z-200	Z-6	NaCN	$CuSO_4$
Grind	10.5	8.25				
Cu rougher	8.9		0.033	0.028		
" cleaner	8.9		0.022			
Pb conditioner	8.8			0.019	0.110	
" cleaner	8.8				0.060	
" recleaner					0.055	
Zn conditioner	10.6	5.5	0.044			1.92
" cleaner	9.5					

Screen Analysis

Mesh	Class O'flow
+65 mesh	0.3 %
+100 "	0.9
+150 "	1.8
+200 "	3.0
+270 "	3.8
+325 "	6.6
-325 "	83.6

Pilot Plant Test No. 2

Product	Assays % Cu	Pb	Zn
Classifier o'flow	1.94	0.62	2.40
#10 cu rougher cell	0.67	1.53	2.88
Cu cleaner concentrate	22.50	1.01	0.56
" " tailing	1.11	0.96	2.95
" rougher tailing	0.25	0.53	2.51
#8 Pb rougher cell	0.56	0.47	2.72
Pb recleaner concentrate	0.51	33.80	1.83
" cleaner tailing	1.22	0.84	2.60
" rougher tailing	0.43	0.34	2.57
#7 Zn rougher cell	2.28	1.13	3.61
Zn cleaner concentrate	2.03	5.20	46.80
" " tailing	3.61	1.92	5.56
Flotation tailing	0.43	0.23	0.50

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Classifier o'flow	100.0	1.94	0.62	2.40	100.0	100.0	100.0
Cu cleaner concentrate	6.55	22.50	1.01	0.56	75.9	10.7	1.5
Pb recleaner "	0.41	0.51	33.80	1.83	0.2	23.9	0.3
Zn cleaner "	4.05	2.03	5.20	46.80	4.2	34.0	79.5
Flotation tailing	88.99	0.43	0.23	0.50	19.7	31.4	18.7

Pilot Plant Test No. 3

The amount of lime to the grind was standardized to give the desired pH. R-242 was added to assist in Pb recovery and provide supplementary frothing.

Point of Addition	pH	Reagent Consumption lb/ton Lime	Z-200	Z-6	NaCN	$CuSO_4$	R-242
Grind	11.4	11.0					
Class o'flow	11.1						
Cu rougher	10.8		0.05	0.022			
" cleaner	9.3		0.017				
Pb conditioner	9.0			0.028	0.110		0.005
" cleaner	9.0				0.060		
" recleaner	9.1				0.055		
Zn conditioner	11.0	6.6				2.09	
" rougher			0.067				
" cleaner	9.3						

Products	Assays % Cu	Pb	Zn
Class o'flow	2.47	0.67	2.50
Cu cleaner concentrate	21.40	0.61	1.01
" " tailing	0.73	1.01	2.83
" rougher "	0.36	0.63	2.59
Pb recleaner concentrate	3.41	23.30	3.12
" cleaner tailing	4.64	0.59	2.68
" rougher "	0.44	0.38	2.59
Zn cleaner concentrate	2.94	2.85	48.50
" " tailing	3.88	1.88	4.52
Flotation "	0.56	0.32	0.67
Pyrite concentrate	1.08	0.70	1.91

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.47	0.67	2.50	100.0	100.0	100.0
Cu cleaner concentrate	8.60	21.40	0.61	1.01	75.5	7.8	3.5
Pb recleaner "	1.00	3.41	23.30	3.12	1.4	34.8	1.2
Zn cleaner "	3.71	2.94	2.85	48.50	4.4	15.8	72.0
Flotation tailing	86.69	0.56	0.32	0.67	19.7	41.6	23.3

Pilot Plant Test No. 4

To increase the Cu recovery the Z-200 was increased to 0.077 lb/ton. A 0.5% solution of Guar was added to the Cu roughers and to the Pb conditioner in an attempt to depress insolubles in both concentrates.

Reagent Consumption lb/ton

Point of Addition	pH	Lime	Guar	Z-200	Z-6	NaCN	$CuSO_4$	R-242
Grind	11.5	11.0						
Class o'flow	11.2							
Cu rougher	11.0		0.044	0.077	0.022			
" cleaner	9.5							
Pb conditioner			0.022			.110		
" rougher	9.0				0.022			.0025
" cleaner	8.9					.060		
" recleaner						.055		
Zn conditioner		6.6					2.21	
" rougher	11.1			.049				
" cleaner	10.0							

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	0.4	1.0	2.5	3.6	6.8	85.7

Pilot Plant Test No. 4

Assays %

Product	Cu	Pb	Zn	Non Sulphide Pb	Insol
Class o'flow	2.01	0.63	2.32	0.31	
Cu rougher concentrate	4.94	0.95	2.47		
" cleaner "	19.00	0.57	1.53		16.9
" " tailing	0.59	1.04	2.85		
" rougher "	0.14	0.63	2.41		
Pb rougher feed	0.22	0.65	2.50		
" " concentrate	1.24	1.86	2.91		
Final Pb "	1.50	13.70	3.29		15.4
Pb cleaner tailing	1.14	0.51	2.73		
" rougher "	0.21	0.32	2.44		
Zn rougher concentrate	1.14	1.66	21.50		
Final Zn "	1.35	2.60	43.40		1.29
Zn cleaner tailing	1.12	1.02	1.47		
Flotation tailing	0.25	0.26	0.27	0.22	

Metallurgical Balance

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Class o'flow	100.00	2.03	0.63	2.32	100.0	100.0	100.0
Cu cleaner concentrate	9.21	19.00	0.57	1.53	86.2	8.3	6.1
Final Pb concentrate	1.78	1.50	13.70	3.29	1.3	38.8	2.5
Final Zn "	4.36	1.35	2.60	43.40	2.9	17.9	81.5
Flotation tailing	84.65	0.23	0.26	0.27	9.6	35.0	9.9

Pilot Plant Test No. 4

Supplementary Metallurgical Balances

Cu Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	39.10	4.94	0.95	2.47	95.2	58.8	42.8
" cleaner "	9.21	19.00	0.57	1.53	86.2	8.2	6.1
" " tailing	29.89	0.61	1.06	2.76	9.0	50.6	36.8
" rougher "	60.90	0.14	0.63	2.41	4.2	60.9	63.2
" " feed	90.79	0.29	0.77	2.52	13.2	11.5	100.0
" rougher " (assay)	-	0.22	0.65	2.50			

Zn Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Zn rougher concentrate	9.12	1.14	1.66	21.50	5.1	23.9	84.8
Final Zn "	4.36	1.35	2.60	43.40	2.9	17.9	81.6
Zn cleaner tailing	4.76	0.94	0.80	1.44	2.2	6.0	3.3

Pilot Plant Test No. 5

A talc circuit was inserted in this test using MIBC with cleaning and recleaning of the talc concentrate.

The Z-6 was increased and the Z-200 was decreased in the Cu rougher circuit. The extra froth produced by the MIBC accounted for the Z-200 decrease.

The Pb rougher concentrate was reground.

The Pb cleaner tailing went directly to the Zn conditioner.

The Z-6 was increased in the Pb rougher circuit.

Reagent Consumption lb/ton

Point of Addition	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$	R-242
Grind	11.5	11.0						
Class o'flow	11.3							
Talc rougher			0.002					
Cu "	10.5			.056	.033			
Pb conditioner				.033		.110		
" rougher	9.1							.024
" cleaner						.060		
" recleaner						.050		
Zn conditioner		5.5			.050		2.27	
" rougher	11.2							

Screen Analysis

Mesh	+65	+100	+150	+200	+270	+325	-325
Class o'flow	.03	.09	1.8	3.0	3.8	6.6	83.6

Pilot Plant Test No. 5

Product	Assays % Cu	Pb	Zn
Classifier o'flow	2.03	0.66	2.39
Talc cleaner concentrate	9.22	1.83	1.36
" " tailing	6.59	1.63	2.42
Cu rougher feed	1.89	0.68	2.45
" " concentrate	5.83	1.31	2.54
" cleaner "	22.80	1.87	1.46
" " tailing	0.58	1.47	2.79
Pb rougher feed	0.21	0.58	2.52
" " concentrate	0.55	1.96	3.21
" cleaner "	1.00	16.20	5.10
" " tailing	0.56	0.43	3.18
Zn rougher feed	0.24	0.22	2.57
" " concentrate	1.46	0.97	22.00
" cleaner "	0.93	1.05	53.50
" " tailing	1.75	1.04	2.86
Flotation "	0.12	0.27	0.38

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.03	0.66	2.39	100.0	100.0	100.0
Talc cl concentrate	1.91	9.22	1.83	1.36	8.7	5.0	1.1
Cu " "	7.45	22.80	1.87	1.46	83.9	19.6	4.5
Pb " "	1.61	1.00	16.20	5.10	0.8	37.1	3.4
Zn " "	3.51	0.93	1.05	53.50	1.6	5.5	77.6
Flotation tailing	85.52	0.12	0.27	0.38	5.0	32.8	13.4
Head (calcd)	100.00	2.03	0.70	2.42	100.0	100.0	100.0
Talc + Cu concentrate	9.36	20.10	1.86	1.44	92.6	24.6	5.6

Pilot Plant Test No. 5

Supplementary Metallurgical Balances

Cu Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	31.60	5.83	1.31	2.59	100.0	100.0	100.0
Cu cleaner "	7.45	22.80	1.87	1.46	92.4	33.6	13.3
Cu " tailing	24.15	0.58	1.14	2.94	7.6	66.4	86.7
Cu " " (assay)		0.58	1.47	2.79			

Pb Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Pb rougher concentrate	16.61	0.55	1.96	3.21	100.0	100.0	100.0
Pb cleaner "	1.61	1.00	16.20	5.10	17.5	80.0	15.4
Pb " tailing	15.00	0.50	0.43	3.02	82.5	20.0	84.6
Pb " " (assay)		0.56	0.43	3.18			

Zn Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Zn rougher concentrate	9.30	1.46	0.97	22.00	100.0	100.0	100.0
Zn cleaner "	3.51	0.93	1.05	53.50	24.3	41.0	92.0
Zn " tailing	5.79	1.48	0.91	2.86	75.7	59.0	8.0
Zn " " (assay)		1.75	1.04	2.86			

Pilot Plant Test No. 6

Depramin No. 75 was added to the Cu rougher circuit in very small amounts.

The Pb rougher concentrate was reground.

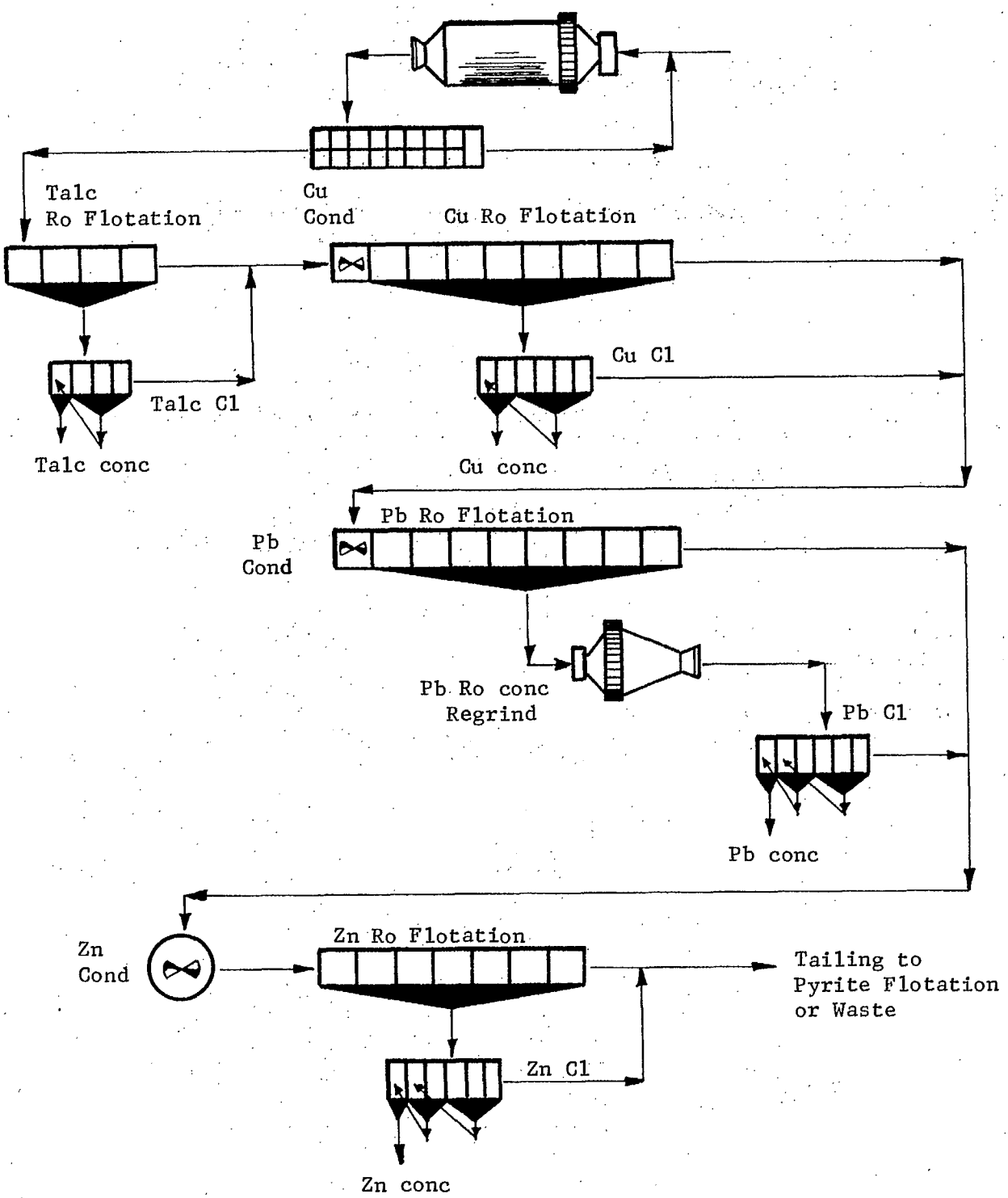
The Zn cleaner circuit was changed so that the three stages comprised 3 - No. 5 cells, 2 - No. 5 cells and 1 - No. 5 cell.

Reagent Consumption lb/ton

Point of Addition	pH	Lime	MIBC	Depramin 75	Z-6	Z-200	NaCN	$CuSO_4$
Grind	11.6	11.0						
Class o'flow	11.4							
Talc rougher			.002					
Cu conditioner					.055	.028		
Cu rougher	10.8							
Cu cleaner				.003				
Pb conditioner	9.3				.033		0.11	
Pb cleaner							.06	
Pb recleaner							.05	
Zn conditioner	11.2	5.5						2.21
Zn rougher						.044		

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	0.4	1.3	2.6	4.5	7.6	83.6



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DATE: 29/9/70 M.R. #6

Pilot Plant Test No. 6

Product	Assays % Cu	Pb	Zn
Classifier o'flow	2.07	0.62	2.32
Talc cleaner concentrate	11.90	1.25	0.46
" " tailing	8.68	1.40	1.68
" rougher "	1.84	0.59	2.27
Cu "" feed	2.04	0.66	2.28
" " concentrate	7.09	1.66	2.38
" cleaner concentrate	19.50	1.43	1.10
" " tailing	0.75	1.59	2.99
" rougher "	0.20	0.34	2.32
Pb " feed	0.24	0.54	2.43
" " concentrate	0.64	1.76	2.85
" cleaner tailing	0.60	0.39	2.80
" recleaner concentrate	0.91	15.20	4.20
" rougher tailing	0.13	0.23	2.32
Zn " feed	0.19	0.30	2.41
" " concentrate	0.49	1.18	27.00
" cleaner "	0.21	0.65	54.50
" " tailing	1.59	1.40	13.70
Flotation "	0.25	0.26	0.83

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.07	0.62	2.32	100.0	100.0	100.0
Talc cleaner concentrate	0.30	11.90	1.25	0.46	1.7	0.5	0.2
Cu " "	9.40	19.50	1.43	1.10	88.5	21.4	4.4
Pb recleaner "	1.87	0.90	15.20	4.20	0.8	45.6	3.4
Zn cleaner "	2.57	0.21	0.65	54.50	0.2	2.6	60.2
Flotation tailing	85.86	0.20	0.26	0.83	8.8	29.9	31.8
Talc + Cu concentrate	9.70	19.2	1.41	1.07	90.2	21.9	4.6

Pilot Plant Test No. 6

Supplementary Metallurgical Balances

Cu Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	27.80	7.09	1.66	2.38	100.0	100.0	100.0
Cu cleaner "	9.40	19.50	1.43	1.10	93.0	28.9	18.4
Cu " tailing	18.40	0.75	1.70	3.04	7.0	71.1	81.6

Pb Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Pb rougher concentrate	20.20	0.64	1.76	2.85	100.0	100.0	100.0
Pb recleaner "	1.87	0.91	15.20	4.20	14.0	79.4	15.6
Pb cleaner tailing	18.33	0.62	0.39	2.72	86.0	20.6	84.4

Zn Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Zn rougher concentrate	7.92	0.49	1.18	27.00	100.0	100.0	100.0
Zn cleaner "	2.57	0.21	0.65	54.50	12.9	17.2	65.4
Zn " tailing	5.35	0.64	1.44	13.70	87.1	82.8	34.6

Pilot Plant Test No. 7

More Z-6 and less Z-200 was used in this test than in No. 6, in the Cu circuit.

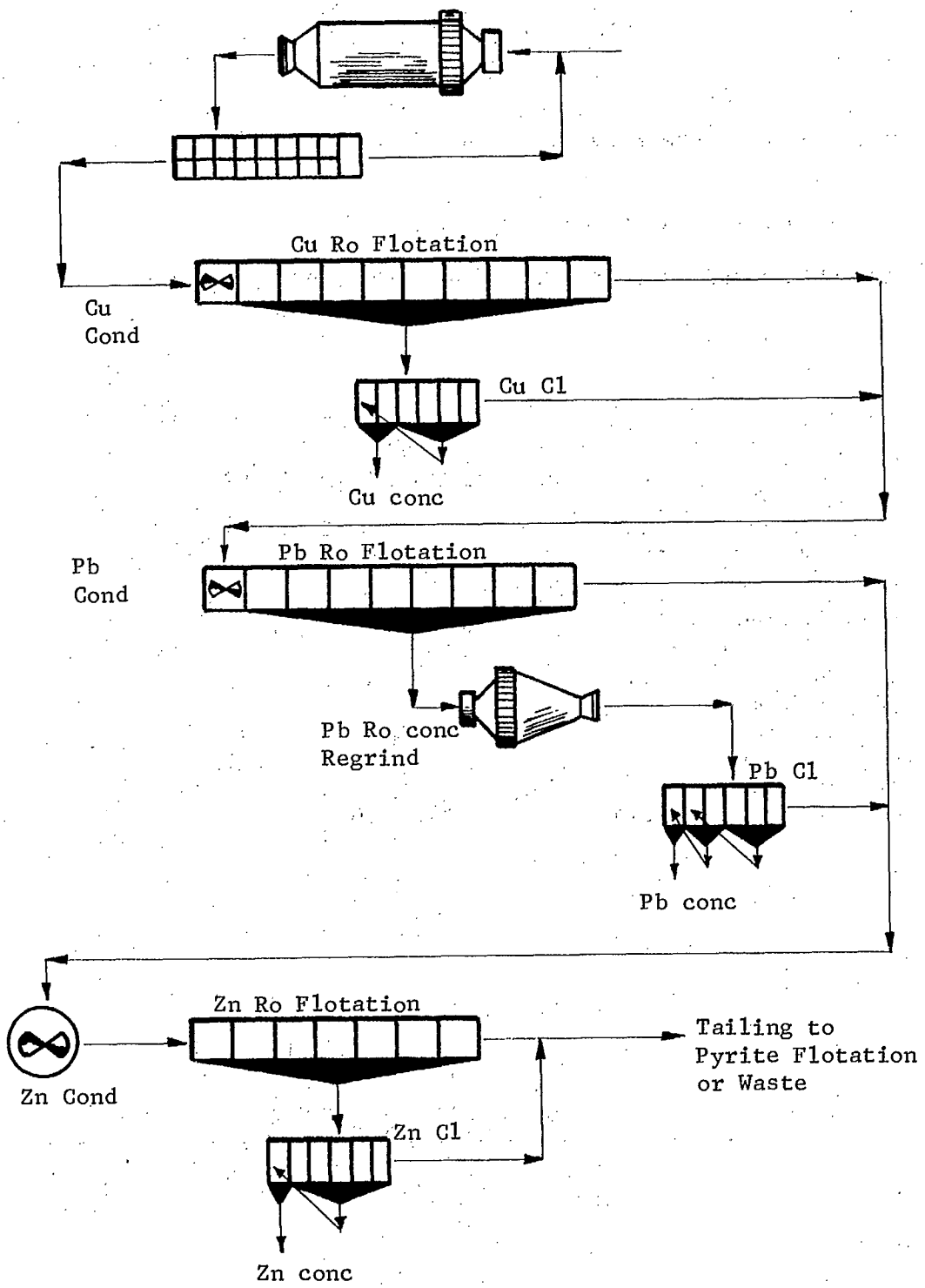
Less Z-6 was used in the Pb circuit.

An attempt was made to reduce the $CuSO_4$ consumption Lime flotation looked poor.

Point of Addition	pH	Reagent Consumption lb/ton Lime	Z-6	Z-200	NaCN	$CuSO_4$
Grind	11.6	11.0				
Class o'flow	11.4					
Cu conditioner			.088			
Cu rougher	11.3			.028		
Pb conditioner	9.4		.028		.138	
Pb cleaner					.066	
Pb recleaner					.050	
Zn conditioner		5.5				1.88
Zn rougher	11.4			.044		

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	.2	1.0	2.6	4.7	8.5	83.0



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Pilot Plant Test No. 7

Product	Assays % Cu	Pb	Zn
Classifier o'flow	2.02	0.64	2.41
Cu rougher concentrate	5.64	1.53	2.82
" " tailing	0.12	0.28	2.33
" cleaner "	0.20	1.99	3.23
Final Cu concentrate	22.10	1,97	1.97
Pb rougher feed	0.12	0.46	2.50
" " concentrate	0.54	1.33	2.85
" " tailing	0.11	0.50	2.44
" cleaner "	0.56	0.41	2.85
Final Pb concentrate	0.57	11.40	2.54
Zn rougher feed	0.14	0.45	2.53
" " concentrate	1.07	2.51	23.10
" cleaner tailing	2.18	1.14	1.50
Final Zn concentrate	2.06	3.58	41.00
Flotation tailing	0.19	0.31	0.30
Pyrite concentrate	0.37	0.58	0.93

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.02	0.64	2.41	100.0	100.0	100.0
Final Cu concentrate	7.93	22.10	1.87	1.97	86.8	24.4	6.5
" Pb "	0.38	0.37	11.40	2.54	0.1	6.9	0.5
" Zn "	4.77	2.06	3.58	41.40	4.9	26.6	82.2
Flotation tailing	86.92	0.19	0.31	0.30	8.2	42.1	10.8

Pilot Plant Test No. 7

Supplementary Metallurgical Balances

Cu Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	31.90	5.64	1.53	2.82	100.0	100.0	100.0
Cu cleaner "	7.93	22.10	1.97	1.97	97.5	32.0	17.3
Cu " tailing	23.97	0.19	1.39	3.11	2.5	68.0	82.7
Cu " " (assay)		0.20	1.99	3.23			

Pb Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Pb rougher concentrate	4.54	0.54	1.33	2.85	100.0	100.0	100.0
Pb recleaner "	0.38	0.37	11.40	2.54	4.0	73.4	2.7
Pb cleaner tailing	4.16	0.58	0.39	2.88	96.0	26.6	92.3
Pb " " (assay)		0.56	00.41	2.85			

Zn Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Zn rougher concentrate	8.82	1.07	2.51	23.10	-	100.0	100.0
Zn cleaner "	4.77	2.06	3.58	41.40	-	76.5	97.1
Zn " tailing	4.05	-	1.28	1.43	-	23.5	2.9
Zn " " (assay)		2.18	1.14	1.50			

Pilot Plant Test No. 8

The tonnage was increased to 650 lb/hr and all of the reagents were increased proportionately to see the metallurgical effect.

Point of Addition	pH	Reagent Consumption lb/ton				
		Lime	Z-6	Z-200	NaCN	$CuSO_4$
Grind	11.7	10.5				
Class o'flow	11.6					
Cu rougher	11.5		.076	.028		
Pb conditioner	10.6		.024		.120	
Pb cleaner					.064	
Pb recleaner					.048	
Zn conditioner	11.4	4.55		.040		1.93

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	0.2	1.2	3.3	5.5	8.5	81.3
Pb rougher concentrate	0.1	0.6	5.7	5.2	6.2	82.2
Regrind mill discharge	0.1	0.3	2.1	5.8	5.9	85.8

Pilot Plant Test No. 8

Product	Assays % Cu	Pb	Zn	Insol	Fe	S
Classifier o'flow	2.22	0.60	2.07			
Cu rougher concentrate	6.49	1.61	2.93			
" " tailing	0.12	0.18	1.85			
" cleaner "	0.61	1.11	3.59			
Final Cu concentrate	22.20	3.67	2.32	6.32		
Pb rougher feed	0.17	0.29	2.10			
" " concentrate	0.54	0.96	2.76			
" " tailing	0.11	0.16	2.21			
" cleaner " (No. 1)	0.51	0.29	2.76			
" " " (No. 2)	1.20	0.61	2.68			
" " " (No. 3)	1.17	1.27	2.87			
Final Pb concentrate	0.28	9.52	3.15	22.90		
Zn rougher feed	0.22	0.24	2.29			
" " concentrate	1.04	0.56	24.80			
" cleaner tailing	0.69	0.55	0.63			
Final Zn concentrate	1.42	0.77	42.80	2.42		
Pyrite concentrate	0.23	0.17	0.19		48.5	49.9
Flotation tailing	0.19	0.29	0.18			

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.22	0.60	2.07	100.0	100.0	100.0
Final Cu concentrate	9.01	22.20	3.67	2.32	90.0	55.4	10.1
" Pb "	0.31	0.28	9.56	3.15	0.1	4.8	0.6
" Zn "	3.99	1.42	0.17	42.80	2.6	5.2	82.6
Flotation tailing	86.69	0.19	0.29	0.18	7.3	34.6	6.7

Pilot Plant Test No. 8

Supplementary Metallurgical Balances

Cu Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	33.10	6.49	1.61	2.93	100.0	100.0	100.0
Cu cleaner "	9.01	22.20	3.67	2.32	93.0	62.4	21.5
Cu " tailing	24.09	0.62	0.83	3.15	7.0	37.6	78.5
Cu " " (assay)		0.61	1.11	3.59			

Pb Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Pb rougher concentrate	4.27	0.54	0.96	2.76	100.0	100.0	100.0
Pb recleaner "	0.31	0.28	9.56	3.15	4.3	70.8	8.5
Pb cleaner tailing	3.96	0.55	0.30	2.70	95.7	29.2	91.5
Pb " " (assay)		0.51	0.29	2.76			

Zn Cleaner Circuit

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Zn rougher concentrate	6.96	1.04	0.56	24.80	100.0	100.0	100.0
Zn cleaner "	3.99	1.42	0.77	42.80	78.1	79.4	99.2
Zn " tailing	2.97	0.54	0.27	0.51	21.9	20.6	0.8
Zn " " (assay)		0.69	0.55	0.63			

Pilot Plant Test No. 9

The tonnage was reduced to 420 lb/hr and the reagents adjusted accordingly. The regrind mill in the Pb circuit was discontinued.

Point of Addition	pH	Reagent Consumption lb/ton Lime	Z-6	Z-200	NaCN	$CuSO_4$
Grind	11.6	10.1				
Class o'flow	11.4					
Cu rougher	11.2		.093	.022		
Pb conditioner	9.4		.012		.116	
Pb cleaner					.062	
Pb recleaner					.047	
Zn conditioner	11.2	5.0				2.02
Zn rougher				.022		

Screen Analysis

Mesh	+65	+100	+150	+200	+270	+325	-325
Class o'flow	0.1	0.2	1.3	3.1	4.6	7.1	83.6

Pilot Plant Test No. 9

Product	Assays % Cu	Pb	Zn
Class o'flow	2.25	0.55	1.78
Cu rougher concentrate	8.90	1.39	1.99
" " tailing	0.15	0.30	1.84
" cleaner "	2.25	1.87	2.68
Final Cu concentrate	30.00	0.87	0.43
Pb rougher feed	0.41	0.49	1.94
" " concentrate	1.64	1.35	2.07
" " tailing	0.22	0.38	1.94
" cleaner "	1.88	0.29	2.16
Final Pb concentrate	1.12	13.80	1.50
Zn rougher feed	0.50	0.37	2.01
" " concentrate	3.96	1.92	24.80
" cleaner tailing	1.33	0.98	1.44
Final Zn concentrate	3.72	2.54	45.40
Pyrite concentrate	0.81	1.17	3.19
Flotation tailing	0.34	0.33	0.49

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.25	0.55	1.78	100.0	100.0	100.0
Final Cu concentrate	6.10	30.00	0.87	0.43	81.4	9.6	1.4
" Pb "	0.92	1.12	13.80	1.50	0.3	23.1	0.8
" Zn "	2.86	3.72	2.54	45.40	4.7	13.3	73.1
Flotation tailing	90.12	0.34	0.33	0.49	13.6	54.0	24.7

Pilot Plant Test No. 9

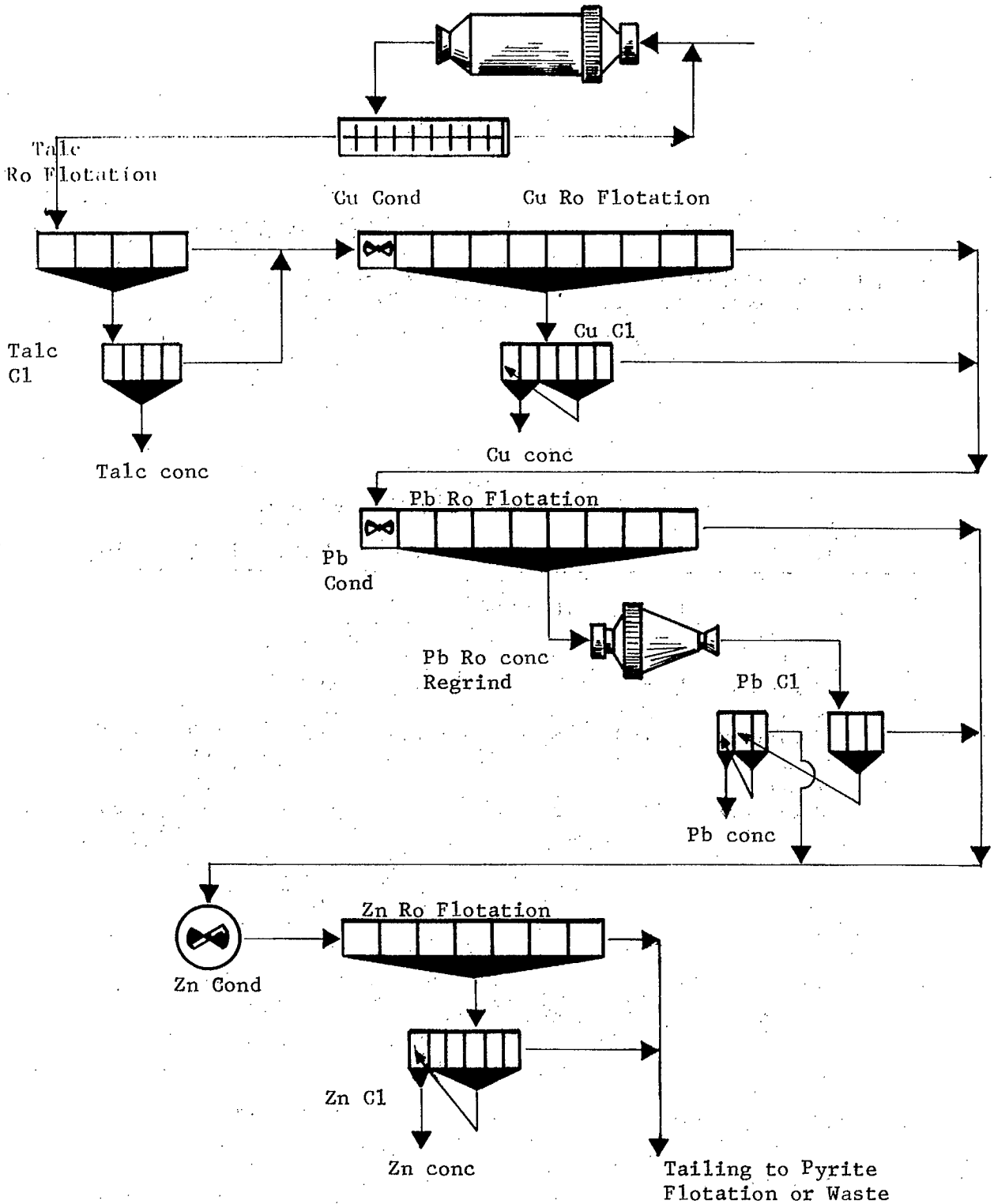
Detailed Metallurgical Balance

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Cu rougher concentrate	24.00	8.90	1.38	1.99	95.1	60.2	26.8
" " tailing	76.00	0.15	0.30	1.89	4.9	39.3	73.2
Final Cu concentrate	6.10	30.00	0.87	0.43	81.9	9.6	1.4
Cu cleaner tailing (calcd)	17.90	1.73	1.56	2.52	13.2	50.6	25.4
" " " (assay)		2.25	1.87	2.68			
Pb rougher feed (calcd)	93.90	0.45	0.54	1.97	18.6	90.4	98.6
" " " (assay)		0.41	0.49	1.94			
" " concentrate	15.50	1.64	1.35	2.07	11.3	38.2	17.4
" " tailing (calcd)	78.40	0.22	0.38	1.95	7.3	52.2	81.2
" " " (assay)		0.22	0.38	1.94			
Final Pb concentrate	0.92	1.12	13.80	1.50	0.3	23.1	0.6
Pb cleaner tailing (calcd)	14.60	1.68	0.57	2.10	11.0	15.1	16.8
" " " (assay)		1.81	0.29	2.16			
Zn rougher feed (calcd)	93.00	0.44	0.41	1.97	18.3	67.3	97.8
" " " (assay)		0.50	0.37	2.01			
Final Zn concentrate	2.86	3.72	2.54	45.40	4.7	13.3	73.1
Zn rougher concentrate	5.40	3.96	1.92	24.80	12.3	24.3	97.1
" cleaner tailing (calcd)	2.54	4.29	1.18	1.57	4.3	5.4	22.2
" " " (assay)		1.33	0.98	1.44			
" rougher tailing	86.02	04.24	0.32	0.58	9.3	48.6	22.5
Final tailings (calcd)	89.28	0.35	0.34	0.60	13.6	54.0	24.7
Final tailings (assay)		0.34	0.33	0.47			

Pilot Plant Test No. 10

This was an attempt to repeat the metallurgical performance of pilot plant Test No. 5. Therefore the talc flotation circuit was re-introduced, the lead rougher concentrate was reground and the first and second lead cleaner tailings were pumped to the zinc conditioner. The feed rate was 480 lb/hr.

		Reagent Consumption lb/ton					
Point of Addition	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$
Grind	11.6	11.0					
Class o'flow	11.5						
Talc rougher			.002				
Cu conditioner	11.1			.055	.028		
Cu rougher							
Pb conditioner	9.8			.033		.110	
Pb cleaner						.061	
Pb recleaner						.050	
Zn conditioner	11.5	5.5					2.20
Zn rougher							



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Pilot Plant Test No. 10

Product	Assays % Cu	Pb	Zn	Tot Fe	Sol Fe	Tot S	Insol
Classifier o'flow	2.34	1.76	0.55	40.60	13.60	35.30	
Talc cleaner tailing	12.90	1.85	1.56				
" rougher "	1.71	1.84	0.49				
Final talc concentrate	19.70	0.74	1.64	25.50	7.00		
Cu cleaner tailing	0.93	2.95	1.15				
" rougher "	0.15	1.65	0.23				
" " feed	2.02	1.82	0.53				
" " concentrate	8.50	2.73	1.69				
Final Cu "	19.70	2.35	2.40	43.50	9.60	30.30	12.30
Pb rougher tailing	0.16	1.65	0.19				
" cleaner " (No. 1)	0.88	3.68	0.42				
" " " (No. 2)	3.25	3.53	0.69				
" rougher feed	0.20	1.61	0.36				
" reg rougher concentrate	1.33	3.13	1.99				
" rougher concentrate	1.22	3.10	1.89				
Final Pb concentrate	1.06	6.80	3.09	35.00	8.80	31.80	20.40
Zn cleaner tailing	1.08	0.65	0.39				
" rougher "	0.20	0.15	0.18				
" " feed	0.28	1.69	0.21				
" " concentrate	1.47	0.67	19.40				
Final Zn "	1.59	0.60	41.0	19.3	10.40	34.90	0.78
Pyrite concentrate	0.25	0.30	0.29	49.30	4.10	50.60	
Flotation tailing	0.21	0.19	0.21				

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.34	1.76	0.55	100.0	100.0	100.0
Final talc concentrate	1.81	19.70	1.09	0.74	15.2	5.5	0.7
Cu rougher feed	98.19	2.02	0.53	1.79	84.8	94.5	99.3
Final Cu concentrate	8.78	19.70	2.40	2.35	73.9	38.4	11.7
Cu rougher "	21.80	8.50	2.73	1.69	79.3	67.1	33.9
" cleaner tailing	13.02	0.96	1.21	2.99	5.4	28.7	22.2
Final Pb concentrate	1.65	1.06	6.80	3.09	0.7	20.3	2.8
" Zn "	3.33	1.59	0.60	41.00	2.3	3.6	77.9
Zn rougher "	7.18	1.47	0.67	19.40	9.5	8.7	79.1
" cleaner tailing	3.85	1.35	0.73	0.73	2.2	5.1	1.7
Flotation "	84.16	0.21	0.19	0.21	7.5	32.0	9.1

Pilot Plant Test No. 12

This was a preliminary test using 1900 lb of high density alumina grinding pebbles all minus 1 inch. The feed rate to the Dominion 44 in. diam by 38 in. long (inside diam) mill was 500 lb/hr.

The production figures for this test were not too accurate. The lead concentrate sample was not representative of that produced.

		Reagent Consumption lb/ton					
Point of Addition	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$
Grind		10.6					
Class o'flow	10.1						
Talc rougher			.01				
Cu conditioner	9.4			.1144	.037		
Pb conditioner				.027		.190	
Pb rougher	8.8						
Pb cleaner						.045	
Pb recleaner						.061	
Zn conditioner	10.8	5.30					2.33

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	0.1	0.3	1.5	2.3	3.5	9.3

Pilot Plant Test No. 12

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.49	0.51	1.85	
Talc rougher tailing	2.24	1.07	1.85	
" cleaner "	10.20	0.85	1.10	
" concentrate	7.12	0.48	0.30	15.1
Cu rougher tailing	0.14	0.42	1.81	
" " feed	2.28	0.56	1.99	
" cleaner tailing	1.41	0.83	2.45	
" rougher concentrate	4.78	0.65	2.11	11.40
Final Cu "	27.10	0.76	0.65	6.57
Pb cleaner tailing	0.89	0.37	2.51	
" rougher "	0.17	0.37	1.87	
" " feed	0.44	0.54	1.96	
" " concentrate	1.79	1.54	2.57	
Final Pb "	4.75	1.36	2.39	20.50
Zn rougher tailing	0.24	0.24	0.34	
" " feed	0.33	0.38	1.97	
" cleaner tailing	1.43	1.22	2.15	
" rougher concentrate	2.59	2.10	24.60	
Final Zn "	3.86	2.62	45.80	1.24
Flotation tailing	0.34	0.35	0.52	

Pilot Plant Test No. 12

Detailed Metallurgical Balance

Product	Wt %	Assays %			Distribution %		
		Cu	Pb	Zn	Cu	Pb	Zn
Class o'flow	100.00	2.49	0.51	1.85	100.0	100.0	100.0
Talc cleaner concentrate	4.34	7.12	0.48	0.30	12.4	4.1	0.7
Cu rougher feed	95.66	2.28	0.56	1.99	87.6	95.9	99.3
Talc cleaner tailing	4.81	10.20	0.85	1.10	19.6	8.1	2.9
" rougher "	90.85	2.24	1.07	1.85	68.0	87.8	96.4
" " concentrate	9.15	8.74	0.68	0.72	32.0	12.2	3.6
Cu cleaner "	5.42	27.10	0.76	0.65	59.0	8.0	1.9
" rougher "	44.20	4.78	0.65	2.11	84.8	56.4	50.5
" cleaner tailing	38.78	1.65	0.64	2.32	25.8	48.4	48.6
" rougher "	51.46	0.14	0.42	1.81	2.8	39.5	48.8
" cleaner " (assay)		1.41	0.83	2.45	-	-	-
Pb rougher feed (calcd)	90.24	0.78	0.51	2.03	28.6	87.9	97.4
" " " (assay)		0.44	0.54	1.96	-	-	-
Final Pb concentrate	6.94	4.75	1.36	2.39	13.3	18.4	9.00
Zn rougher feed	83.30	0.45	0.43	1.96	15.3	69.5	88.4
" " concentrate	5.13	2.59	2.10	24.6	5.3	21.2	68.3
Final Zn "	2.64	3.86	2.62	45.8	4.1	13.5	65.4
Zn cleaner tailing	2.49	1.25	1.57	2.17	1.2	7.7	2.9
Final cleaner tailing	80.66	0.34	0.35	0.52	11.2	56.0	23.0

Pilot Plant Test No. 13

Due to the fine grind produced in Test No. 12 the feed rate was increased in this test to 1000 lb/hr.

Point of Addition	Reagent Consumption lb/ton					
	pH	Lime	Z-6	Z-200	MIBC	NaCN	$CuSO_4$
Grind		6.62					
Class o'flow	10.1						
Talc rougher					.004		
Cu "	9.6		.077	.007			
" cleaner				.026			
Pb conditioner	8.9					.106	
" rougher			.007				
" cleaner						.04	
" recleaner						.05	
Zn conditioner		2.65					1.91
" rougher	11.0			.011			

Screen Analysis

Mesh	+100	+150	+200	+270	+325	-325
Class o'flow	0.1	0.7	1.9	3.8	5.9	87.6

Pilot Plant Test No. 13

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.54	0.56	1.90	
Talc rougher tailing	2.15	0.58	1.96	
" cleaner "	10.00	0.59	1.46	
Talc concentrate	17.90	0.73	0.34	21.50
Cu rougher feed	2.30	0.57	1.99	
" " concentrate	7.94	1.09	2.15	
" " tailing	0.19	0.24	0.29	
" cleaner "	1.09	0.69	2.65	
Final Cu concentrate	25.80	1.39	1.05	
Pb rougher feed	0.26	0.50	1.97	
" " concentrate	1.18	2.47	2.82	
" " tailing	0.15	0.22	1.96	
" cleaner "	0.63	0.38	2.56	
" " " (No. 2)	2.78	0.82	2.72	
Final Pb concentrate	2.72	12.40	3.31	17.70
Zn rougher feed	-	0.28	1.99	
" " concentrate	1.25	1.58	22.80	
" " tailing	0.16	0.45	-	
" cleaner "	0.68	0.80	0.88	
Final Zn concentrate	0.82	2.38	50.20	1.28
Flotation tailing	0.19	0.23	0.30	

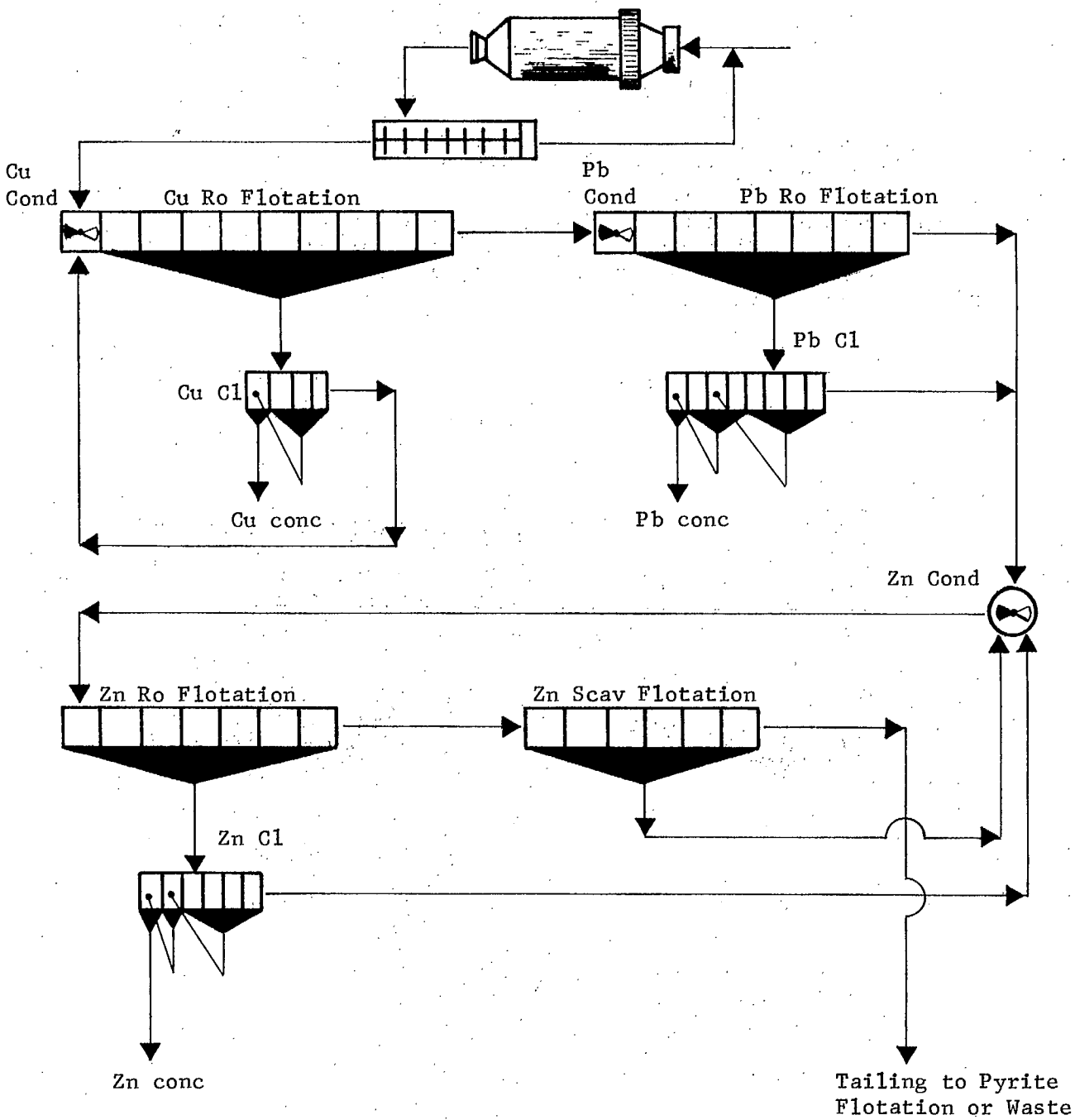
Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.54	0.56	1.90	100.0	100.0	100.0
Final talc concentrate	1.54	17.90	0.73	0.34	10.9	1.9	0.3
" Cu "	7.91	25.80	1.39	1.05	80.2	19.2	4.2
" Pb "	1.45	2.72	12.40	3.31	1.5	31.4	2.4
" Zn "	3.13	0.82	2.38	50.20	1.0	12.9	80.0
Flotation tailing	85.97	0.19	0.23	0.30	6.4	34.6	13.1

Pilot Plant Test No. 14

The talc circuit was discontinued. The Cu cleaner tailing was returned to the head of the Cu rougher circuit. The Cu rougher concentrate was cleaned in 3 - No. 7 cells and recleaned in 1 - No. 5 cell. The Zn rougher tailing was scavenged in 6 Fagergeen cells. The Zn rougher concentrate was cleaned in 4 - No. 5 cells again in 1 - No. 5 cell and yet again in 1 - No. 5 cell. Zn cleaner tailings were returned to the zinc conditioner. Feed rate was 1000 lb/hr as in Test No. 13.

Point of Addition	Reagent Consumption lb/ton					
	pH	Lime	Z-6	Z-200	NaCN	R-242	$CuSO_4$
Grind		8.50					
Class o'flow	10.4						
Cu conditioner			.092				
" rougher	10.7			.009			
" " cell (No. 6)			.004				
Pb conditioner			.008		.290		
" rougher	9.5					.005	
" cleaner					.053		
" recleaner					.061		
Zn conditioner		4.0					2.14
" rougher	11.0			.011			
" scavenger				.007			



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DATE:
MR #14

Pilot Plant Test No. 14

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.52	0.53	1.86	
Cu rougher concentrate	16.70	1.65	1.29	10.50
" " tailing	0.32	0.55	1.95	
Final Cu concentrate	25.20	0.74	0.89	12.50
(Grab sample - Cu)	26.10	1.02	0.67	11.70
Cu cleaner tailing	0.62	1.56	2.49	
Pb rougher concentrate	0.92	5.99	2.40	16.70
" " tailing	0.21	0.23	1.83	
Final Pb concentrate	0.17	33.50	2.58	30.50
(Grab sample - Pb)	0.38	35.00	3.12	26.50
Pb cleaner tailing (No. 1)	0.85	0.82	2.31	
" " " (No. 2)	1.12	3.81	4.05	
" scavenger "	2.16	1.81	15.50	11.90
Zn rougher concentrate	1.62	1.53	31.10	4.39
" " tailing	0.32	0.31	0.96	
Final Zn concentrate	1.04	0.74	53.50	0.51
(Grab sample - Zn)	0.78	1.09	54.00	0.38
Zn cleaner tailing	1.46	1.30	23.60	
Flotation "	0.23	0.25	0.36	

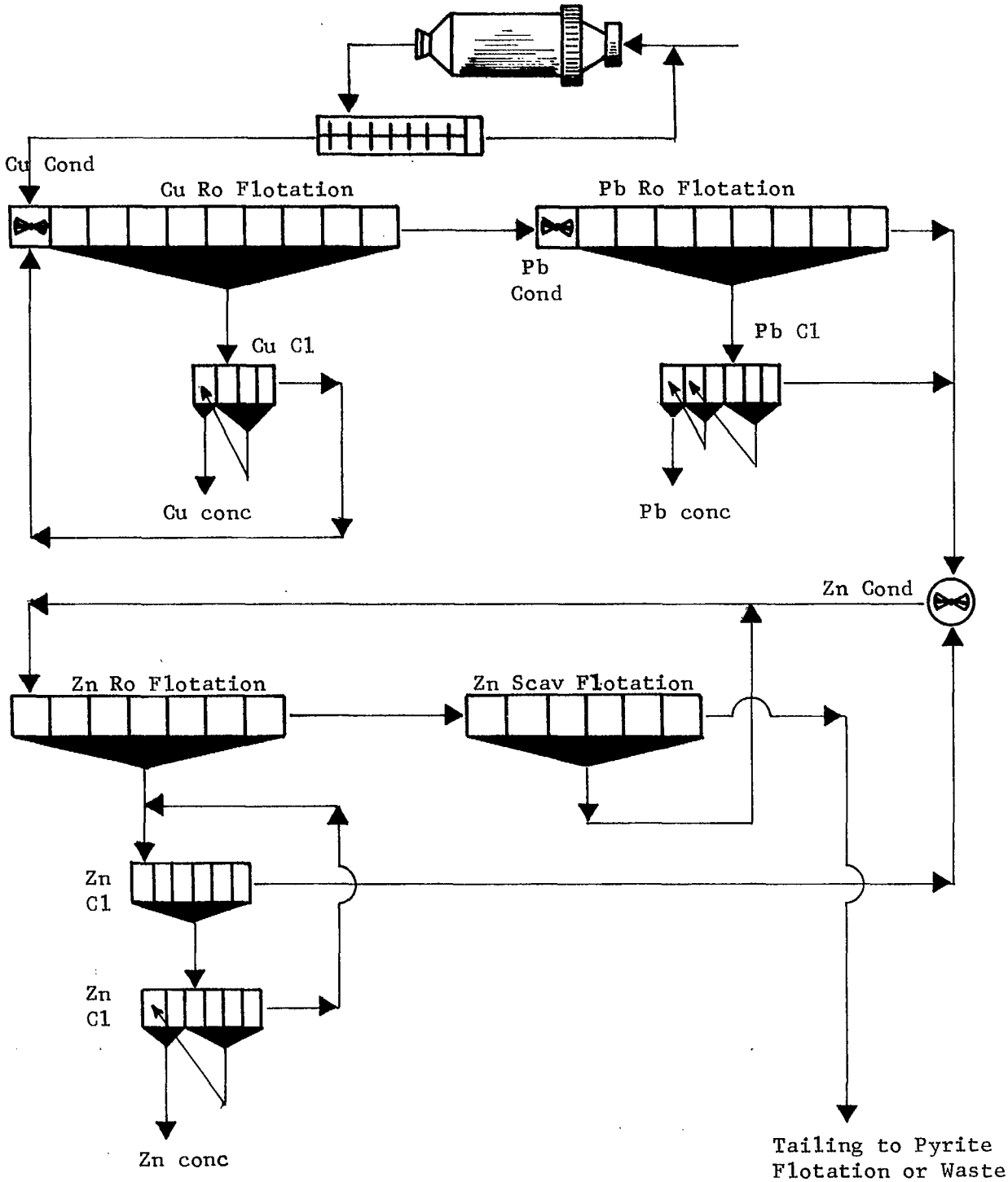
Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.52	0.53	1.86	100.0	100.0	100.0
Final Cu concentrate	9.08	25.20	0.74	0.80	90.92	12.64	3.92
" Pb "	0.67	0.17	33.50	2.58	0.04	42.26	0.91
" Zn "	2.72	1.04	0.74	53.50	1.11	3.77	78.28
Flotation tailing	87.53	0.23	0.25	0.36	7.93	41.33	16.89

Pilot Plant Test No. 15

This test was almost identical to Test No. 14 except that the copper collectors, Z-6 and Z-200 were both increased significantly. The feed rate was 1000 lb/hr as before.

Point of Addition	pH	Reagent Consumption lb/ton					
		Lime	Z-6	Z-200	NaCN	R-242	$CuSO_4$
Grind		8.5					
Class o'flow	11.0						
Cu conditioner			.145				
" rougher	10.8		.006	.013			
Pb conditioner			.013		.290	.001	
" rougher	9.9						
" cleaner					.050		
" recleaner					.063		
Zn conditioner		4.0					2.40
" rougher	11.1			.018			
" scavenger	10.9			.004			



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M.R. No. 15

Pilot Plant Test No. 15

Product	Assays % Cu	Pb	Zn	Insol	Tot Fe	Sol S
Classifier o'flow	2.49	0.53	1.79			
Cu rougher concentrate	9.82	2.68	1.85	11.1		
" " tailing	0.16	0.38	1.85			
" cleaner "	0.30	2.48	2.38			
(Grab sample - Cu)	20.00	1.78	1.52	15.6		
Final Cu concentrate	19.60	1.81	1.49	15.3		
Pb rougher "	0.35	2.99	2.44	11.2		
" " tailing	0.13	0.16	1.85			
" cleaner " (No. 1)	0.33	0.46	2.06			
" " " (No. 2)	0.82	1.17	2.74			
(Grab sample - Pb)	0.18	12.50	3.65	11.6		
Final Pb concentrate	0.18	11.40	3.58	11.7		
Zn rougher "	1.05	0.70	14.0	7.18		
" scavenger "	1.12	0.83	3.73	11.4		
" rougher tailing	0.24	0.21	0.49			
" cleaner " (No. 1)	1.01	0.59	2.35			
" " " (No. 2)	4.78	2.67	27.1			
(Grab sample - Zn)	0.35	0.76	52.5	0.28		
Final Zn concentrate	0.92	0.93	52.00	0.28		
Pyrite concentrate	0.52	0.43	0.66		45.0	42.6
Flotation tailing (grab)	0.15	0.16	0.27			
" "	0.15	0.19	0.29			

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.49	0.53	1.79	100.0	100.0	100.0
Final Cu concentrate	11.93	19.60	1.81	1.49	93.9	40.7	9.9
" Pb "	1.14	0.18	11.40	3.58	0.1	24.5	2.3
Pb rougher feed	88.07	0.17	0.36	1.83	6.1	59.3	90.1
" " concentrate	6.13	0.35	2.99	2.44	0.8	34.5	8.4
" " tailing	81.94	0.16	0.16	1.78	5.3	24.8	81.7
" cleaner "	4.99	0.38	1.06	2.18	0.7	10.0	6.1
Final Zn concentrate	2.58	0.92	0.93	51.50	1.0	4.5	74.2
Flotation tailing	84.35	0.15	0.19	0.29	5.0	30.3	13.6

Pilot Plant Test No. 17

This was the first complete test using coarse ore pebbles as feed to the 24 in. dia x 48 in. long ball mill with a grate discharge. It was noticeable that a much purer appearing talc concentrate was being produced. An increase in MIBC was made. Although copper flotation looked quite good the assays were disappointing. More lead seemed to be floating with the copper concentrate. After sampling the cyanide addition to the lead conditioner was halved to see if there would be any effect on the copper sulphate consumption. The zinc rougher froth immediately started to tighten up.

	Reagent Consumption lb/ton					
Point of Addition	pH	Lime	Z-6	Z-200	MIBC	NaCN	$CuSO_4$
Grind		10.2					
Class o'flow	11.1						
Talc rougher					.01		
Cu "	10.8		.079	.032			
Pb conditioner	10.1		.01			.369	
" cleaner						.079	
" recleaner						.059	
Zn conditioner		7.0					3.50
" rougher	11.3			.021			

Pilot Plant Test No. 17

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.84	0.82	3.14	
Talc rougher concentrate	2.05	0.77	2.03	
" " tailing	2.88	0.83	3.17	
" cleaner concentrate	0.28	0.09	0.16	
" " tailing	2.31	0.76	2.32	
Cu rougher concentrate	9.47	2.25	5.49	14.80
" " tailing	1.18	0.51	2.89	
Final Cu concentrate	23.20	4.53	4.61	14.00
Cu cleaner tailing	5.27	1.87	4.99	
Pb rougher concentrate	2.29	2.86	2.94	15.60
" " tailing	1.12	0.29	2.87	
" cleaner "	2.30	0.55	2.87	
" recleaner "	2.17	0.87	2.56	
Final Pb concentrate	0.75	19.70	3.64	30.40
Zn rougher "	7.50	0.82	24.00	4.70
" cleaner tailing	7.06	0.85	5.11	
Final Zn concentrate	5.22	0.31	47.50	0.47
Flotation tailing	1.22	0.28	1.23	

Metallurgical Balance

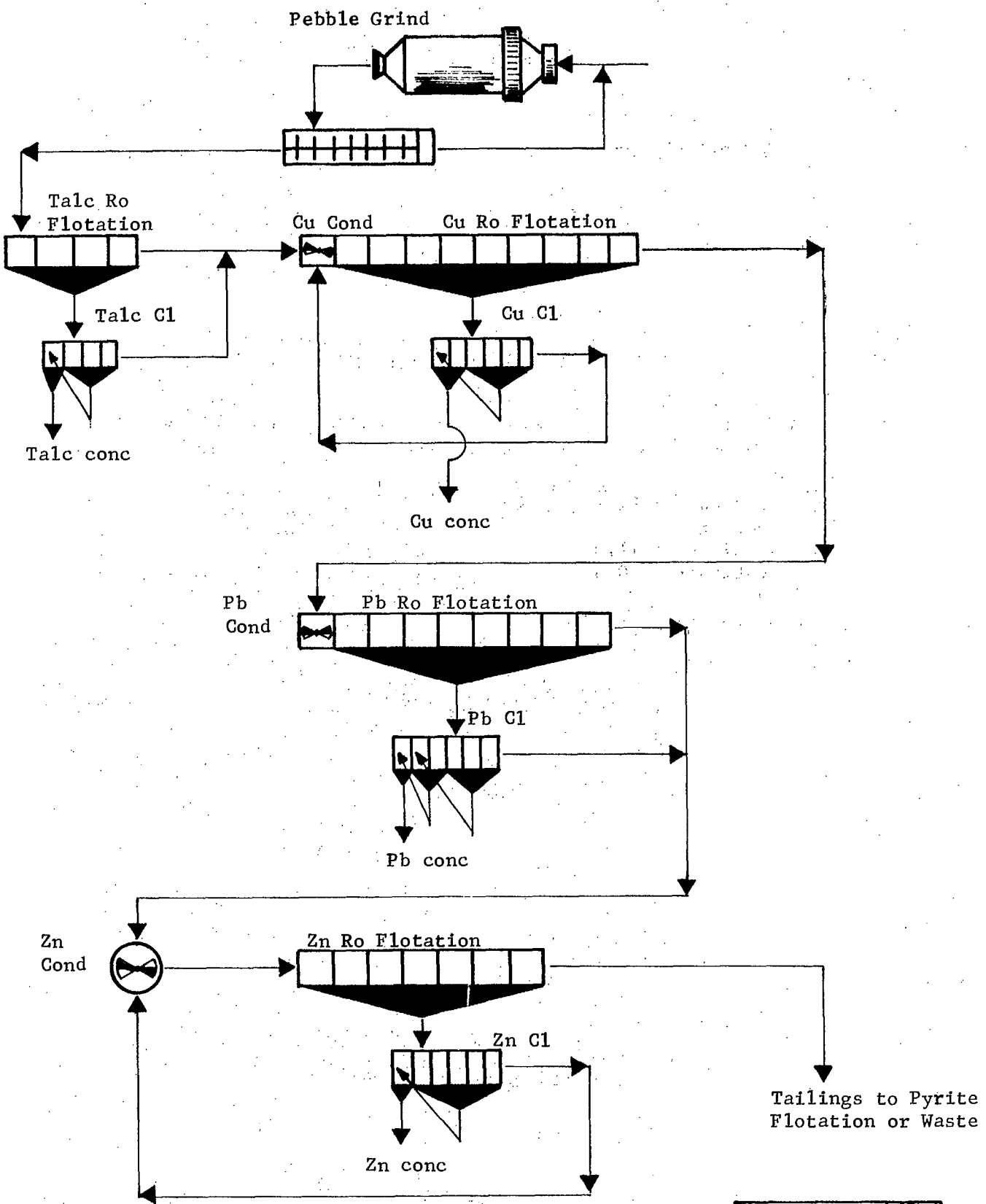
Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.84	0.82	3.14	100.0	100.0	100.0
Talc rougher concentrate	4.81	2.05	0.77	2.03	3.49	4.51	3.12
" cleaner "	0.62	0.28	0.09	0.16	0.07	0.12	0.03
" " tailing	4.19	2.31	0.76	2.32	3.42	4.39	3.09
Cu rougher feed	99.38	2.86	0.82	3.15	99.93	99.88	99.97
Final Cu concentrate	6.69	23.20	4.53	4.61	55.00	36.90	9.78
" Pb "	1.28	0.75	19.70	3.64	0.35	31.09	1.50
" Zn "	3.58	5.22	0.31	47.50	6.62	1.34	54.14
Flotation tailing	87.83	1.22	0.28	1.23	37.96	30.55	34.55

Pilot Plant Test No. 18

This was a repeat of Test No. 17, with a decrease in reagents.

Reagent Consumption lb/ton

Point of Addition	pH	Lime	Z-6	Z-200	MIBC	NaCN	$CuSO_4$
Grind		10.16					
Class o'flow	11.1						
Talc rougher					.01		
Cu conditioner	11.0		.266	.011			
Pb conditioner	10.8		.01			.138	
" cleaner						.080	
" recleaner						.105	
Zn conditioner	11.3	6.8		.027			2.38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Talc Ro Flotation
Cu Cond
Cu Ro Flotation
Talc Cl
Cu Cl
Talc conc
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Pb Cond
Pb Ro Flotation
Pb Cl
Pb conc
Zn Cond
Zn Ro Flotation
Zn Cl
Zn conc
Tailings to Pyrite Flotation or Waste
MINES BRANCH, OTTAWA
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DATE:
M.R.#18

Pilot Plant Test No. 18

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.24	0.69	2.48	
Talc rougher concentrate	1.53	0.74	1.65	
" " tailing	2.31	0.75	2.58	
" cleaner "	2.21	0.85	2.43	
Final talc concentrate	0.34	0.14	0.15	
Cu-Pb rougher "	9.00	2.83	8.13	8.79
Cu rougher tailing	0.81	0.34	1.56	
" cleaner "	4.56	1.40	5.69	
Final Cu-Pb concentrate	18.30	5.54	13.50	3.13
Deleaded Cu-Pb concentrate	19.40	1.36	14.30	10.40
Pb concentrate	1.16	35.40	3.82	4.17
" rougher concentrate	2.18	1.43	3.42	13.20
" " tailing	0.78	0.20	1.48	
" cleaner "	2.55	0.67	3.17	
Final Pb concentrate	1.11	6.50	3.90	27.30
Zn rougher "	5.00	0.84	20.60	4.29
" " tailing	0.71	0.28	0.24	(flotation tailing)
" cleaner "	5.79	1.01	1.74	
Final Zn concentrate	2.12	0.77	51.90	0.14

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.24	0.69	2.48	100.00	100.00	100.00
Talc rougher concentrate	8.98	1.53	0.74	1.65	-	-	-
" cleaner "	3.26	0.34	0.14	0.15	0.49	0.72	0.20
" " tailing	5.72	2.21	0.85	2.43	-	-	-
Cu rougher feed	96.74	2.30	0.71	2.56	99.51	99.28	99.80
Deleaded Cu concentrate	8.05	19.40	1.36	14.30	69.92	15.80	46.37
Final Pb concentrate	0.91	1.16	35.40	3.82	0.49	46.67	1.41
" Zn "	2.09	2.12	0.77	51.90	1.96	2.32	43.76
Flotation tailing	85.69	0.71	0.28	0.24	27.14	34.49	8.26

Pilot Plant Test No. 19

The amount of lime added to the grinding circuit was cut to about 5.0 lb/ton. The amount of Z-6 was cut to 0.17 lb/ton. The lead rougher circuit was eleminated and a lead concentrate was recovered by deleading a copper-lead concentrate. Due to these changes the copper sulphate was reduced to 0.50 lb/ton to prevent a tightening of the zinc froth. A small amount of R-242 was added to the copper rougher circuit.

Point of Addition	Reagent Consumption lb/ton					
	pH	Lime	Z-6	MIBC	Z-200	NaCN	$CuSO_4$
Grind		5.77					
Class o'flow	9.2						
Talc rougher				0.07			
Copper conditioner	8.9		0.17				
" rougher					0.10		
Cu-Pb separation (No. 1)	9.9					0.47	
" " " (No. 2)						0.32	
" " " (No. 3)						0.10	
Zn conditioner	11.3	8.34					0.64
" rougher					0.027		

Screen Analysis

Mesh	+20	+48	+65	+100	+150	+200	+270	+325	-325
Class sand	3.3	1.7	3.2	8.7	18.6	28.2	19.3	9.4	8.6
Class o'flow	-	-	0.4	1.5	2.6	5.8	8.1	8.5	73.1

Pilot Plant Test No. 19

Product	Assays % Cu	Pb	Zn	Insol
Classifier o'flow	2.03	0.67	1.65	9.68
Talc rougher concentrate	1.31	0.48	0.90	
" " tailing	2.19	0.69	1.72	
" cleaner "	1.73	0.64	1.33	
Final talc concentrate	0.32	0.04	0.09	
Cu-Pb rougher concentrate	8.06	2.06	1.75	12.5
Cu rougher tailing	0.64	0.30	1.83	
" cleaner "	3.55	0.91	2.34	
Final Cu-Pb concentrate	22.90	5.94	0.78	11.6
Cu-Pb separation concentrate	19.70	8.13	0.83	16.8
Final Cu concentrate	26.40	0.29	0.62	7.78
" Pb "	3.60	42.50	2.97	16.50
Zn rougher "	4.15	0.73	15.50	6.26
" " tailing	0.43	0.29	0.81	7.61
" cleaner "	2.65	0.84	1.51	
Final Zn concentrate	5.03	0.69	48.00	0.62

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.03	0.67	1.65	100.00	100.00	100.00
Final talc concentrate	1.87	0.32	0.04	0.09	0.31	0.15	0.12
" Cu "	5.73	26.40	0.29	0.62	74.63	2.54	2.18
" Pb "	0.88	3.60	42.50	2.97	1.57	56.29	1.47
" Zn "	1.80	5.03	0.84	48.00	4.48	2.24	52.38
Flotation tailing	89.72	0.43	0.29	0.81	19.01	3.88	43.75

Pilot Plant Test No. 20

Lime addition to grinding circuit decreased from 5.30 lb/ton to 2.65 lb/ton. Increased Z-200 to 0.0264 lb/ton to copper-lead rougher circuit. Copper sulphate reduced to about 0.40 lb/ton.

Point of Addition	Reagent Consumption lb/ton						
	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$
Grind		2.76					
Class o'flow	8.7						
Talc rougher			0.07				
Cu rougher	8.5			0.112	0.026		
Cu-Pb separation (No. 1)	9.4					0.262	
" " " (No. 2)						0.168	
" " " (No. 3)						0.105	
Zn conditioner	10.6	4.22			0.01		0.42

Screen Analysis

Mesh	+20	+48	+65	+100	+150	+200	+270	+325	-325
B.M. discharge	0.4	1.3	2.1	6.6	14.8	24.5	18.0	8.5	23.8
Class sands	1.2	1.4	2.2	6.9	15.6	29.2	19.4	8.8	16.3
Class o'flow		0.2	1.6	3.3	4.4	7.0	9.4	12.2	61.5

Pilot Plant Test No. 20

Product	Assays % Cu	Zn	Pb	Insol
Classifier o'flow	2.71	1.85	0.50	
Talc rougher concentrate	1.21	0.61	0.36	
" " tailing	2.79	1.91	0.52	
" cleaner "	2.15	1.10	0.60	
Final talc concentrate	0.28	0.06	0.02	
Cu rougher "	10.00	2.39	1.82	11.50
" " tailing	0.65	1.79	0.11	
" cleaner "	2.53	2.75	0.41	
Cu-Pb concentrate	21.50	1.66	3.99	10.60
" " separation (No. 1)	11.60	2.36	6.75	26.20
Final Cu concentrate	26.50	1.31	0.52	7.47
" Pb "	2.03	4.60	43.00	4.30
Zn rougher "	4.68	13.8	0.26	5.79
" cleaner tailing	2.29	3.41	0.24	
Final Zn concentrate	7.18	40.70	0.32	0.64
Zn rougher tailing	0.37	0.69	0.08	

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.71	0.50	1.85	100.00	100.00	1100.00
Talc rougher concentrate	5.06	1.21	0.36	0.61	2.25	3.60	1.68
" cleaner "	2.54	0.28	0.02	0.06	0.25	-	0.11
" " tailing	2.15	0.60	1.10	0.054	2.00	3.60	1.57
" rougher "	94.94	2.79	0.52	1.91	97.75	98.60	98.05
Cu rougher feed	97.46	2.77	0.51	1.90	99.75	100.00	99.89
Cu-Pb concentrate	9.07	24.12	4.54	1.63	80.73	84.20	8.00
Final Cu "	8.19	26.50	0.52	1.31	80.07	8.6	5.78
" Pb "	0.88	2.03	43.00	4.60	0.66	75.6	2.22
" Zn "	2.74	7.18	0.32	40.70	7.26	1.80	60.27
Flotation tailing	85.65	0.37	0.08	0.69	11.70	13.60	31.95

Pilot Plant Test No. 20

Except for the high circulating load of copper in the cleaner and rougher circuits this was probably the best of all the tests. If the copper cleaner tailing had been sent directly to the zinc circuit the overall results might have been much better. During the morning the flotation looked very good in all the circuits but gradually deteriorated in the zinc circuit during sampling in the afternoon.

It was thought that the reduction of lime to the grinding circuit improved the talc recovery slightly.

Careful control of the Z-200 added to the copper rougher circuit is necessary since this reagent appears to affect the copper-lead separation. The amount of dilution is also of great importance. If no Z-200 is added to the copper rougher circuit the Cu-Pb separation froth will go flat. On the other hand if too much Z-200 is added, too much copper will float in the separation circuit and there will be an excess of froth which can only be controlled by using excess spray water. This of course will cause serious dilution in the cleaner circuit.

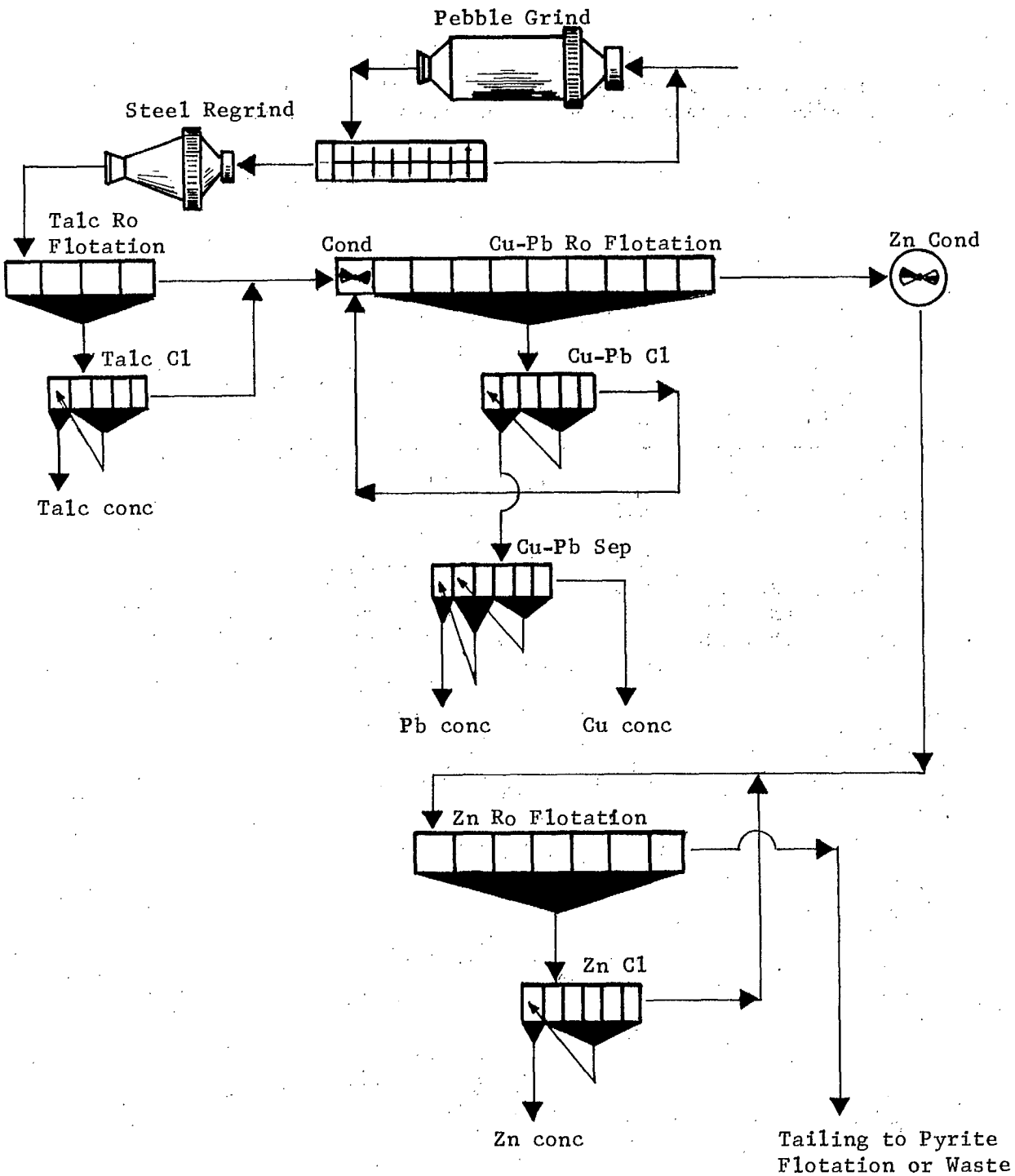
During this test in the deleading circuit the lead rougher concentrate was obtained using 3 - No. 5 cells. This concentrate was cleaned in 2 - No. 5 cells and recleaned in 1 - No. 5 cell. It was felt that a different combination such as 3-1-1 might have produced better results. As can be seen in the metallurgical balance a good lead recovery was obtained. The low lime addition to the grind was probably the reason. Perhaps even a lower pH might be advantageous.

Zinc recovery might have been higher if the amount of Z-200 had been increased slightly. An increase in the amount of $CuSO_4$ would only produce a flat froth.

Pilot Plant Test No. 21

This test was basically a repeat of Test No. 20 except that the classifier overflow was reground in open circuit in a mild steel mill.

Point of Addition	Reagent Consumption lb/ton						
	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$
Grind		2.64					
Class o'flow	8.2						
Talc rougher			0.08				
Cu-Pb "	8.3			0.152	0.031		
Cu-Pb separation (No. 1)	9.9					0.276	
" " " (No. 2)						0.156	
" " " (No. 3)						0.109	
Zn conditioner	10.5	4.22			0.037		0.43



MINES BRANCH, OTTAWA	
DRAWN : J.D MacLeod	
DATE :	M.R.# 21

Pilot Plant Test No. 21

Product	Assays % Cu	Pb	Zn	Sol Fe	Tot S
Classifier o'flow	2.58	0.71	2.65		
Regrind mill disch	2.54	0.70	2.59		
Talc rougher concentrate	1.15	0.56	0.90		
" " tailing	2.43	0.67	2.46		
" cleaner "	1.64	0.77	1.41		
Final talc concentrate	0.37	0.03	0.14		
Cu-Pb rougher feed	2.33	0.55	2.62		
" " " concentrate	9.94	2.48	3.17		
" " " tailing	0.76	0.11	2.32		
" " cleaner "	5.79	0.41	3.54		
Final Cu-Pb concentrate	22.40	8.15	2.74		
Cu-Pb sep ro concentrate	2.85	12.10	4.32		
Final Cu concentrate	25.80	0.46	2.16		
" Pb "	2.85	43.90	5.27		
Zn rougher "	5.23	0.27	17.20		
" cleaner tailing	3.17	0.31	5.70		
Final Zn concentrate	2.15	0.34	44.20		
Flotation tailing	0.51	0.14	1.64		
Pyrite concentrate	0.82	0.07	1.30	45.00	57.00

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.58	0.71	2.65	100.0	100.0	100.0
Final talc concentrate	1.00	0.37	0.03	0.14	0.2	-	0.1
Cu rougher feed	99.00	2.60	0.72	2.62	99.8	100.0	99.9
Final Cu concentrate	7.72	25.80	0.46	2.16	77.2	5.2	6.3
" Pb "	1.22	7.35	43.90	5.27	3.5	76.0	2.4
" Zn "	2.18	2.15	0.34	44.20	1.8	1.0	36.9
Flotation tailing	87.88	0.51	0.14	1.64	17.3	17.8	54.3

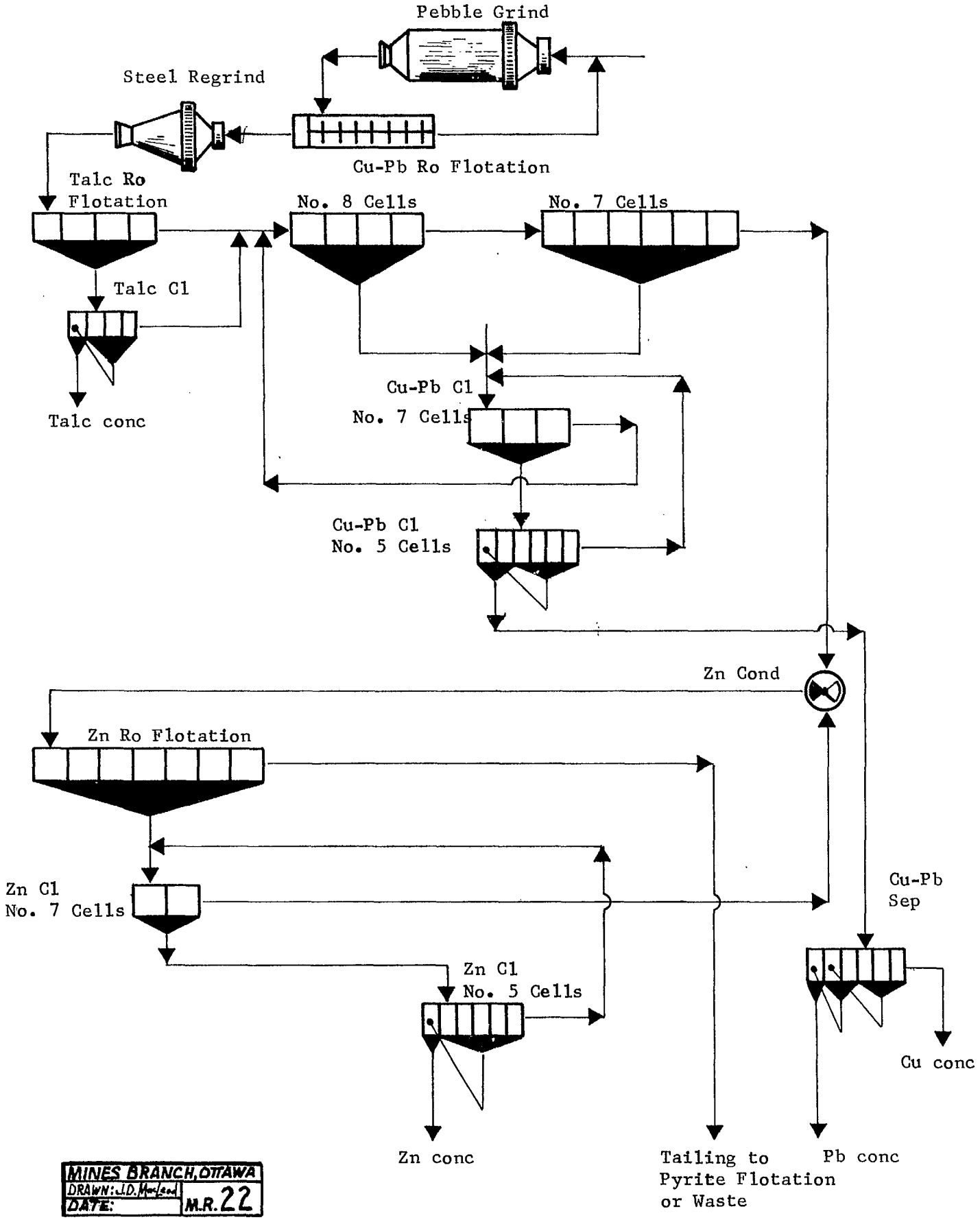
Pilot Plant Test No. 22

Repeat of Test No. 21

Point of Addition	Reagent Consumption lb/ton						
	pH	Lime	MIBC	Z-6	Z-200	NaCN	$CuSO_4$
Grind		5.28					
Class o'flow	8.9						
Talc rougher			0.08				
Cu-Pb rougher	8.9			0.156	0.026		
" " scavenger				0.023			
" " separation (No. 1)	9.0					0.52	
" " " (No. 2)						0.37	
" " " (No. 3)						0.26	
Zn conditioner	10.4	4.22			0.031		0.52

Screen Analysis

Mesh	+20	+35	+48	+65	+100	+150	+200	+270	+325	-325
B.M. discharge	0.4	0.7	0.9	2.0	6.7	15.6	24.2	16.2	9.7	23.6
Class sand	1.4	0.7	1.0	2.1	8.3	20.3	37.5	16.4	6.2	6.1
Class o'flow	-	-	0.4	0.7	3.4	6.8	14.8	13.5	9.8	50.6
Regrind disch	-	-	-	0.4	0.9	2.0	3.6	4.3	7.0	81.8


Pebble Grind
Steel Regrind
Cu-Pb Ro Flotation
Talc Ro Flotation
No. 8 Cells
No. 7 Cells
Talc Cl
Talc conc
Cu-Pb Cl No. 7 Cells
Cu-Pb Cl No. 5 Cells
Zn Cond
Zn Ro Flotation
Zn Cl No. 7 Cells
Zn Cl No. 5 Cells
Cu-Pb Sep
Cu conc
Zn conc
Tailing to Pyrite Flotation or Waste
Pb conc
MINES BRANCH, OTTAWA
DRAWN: J.D. Mac Leod
DATE:
M.R. 22

Pilot Plant Test No. 22

Product	Assays % Cu	Pb	Zn
Ball mill discharge	2.68	0.70	2.46
Talc rougher concentrate	1.07	0.34	0.83
" " tailing	2.76	0.72	2.51
" cleaner "	1.49	0.46	1.21
Final talc concentrate	0.21	0.02	0.07
Cu rougher feed	2.63	0.73	2.43
" " concentrate	15.20	4.21	3.34
" scavenger "	8.97	1.06	5.60
" " tailing	0.54	0.21	2.11
No. 1 Cu cleaner concentrate	18.30	4.21	5.00
No. 2 " " "	16.90	4.08	4.97
No. 1 " " tailing	1.66	0.57	2.83
No. 2 " " "	1.94	0.81	2.44
Cu-Pb concentrate	19.40	5.86	4.86
Final Cu "	24.00	0.35	4.71
Cu grab sample	23.3	0.30	4.86
Pb rougher concentrate	10.3	12.90	3.54
" " "	1.26	30.30	5.26
Final Pb "	0.75	36.40	5.08
Zn rougher concentrate	3.93	0.51	24.60
No. 1 Zn cleaner concentrate	5.20	0.51	38.10
No. 1 " " tailing	1.97	0.59	2.51
No. 2 " " "	7.54	0.81	17.50
Final Zn concentrate	2.23	0.40	52.50
Zn grab sample	2.13	0.57	50.80
Pyrite concentrate	0.56	0.10	0.54
Flotation tailing	0.39	0.23	0.34

Metallurgical Balance

Product	Wt %	Assays % Cu	Pb	Zn	Distribution % Cu	Pb	Zn
Class o'flow	100.00	2.68	0.70	2.46	100.00	100.00	100.00
Talc rougher concentrate	4.13	1.07	0.34	0.83			
" cleaner "	1.55	0.21	0.02	0.07	0.10	-	0.04
" " tailing	3.18	1.49	0.46	1.21			
Cu rougher feed	98.45				99.89	100.00	99.96
" cleaner concentrate	9.42	24.00	0.35	4.71	84.65	4.10	17.92
Pb " "	1.27	0.75	36.40	5.08	0.38	66.50	2.60
Zn " "	3.19	2.23	0.40	52.50	2.68	1.80	61.50
Flotation tailing	84.57	0.39	0.23	0.34	12.27	27.60	11.58