CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 71-53

A FEASIBILITY STUDY OF THE CONCENTRATION CHARACTERISTICS OF A COMPLEX MULTI-MINERAL ORE FROM BRUNSWICK TIN MINES LIMITED, CHARLOTTE COUNTY, NEW BRUNSWICK

by

G. I. MATHIEU, T. F. BERRY AND R. W. BRUCE

MINERAL PROCESSING DIVISION

COPY NO. 16

APRIL 1971

Mines Branch Investigation Report IR 71-53

A FEASIBILITY STUDY OF THE CONCENTRATION CHARACTERISTICS OF A COMPLEX MULTI-MINTERAL ORE FROM BRUNSWICK TIN MINES LIMITED, CHARLOTTE COUNTY, NEW BRUNSWICK

by

G.I. Mathieu*, T.F. Berry** and R.W. Bruce***

SUMMARY OF RESULTS

The ore treated in the investigation contained the following values:

Cu	Pb	Zn	Bi	MoS_2	Fl	WO_3	Sn
0.08%	0.14%	0.43%	0.09%	0.08%	4.4%	0.31%	0.07%

Indium in minor amounts was also found in the ore. Several of the valuable constituents were closely associated with the arsenic minerals (loellingite and arsenopyrite). Consequently, grinding to about 65% minus 325 mesh was necessary to achieve acceptable liberation.

The most representative results obtained in the pilot plant investigation were those of Tests 27 and 28, i.e., during the last 48 hours of the mill run. The following table shows integrated results from the two tests, although all the concentrates were not produced simultaneously because of the shortage of facilities.

*Research Scientist, **Technical Officer and ***Head, Non-Ferrous Minerals Section, Mineral Processing Division, Mines Branch, Department of Energy, Mines and Resources, Ottawa, Canada.

Typical Pilot Plant Results

Part 1: Analysis%

Product	Analysis %						
	Cu	Pb	Zn	Bi	MoS_2	As	Sn
Cu conc	13.9	3.3	23.1	0.7	0.3	3.8	5.3
Pb conc	0.9	23.0	8.9	5.9	2.7	3.4	0.7
Zn conc	1.6	0.5	40.3	1.3	0.5	11.7	1.2
MoS_2 conc(1)	4.5	2.1	5.8	1.3	18.6	4.5	0.5
MoS_2 conc(2)	0.4	4.7	1.4	1.9	20.8	10.0	0.4
As conc	0.07	0.10	0.25	0.22	0.16	6.0	-
Tailing	0.009	0.014	0.031	0.023	0.015	0.88	-

Part 2: Distribution %

Product	Distribution %					
	Cu	Pb	Zn	Bi	MoS_2	As
Cu conc	49.2	6.9	13.7	2.2	0.9	0.5
Pb conc	4.1	62.3	6.8	22.6	11.0	0.6
Zn conc	14.8	2.8	62.6	10.1	4.1	4.1
MoS_2 conc(1)	5.3	1.5	1.2	1.3	19.9	0.2
MoS_2 conc(2)	0.1	2.7	0.2	1.8	18.5	0.4
As conc	10.3	8.7	6.1	27.1	21.2	33.5
Tailing	16.2	15.1	9.4	35.1	24.4	60.7

(1) Separated from copper concentrate

(2) Separated from lead concentrate

Further to the production of the above concentrates in pilot plant, a 38%-grade fluorspar concentrate was obtained in the laboratory with a recovery of 37% of the fluorine. Also, 81% of the tungsten contained in the mill tailings was recovered by high-intensity magnetic separation in a concentrate assaying 2.1% WO_3.

CONTENTS

INTRODUCTION

On June 29, 1970, a 50-ton shipment of ore was received on behalf of Brunswick Tin Mines Ltd. An additional lot of 15 tons was received on August 13, 1970. The property, from which the material originated, was the former Mount Pleasant Mines Ltd. prospect located 37 miles south of Fredericton in Charlotte County, New Brunswick.

On July 9, 1970, a pilot plant investigation was started to assess the feasibility of concentrating the valuable constituents of the ore, namely, copper, lead, zinc, molybdenite, bismuth, fluorine, tungsten and tin. This study, which used the facilities of the Mineral Processing Division, was requested by and under the direction of Mr. E.W.J. Thornton, Chief Metallurgist, Sullivan Mining Group Ltd. This company has a controlling interest in Brunswick Tin Mines Ltd. Messrs. G.I. Mathieu and T.F. Berry provided technical and operational assitance to Mr. Thornton during the investigation.

In addition to the pilot plant work, several laboratory tests were conducted either to solve shortcomings observed in the pilot plant or to supplement the latter in some respects.

OUTLINE OF INVESTIGATION

Since the mineralogy of the ore from this property (i.e., Mount Pleasant ore) has been studied previously in detail, no further mineralogical examination of either the ore or the products was made during this investigation.

No head sample was cut due to the large quantity of ore. However, the average metal content of the daily classifier overflow (i.e., the mill feed) may be considered as a reliable head analyses. This was as follows:

Copper (Cu)	0.08%	Bismuth (Bi)	0.09%	Tungsten (WO_3)	0.31%
Lead (Pb)	0.14%	Molybdenite (MoS_2)	0.08%	Tin (Sn)	0.07%
Zinc (Zn)	0.43%	Fluorine (F)	4.40%	Arsenic (As)	1.50%

The pilot plant investigation, which lasted from July 9 to August 20, 1970, and consisted of 28 individual tests under various conditions, was mainly aimed at (1) floating separate concentrates of copper, lead, zinc, molybdenum, fluorine, and arsenic, (2) concentrating tungsten and tin by gravity, and (3) recovering the bismuth with the flotation and gravity concentrates. In practice, (a) considerable molybdenum reported in the copper and lead concentrates and had to be separated from them, (b) most of the tin was present in the copper concentrate, (c) fluorine and arsenic minerals proved difficult to float and (d) the gravity concentrate contained large amounts of unfloated arsenopyrite and loellingite. These difficulties plus others encountered in the operation of the pilot plant made it impossible to produce all the concentrates expected, particularly in the early stages. Therefore, experience had to be gained in the pilot plant and the laboratory to improve the process. As a result, frequent changes in reagents and conditions of flotation were made during the investigation. These changes, along with the corresponding results are shown in detail in Appendix III of this report. The appendix also includes pertinent comments, observations, and features of the individual pilot plant tests.

Although several changes in reagents and conditions were made, the basic flowsheet remained practically the same throughout the pilot plant work. In fact, the only important modification was the use of a flotation circuit for separating the molybdenite from the copper and the lead concentrate. Both separations could not be conducted at the same time because of insufficient flotation capacity. As the pilot plant circuit was rather complex, it is best illustrated by the flowsheet shown in Appendix II, on page 10.

During the pilot plant investigation, several laboratory tests were carried out with the object of improving the process and solving metallurgical problems encountered in the mill operation. This bench-scale investigation included five series of tests which followed the chronological order of the work. The waiting period for the chemical analyses caused some irregularity in the sequence which is given below:

(1) flotation separation of lead and molybdenite using either potassium permanganate or potassium dichromate;

(2) re-flotation of arsenic minerals;

(3) molybdenite-copper separation by flotation in presence of potassium permanganate or dichromate or of arsenic trioxide;

(4) molybdenite-lead separation by the preceding methods, but after a mineral surface alteration by washing, boiling, regrinding, etc...;

(5) selective flotation of molybdenite from the lead and copper concentrates using sodium sulphide to depress galena and chalcopyrite.

The latter technique gave the most satisfactory results and was integrated in the pilot plant circuit. The detailed procedures and results of the above laboratory tests are shown in Appendix IV along with appropriate explanations.

During the mill run, a few products were kept for subsequent bench-scale tests in order to supplement the pilot plant work. This laboratory work was done under three major headings, namely, flotation, gravity concentration, and magnetic separation. The flotation investigation (Part 1) was aimed at (i) improving the grade of the copper, lead, zinc, and arsenic concentrates by further cleaning stages under various conditions, (i i) recovering fluorspar from the arsenic rougher flotation tailings, (iii) molybdenite-lead separation by the sodium sulphide method. The gravity concentration series (Part 2) consisted of tabling sized fractions of copper and zinc concentrates for removing heavy undesired minerals, such as bismuth, galena, and the coarser particles of arsenopyrite. Finally, high-intensity magnetic separation (Part 3) was investigated as a means of recovering the wolframite (tungsten) left in the mill tailings. In some cases, the magnetic separation was complemented by screening and tabling. The details of this laboratory work are shown in Appendix V.

CONCLUSIONS

Copper Flotation

It seems advantageous to make a separate copper concentrate because most of the stannite and indium accompany the chalcopyrite. In the pilot plant, the rougher copper concentrate was easily upgraded to 15% Cu by several cleaning stages with little loss. Screening and tabling sized fractions of copper concentrate showed that further improvement of this could be obtained by lowering the bismuth and arsenic content.

The results from the experiments conducted in both the laboratory and pilot plant indicate the following points are pertinent to the flotation of copper in this ore

(1) sulphur dioxide addition is required to obtain sufficient lead depression;

(2) best pH is from 6.3 to 6.5 .

(3) addition of starch is useful in depressing fluorspar, arsenopyrite, galena, bismuth and molybdenite.

It was possible to separate the molybdenite which floated with the copper by depressing the chalcopyrite with sodium sulphide. There was a tendency for the insolubles to float with the molybdenite. As a result, the molybdenite concentrate assayed only 18.6% MoS_2. Further cleaning of this concentrate would be necessary to obtain a marketable grade. On the other hand, it is thought the residual copper concentate still contained fluorine in a quantity that would make it difficult to sell. Supplementary experimentation with various starches might solve this problem.

Lead Flotation

As it is expected that bismuth payment in a lead concentrate would be more remunerative than bismuth recovered by leaching an arsenic concentrate, it was found beneficial to make a lead concentrate with as much bismuth as possible. However, the two techniques investigated to increase the bismuth recovery with the lead, i.e., the use of an excess of Z-6 and the reduction of sodium cyanide (this reagent has some depressing effect on native bismuth), lowered considerably the grade of the lead concentrates due to high dilution by contaminates, particularly sphalerite and arsenopyrite. Cyanide is not only necessary in the lead float for zinc depression but also for froth control. The best overall results were achieved when about 20% of the bismuth reported in the lead concentrate.

Variations in the soda ash addition to the lead circuit indicated that the optimum operational pH was at 9.5. Again, the molybdenite could be removed from the lead concentrate by selective flotation in presence of sodium sulphide. This method proved to be much more effective than the conventional technique with potassium permanganate or dichromate.

Zinc Flotation

The zinc concentrate may be of little economic importance, but the sphalerite can be floated with a small amount of copper sulphate. Concentrates containing as high as 54% zinc were obtained but might be difficult to sell due to the contained tin, fluorspar, and arsenic. Sphalerite and stannite are intimately associated with each other, and for this reason it was felt advantageous for much of the zinc to float with the copper. Tabling of the screened products of the zinc concentrate can eliminate one half of the arsenic which is in the zinc flotation product. No collectors should be used in the zinc float, and the copper sulphate should be kept to a minimum, because it causes too much arsenic to float. Lime will not aid in the zinc cleaning. If the above conditions are met, little molybdenite or bismuth will report in this concentrate. Because the best zinc froth for selectivity was very tight and difficult to skim, cells had to be operated in a flooding condition.

Arsenic Flotation

It is necessary to float the arsenopyrite for the following reasons:

(1) if it is not floated, the arsenopyrite will contaminate the fluorspar concentrate;

(2) it is hoped to separate the molybdenite from the arsenopyrite concentrate in the same manner that it is floated from the copper and lead concentrates.

Bismuth Leaching

Leaching tests are presently being carried out to dissolve the bismuth in the arsenic concentrate with H Cl. The pregnant solution containing bismuth is diluted with water to a pH of 1.4 and BiOCl is precipitated out. From this bismuth,bars can be prepared which may assay approximately 95% bismuth. Tests to date indicate that it will cost about $65.00 per ton of arsenic concentrate to recover this bismuth. About 0.15 lbof R404 and 0.04 lb of Dowfroth 250 per ton of ore were sufficient for arsenopyrite concentration. $CuSO_4$, Na_2S, Na_2CO_3, Z-6 and H_2SO_4 were also tried but are not necessary.

Fluorspar Flotation

No satisfactory products were produced from the pilot plant circuit. Three reagents, Pamak No. 4, oleic acid, and reagent 825 were tried as collectors. Desliming of the fluorspar feed was tried prior to flotation. The best looking float was obtained with oleic acid,and cleaner concentrates produced in the pilot plant were upgraded to 40% fluorine by three more stages of cleaning in laboratory cells. Bench-scale tests previously had indicated that Reagent 765 would be the best fluorspar collector but samples of this were not available because this product is not now commercially produced. There were not enough cells available to operate the necessary cleaning circuits for fluorspar and, at the same time, continue with sulphide beneficiation. This circuit was given the least attention.

Tungsten Beneficiation

During the pilot plant investigation, the arsenic rougher tailings or fluorspar rougher tailings were passed over a Wilfley table, mainly as a guide to see if the arsenic rougher float was recovering any of the loellingite which remained in the tailings. Occasionaly, this table was sampled to determine its performance with respect to wolframite and cassiterite. A large sample of this product was kept for subsequent research on the flotation of loellingite. No further gravity concentration of either wolframite or cassiterite can be considered until this loellingite can be selectively removed. For these reasons all test work in connection with wolframite was done with a Jones magnetic separator. Eighty-one per cent of the tungsten could be removed by this process in a concentrate assaying 2.10 WO_3.

This could be upgraded either by screening followed by tabling or by tabling followed by screening. It was found beneficial to pass the mill tailings through the Jones separator at least twice for maximum recovery. It might also be advantageous to screen out all the plus 200-mesh material and to pass this through separately because the Jones separator is equipped with different types of plates for different feed sizes. From this point on, good upgrading of the concentrates can be obtained by tabling and screening. If this scheme were adopted,the magnetic concentrate should be screened on 150-, 200-, 325-, and 400-mesh screens. These products should be tabled separately and the concentrates screened again. The table tailings from the minus 400-mesh fraction should be fed to blankets. The final concentrates will have to be acid leached with HCl and HNO_3 to obtain market grade.

A considerable amount of the Jones magnetic concentrate has been retained so that the chlorites which contaminate it can be tested for floatability. Other retained material will be used for leaching of the magnetic concentrate with sodium hydroxide or fusion with sodium carbonate followed by water leaching.

Molybdenite Flotation

Unfortunately, the molybdenite floats and is concentrated in the copper concentrate, lead concentrate, and arsenic concentrate. However, it can be floated from these products if sodium sulphide is used to depress Cu, Pb, or As. The amount of sodium sulphide for best results is the subject of tests that will be carried out later using sodium silicate for gangue depression. Other reagents such as arsenious trioxide and potassium permanganate and dichromate have been tried in place of sodium sulphide, but they show practically no selectivity.

Bismuth Recovery

Bismuth reports with copper, zinc, lead, and arsenic concentrates (particularly with the latter two). If no payment for this valuable constituent can be obtained when the concentrate is marketed it should be recovered by hydrometallurgical processes. The best known of these is hydrochloric acid leaching followed by precipitation as bismuth oxychloride.

General Conclusions

As shown above, the metallurgy of the Brunswick Tin ore is extremely complex and its complete solution needs additional reasearch in several areas. Nevertheless, the pilot plant investigation resulted in major advances on the selective concentration of the several valuable constituents of the ore. The main advantage of the present process is that most of the concentrates would be saleable either directly or after limited hydrometallurgical treatment. Despite the merit of this method, other approaches to solving the metallurgy of the ore are mentioned. All these would consist of bulk concentration (flotation and gravity) with treatment of the concentrate by one of the following techniques:

1. chloridizing roast in order to either volatilize the metals (in chloride form) or render them more readily soluble;
2. acid solution and selective precipitation (the acid-consumption might be prohibitive);
3. fusing, vapourizing, and, then, distilling metals Ionarc technique which is still at the experimental level;
4. dry chlorination with differential distillation of the various metal chlorides; this might be supplemented by hydrometallurgical processes; this method appears more attractive than the previous ones and it has been investigated by the Extraction Metallurgy Division.

ACKNOWLEDGEMENTS

The chemical analyses during this investigation were performed by Bondar-Clegg and Company Limited.

APPENDIX I

Code of Symbols

In the tables that follow symbols are used not only for the elements in the chemical analyses but also for the reagents used in the tests. A list of these symbols is shown below:

Copper (Cu)
Lead (Pb)
Zinc (Zn)
Bismuth (Bi)
Molybdenite (MoS_2)
Arsenic (As)
Fluorine (F)
Tungsten trioxide (WO_3)
Tin (Sn)
Insoluble (Insol)
Manganese (Mn)
Yttium (X)
Titanium (Ti)
Barium (Ba)
Chromium (Cr)
Gallium (Ga)
Indium (In)
Silver (Ag)
Zirconium (Zr)

Sulphuric dioxide (SO_2)
Soda ash (Na_2CO_3)
Dow Z-200 (Z-200)
Sodium cyanide (NaCN)
Aerofloat 242 (R-242)
Copper sulfate ($CuSO_4$)
Dowfroth 250 (R-250)
Potassium amyl xanthate(Z-6)
Sodium sulphide (Na_2S)
Potassium permanganate ($KMnO_4$)
Aero Promoter 825 (R-825)
Potassium dichromate (K_2Cr_2O7)
Dextrin (Dex)
Kerosene (Ker)
Sulfuric acid (H_2SO_4)
Citric acid (CA)
Oleic acid (OA)
Sodium silicate (Na_2SiO_3)
Arsenic trioxide (As_2O_3)

APPENDIX II

Pilot Plant Flowsheet

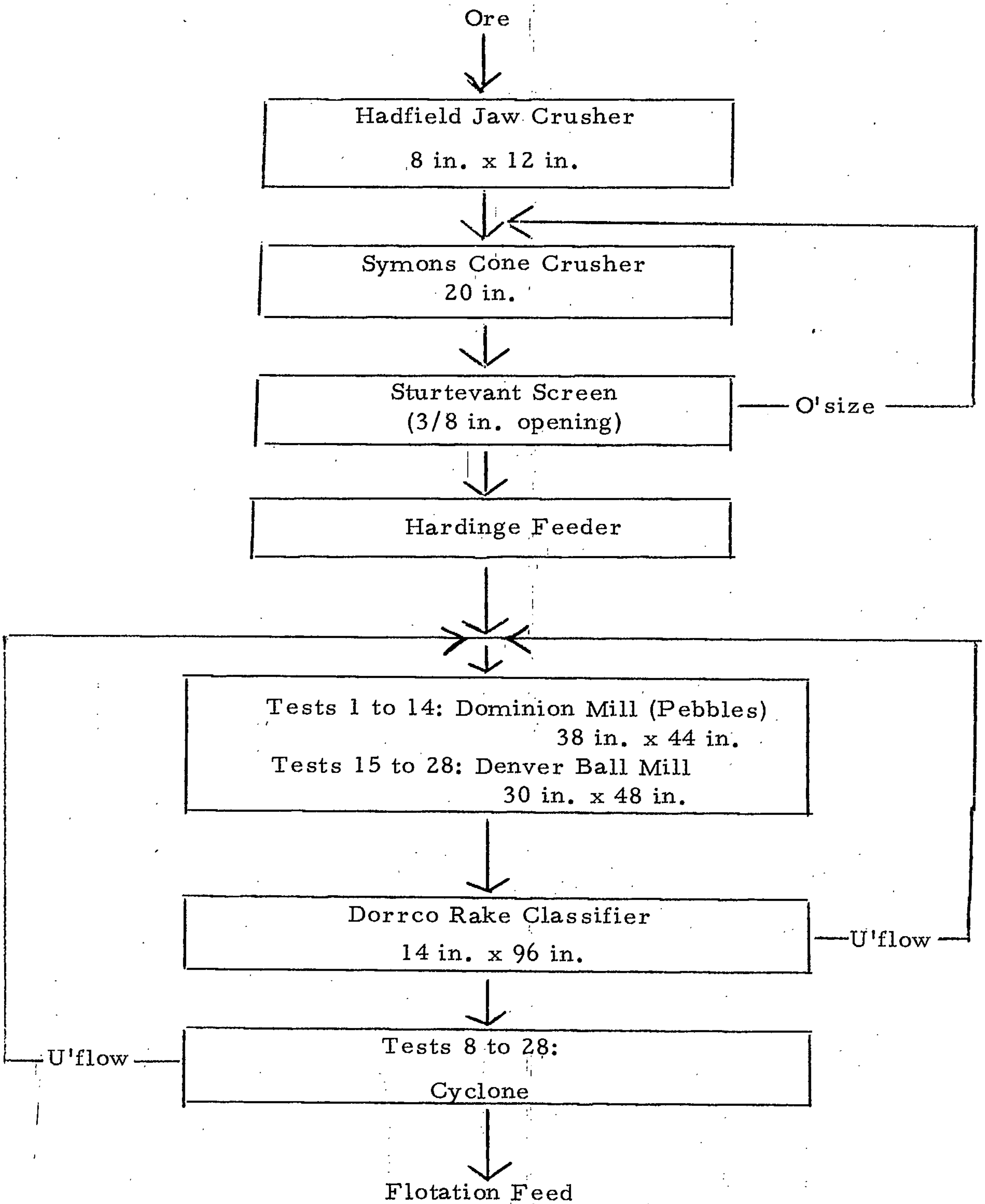

Figure 1 - Flowsheet Part 1: Crushing and Grinding

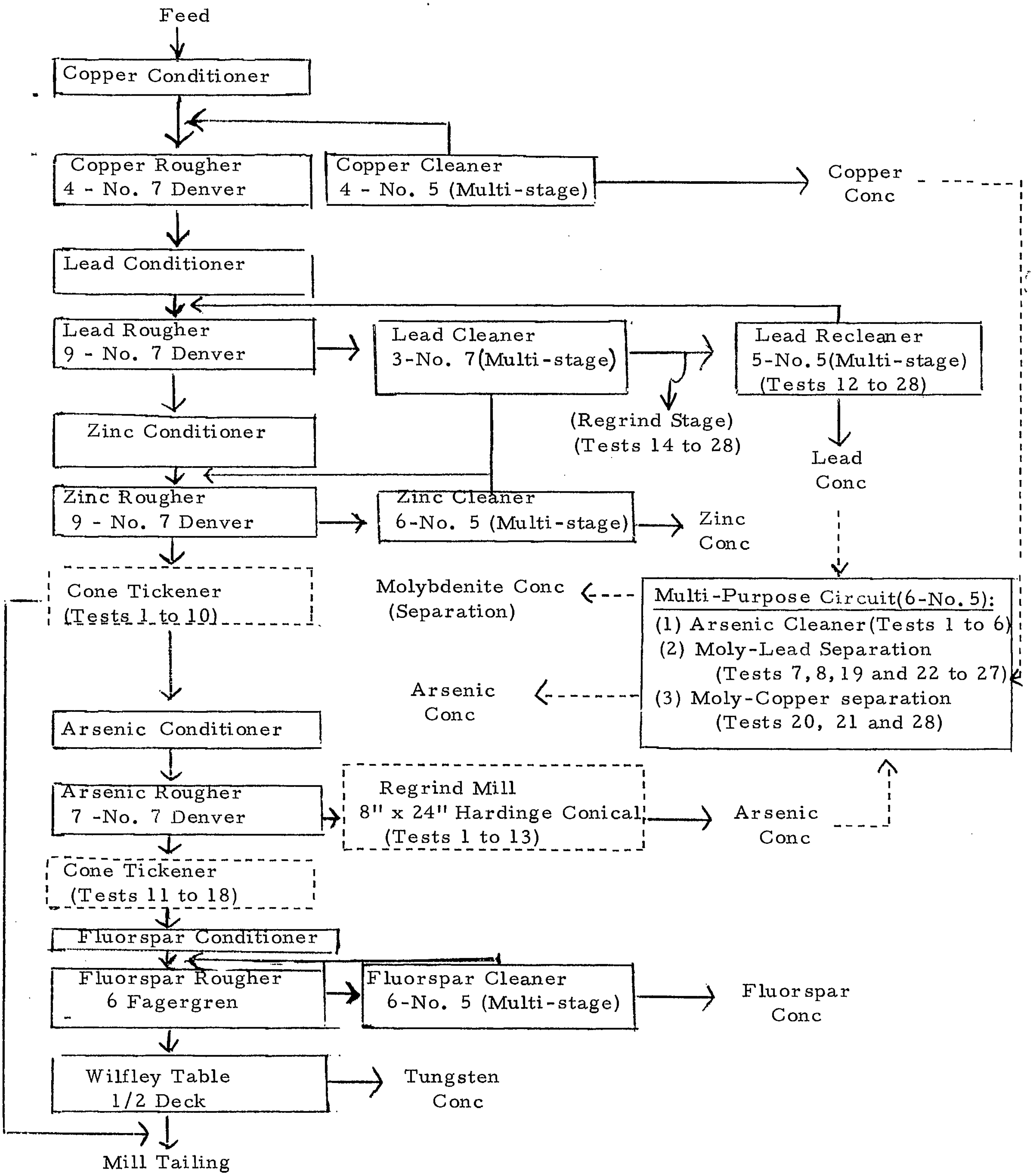

Figure 2 - Flowsheet Part 2: Flotation and Gravity Concentration

APPENDIX III

Details of Pilot Plant Investigation

Test No. 1

(July 9th, 1970)

Features of the Test

(1) This was a preliminary test to check all the operating features. It was found that the grinding circuit had too large a circulating load, so some of the smaller flint pebbles had to be replaced by larger ones.

(2) In all of the pilot plant tests, the emulsified form of Z-200 was used.

(3) Initially starch was added to the grind but was later fed at other places. This starch was supposed to be a soluble form requiring no heat, and was supplied by Stein Hall.

(4) All SO_2 was added by bubbling it into a large bottle of water and then the SO_2 - saturated water was added to the circuit to obtain the desired pH.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'Flow
8	4.8	--	
10	1.3	8.2	
14	0.7	1.5	
20	0.5	1.4	
28	0.2	0.7	
35	0.7	2.4	
48	0.6	2.8	
65	0.5	3.6	
100	2.5	7.6	
150	3.9	12.5	1.2
200	8.5	18.6	5.2
270	9.2	12.0	7.6
+ 325	8.4	7.4	8.4
- 325	58.2	21.3	77.6

Reagent Consumption*

Point of Addition	pH	Starch	Na_2CO_3	Z-200	NaCN	Z-6	R-242	$CuSO_4$
Grind	7.1	.062						
Copper Conditioner								
Copper Rougher	6.8			.053				
Lead Conditioner	9.1		4.42					
Lead Rougher					.056	.014	.025	
Lead Cleaner								
Zinc Conditioner								.044
Arsenic Conditioner	7.8							

*In lb/ton based on a 750 lb/hr feed rate. This will apply to all subsequent pilot plant tests.

Spectrographic Semi-Quantitative Analysis made on the Classifier Overflow at Correlation Laboratories Ltd., Cobden, Ont., showed the following detections.

Fe - 1% to 5%

As, Zn - 1% to 0.5%

Bi, Cu, Mo, Sn, W - .05% to 0.30%

Pb, Mn - .02% to 0.1%

Y, Ti - .01% to .05%

Ba, Cr, Ga, In, Ag, Zr - less than .01%

RESULTS

Assays of Samples

	Cu	Pb	Zn	Bi	MoS_2	F	As	Sn	WO_3	Insol
Classifier O'flow	0.083	0.118	0.364	0.076	0.084	4.41	1.98	0.04	0.30	86.00
Final Copper Conc	12.10	3.93	21.76	1.43	4.60	1.85	6.01	6.65	0.79	10.90
Copper Cleaner Tail	0.67	0.82	2.04	0.60	0.86	5.62	3.24	0.10	0.55	72.90
Final Zinc Conc	1.37	1.44	27.75	1.34	0.81	1.55	18.06	0.26	0.20	14.20
Zinc Cleaner Tail	0.02	0.01	0.06	0.07	0.04	4.56	1.51	0.16	0.20	86.20
Final Lead Conc	1.51	4.10	11.31	1.55	1.60	4.41	3.56	0.33	0.58	52.60
Lead Cleaner Tail	0.12	0.12	1.42	0.09	0.11	4.38	1.03	0.03	0.27	81.70
Zinc Rougher Tail	0.01	0.02	0.04	0.04	0.02	4.20	1.09	0.01	0.25	88.20
Tungsten Table Conc				0.05			1.98	0.13	0.65	
Tungsten Table Middling				0.02			0.27	0.14	0.05	
Table Tail				0.02			0.62	0.01	0.09	

	Distribution %										
	Wt	Cu	Pb	Zn	Bi	MoS_2	F	As	Sn	WO_3	Insol
Copper Conc	0.31	45.4	10.3	81.6	6.1	20.6	0.14	1.6	55.0	9.3	0.1
Lead Conc	2.07	37.6	71.8	64.1	44.1	47.4	2.17	6.3	18.1	4.7	1.2
Zinc Conc	0.10	1.7	1.2	7.6	1.8	1.2	0.04	1.5	0.8	0.8	---
Tailing	97.52	15.3	16.7	9.7	48.0	30.8	97.65	90.6	26.1	85.2	98.7
Feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST No. 2

(July 10, 1970)

Features of the test

(1) A preliminary test with zinc flotation product going to a Wilfley Table. Only the copper, lead, zinc and arsenic circuits were operated.

(2) The arsenic float was operated at a pH of 6.2; it was made acid with H_2SO_4.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'Flow
+ 10 mesh	1.6	7.6	
+ 14	0.6	1.8	
+ 20	0.5	1.6	
+ 28	0.1	0.8	
+ 35	1.2	2.6	
+ 48	1.1	3.0	
+ 65	1.5	3.5	
+ 100	2.9	7.3	0.2
+ 150	6.2	14.2	0.9
+ 200	11.4	19.4	5.9
+ 270	10.2	12.0	9.8
+ 325	9.2	7.8	9.7
- 325	53.5	18.4	73.5

Reagent Consumption

Point of Addition	H_2SO_4	pH*	Starch	Z-6	Z-200	Na_2CO_3	R-242	NaCN	$CuSO_4$	R-404
Grind			.062							
Copper Conditioner		7.5								
Copper Rougher					.070					
Lead Conditioner		10.2				4.24		.088		
Lead Rougher				.014			.025			
Zinc Conditioner		9.8							.053	
Zinc Rougher					.099					
Lead Cleaner								.029		
Arsenic Conditioner		5.2								
Arsenic Rougher	3.54									.124

RESULTS

Assays of Samples %

	Cu	Pb	Zn	Bi	MoS_2	Fl	As	Sn	WO_3	Insol
Classifier O'flow	.088	.142	.38	.093	.091	4.56	1.33	.05	.35	87.7
Final Copper Conc	9.73	5.90	17.9	1.71	5.39	1.95	3.08	2.33	.81	14.8
Copper Cleaner Tail	.52	.97	1.89	.555	.792	4.86	2.72	.12	.48	77.5
Final Zinc Conc	0.88	.92	42.3	2.76	.772	1.13	11.22	.34	.27	10.6
Zinc Cleaner Tail	.046	.043	.16	.528	4.86	4.75	.03	.49		80.9
Final Lead Conc	1.21	4.57	4.62	1.48	2.59	5.32	3.90	.19	1.25	56.5
Lead Cleaner Tail	.23	.050	1.79	.09	.043	4.80	1.95	.08	0.39	83.3
Zinc Rougher Tail	.013	.016	.048	.035	.018	4.41	1.16	.01	.27	89.7
Zinc Table Conc	2.62	.50	28.4	1.06	1.42	--	8.48	--	.28	
Zinc Table Tailing	2.15	1.00	45.8	2.31	.884	--	2.76	--		
Wilfley Table Conc	.024	.065	.038	.116	.062	--	16.75	.63	2.25	65.8
Arsenic Rougher Conc	.067	.013	.30	.250	.100	3.95	9.28	.39	.20	74.5
Arsenic Rougher Tail	.007	.012	.012	.020	.012	3.65	.75	.19	.05	91.2

Distribution %

	Wt%	Cu	Pb	Zn	Bi	MoS_2	F	As	Sn	WO_3	Insol
Copper Conc	0.48	53.2	19.9	22.6	8.8	23.6	0.2	1.1	22.4	1.1	.1
Lead Conc	2.07	28.5	66.6	25.1	33.0	59.0,	2.4	0.6	7.8	7.4	1.3
ZincConc	0.39	3.9	2.5	43.4	11.6	3.3	0.1	0.3	2.6	0.3	.1
Arsenic Conc	4.81	3.6	0.4	3.8	12.9	5.3	4.2	33.5	37.6	2.7	4.1
Tailing	92.25	10.8	10.6	5.1	33.7	8.8	93.1	64.5	29.6	88.5	94.4
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 3
(July 13th, 1970)

Features of the test

(1) Up to this point, the starch solution was added cold to the grinding circuit. The starch used in this pilot plant was supplied by Stein Hall and is of the water soluble form. However, in all subsequent tests, the starch was heated with small strip heaters. This was found essential in bench scale-tests with the starch used at Nigadoo River Mines Limited.

(2) Sodium sulphide was tried in the arsenic float and found useful as a froth promoter if stage added.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'Flow
+ 10 mesh	1.3	14.4	
+ 14	0.3	2.2	
+ 20	0.2	1.8	
+ 28	0.1	0.1	
+ 35	0.6	3.5	
+ 48	0.7	3.0	
+ 65	1.2	3.7	
+ 100	2.6	6.8	0.2
+ 150	5.5	12.0	1.7
+ 200	10.0	14.9	7.2
+ 270	10.2	9.1	9.6
+ 325	8.9	5.7	9.7
- 325	58.4	22.8	71.6

Weighing of Concentrates

Copper Conc:

1.377 grams in 30 min.	=	0.805% of weight
Calculated % weight	=	0.96 % " "

Lead Conc:

230 grams in 30 min.	=	0.135 % of weight
Calculated % weight	=	0.29 % " "

Zinc Conc:

146.2 grams in 30 min.	=	0.085 % of weight
Calculated % weight	=	0.080 %

Arsenic Conc:

330 grams in 30 min.	=	0.335 % weight

Reagent Consumption

Point of Addition	Starch	pH	SO_2	Na_2CO_3	Z-6	Z-200	R-242	NaCN	$CuSO_4$	R-250	Z-6
Grind	.176										
Copper Conditioner		6.6	-								
Copper Rougher						.071					
Lead Conditioner		9.5		4.24				.088			
Lead Rougher					.034						
Lead Cleaner								.030			
Zinc Conditioner		9.2							.053		
Zinc Rougher						.098					
Arsenic Rougher										.049	.113
Arsenic Conditioner		9.1									

RESULTS

Assays of Samples %

	Cu	Pb	Zn	As	F	MoS_2	Bi	WO_3	Insol
Copper Cleaner Conc	6.44	3.70	22.2	13.4	1.14	3.22	1.14		9.4
Copper Cleaner Tail	0.61	1.35	3.62	4.92	4.71	.954	.565	.50	71.1
Copper Rougher Tail	.022	.085	.24	1.25	4.50	.050	.065	.28	88.9
Lead Cleaner Conc.	0.20	28.4	1.11	4.09	3.50	5.89	4.30	1.50	23.0
Lead Cleaner Tail	.079	.096	0.59	1.31	4.41	.085	0.10	.26	87.4
Lead Rougher Tail	.025	.042	.26	1.32	4.10	.047	.073	.26	88.9
Zinc Cleaner Conc	2.28	2.61	37.6	4.57	1.06	4.20	5.10	.55	7.4
Zinc Cleaner Tail	.091	.126	1.31	2.67	4.41	.183	.315	.32	82.3
Zinc Rougher Tail	.015	.023	.142	1.20	3.65	.023	.045	.25	90.3
Arsenic Cleaner Conc	.212	.310	2.01	18.6	3.34	.540	1.06	1.48	46.9
Arsenic Cleaner Tail	.015	.016	.023	2.66	3.65	.022	.026	.25	88.6
Arsenic Rougher Tail	.010	.012	.020	0.86	3.28	.015	.016	.25	91.4
Classifier O'Flow	.082	.145	.40	1.28	4.26	.080	.094	.28	88.8

Distribution %

	Wt%	Cu	Pb	Zn	As	F	MoS_2	Bi
Copper Conc	0.96	78.5	25.0	55.4	9.8	0.3	41.9	15.4
Lead Conc	0.29	0.8	57.5	0.8	0.9	0.3	23.0	17.3
Zinc Conc	.08	2.2	1.5	7.8	0.3	0.1	4.6	5.7
Tailing	98.67	18.5	16.0	36.0	89.0	99.3	30.5	61.6
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 4

(July 14th 1970)

Features of the Test

(1) The starch was increased to 0.18 lb per ton in an attempt to depress all molybdenite from the copper concentrate. However, this had little effect, but fair grades of concentrate were produced and the starch might be partially responsible for this. The starch did not seem to harm recoveries.

(2) Much of the time was spent trying to float all the arsenopyrite. A lot of the arsenopyrite is quite easy to float but the remainder is almost impossible by any sulphide flotation methods. In this test, various combinations of sulphuric acid, copper sulphate, Z-6, R404, and Dow Froth 250 were tried.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'Flow
+ 10 mesh	2.1	7.2	
+ 14	0.5	1.7	
+ 20	0.4	1.1	
+ 28	0.2	0.5	
+ 35	0.5	2.2	
+ 48	0.7	2.8	
+ 65	0.8	3.3	
+ 100	2.5	8.4	0.2
+ 150	4.7	13.7	1.5
+ 200	10.2	19.6	6.8
+ 270	10.1	12.0	9.8
+ 325	7.4	6.4	8.8
- 325	59.9	21.7	72.9

Weighing of Concentrates

Copper Concentrate:

334 gram in 10 minutes = 0.59 % of weight
Calculated % weight = 0.67 %

Lead Concentrate:

198 grams in 10 minutes = .35 % of the weight
Calculated % weight is = .72%

Zinc Concentrate:

1724 grams in 10 minutes = 3.05 % of the weight
Calculated % weight = 3.36 %

Arsenic Concentrate:

410 grams in 10 minutes = 0.72 % of the weight

Reagent Consumption

Point of Addition	Starch	pH	SO_2	Z-200	Na_2CO3	NaCN	Z-6	R-242	CuSO4	Na_2S	R-250
Grind	.176	7.4									
Copper Conditioner		5.2									
Copper Rougher			-	.076							
Lead Conditioner		9.4			4.24	.095					
Lead Rougher							.091				
Lead Cleaning						.035					
Zinc Conditioner		8.9							.067		
Zinc Rougher				.028							
Arsenic Conditioner							.117		.117		
Arsenic Rougher										.113	.017

RESULTS

Assays of Samples %

	Cu	Pb	Zn	As	Fl	MoS_2	Bi	Insol
Copper Cleaner Conc	9.57	4.49	19.1	9.41	0.70	1.77	.888	8.5
Copper Cleaner Tail	.67	2.13	4.71	7.74	3.80	.510	.575	
Copper Rougher Tail	.044	.070	.23	1.28	4.26	.063	.060	
Lead Cleaner Conc	3.61	11.17	8.81	7.70	3.70	4.49	5.98	26.3
Lead Cleaner Tail	.063	.042	.36	1.57	4.35	.045	.050	
Lead Rougher Tail	.044	.044	.24	1.39	3.34	.052	.053	
Zinc Cleaner Conc	.84	0.46	6.64	14.8	3.95	1.25	1.21	47.3
Zinc Cleaner Tail	.020	.021	.07	.85	4.10	.033	.026	
Zinc Rougher Tail	.010	.015	.027	.90	3.80	.017	.020	
Arsenic Cleaner Conc	.39	.335	3.72	24.2	2.92	.567	.933	35.1
Arsenic Cleaner Tail	.06	.048	.130	3.14	5.47	.067	.075	
Arsenic Rougher Tail	.01	.010	.018	.75	3.56	.013	.014	
Classifier O'Flow	.128	.140	.44	1.46	3.95	.087	.097	

Distribution %

	Wt %	Cu	Pb	Zn	As	Fl	MoS_2	Bi
Copper Conc	0.67	50.10	21.5	29.1	4.75	0.0	11.55	5.40
Lead Conc	0.72	20.35	57.3	14.4	4.17	0.7	31.60	39.70
Zinc Conc	3.36	22.10	11.0	50.7	37.40	3.5	41.00	37.40
Tailing	95.25	7.45	10.2	5.8	53.68	95.8	15.85	17.50
Feed	100.00	100.00	100.0	100.0	100.00	100.0	100.00	100.00

TEST NO. 5

(July 15, 1970)

Features of the Test

(1) The zinc cleaner circuit was changed so that the zinc rougher concentrate was cleaned four times in No. 5 cells arranged in 3-1-1-1 order.

(2) It was found out during this test that the grade of lead concentrate could be controlled to a large extent by the amount of dilution water added at each stage of cleaning.

(3) Hot starch solution was added to the copper conditioner.

(4) The frother in the fluorspar flotation was very difficult to control and was greatly effected by the condition of the pulp coming from the arsenic circuit. If too much R404 or Dowfroth was added to the arsenic float for maximum recovery in this circuit, then the fluorspar float was unmanageable.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'Flow
+ 10 mesh	0.6	7.2	
+ 14	0.1	1.4	
+ 20	0.1	1.3	
+ 28	0.1	0.7	
+ 35	0.3	2.8	
+ 48	0.5	3.3	
+ 65	0.9	4.0	
+ 100	2.1	8.3	0.2
+ 150	5.0	12.7	0.9
+ 200	10.4	17.2	5.8
+ 270	10.4	11.4	8.0
+ 325	9.2	6.6	9.5
- 325	60.3	23.1	75.6

Weighing of the Concentrates

Copper Concentrate			
	339 grams in 20 min.	=	0.31 % of weight
	Calculated % weight	=	0.64%
Lead Concentrate			
	1358 grams in 20 min.	=	1.23 % of weight
	Calculated % weight	=	1.42 %
Zinc Concentrate			
	397 gram in 20 min.	=	.37 % of weight
	Calculated % weight	=	.40 %
Arsenic Concentrate			
	437 gram in 5 min.	=	1.55 % of weight
Molybdenite Concentrate			
	406 gram in 20 min.	=	.37 % of weight

Reagent Consumption

Point of Addition	pH	Starch	SO_2	Na_2CO3	Z-200	NaCN	Z-6	R-242	R-250	CuS04	NazS
Copper Conditioner	4.6	.088	-								
Copper Rougher					.081						
Lead Conditioner	9.8			4.24		.091	.144	.028			
Lead Rougher											
Lead Cleaner						.035					
Zinc Conditioner	9.5									.337	
Zinc Rougher					.049						
Arsenic Conditioner	9.0						.106			.248	.130
Arsenic Rougher							.135		.046		.124

RESULTS

Assay of Samples %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Classifier O'Flow	.125	.110	.37	.095	.090	1.60	4.86	
Final Copper Conc	9.59	3.21	14.0	1.17	1.72	10.40	1.01	7.6
Copper Cleaner Tail	0.50	1.72	2.0	.795	.450	3.97	5.17	
Copper Rougher Tail	.052	.072	.27	.062	.073	1.48	4.56	
Final Lead Conc	2.02	4.48	5.22	3.68	3.64	6.37	5.23	42.7
Lead Cleaner Tail	0.11	.075	.63	.109	.147	1.93	5.78	
Lead Rougher Tail	.027	.022	.21	.035	.040	1.43	4.26	
Final Zinc Conc	3.60	1.33	41.7	2.53	4.45	3.75	1.11	6.7
Zinc Cleaner Tail	.04	.038	.11	.061	.070	2.26	4.16	
Zinc Rougher Tail	.021	.021	.04	.018	.023	1.06	4.04	
Arsenic Conc	0.33	.235	1.25	.612	.490	16.9	4.17	
Arsenic Cleaner Tail	.052	.054	.22	.054	.053	2.54	5.17	
Arsenic Rougher Tail	.014	.016	.038	.016	.013	.78	4.56	
Final Moly Conc	1.21	.33	15.8	1.93	2.32	18.0	2.74	26.2

Distribution %

	Wt %	Cu	Pb	Zn	As	Bi	MoS_2
Copper Conc	0.64	49.2	18.8	24.3	5.5	8.6	10.7
Lead Conc	1.42	23.0	57.8	20.1	7.5	59.8	50.2
Zinc Conc	0.40	11.5	4.8	45.1	1.3	11.6	17.3
Tailing	97.54	16.3	18.6	10.4	85.7	20.0	21.8
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 6

(July 16, 1970)

Features of the Test

(1) To attempt to promote arsenic flotation with sodium sulphide. Some reagents were stage added to the 5th cell.

(2) The addition of starch and SO_2 to copper cleaning circuit.

Weighing of Concentrates

Copper Concentrate

	762 grams in 15 minutes	=	0.90% of the weight
	Calculated % weight is	=	1.02

Lead Concentrate

	304 grams in 10 minutes	=	0.54% of the weight
	Calculated % weight is	=	0.692%

Zinc Concentrate

	688 grams in 15 minutes	=	0.81% of the weight
	Calculated % weight is	=	0.82%

Arsenic Concentrate

	510 grams in 10 minutes	=	0.91% of the weight

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	Z-6	R-242	$CuSO_4$	Na_2S	R-250
Copper Conditioner	4.6	.088								
Copper Cleaner	4.0	.018								
Copper Rougher			.081							
Lead Conditioner	8.9			4.24	.111					
Lead Rougher						.142	.021			
Lead Cleaner					.035					
Zinc Conditioner	8.7							.284		
Zinc Rougher			.049							
Arsenic Rougher						.153			.111	.032
Arsenic Conditioner	8.0					.176		.319	.123	

RESULTS

Assays of Samples %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	Sn	WO_3
Classifier O'Flow	.095	.120	0.35	.101	.102	1.42	4.86	9.11	.05	.27
Copper Cleaner Conc	5.40	4.69	12.75	4.11	2.69	20.4			1.84	
Copper Cleaner Tail	0.53	0.59	3.34	0.84	.844	7.75			0.58	
Copper Rougher Tail	.023	.042	0.18	.045	.055	1.22			0.06	
Lead Cleaner Conc	1.65	6.10	6.25	7.10	4.42	10.85	4.26	32.5		.94
Lead Cleaner Tails	.130	.145	0.92	.248	.260	3.51				
Lead Rougher Tail	.055	.040	0.17	.063	.075	2.10				
Zinc Cleaner Conc	1.21	.46	16.6	1.56	2.52	23.2	1.82	14.9	0.38	0.62
Zinc Cleaner Tail	.049	.075	0.13	.135	.088	5.68				
Zinc Rougher Tail	.019	.027	.042	.027	.023	0.92				
Arsenic Rougher Conc	0.13	.075	0.179	.145	.180	6.95		75.4	1.29	
Arsenic Cleaner Tail	.077	.150	.046	.065	.025	1.61				
Arsenic Rougher Tail	.021	.024	.038	.028	.013	.780	4.26		.03	.25

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	1.02	58.1	39.8	37.2	32.2	27.2	15.2
Lead Conc	0.69	12.0	35.2	12.4	37.7	30.2	5.5
Zinc Conc	0.82	10.4	3.2	38.8	9.8	20.5	13.8
Tailing	97.47	19.5	21.8	11.6	20.3	22.1	65.5
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 7

July 17, 1970

Features of the Test

(1) An attempt to separate the molybdenite from the lead concentrate using potassium permanganate. The molybdenite was floated in three No. 5 cells and cleaned three times.

(2) The addition of hot starch solution to the copper cleaning as well as to copper conditioning; SO_2 was also added to copper cleaning to a pH of 4.0.

(3) Poor lead grades might be the result of decreasing starch to the copper conditioner or incorrect water dilution to lead cleaning circuits.

Screen Analysis of Grinding Circuit Products

Mesh Size	Ball Mill Discharge	Classifier Sands	Classifier O'flow
+ 10	1.7	7.2	
+ 14	0.2	1.4	
+ 20	0.1	1.3	
+ 28	0.1	0.7	
+ 35	0.5	2.8	
+ 48	0.6	3.3	
+ 65	0.7	4.0	
+ 100	1.6	8.3	0.4
+ 150	3.6	12.7	2.2
+ 200	8.6	17.1	8.8
+ 270	9.3	11.4	10.0
+ 325	8.4	6.6	9.8
- 325	64.6	23.1	68.8

Weighing of the Concentrates

Copper Concentrate:

886 grams in 30 min. = 0.52% of the weight
Calculated % weight = 0.58%

Lead Concentrate: 1158 grams in 15 min. = 1.37% of the weight
Calculated % weight = 2.87%

Molybdenite Concentrate:

208 grams in 30 min. = 0.12% of the weight

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	Z-6	R-242	$KMnO_4$	$CuSO_4$
Copper Conditioner	5.5	.053							
Copper Rougher			.081						
Copper Cleaner	4.0	.018							
Lead Conditioner	9.5			4.24	1.11				
Lead Rougher						1.42	.026		
Lead Cleaner					.035				
Lead-Moly Separation								.053	
Zinc Conditioner	9.2								
Zinc Rougher		.095							.142

Temperature of starch solution feeding copper roughers 47°C
" " " " " " cleaners 75°C

RESULTS

Assays of Samples %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	Sn	WO_3
Classifier O'Flow	.102	.125	.50	.096	.088	1.48	4.96		.06	.29
Final Copper Conc	9.97	5.33	17.3	1.60	3.30	10.8	1.64	10.1	4.44	
Copper Cleaner Conc	5.43	4.84	15.4	2.25	3.00	13.7			2.88	
Copper Cleaner Tail	0.87	2.27	7.34	1.39	1.51	12.1			0.70	
Copper Rougher Tail	.027	.060	.20	.079	.043	1.36			.06	
Final Lead Conc	0.87	2.72	9.16	3.45	1.55	1.45	4.26	42.0	0.61	
Lead Cleaner Tail	.034	.057	.26	.055	.030	1.16				
Lead Rougher Tail	.025	.030	.22	.048	.030	1.34				.24
Final Zinc Conc	1.46	.65	32.3	1.09	1.59	18.6	0.88	4.84	0.57	
Zinc Cleaner Tail	.032	.046	.17	.133	.073	5.74				
Zinc Rougher Tail	.014	.016	.024	.033	.017	.95				
Molybdenite Conc	1.89	15.7	14.6	4.56	6.94	4.23				
Lead Cleaner Conc	0.32	1.71	2.29	1.18	.847	4.60	5.17	76.3	1.44	

	Distribution %						
	Wt %	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	.59	57.3	24.7	20.3	6.5	22.5	4.6
Lead Conc	2.87	24.5	61.3	52.4	68.7	52.0	23.9
Zinc Conc	.35	5.0	1.8	22.7	2.6	6.5	4.8
Tailing	96.19	13.2	12.2	4.6	22.2	19.0	66.7
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 8

July 20, 1970

Survey of the Classification Circuit

In this circuit, the classifier overflow was pumped to a small cyclone. The cyclone underflow was returned to the grinding circuit while the overflow went on to flotation. This was the method of classification for all ensuing tests.

Features of the Test

(1) The classifier overflow was retreated in a small cyclone.

(2) One more stage of copper cleaning was added. This gave three stages and helped to drop the insolubles.

(3) Lead recleaner tailings were returned as feed to the head of the lead cleaner cells.

(4) The copper concentrate was sampled for copper tabling tests.

(5) The arsenic float was operated so that it would not interfere with the fluorspar froth.

(6) An attempt was made to separate molybdenum from the lead concentrate by adding $KMnO_4$.

Screen Analysis of Classification Circuit Products

Mesh Size	Classifier O'Flow	Cyclone O'Flow	Cyclone O'Flow
+ 65 mesh	-	0.4	-
+ 100	1.4	2.0	-
+ 150	3.6	6.8	0.2
+ 200	11.5	21.8	1.1
+ 270	14.1	20.6	5.5
+ 325	11.2	13.0	8.4
- 325	58.2	35.4	84.8

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	Z-6	R-242	$KMnO_4$	R-250	R-825	Dex
Copper Conditioner	6.0	.053									
Copper Rougher			.081								
Copper Cleaner	6.1										
Lead Conditioner	10.1			3.2	0.13						
Lead Rougher						.14	.03	.14			
Lead Cleaner					.067						
Moly-Lead Separation											
Zinc Conditioner	9.7										
Arsenic Rougher						.14			.035		
Zinc Rougher			.042								
Fluorspar Conditioner	10.1										
Fluorspar Rougher	10.1			1.77						.035	.42
Fluorspar Cleaner											

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	WO_3	Insol
Cyclone O'Flow		.071	.115	.40	.085	.087	1.26			
Cyclone O'Flow		.103	.220	.55	.147	.092	4.06			
Copper Rougher Conc	.98	1.99	2.88	6.05	1.06	1.45	4.40	4.80		60.2
Copper Cleaner Conc		8.06	7.71	16.3	3.63	5.58	2.95	1.98		16.4
Copper Rougher Tail	.13	.02	.05	.28	.067	.047	1.14			
Final Lead Conc		.76	3.56	3.35	2.89	2.37	4.61	5.93		60.7
Lead Cleaner Conc		.49	2.30	2.17	1.55	1.98	3.14	6.08		69.9
Lead Cleaner Tail		.069	.105	0.61	.124	.125	1.67			
Lead Re Cleaner Tail		.23	.35	1.34	.519	.517	2.73			
Final Zinc Conc	0.70	1.70	1.93	48.5	2.82	2.45	5.10	.49		3.40
Zinc Tail		.015	.021	.076	.035	.028	1.11			
Molybdenite Conc		2.14	8.88	18.0	3.43	5.59	8.21			
Arsenic Rougher Tail	.05	.010	.015	.034	.016	.010	.65	4.41	.25	
Arsenic Rougher Conc		.12	.152	.71	.305	.294	8.90		.50	72.7

Distribution %

	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	54.6	32.2	19.6	17.0	27.7	1.2
Lead Conc	14.8	42.9	11.5	38.6	33.7	5.4
Zinc Conc	10.0	6.9	50.5	11.3	10.5	1.8
Tailing	20.5	17.9	18.4	33.1	28.1	91.6
Feed	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 9
(July 21, 1970)

Features of the Test

(1) To use sodium sulphide and Z-6 in the arsenic float. Sodium sulphide produced considerable froth, but did not help the loellingite to float.

Screen Analysis of Classification Circuit Products

Mesh Size	Classifier O'Flow	Cyclone O'Flow	Cyclone O'Flow
+ 48	-	0.2	-
+ 65	-	0.8	-
+ 100	0.2	2.8	Trace
+ 150	0.4	7.4	1.7
+ 200	3.6	21.2	5.7
+ 270	13.2	18.6	7.4
+ 325	16.0	10.7	4.5
- 325	62.6	38.3	80.7

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	Z-6	R-242	NaCN	$KMnO_4$	R-250	$CuSO_4$	Na_2S	R-825	Dex
Copper Conditioner	6.1	.053											
Copper Rougher			.082										
Copper Cleaner	6.3												
Lead Conditioner	9.7			4.42			.130						
Lead Rougher					.070	.018							
Lead Cleaner							.067						
Lead-Moly Separation								.088					
Zinc Conditioner	9.3												
Zinc Rougher			.039										
Arsenic Conditioner					.140								
Arsenic Rougher					.176				.069	.33	.092		
Fluorspar Conditioner	9.7			1.72								.035	.43

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow		.087	.125	.43	.088	.090	1.40	-	-	-
Cyclone U'Flow		.137	.195	.53	.149	.080	4.06			
Copper Rougher Conc	1.22	3.40	3.81	13.3	1.53	1.77	14.8	2.31	20.9	
Copper Cleaner Conc		4.72	4.80	19.2	1.53	2.30	19.1	0.85	6.59	
Copper Rougher Tail		.032	.05	.16	.061	.053	1.15	-	-	
Final Lead Conc		.58	1.56	1.82	1.40	1.92	3.08	6.20	69.0	
Lead Cleaner Conc		.90	1.70	3.31	1.70	2.56	5.61			
Lead Cleaner Tail		.066	.085	.53	.115	.087	2.21	-	-	
Lead Recleaner Tail		.220	.33	1.14	.405	.405	2.44			
Final Zinc Conc	.65	1.72	1.19	51.7	2.55	1.03	4.66	.45	1.49	
Final Zinc Tail		.009	.017	.036	.022	.020	1.15			
Arsenic Rougher Conc		.12	.135	.68	.325	.256	13.3	-	61.9	.45
Arsenic Rougher Tail	.04	.011	.011		.014	.008	.75	4.59	-	.20

Distribution %

	Wt%	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.86	46.7	33.0	38.4	12.5	14.6	10.9
Lead Conc	3.85	39.9	52.4	29.6	61.8	72.5	14.3
Zinc Conc	0.20	3.9	1.9	24.0	3.9	1.5	0.6
Arsenic Conc	3.19	4.4	3.4	5.0	9.8	6.0	28.3
Tailing	91.90	5.1	9.3	23.0	12.0	5.4	45.9
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 10
(July 22, 1970)

Features of the Test

(1) To cut back on soda ash to the lead circuit to see if less insol would float. The froth became darker but selectivity did not improve.

(2) A kerosene mixture with pine oil was added to the lead float to see if molybdenite recovery would improve, but molybdenite content in the arsenic concentrate remained the same.

(3) To reduce R-242 and Z-6 consumption to the lead circuit to compensate for the kerosene addition.

Reagent Consumption

Point of Addition	pH	Starch	Kerosene	Z-200	Na_2CO_3	NaCN	Z-6	R-242	$CuSO_4$	R-250	$KMnO_4$	R-825	Dex
Copper Conditioner	5.3	.053											
Copper Rougher (SO_2 Added)				.077									
Lead Conditioner	9.5		.036		3.18	.120							
Lead Rougher							.053	.025					
Lead Cleaner						.077							
Zinc Conditioner	9.0								.317				
Zinc Rougher				.042									
Moly-Lead Separation											.053		
Arsenic Conditioner							.137		.317				
Arsenic Rougher							.176			.095			
Fluorspar Conditioner	10.0				1.72							.035	.43
Fluorspar rougher	10.0												

Screen Analysis of Classification Circuit Products

Mesh Size	Classifier O'Flow	Cyclone O'Flow	Cyclone U'Flow
+ 48 mesh	-	0.3	-
+ 65	0.3	0.8	-
+ 100	1.3	2.4	-
+ 150	3.3	6.5	0.2
+ 200	11.4	19.3	1.5
+ 270	13.0	19.5	6.0
+ 325	9.9	10.9	7.9
- 325	60.8	40.3	84.4

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow		.08	.150	.45	.078	.097	1.34			
Cyclone O'Flow		.110	.235	.61	.164	.105	4.09			
Copper Rougher Conc	1.16	2.81	3.84	8.18	1.25	1.69	9.96	3.44	51.1	
Copper Cleaner Conc	2.64	5.80	7.43	16.9	1.96	3.16	15.8	1.00	43.7	
Copper Rougher Tailing	0.13	.033	.075	.28	.072	.062	1.31			
Final Lead Conc		0.97	4.21	3.92	2.70	3.62	5.12	4.71	35.2	
Lead Cleaner Conc		1.00	4.73	5.27	3.20	3.44	6.26	4.71	8.58	
Lead Cleaner Tailing		.101	.215	.79	.238	.195	2.48			
Lead Re cleaner Tailing		.200	.40	.93	.333	.409	1.75			
Final Zinc Conc	.25	.51	.53	11.31	1.47	.794	17.1	3.19	76.4	
Final Zinc Tailing		.019	.026	.046	.025	.018	1.03			
Arsenic Rougher Conc		.190	.178	.48	.220	.222	5.90		54.4	0.42
Arsenic Rougher Tailing		.015	.016	.058	.025	.010	.83			
Molybdenite Conc		.97	4.89	5.43	3.89	6.05	17.0			

Distribution %

	Wt%	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.66	47.9	32.9	25.7	11.8	20.7	6.9
Lead Conc	1.37	17.1	43.4	16.0	40.1	46.7	5.7
Zinc Conc	1.94	12.4	6.9	48.7	26.1	15.3	21.8
Tailing	96.03	22.6	16.8	9.7	22.0	17.3	65.6
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 11

(July 23, 1970)

Features of the Test

(1) Eliminate soda ash to lead float in an attempt to reduce the insol, pH in lead float lowered to 8.0.

(2) The use of the kerosene-pine oil mixture was discontinued.

(3) The cyanide was increased to see if its frothing effect could replace Reagent 242.

(4) The copper sulphate consumption had to be increased considerably to overcome the effect of the cyanide.

(5) The copper flotation concentrate was fed to a Concenco table.

Screen Analysis of Cyclone O'Flow

Mesh Size	Distribution
+ 150	0.2
+ 200	1.2
+ 270	5.5
+ 325	8.4
- 325	83.7

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	Z-6	R-242	$CuSO_4$	R-250	$KMnO_4$	R-825	Dex
Copper Conditioner	4.9	.088										
Copper Rougher			.092									
Copper Cleaning	5.2											
Lead Conditioner	8.0			2.47	.312							
Lead Rougher						.051	.051					
Lead Cleaner					.064							
Zinc Conditioner	8.0							.780				
Zinc Rougher			.037									
Lead-Moly Separation										.053		
Fluorspar Conditioner	10.0			1.94							.035	
Fluorspar Rougher	10.0											.43
Arsenic Conditioner						.127		.281	.051			
Arsenic Rougher						.160						

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow	-	.078	.140	.460	.091	.097	1.29	-	
Copper Cleaner Conc	-	5.70	4.47	16.4	2.03	2.84	17.2	-	8.50
Copper Rougher Tailing	.04	.030	.068	.24	.063	.053	1.12	5.02	
Lead Rougher Conc	.08	.085	.29	.45	.225	.247	2.0	-	83.3
Lead Cleaner Conc		.71	2.26	7.69	2.75	1.77	6.72	5.47	51.6
Lead Re cleaner Conc		.94	4.07	8.43	3.43	2.37	7.95	5.32	45.9
Lead Cleaner Tail		.053	.084	.53	.093	.105	1.92		
Lead Re clenaer Tail		.20	.33	2.48	.615	.509	7.32		
Lead Rougher Tail		.028	.031	.16	.033	.028	1.00		
Final Zinc Conc	.07	.97	.63	19.6	1.09	1.10	21.2	1.34	18.6
Zinc Rougher Tailing		.031	.031	0.11	.031	.025	.98		
Copper Table Conc	.90	1.71	1.34	3.40	1.30	.20	36.3	.30	2.8
Copper Table Tailing	2.42	6.00	5.36	18.1	1.88	2.87	16.0	1.28	8.8

Selected Assays For Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	5.70	4.47	16.4	2.03	2.84	17.2		8.50
Lead Conc	.94	4.07	8.43	3.43	2.37	7.95	5.32	45.9
Zinc Conc	.97	.63	19.6	1.09	1.10	21.2	1.34	18.6
Tailing	.031	.031	.040	.031	.025	.98		
Feed	.078	.14	.46	.116	.096	1.37		

Distribution %

	Wt %	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.63	46.2	20.0	22.4	11.0	18.7	7.9
Lead Conc	1.89	22.8	55.0	34.7	55.8	46.9	10.9
Zinc Conc	0.80	10.0	3.6	34.5	7.5	9.2	12.3
Tailing	96.68	21.0	21.4	8.4	25.7	25.2	68.9
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 12

(July 27, 1970)

Features of the Test

(1) This was a repeat of Test No. 11 but the amount of starch was doubled.

(2) For a short period, the Z-6 was removed from the lead rougher circuit, and the froth became very scummy.

(3) The lead rougher concentrate was floated in ten No. 7 cells and was cleaned in two No. 7 cells. The tailings from this cleaner flotation were fed to the zinc conditioner, while the concentrate was multi-cleaned in five No. 5 cells. The Zn recleaner tailing returned to the Zn rougher circuit.

Screen Analysis of Grinding Circuit Products

Mesh Size	Distribution
+ 150 mesh	0.3
+ 200	1.8
+ 270	6.4
+ 325	9.6
- 325	81.9

Reagent Consumption

Point of Addition	pH	Starch	Na_2CO_3	NaCN	Z-6	R-242	$CuSO_4$	R-250	Z-200
Copper Conditioner	4.2	.176							
Copper Rougher									.105
Lead Conditioner	6.7		2.12	.176					
Lead Rougher					.070	.063			
Lead Cleaner		.070							
Zinc Conditioner	6.5						.316		
Zinc Rougher									nil
Arsenic Conditioner									
Arsenic Rougher					.140			.063	

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow		.100	.128	.47	.074	.093	1.62		
Copper Cleaner Conc	1.76	5.96	4.39	20.8	1.21	1.27	17.6	.73	17.8
Copper Rougher Tail	0.20	.04	.055	.14	.030	.070	1.30		
Lead Rougher Conc		.35	.45	1.64	.615	.609	4.25	5.29	70.7
Lead Cleaner Conc		.87	1.15	4.07	1.41	1.79	5.42	9.12	53.0
Lead Rougher Tail		.044	.037	.14	.035	.037	1.17		
Lead Cleaner Tail		.152	.18	.94	.223	.334	3.23		
Lead Re Cleaner Tail		.28	.26	2.38	.263	.631	3.65		
Final Zinc Conc	.40	1.26	.76	34.0	.920	1.59	15.9	.54	3.85
Zinc Rougher Tail		.035	.04	.125	.042	.050	1.17		
Moly-Lead Recleaner	3.36	2.81	6.93	9.31	6.95	5.22	6.13	9.12	28.6

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.61	36.8	21.1	27.2	6.7	7.2	7.8
Lead Conc	0.85	23.7	45.7	16.8	52.9	41.2	3.8
Zinc Conc	0.41	5.2	2.4	30.0	3.4	6.1	4.8
Tailing	98.13	34.3	30.8	26.0	37.0	45.5	83.6
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 13

(July 28, 1970)

Features of the Test

(1) The starch addition was again raised to .26 lbs/ton.

(2) Thickening prior to the arsenic float was discontinued but the pulp was thickened prior to the fluorspar float; no cha ge in the selectivity was noticed.

(3) Towards the end of the test it was necessary to add soda ash to the zinc circuit because of the low pH in the lead circuit.

Screen Analysis of Cyclone O'Flow

Mesh Size	Distribution
+ 150 mesh	0.2
+ 200	1.2
+ 270	5.5
+ 325	8.4
- 325	83.7

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	Z-6	R-242	Cu SO_4	R-250	R-825	Dex
Copper Conditioner	4.6	.264									
Copper Rougher			.105								
Lead Conditioner	7.6			2.48	.211	.077	.058				
Lead Rougher	8.6			1.77				.985			
Zinc Conditioner											
Zinc Rougher			2 drops/min								
Arsenic Conditioner						.140		.307	.053		
Arsenic Rougher						.180					
Fluorspar Conditioner	8.5			1.60						.035	.43
Fluorspar Rougher	8.7										

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	WO_3	Insol
Cyclone L'Flow	0.12	.085	.122	.43	.093	.093	1.43	4.71	.21	
Final Copper Conc	2.24	5.44	5.28	18.2	1.18	1.23	19.0	-	-	
Copper Rougher Tail		.020	.038	.16	.080	.073	1.08			
Moly-Lead Conc		2.51	8.80	7.84	6.19	3.92	3.94			
Lead Rougher Tail		.027	.030	.17	.070	.048	1.20	4.80		88.0
Final Zinc Conc	.37	.93	.67	16.5	1.10	3.34	20.0	1.25	-	16.5
Zinc Rougher Tail		.025	.020	.054	.067	.038	1.05			
Arsenic Rougher Conc		.19	.18	0.64	.260	.360	5.14	-	.50	77.0
Arsenic Rougher Tail	0.11	.020	.018		.023	.022	.80	4.86	.32	

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	5.44	5.28	18.2	1.18	1.23	19.0
Moly-Lead Conc	2.51	8.80	7.84	6.19	3.92	3.94
Zinc Conc	.93	.67	16.5	1.10	3.34	20.0
Arsenic Ro Conc	.19	.18	.64	.26	.36	5.14
Arsenic Ro Tail	.20	.018	.030	.023	.022	.80
Feed	.085	.122	.043	.093	.093	1.43

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.54	34.6	23.4	22.8	6.9	7.9	7.2
Moly-Lead Conc	0.75	22.1	54.1	13.7	49.8	24.4	2.1
Zinc Conc	1.33	14.5	7.3	50.9	13.6	36.9	18.6
Arsenic Conc	5.75	12.8	8.4	8.6	16.1	17.2	20.6
Tailing	91.63	16.0	6.8	4.0	13.6	13.6	51.5
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 14

(July 29, 1970)

Features of the Test

(1) Again the starch was increased, but it had to be lowered somewhat, otherwise Z-200 would have had to be increased as well.

(2) The lead rougher concentrate was reground before the first stage of cleaning.

(3) The Z-6 consumption was increased to see if more bismuth would float with the lead.

(4) Staley Dextrin was used instead of Stein Hall Dextrin to see if it would help fluorspar selectivity.

Screen Analysis of Cyclone O'Flow

Mesh Size	Distribution
+ 150 mesh	0.2
+ 200	2.8
+ 270	7.8
+ 325	9.9
- 325	79.3

Reagent Consumption

Point of Addition	pH	Starch	Na_2CO_3	NaCN	Z-200	Z-6	R-242	$CuSO_4$	R-250	R-825	Dex
Copper Conditioner	4.7	.30									
Copper Rougher											
Lead Conditioner	7.8		2.12	.133							
Lead Rougher						.140	.053				
Zinc Rougher			1.52								
Zinc Conditioner	8.9							.91			
Arsenic Conditioner						.141		nil			
Arsenic Rougher						.176			.053		
Fluorspar Conditioner	10.0		1.52							.035	.43
Fluorspar Rougher	10.0										
Lead Cleaner				.070							

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow	0.14	.125	.138	.50	.094	.092	1.49	5.17		.29
Final Copper Conc	4.27	7.52	6.32	15.3	1.76	1.74	19.5	1.12	7.94	
Copper Rougher Tail	.08	.045	.057	.32	.085	.070	1.31	-	-	
Moly-Lead Conc	.96	2.06	5.21	8.20	6.75	5.20	8.78	11.9	20.6	
Lead Rougher Tail		.047	.034	.20	.041	.032	1.00	-	-	
Zinc Conc	0.78	1.90	1.45	39.9	1.54	3.99	8.04	1.00	8.38	
Zinc Rougher Tail	-	.040	.037	.078	.034	.043	1.15			
Arsenic Rougher Conc		.182	.160	.50	.225	.325	5.68	-	76.0	0.44
Arsenic Rougher Tail	0.10	.023	.032	.034	.026	.025	0.95	5.32	-	0.45

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	7.52	6.32	15.3	1.76	1.74	19.5	1.12
Lead-Moly Conc	2.06	5.21	8.20	6.75	5.20	8.78	11.9
Zinc Conc	1.90	1.45	39.9	1.54	3.99	8.04	1.0
Arsenic Conc	.82	.16	.50	.225	.325	5.68	-
Tailing	.034	.031	.061	.026	.025	1.05	
Feed	.125	.138	.50	.115	.119	1.49	5.17

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.75	45.1	34.4	22.96	11.4	10.9	9.8
Lead-Moly Conc	0.88	14.5	33.2	14.44	51.4	38.2	5.2
Zinc Conc	0.59	9.0	6.1	47.00	7.9	19.7	3.2
Arsenic Conc	4.23	6.2	4.9	4.22	8.2	11.5	16.1
Tailing	93.55	25.2	21.4	11.38	21.1	19.7	65.7
Feed	100.00	100.0	100.0	100.00	100.0	100.0	100.0

TEST NO. 15

(July 30, 1970)

Because much trouble was being encountered in obtaining grades of concentrates, the grinding in a grate discharge mill using flint pebbles was discontinued and continued in a smaller mill using steel balls. Because of this change, the grind appears somewhat coarser.

Features of the Test

(1) Because of the change in grinding the reagents had to be readjusted to get a suitable froth.

(2) The soda ash was increased in the lead circuit.

(3) The copper sulphate was reduced in the zinc circuit.

(4) The starch addition had to be reduced in the copper circuit to get a suitable froth.

(5) It was no longer necessary to add R-242 in the lead rougher cells to produce a good froth.

(6) Generally speaking, the selectivity of everything doubled.

(7) It was impossible to obtain pH's in the 4 to 5 range, and much more soda as ash was required to raise the lead float to the 9.5 range.

(8) Hot starch was added to the copper cleaner circuit but it did not aid in fluorine depression.

Screen Analysis of Classification Circuit Products

Mesh Size	Cyclone O'Flow	Classifier Sands
+ 150	1.5	11.9
+ 200	7.0	13.6
+ 270	9.8	11.8
+ 325	9.7	10.0
- 325	72.0	52.7

Reagent Consumption

Point of Addition	pH	Starch	Na_2CO_3	NaCN	Z-200	Z-6	$CuSO_4$	Dex	R-825	R-250
Copper Conditioner	7.1	.088								
Copper Rougher					.102					
Copper Cleaner		.018								
Lead Conditioner	10.1		4.25							
Lead Rougher						.148				
Lead Cleaner				.074						
Zinc Conditioner	10.0		1.52				.176			
Zinc Rougher					.027					
Arsenic Rougher						.141				.074
Fluorspar Conditioner	9.5							.43	.014	
Fluorspar Cleaner	9.5									

RESULTS

Assays of Samples

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow		.09	.163	.52	.109	.090	1.30	-	-	
Final Copper Conc	3.70	10.2	2.30	19.3	.670	2.69	3.25	6.38	13.5	-
Copper Cleaner Tail	0.40	.50	1.83	4.4	.825	1.15	2.94			
Copper Rougher Tail	0.11	.022	.080	.31	.070	.051	1.34			
Moly-Lead Conc	.84	1.05	12.3	7.63	5.37	5.64	10.5	3.8	30.7	
Moly-Lead Cleaner Tail	-	.16	.79	.28	.425	.457	.457	2.20	78.9	
Moly-Lead Recleaner Tail	.23	.50	1.53	2.77	1.01	1.27	3.03	5.17		
Moly-Lead Rougher Tail		.030	.037	.42	.043	.023	1.23	-	-	
Final Zinc Conc	.98	2.22	.88	43.8	.90	1.03	8.75	.76	5.90	
Zinc Cleaner Tail		.020	.035	.11	.048	.030	1.30			
Zinc Rougher Tail		0.11	.025	.045	.043	.019	1.21			
Arsenic Rougher Conc	-									
Arsenic Cleaner Tail	-	.13	.17	.86	.238	.208	8.03	-	71.7	.29
Arsenic Rougher Tail	.09	.018	.033	.050	.036	.036	.95	5.02	-	.19

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	10.2	2.30	19.3	.67	2.69	3.25	6.38	13.5
Moly-lead Conc	1.05	12.3	7.63	5.37	5.64	10.50	3.8	30.7
Zinc Conc	2.22	.88	43.8	.90	1.03	8.75	.76	5.90
Arsenic Conc	.13	.17	.86	.238	.208	8.03	-	71.7
Tailing	.007	.021	.018	.042	.008	.95		
Feed	.09	.16	.52	.11	.09	1.30		

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.53	60.0	7.5	19.7	3.3	15.9	1.3
Lead-Moly Conc	0.98	11.5	73.9	14.3	48.3	61.4	7.8
Zinc Conc	0.69	17.0	3.8	58.0	5.7	7.9	4.6
Arsenic Conc	2.72	3.9	2.8	4.5	6.0	6.2	16.4
Tailing	95.08	7.6	12.0	3.5	26.7	8.6	69.9
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 16

(July 31, 1970)

Features of the Test

(1) Considerable difficulties were experienced with the method of feeding SO_2. It was not until 2:00 P.M. that pH was adjusted to the required value.

(2) When the pH in the lead float dropped below 7.5, all froth disappeared.

(3) A combination of sulphuric acid and R-404 was tried in the arsenic flotation circuit.

Screen Analysis of Classifier Overflow

Mesh Size	Distribution
+ 100 mesh	5.5
+ 150	7.0
+ 200	13.9
+ 270	12.3
+ 325	8.3
- 325	53.0

Reagent Consumption

Point of Addition	pH	Starch	Na_2CO_3	NaCN	Z-200	Z-6	$CuSO_4$	H_2SO_4	R-404	Dex	R-825
Copper Conditioner	6.0	.088									
Copper Rougher					.074						
Lead Conditioner	8.8		4.25	.127							
Lead Rougher			4.66			.151					
Lead Cleaner				.070							
Zinc Conditioner	9.0						.128				
Zinc Rougher					.019						
Arsenic Rougher	5.8							1.90	.211		
Fluorspar Conditioner	10.0									.26	.032

RESULTS

Asssys of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS2	As	F	Insol
Final Copper Conc	4.00	11.5	2.08	20.4	.735	3.77	3.85	2.31	12.9
Copper Cleaner Tail	.26	.27	0.88	1.40	.575	.73	2.86		
Copper Rougher Tail	.10	.017	.100	.32	.079	.061	1.43		
Moly-Lead Conc	4.40	.82	14.0	5.78	5.40	7.30	5.40	4.26	34.6
Moly-Lead Recleaner Tail		.13	1.58	1.06	.725	.717	2.88		
Moly-Lead Cleaner Tail		.17	.75	1.27	.343	.498	2.26		
Moly-Lead Rougher Tail		.055	.027	.27	.037	.032	1.31		
Final Zinc Conc	.88	1.98	1.03	46.3	.900	.664	5.56	0.52	3.53
Zinc Recleaner Tail		.016	.034	.12	.053	.038	1.51		
Zinc Rougher Tail		.010	.025	.058	.037	.029	.90		
Arsenic Rougher Conc	.14	.17	.21	3.36	.310	.262	8.18	4.35	68.4
Arsenic Rougher Tail	.07	.010	.018	.035	.027	.018	.68		

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS2	As	F
Copper Conc	4.00	11.5	2.08	20.4	.735	3.77	3.85	2.31
Lead Conc	4.4	.82	14.0	5.78	5.40	7.30	5.40	4.26
Zinc Conc	0.88	1.98	1.03	4.63	0.900	.664	5.56	.52
Arsenic	.14	.17	0.18	3.36	.310	.262	8.18	4.35
Tailing	.07	.005	.021	.035	.027	.018	.68	
Feed	.13	.083	.157	.49	.088	.106	.98	

Distribution %

	Wt	Sn	Cu	Pb	Zn	Bi	MoS2	As
Copper Conc	0.47	14.3	65.2	6.2	19.6	4.0	16.6	1.8
Lead Conc	0.82	27.6	8.1	73.3	9.7	50.2	56.2	4.5
Zinc Conc	0.64	4.3	15.2	4.2	60.4	6.6	3.9	3.6
Arsenic Conc	2.89	3.1	5.9	3.3	3.4	10.2	7.1	24.1
Tailing	95.18	50.7	5.6	13.0	6.9	29.0	16.2	65.9
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 17

(August 5, 1970, to 12:00 A.M.)

Features of the Test

(1) During this test, the circuit was operated with as little change as possible with the best known reagent combination.

(2) The circuit was sampled from 11:30 A.M. until 12:00 P.M. after which the circuit was changed.

Reagent Consumption

Point of Addition	pH	Starch	Z-200	Na_2CO_3	NaCN	$CuSO_4$	Z-6
Copper Conditioner	6.4	.14	.074				
Copper Rougher							
Lead Conditioner	9.5			4.25	.078		
Lead Rougher				4.77			.053
Zinc Conditioner	9.4					.026	
Zinc Rougher			.017				

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	4.30	14.4	2.27	20.7	1.00	5.78	1.80	1.31	13.0
Lead Conc	1.58	1.63	23.2	11.2	4.50	6.91	4.40	3.82	18.6
Zinc Conc	.41	1.86	1.23	48.2	1.35	0.86	4.55	.97	4.58
Tailing	.02	.010	.028	.035	.048	.032	1.17	-	-
Feed	.15	.10	.16	.54	.100	.090	1.32	4.42	-

Distribution %

	Wt%	Sn	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.48	39.8	67.0	6.6	17.8	5.6	27.4	0.7
Lead Conc	0.48	15.3	7.8	70.6	10.0	26.1	34.2	1.8
Zinc Conc	0.73	6.0	13.6	5.7	65.8	12.0	6.4	2.7
Tailing	98.31	36.9	11.6	17.1	6.4	56.3	32.0	94.8
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 18

(August 5, 1970)

Feature of the Test

(1) Citric acid was added to the copper conditioner to see if it would depress fluorspar.

Reagent Consumption

Point of Addition	pH	Starch	CA	Na_2CO_3	NaCN	Z-200	Z-6	$CuSO_4$	R-404	R-250
Copper Conditioner	6.4	.141	.322							
Copper Rougher						.07				
Lead Conditioner	9.5			4.25	.07					
Lead Rougher				4.77			.053			
Zinc Conditioner	9.4							.026		
Zinc Rougher						.017				
Arsenic Conditioner	7.6								.20	.026
Arsenic Rougher										

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow		.068	.150	.47	.091	.098	1.33	-	-
Regrind Mill Discharge	.15	.131	1.00	.82	.363	.449	2.11	5.23	80.5
Final Copper Conc	2.40	10.4	2.33	12.1	1.12	9.93	2.67	-	-
Copper Rougher Tail	-	.035	.130	.40	.093	.065	1.36	-	-
Final Lead-Moly Conc	2.30	1.92	20.3	11.9	3.83	6.84	3.58	3.59	19.5
Lead-Moly Recleaner Tail	-	0.40	2.18	1.78	1.47	1.85	2.35	-	-
Lead-Moly Cleaner Tail		.040	.14	.38	.115	.108	1.53		-
Lead-Moly Rougher Tail	.07	.030	.039	.35	.071	.050	1.41	4.56	-
Zinc Conc	1.18	.81	1.27	42.7	1.93	1.11	7.58	.97	5.56
Zinc Rougher Tail		.008	.027	.039	.043	.032	1.18	-	-
Arsenic Rougher Conc		.078	.160	.42	.335	.335	8.64		
Arsenic Rougher Tail		.014	.020	.059	.031	.025	0.89		

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	10.4	2.33	12.1	1.12	9.93	2.67
Lead Conc	1.92	20.3	11.9	3.83	6.84	3.58
Zinc	.81	1.27	42.7	1.93	1.11	7.58
Arsenic	.078	.160	.42	.335	.335	8.64
Tailing	.008	.027	.039	.043	.032	1.18
Feed	.068	.150	.47	.077	.113	1.51

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.36	55.2	5.6	9.3	5.1	31.6	0.6
Lead Conc	0.50	14.1	67.6	12.6	24.6	30.1	1.2
Zinc Conc	0.66	7.8	5.6	60.0	16.5	6.4	3.3
Arsenic Conc	3.68	4.3	3.9	3.3	15.9	10.9	20.9
Tailing	94.80	18.6	17.3	14.8	37.9	21.0	74.0
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 19

(August 6, 1970)

Features of the Test

(1) The amount of Z-6 to the lead roughers was increased. This did not seem to change the lead circuit very much, but could be detrimental to the grade of the zinc concentrate and the separation of the lead from the molybdenite.

(2) The amount of citric acid to the copper conditioner was increased to see if it would improve fluorine depression.

(3) The lead-molybdenite separation circuit was operated using three No. 5 cells for molybdenite roughing and one No. 5 cell for molybdenite cleaning. This circuit was very difficult to control.

(4) No collector was added to the zinc circuit.

Reagent Comsumption

Point of Addition	pH	Starch	NaCN	Z-200	Z-6	CA	$CuSO_4$	Na_2S	H_2SO_4	R-404
Copper Conditioner	6.5	.141				.527				
Copper Rougher				.084						
Lead Rougher					.176					
Lead Conditioner	9.6		.088							
Zinc Conditioner	9.5						.088			
Lead-Moly Circuit								.021		
Arsenic Rougher	7.4								2.30	.23

Screen Analysis of Classifier Sands

Mesh Size	Size Distribution
+ 65 mesh	2.5
+ 100	3.3
+ 150	6.8
+ 200	13.9
+ 270	11.5
+ 325	8.1
- 325	53.9

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow		.089	.160	.540	.119	.099	2.32	3.95	83.5	0.36
Copper Final Conc	4.30	12.0	3.02	18.4	1.55	6.77	2.32	1.57	13.0	-
Copper Rougher Tail	.17	.039	.120	.38	.088	.060	1.22	4.42	84.1	-
Final Lead Conc	-	1.98	22.0	15.0	5.83	2.66	9.10	-	-	-
Moly-Lead Conc	1.26	2.71	12.6	10.0	5.13	7.14	2.82	3.20	26.2	.61
Moly-Lead Recleaner Tail	.03	.043	.11	.32	.153	.083	1.79	3.90	-	.37
Moly-Lead Rougher Tail	.02	.033	.056	.30	.054	.045	1.12	4.42	-	.25
Molybdenite Rougher Conc	.51	2.53	8.23	8.55	1.71	12.8	6.10	4.72	23.6	-
Molybdenite Rougher Tail	-	2.12	15.1	15.8	6.55	4.22	3.16	-	-	-
Final Zinc Conc	.43	1.15	.82	20.8	1.23	1.00	24.70	.73	4.22	-
Zinc Rougher Tail	-	.020	.034	.035	.048	.030	1.11	-	-	-
Arsenic Rougher Conc	-	.15	.19	.50	.340	.282	9.10	-	65.9	.43
Arsenic Rougher Tail	.15	.02	.022	.035	.028	.026	.68	3.50	-	0.20

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	4.30	12.0	3.02	18.4	1.55	6.77	2.32	1.57	13.0
Moly Conc	.51	2.53	8.23	8.55	1.71	12.80	6.10	4.72	23.6
Lead Conc	1.65	2.80	15.0	10.7	6.86	4.22	1.15		
Lead-Moly Conc	1.26	2.71	12.6	10.0	5.13	7.14	2.82	3.20	26.2
Zinc Conc	.43	1.15	.82	20.8	1.23	1.00	24.7	.73	4.22
Arsenic Conc		.15	.19	.50	.34	.282	9.10		65.9
Tailing		.013	.025	.010	.032	.016	.66		

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.22	29.1	4.1	7.2	2.9	12.1	0.3
Moly Conc	0.28	6.1	9.9	4.4	4.2	14.1	1.1
Lead Conc	0.55	19.2	56.1	11.0	32.7	34.9	0.4
Lead-Moly Conc	0.83	25.3	66.0	15.4	36.9	49.0	1.5
Zinc Conc	1.84	23.8	9.4	71.1	19.7	15.0	29.1
Arsenic Conc	5.10	8.7	6.1	4.6	15.1	11.9	29.6
Tailing	92.02	13.1	14.4	0.7	25.4	12.0	39.5
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 20

(August 7, 1970)

Features of the Test

(1) The copper rougher concentrate was recleaned four times in No. 5 cells.

(2) The copper cleaner concentrate was pumped to 3 No. 5 cells for molybdenite roughing. This molybdenite rougher concentrate was cleaned three times in No. 5 cells with no reagents. The froth in all these cells was hard to regulate because of the small quantity of molybdenite being treated.

(3) The lead rougher concentrate was ground and cleaned in two No. 7 cells. The lead cleaner concentrate was cleaned five times in No. 5 cells.

Reagent Consumption

Point of Addition	pH	Starch	CA	Na_2CO_3	Z-200	NaCN	$CuSO_4$	Z-6	H_2SO_4	R-404	Na_2S	R-250
Copper Conditioner	6.5	.141	.53									
Copper Rougher					.084							
Lead Conditioner	9.8			4.28		.088						
Lead Rougher				4.77				.176				
Lead Cleaner						.073						
Copper-Moly Separation											.176	
Zinc Conditioner	9.7						.088					
Zinc Rougher												
Arsenic Conditioner	7.6								2.10	.21		
Arsenic Rougher												.026

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow *	.04	.073	.15	.43	.129	.093	2.56	4.75	
Copper Conc	3.80	8.20	3.41	23.6	1.74	2.99	2.46	2.50	16.6
Moly-Copper Conc	3.63	10.3	2.42	20.2	1.55	6.64	5.00	1.95	15.6
Copper Rougher Tail	.03	.04	0.15	.37	.101	.073	1.28	-	-
Lead Conc	.79	.95	23.5	5.72	7.55	7.17	5.45	3.10	20.2
Lead Cleaner Conc	.58	.55	15.0	4.99	5.45	2.39	10.90	3.50	-
Lead Rougher Tail	-	.04	.028	.30	.049	.033	1.18	-	-
Molybdenite Conc	4.54	13.9	2.24	6.27	1.15	8.30	2.85	1.46	11.6
Final Zinc Conc	.66	1.59	1.08	35.0	1.13	2.19	14.0	3.35	16.5
Zinc Rougher Tail	-	.007	.017	.018	.048	.022	1.00	-	-

* 0.44 % WO_3

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	3.43	9.49	2.47	23.55	1.66	6.24	5.49	2.08	16.6
Molybdenite Conc	4.54	13.9	2.24	6.27	1.15	8.30	2.85	1.46	11.6
Copper-Moly Conc	3.63	10.3	2.42	20.2	1.55	6.64	5.00	1.95	15.6
Lead Conc	.79	.95	23.5	5.72	7.55	7.17	5.45	3.10	20.2
Zinc Conc	.66	1.59	1.08	35.0	1.13	2.19	14.0	3.35	16.5
Tailing		.007	.017	.018	.048	.022	1.00	-	-
Feed	.04	.073	.150	.043	.10	.106	1.15	4.75	-

	Distribution %								
	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	0.38	32.5	49.4	6.3	20.8	6.2	23.5	1.8	0.17
Molybdenite Conc	0.09	5.3	17.1	1.3	1.3	1.0	7.1	0.2	0.10
Copper-Moly Conc	0.47	37.8	66.5	7.60	22.1	7.2	30.6	2.0	0.27
Lead Conc	0.49	5.1	6.4	76.6	6.5	36.7	33.1	2.3	0.32
Zinc Conc	0.83	7.2	18.1	6.0	67.5	9.3	17.2	10.1	0.58
Tailing	98.24	49.9	9.0	9.8	3.9	46.8	19.1	85.6	98.83
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00

TEST NO. 21

August 11, 1970

Features of the Test

(1) The consumption of citric acid was raised to .70 lb/ton and this seemed to have a depressing effect on the copper and tin sulphides.

(2) The molybdenite was separated from the copper concentrate with .088 lbs of sodium sulphide per ton. This quantity of sodium sulphide seems insufficient for optimum copper-molybdenite separation.

Reagent Consumption

Point of Addition	pH	Starch	C.A.	Z-200	Na_2CO_3	NaCN	Z-6	Na_2S	$CuSO_4$	R-404	H_2SO_4	R-250
Copper Conditioner	6.5	.105	.70									
Copper Rougher				.088								
Lead Conditioner	9.5				4.24	.112						
Lead Rougher							.128					
Lead Cleaner						.064						
Zinc Conditioner	9.3								.064			
Zinc Rougher				.013								
Arsenic Conditioner	7.0										2.10	
Arsenic Rougher										.190		.032
Copper-Moly Separation								.088				

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'flow	.12	.10	.165	.40	.111	.095	2.21	5.02	-	.21
Copper-Moly Conc	2.76	9.21	4.16	13.2	1.35	5.38	4.18	2.43	22.4	
Copper Rougher Tail	-	.058	.132	.33	.095	.072	1.55	-	-	
Lead-Moly Conc	3.21	4.35	10.5	11.5	2.98	8.33	3.41	3.19	25.2	
Lead Rougher Tail	-	.027	.035	.34	.064	.050	1.55	-	-	
Molybdenite Conc (from Copper)	3.43	11.7	4.16	15.4	1.16	13.1	2.85	1.88	10.4	
Zinc Conc	.96	2.04	1.10	35.3	.855	1.51	10.0	1.49	8.29	.19
Zinc Rougher Tailing	-	.008	.016	.025	.052	.030	1.12	-	-	-

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	2.76	9.21	4.16	13.2	1.35	5.38	4.18	2.43	22.4
Lead Conc	3.21	4.35	10.5	11.5	2.98	8.33	3.41	3.17	25.2
Zinc Conc	.96	2.04	1.10	35.3	.855	1.51	10.0	1.49	8.29
Tailing	.067	.008	.016	.025	.052	.030	1.12	5.07	
Feed	.12	.10	.165	.40	.096	.158	1.10	5.02	

Distribution %

	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	0.29	6.6	26.7	7.3	9.6	4.0	9.9	1.0	0.14
Lead Conc	1.25	33.4	54.4	79.4	36.0	38.5	66.2	3.5	0.79
Zinc Conc	0.55	4.4	11.2	3.7	48.4	4.9	5.3	4.6	0.16
Tailing	97.91	55.6	7.7	9.6	6.0	52.6	18.6	90.9	98.91
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00

TEST NO. 22

August 13, 1970

Features of the Test

(1) The amount of citric acid was increased for fluorine depression. The use of citric acid seems to cause an increase in the amount of Z-200 that is required.

(2) High Z-6 consumption was used to see if it would increase the recovery of bismuth in the lead concentrate.

Screen Analysis of Grinding Circuit Products

Mesh Size	Distribution
+ 100 mesh	0.3
+ 150	1.6
+ 200	8.3
+ 200	8.3
+ 270	10.1
+ 325	9.3
- 325	70.4

Reagent Consumption

	pH	Starch	C.A.	Z-200	Na_2CO_3	NaCN	Z-6	Na_2S	$CuSO_4$	R-404	R-250
Copper Conditioner	6.2	.105	.70								
Copper Rougher				.105							
Lead Conditioner	9.1				16.0	.123					
Lead Rougher							.246				
Lead Cleaner						.088					
Lead-Moly Separation								.088			
Zinc Conditioner	9.1								.07		
Zinc Rougher				.014							
Arsenic Rougher										.211	.035

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow	0.10	.10	.165	.47						.17
Copper Conc	4.62	15.2	2.62	14.4	.875	4.59	2.74	1.76	14.9	-
Copper Rougher Tailing		.088	.18	.41	.149	.077	1.61	-	-	-
Lead Conc	.96	2.36	27.0	15.9	3.31	3.52	2.29	2.74	9.81	-
Lead Cleaner Tail	.26	.55	2.36	4.49	.950	.814	3.90	4.71	64.0	
Lead Rougher Tail	-	.018	.021	.139	.038	.042	1.64			
Molybdenite Conc	1.49	3.98	12.1	5.91	1.68	19.1	3.08	2.74	14.1	
Zinc Conc	1.16	1.46	3.30	19.1	2.05	1.69	18.7	1.64	10.7	0.3
Zinc Rougher Tail	-	.014	.037	.049						

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	4.62	15.2	2.62	14.4	.825	4.59	2.74	1.76	14.9
Lead Conc	.96	2.36	27.0	15.9	3.31	3.52	2.29	2.74	9.81
Moly Conc	1.49	3.93	12.1	5.91	1.68	19.1	3.08	2.74	14.1
Lead-Moly Conc	1.00	2.42	26.4	15.4	3.26	4.09	2.33	2.74	10.0
Zinc Conc	1.16	1.46	3.30	19.1	2.05	1.69	18.7	1.64	10.7
Tailing		.014	.037	.049	.046	.040	1.15	5.00	
Feed		.10	.165	.47	.091	.095	1.48	4.92	

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.36	54.8	5.7	11.1	3.5	17.4	0.7
Lead Conc	0.23	5.4	37.6	7.8	8.3	8.5	0.4
Moly Conc	0.01	0.4	0.7	0.1	0.2	1.8	-
Lead-Moly Conc	0.24	5.8	38.3	7.9	8.5	10.3	0.4
Zinc Conc	1.75	25.5	35.0	71.3	39.0	31.2	22.2
Tailing	97.65	13.9	21.1	9.7	49.0	41.1	76.7
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 23

August 14, 1970

Features of the Test

(1) Starch was discontinued in the copper conditioner to see its effect on molybdenite flotation. As a result, more molybdenite and lead floated with the copper.

(2) Citric acid was used in the hope that it might depress the fluorine.

(3) Lime was tried in the copper cleaning circuit for a short while but this was doscontinued because the froth looked poor.

(4) Though the increased amount of Z-6 did not improve bismuth recovery, it was thought that it lowered zinc concentrate grade.

Screen Analysis of Cyclone O'Flow

Mesh Size	Distribution
+ 100 mesh	0.6
+ 150	1.7
+ 200	7.1
+ 270	9.7
+ 325	8.9
- 325	72.0

Reagent Consumption

	pH	C.A.	Z-200	Na_2CO_3	NaCN	Z-6	$CuSO_4$	Na_2S
Copper Cleaner	8.3							
Copper Conditioner	6.5	.35	.105					
Copper Rougher								
Lead Conditioner	10.0			12.8	.09			
Lead Rougher						.246		
Lead-Moly Separation								
Zinc Conditioner	10.0						.176	.176
Lead Cleaner					.088			

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Classifier O'Flow	0.18	.080	.122	.40	.112	.080	1.70	4.71	-	0.16
Copper Conc	5.03	10.45	6.86	18.1	2.59	7.59	4.55	1.82	12.5	
Copper Rougher Tail	0.11	.04	.080	.36	.071	.050	1.64	-	-	
Final Lead Conc	1.30	2.07	25.0	7.71	5.73	5.04	9.55	3.19	16.6	
Lead Rougher Tail		.032	.032	.30	.036	.018	1.55	-	-	
Zinc Conc	1.36	1.54	.96	26.7	.975	.751	19.0	1.09	7.48	
Zinc Rougher Tail	-	.020	.035	.037	.040	.018	1.26			
Molybdenite Conc	1.64	3.17	5.09	12.5	2.67	16.6	4.40	3.80	18.9	
Lead Cleaner Tail	.20	.40	2.88	2.09	1.64	1.67	3.71	5.47	64.4	

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Sn
Copper Conc	10.45	6.86	18.1	2.59	7.59	4.55	1.82	5.03
Lead Conc	2.07	25.00	7.71	5.73	5.04	9.55	3.19	1.30
Moly Conc	3.17	5.09	12.5	2.67	16.6	4.40	3.8	1.64
Lead-Moly Conc	2.46	19.0	9.12	4.83	8.55	8.00	3.37	1.37
Zinc Conc	1.54	.96	26.7	.975	.751	19.00	1.09	1.36
Tailings	.020	.020	.037	.040	.018	1.26	4.76	
Feed	.080	.122	.400	.0736	.080	1.48	4.71	

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	0.38	49.6	21.4	17.2	13.3	36.1	1.2	0.15
Lead Conc	0.21	5.5	43.0	4.0	16.5	13.2	1.4	0.14
Moly Conc	0.09	3.5	3.8	2.8	3.3	18.8	0.3	0.07
Lead-Moly Conc	0.30	9.0	46.8	6.8	19.8	32.0	1.7	0.21
Zinc Conc	1.04	20.0	8.2	69.5	13.8	9.7	13.4	0.24
Tailing	98.37	21.4	23.6	6.5	53.1	22.2	83.7	99.4
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 24
August 17, 1970

Features of the Test

(1) Flotation without starch, citric acid, and SO_2 was tried. This resulted in a bulk float, with more arsenic floating in all circuits. Molybdenite recovery rate improved greatly, but bismuth recovery did not improve to the same extent.

(2) The lead-molybdenite separation circuit did not work well, because most of the lead and molydenite floated in the copper circuit.

Screen Analysis of Classifier O'Flow

Mesh Size	Distribution
+ 65 mesh	1.9
+ 100	3.8
+ 150	6.9
+ 200	12.4
+ 270	11.2
+ 325	8.0
- 325	55.8

Reagent Consumption

	pH	Z-200	Na_2CO_3	NaCN	Z-6	$CuSO_4$	Na_2S
Copper Conditioner	7.9						
Copper Rougher		.07					
Lead Conditioner	10.1		5.32	0.14			
Lead Rougher					.07		
Lead-Moly Separation							.176
Lead Cleaner				.05			
Zinc Conditioner	9.8					0.12	
Zinc Rougher		.007					

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow	.16	.070	.125	.40	.087	.068	2.29	3.65		0.30
Final Copper Conc	4.28	5.05	8.95	19.7	3.19	4.34	10.0	1.49	13.2	
Copper Rougher Tail	0.10	.041	.065	.22	.056	.030	1.32			
Final Lead Conc	.88	1.54	6.68	6.58	4.81	3.82	10.6	2.68	34.4	
Lead Cleaner Conc	.30	.55	1.84	3.16	1.63	2.12	9.4	3.80	52.5	
Lead Rougher Tail		.035	.045	.25	.042	.025	1.23			
Final Zinc Conc	1.68	1.62	0.44	47.4	.588	.207	8.72	.53	3.40	
Zinc Rougher Tail		.016	.040	.12	.036	.017	1.21			
Lead-Moly Conc	.51	1.70	5.61	5.78	4.36	5.87	8.49	2.86	38.5	
Molybdenite Conc	1.90	1.43	6.12	2.86	2.80	18.00	5.99	2.86	32.7	

Selected Assays for Metallurgical Balance %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Conc	4.28	5.05	8.95	19.7	3.19	4.34	10.0	1.49	13.2
Lead-Moly Conc	.51	1.70	5.61	5.78	4.36	5.87	8.49	2.86	38.5
Lead Conc	.88	1.54	6.68	6.58	4.81	3.82	10.6	2.68	34.4
Moly Conc	1.90	1.43	6.12	2.86	2.80	18.0	5.99	2.86	32.7
Zinc Conc	1.68	1.62	0.44	47.4	.588	.207	8.72	0.53	3.40
Tailing		.016	.040	.12	.036	.017	1.21		
Feed	.16	.070	.125	.40	.087	.068	2.29	3.65	

Distribution %

	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	1.07	28.6	77.3	76.7	52.7	39.3	68.5	4.7	0.41
Lead-Moly Conc	.16	0.5	3.9	7.2	2.3	8.0	13.8	0.6	0.13
Lead Conc	.14	0.3	3.4	6.1	2.1	7.4	7.8	0.5	0.11
Molybdenite Conc	.02	0.2	0.5	1.1	0.2	0.6	6.0	0.1	0.02
Zinc Conc	.17	1.8	3.9	0.6	20.1	11.5	0.4	0.7	0.02
Tailing	98.60	69.1	14.9	15.5	24.9	41.2	17.3	94.0	99.44
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00

TEST NO. 25

August 18, 1970

Features of the Test

(1) This test was performed without the use of SO_2. Results generally were quite good but a little more lead reported in the copper concentrate.

(2) Fluorspar was floated with double-distilled oleic acid manufactured by Canada Packers. The float was quite non selective but superior to the other reagents that were tried.

(3) Citric acid was used in the copper conditioner for fluorspar depression.

Reagent Consumption

	pH	Starch	C.A.	Na_2CO_3	NaCN	Z-200	Z-6	$CuSO_4$	Na_2S	R-404	R-250	OA	Dex
Copper Conditioner		.088	.176										
Copper Rougher	7.7					.07	.07						
Lead Conditioner	10.0			5.32	0.14								
Lead Rougher													
Lead-Moly Separation									.176				
Zinc Conditioner	9.7							0.21					
Arsenic Rougher										.211	.035		
Fluorspar Conditioner	9.6											.124	.440
Fluorspar Rougher	9.5												

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow		.051	.116	.54	.084	.067	1.62		
Final Copper Conc	2.93	11.8	4.93	22.9	1.41	4.98	5.84	1.25	10.6
Copper Rougher Tail	0.17	.036	.090	.500	.08	.062	1.55		
Final Zinc Conc	.74	1.98	.57	52.6	2.43	.187	2.59	0.55	3.43
Zinc Rougher Tails		.013	.018	.129	.049	.037	1.56		
Moly-Lead Cleaner Conc	1.40	.92	25.8	6.38	4.36	9.67	6.37	3.16	17.7
Lead Rougher Tail		.024	.031	.43	.069	.038	1.62		
Arsenic Rougher Conc		.10	.105	.88	.289	.185	5.15		75.3
Arsenic Rougher Tail	.19	.006	.014	.03	.023	.012	.96	3.89	
Fluorspar Rougher Conc	.10	.016	.025	.045	.028	.013	.86	7.30	81.0
Fluorspar Cleaner Conc	.10	.014	.021	.050	.025	.013	.61	13.7	70.9
Fluorspar Cleaner Tail		.010	.017	.038	.035	.010	1.02		
Fluorspar Rougher Tail		.008	.016	.021	.024	.017	.62		

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	11.8	4.93	22.9	1.41	4.98	5.84
Lead Conc	.92	25.8	6.38	4.36	9.67	6.37
Zinc Conc	1.98	.57	52.6	2.43	.187	2.59
Arsenic Conc	.10	.105	.88	.289	.185	5.15
Tailing	.006	.14	.03	.023	.013	.86
Feed	.051	.116	.540	.084	.067	1.62

		Distribution %					
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.19	43.13	7.92	7.91	3.2	14.2	0.7
Lead Conc	0.33	5.96	73.45	3.90	17.1	47.6	1.3
Zinc Conc	0.66	25.74	3.26	64.58	19.1	1.8	1.1
Arsenic Conc	14.20	25.10	12.85	23.20	48.8	36.4	45.2
Tailing	84.62	.07	2.48	.41	11.8	nil	51.7
Feed	100.00	100.00	100.00	100.00	100.0	100.0	100.0

TEST NO. 26

(August 19, 1970)

Features of the Test

(1) Sodium silicate was added to the copper conditioner and copper cleaner to see if it would reduce the insol and, perhaps, the fluorine content in all the products. Selectivity was perhaps improved.

(2) The fluorspar float with the double-distilled oleic acid from Canada Packers looked very good but was still of low grade despite one stage of cleaning. This was the only fluorspar float worth sampling.

Screen Analysis of Cyclone O'Flow

Mesh Size	Distribution
+100 mesh	0.6
+150	2.8
+200	10.2
+270	10.2
+325	10.3
-325	65.9

Reagent Consumption

Point of Addition	pH	Starch	Na_2S	Na_2CO_3	NaCN	Z-6	Z-200	$CuSO_4$	R-404	R-250	OA	Dex	Na_2S
Copper Conditioner		.088	.33										
Copper Rougher	6.5						.070						
Lead Conditioner				5.29	.088								
Lead Rougher	9.8			3.25		.053							
Lead Cleaner			.033		.049								
Lead-Moly Separation													.176
Zinc Conditioner	9.6							.035					
Zinc Rougher													
Arsenic Rougher									.176	.035			
Fluorspar Conditioner	9.6											.135	
Fluorspar Rougher											.107		
Fluorspar Cleaner												.120	

RESULTS

Assays of Samples %

	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3	Sn
Cyclone O'Flow	.056	.100	.35	.078	.070	1.62	--	-	-	-
Final Copper Conc	14.8	2.37	21.6	.893	2.35	4.23	1.31	8.18	-	3.95
Copper Rougher Tailing	.022	.095	.36	.081	.057	1.62	-	-	-	0.11
Final Lead Conc	2.87	24.4	15.0	4.25	3.90	5.41	2.28	12.2	-	2.22
Lead Rougher Tail	.018	.030	.38	.057	.030	1.58	-	-	-	-
Moly-Lead Cleaner Conc	3.45	15.4	18.5	3.71	5.07	2.90	2.07	13.8		2.61
Molybdenite Conc	1.43	18.9	4.73	2.68	15.05	6.52	2.07	16.5	-	1.01
Final Zinc Conc	1.23	0.46	54.5	.513	.057	4.68	.46	2.98	-	0.71
Zinc Rougher Tail	.017	.035	.084	.046	.032	1.33	-	-		-
Arsenic Rougher Tailing	.014	.025	.039	.034	.025	.88	3.89	-	.015	.25
Arsenic Rougher Conc	.08	.125	.88	.278	.162	8.56	-	69.4	.19	-
Fluorspar Rougher Conc	.017	.030	.052	.041	.017	.92	9.12	73.4	-	.13
Fluorspar Final Conc	.023	.028	.065	.033	.020	0.80	11.2	74.8	-	.18
Fluorspar Cleaner Tail	.025	.039	.107	.051	.018	1.03	-	-	-	-
Fluorspar Rougher Tail	.011	.018	.028	.028	.017	.96				

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Conc	14.80	2.37	21.60	.893	2.35	4.23	1.31
Lead-Moly Conc	3.45	15.40	18.5	3.71	5.07	2.90	2.07
Zinc Conc	1.23	.46	54.5	.513	.057	4.68	.46
Arsenic Conc	.08	.125	.88	.278	.162	8.56	-
Tailing	.105	.026	.024	.0391	.035	0.88	
Feed	.056	.100	.35	.078	.070	1.62	

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.15	39.50	3.54	9.22	1.67	5.0	0.39
Lead-Moly Conc	0.39	24.09	60.23	20.67	18.58	28.3	0.70
Zinc Conc	0.30	6.53	1.37	46.31	1.92	0.3	0.86
Arsenic Conc	9.24	13.20	11.50	23.20	32.80	21.3	48.80
Tailing	89.92	16.90	23.21	0.60	45.03	45.1	49.25
Feed	100.00	100.00	100.00	100.00	100.00	100.0	100.00

TEST NO. 27

(August 20, 1970)

Features of the Test

(1) This test was operated so that the lead and the molybdenite could be separated. After eight hours of operating the circuit, it was found that much trouble was encountered in keeping a steady float in the lead recleaners, even though the rougher float looked very good. Because of this, the regrind ball mill that was grinding the lead rougher concentrate was shut down. No more problems were encountered in the lead recleaner circuit.

(2) During this test, an attempt was made to cut back on the cyanide in the lead circuit, but it appeared that more zinc was floating in the lead concentrate as the cyanide was reduced.

(3) This was the first day of a 48-hour mill run operating under best known conditions.

Screen Analysis of Cyclone O'Flows

Mesh Size	Cyclone O'Flow 8:00 A.M. - 8:00 P.M.	Cyclone O'Flow 8:00 P.M. - 8:00 A.M.	Cyclone O'Flow Head Sample
+ 100 mesh	0.6	1.0	1.0
+ 150	2.8	3.6	3.9
+ 200	9.7	11.2	11.6
+ 270	10.7	10.4	10.9
+ 325	8.7	9.3	9.5
- 325	67.5	64.5	63.3

Reagent Consumption

Point of Addition	pH	Starch	Na_2SiO_3	Na_2S	Na_2CO_3	Z-200	Z-6	Cu SO_4	NaCN	R-404	R-250
Copper Conditioner	6.4	.088	.35								
Copper Rougher						.077					
Lead Conditioner	9.8				7.1				.115		
Lead Rougher					2.1		.053				
Lead Cleaner			.035						.022		
Lead-Moly Separation				.176							
Zinc Condition	9.7							.022			
Zinc Rougher											
Arsenic Conditioner	9.6									.176	
Arsenic Rougher											.022

RESULTS

Assays of Samples %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol	WO_3
Cyclone O'Flow 8:00 AM/8:00 PM		.058	.105	.34	.076	.070	1.61	-	-	-
Cyclone O'Flow 8:00 PM/8:00 AM		.072	.100	.34	.073	.072	1.65	-	-	-
Copper Conc	3.52	10.1	2.52	17.1	1.33	3.67	2.43	3.65	-	-
Lead	.71	.87	23.0	8.86	5.90	2.67	3.37	6.54	13.5	
Lead-Moly Conc	.51	.61	27.2	7.13	3.44	6.71	6.70	3.65	20.6	
Zinc Conc	1.11	1.52	.67	36.6	1.67	.684	13.3	.85	4.73	
Molybdenite Conc	.43	.44	4.71	1.40	1.89	20.8	10.0	3.19	28.1	0.18
Arsenic Rougher Conc		.074	.105	.25	.223	.158	5.99	-	75.2	.16
Zinc Rougher Tailing		.014	.023	.048	.039	.030	1.26	-	-	-
Arsenic Rougher Tailing	.05	.009	.016	.032	.025	.015	.88	3.65	-	-
Arsenic Feed 8:00 AM/8:00 PM		.023	.031	.079	.050	.032	1.33		87.2	0.15
Arsenic Feed 8:00 PM/8:00 PM		.015	.024	.057	.043	.030	1.39	-	87.5	0.16
Arsenic Tail 8:00 AM/8:00 PM	.05	.008	.013	.029	.020	.015	.79	3.34	-	0.13
Arsenic Tail 8:00 PM/8:00 AM	.04	.009	.017	.032	.023	.015	.83	3.59	-	0.13

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	Sn
Copper Conc	10.1	2.52	17.1	1.33	3.67	2.43	3.52
Lead Conc	.87	23.0	8.86	5.90	2.67	3.37	.71
Molybdenite Conc	.44	4.71	1.40	1.89	20.80	10.0	.43
Zinc Conc	1.52	.67	36.6	1.67	.684	13.3	1.11
Arsenic Conc	.074	.105	.25	.223	.158	5.99	-
Tailing	.009	.0136	.0315	.023	.0150	0.88	
Feed	.072	.100	.34	.067	.0632	1.344	

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	.48	67.2	12.1	24.2	9.5	27.8	0.9
Lead Conc	.23	2.2	61.7	4.7	20.0	9.8	0.5
Molybdenite Conc	.05	0.3	2.4	0.2	1.3	16.5	0.4
Zinc Conc	.53	11.2	3.6	57.2	13.3	5.7	5.2
Arsenic Conc	7.42	7.6	7.8	5.4	24.6	18.5	33.2
Tailing	91.29	11.5	12.4	8.3	31.3	21.7	49.8
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

Survey of Copper Cleaning Circuit Pilot Plant No. 27

1st Stage Copper Cleaning

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	Insol	Fl
Copper Cleaner Conc	1.01	2.35	1.33	5.43	.71	1.22	4.02	59.0	4.65
Copper Cleaner Tail	.07	.10	.33	.86	.23	.24	2.93		
Copper Rougher Conc (C)*	.57	1.30	0.87	3.30	.48	.76	3.51		
Copper Rougher Conc (A)**	.41	1.30	0.77	2.81	.40	.53	3.08	72.3	3.95

*(C) = calculated **(A) = assayed

	Distribution %						
	Wt	Sn	Cu	Pb	Zn	MoS_2	As
Copper Cleaner Conc	53.3	94.3	96.6	82.2	87.8	77.9	61.0
Copper Cleaner Tail	46.7	5.7	3.4	17.8	12.2	22.1	39.0
Copper Rougher Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2nd Stage Copper Cleaning

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	Insol	Fl
Copper Cleaner Conc	1.12	3.01	1.73	7.14	1.03	1.78	4.70	49.6	4.71
Copper Cleaner Tail	.14	.31	.61	1.96	.49	.45	3.87		
1st Stage Copper Conc (C)	.88	2.35	1.46	5.88	.90	1.46	4.49		
1st Stage Copper Conc (A)	1.01	2.35	1.33	5.43	.71	1.22	4.02	59.0	4.65

	Distribution %							
	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As
Copper Cleaner Conc	75.6	96.1	96.8	89.8	91.9	86.5	92.3	79.0
Copper Cleaner Tail	24.4	3.9	3.2	10.2	8.1	13.5	7.7	21.0
1st Stage Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

3 rd Stage Copper Cleaning

Assays %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	Insol	F
Copper Cleaner Conc	2.97	7.66	3.24	15.4	1.48	3.66	5.0	22.0	3.8
Copper Cleaner Tail	.25	0.47	1.05	3.54	.81	.82	4.4		
2nd Stage Copper Conc (C)	1.21	3.01	1.82	7.73	1.05	1.82	4.6		
2nd Stage Copper Conc (A)	1.12	3.01	1.73	7.14	1.03	1.78	4.7	49.6	4.71

Distribution %

	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As
Copper Cleaner Conc	35.3	86.6	89.8	62.7	70.5	49.9	70.7	38.5
Copper Cleaner Tail	64.7	13.4	10.2	37.3	29.5	50.1	29.3	61.5
2nd Stage Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

4th Stage Copper Cleaning Circuit

Assays %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Cleaner Conc	4.63	11.6	3.45	18.0	1.43	4.60	4.75	3.65	10.5
Copper Cleaner Tail	0.73	1.54	1.98	8.85	1.50	2.12	5.53		
3rd Stage Copper Conc (C)	3.10	7.65	2.87	14.4	1.46	3.63	5.0		
3rd Stage Copper Conc (A)	2.97	7.65	3.24	15.4	1.48	3.66	5.0	3.8	22.0

Distribution (%)

	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As
Copper Cleaner Conc	60.8	91.0	92.2	73.1	76.0	59.6	77.2	57.1
Copper Cleaner Tail	39.2	9.0	7.8	26.9	24.0	40.4	22.8	42.9
3rd Stage Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

OVERALL METALLURGY OF COPPER CLEANING CIRCUIT

Assays %

	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Cleaner Conc	4.63	11.6	3.45	18.0	1.43	4.60	4.75	3.65	10.5
Copper Cleaner Tail	.07	.098	.33	.86	.23	.24	2.93		
Copper Cleaner Feed (C)	.55	1.30	.66	2.65	.36	.70	3.12		
Copper Cleaner Feed (A)	.41	1.30	.77	2.81	.40	.53	3.08	3.95	72.3

Distribution %

	Wt	Sn	Cu	Pb	Zn	Bi	MoS_2	As
Copper Cleaner Conc	10.45	89.3	93.0	55.0	71.0	37.5	68.7	16.1
Copper Cleaner Tail	89.55	10.7	7.0	45.0	29.0	62.5	31.3	83.9
Copper Cleaner Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TEST NO. 28
August 21, 1970

Feature of the Test

This was part of the 48-hour mill run. Sodium silicate did not seem to help insol depression too much. In this portion of the 48-hour run, molybdenite was separated from the copper concentrate with sodium sulphide.

Screen Analysis of Cyclone O'Flows

Mesh Size	Cyclone O'Flow 8:00 A.M. - 3:00 A.M.	Cyclone O'Flow Head Sample
+ 100	0.7	0.5
+ 150	3.1	3.4
+ 200	10.5	9.9
+ 270	10.8	10.0
+ 325	10.4	10.0
- 325	64.5	66.2

Reagent Consumption (Separating Molybdenite from the Copper Conc)

Point of Addition	pH	Starch	Na_2SiO_3	Z-200	Na_2CO_3	NaCN	Z-6	$CuSO_4$	Na_2S	R-404	R-250
Copper Conditioner	6.5	.088	.35								
Copper Rougher				.077							
Lead Conditioner	9.7				7.05	.088					
Lead Rougher							.053				
Copper-Moly Separation									.176		
Lead Cleaner			.35								
Zinc Conditioner	9.7							.053			
Zinc Cleaner											
Arsenic Rougher											.04
Arsenic Conditioner	9.7									.176	

RESULTS

Assays of Samples %

Product	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Cyclone O'Flow		.049	.085	.30	.073	.060	1.59		
Cyclone Shift Sample		.053	.090	.35	.068	.068	1.62		
Copper Conc	5.34	13.9	3.32	23.1	.743	.330	3.82	3.80	7.08
Copper-Moly Conc	5.48	12.7	1.92	19.6	1.04	6.39	2.46	3.80	10.0
Molybdenite Conc	.48	4.51	2.11	5.76	1.26	18.6	4.47	2.43	18.9
Lead-Moly Conc	.93	1.43	18.4	5.81	7.69	8.85	6.97	3.44	17.8
Zinc Concentrate	1.22	1.61	0.42	44.8	.688	.207	9.25	0.62	5.75
Zinc Rougher Tail		.015	.022	.067	.044	.032	1.25	-	-
Arsenic Feed Shift Sample		.018	.027	.074	.048	.037	1.44	-	-
Arsenic Rougher Tail Shift Sample	.04	.009	.017	.032	.023	.015	.83	3.59	-

Selected Assays for Metallurgical Balance %

	Cu	Pb	Zn	Bi	MoS_2	As	Sn
Copper Conc	13.9	3.32	23.1	.743	.330	3.82	5.34
Moly Conc	4.51	2.11	5.76	1.26	18.6	4.47	.48
Lead-Moly Conc	1.43	18.4	5.81	7.69	8.85	6.97	.93
Zinc Conc	1.61	.42	44.8	.688	.207	9.25	1.22
Tailing	.010	.0175	.0576	.044	.0320	1.54	
Feed	.049	.085	.30	.073	.080	1.59	

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Conc	0.18	51.2	6.9	13.9	1.8	0.7	0.4
Moly Conc	0.06	5.5	1.5	1.2	1.1	23.2	0.2
Lead-Moly Conc	0.32	9.4	69.1	6.2	33.7	35.3	1.4
Zinc Conc	0.40	13.1	1.7	59.8	3.8	1.0	2.3
Tailing	99.04	20.8	20.8	18.9	59.6	39.8	95.7
Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0

APPENDIX IV - Laboratory Tests During Pilot Plant

Part 1 - Molbydenite-lead Separation Using Tests 1 and 2

The first series of tests was made in an attempt to separate the molybdenite from the lead concentrate. Conventional methods using (1) potassium permanganate and (2) potassium dichromate were first investigated. Each test was carried out on a 500-g sample of lead concentrate cut from the mill circuit between 11.30 and 13.30, on July 15, 1970. Test details are shown in Table 1.

TABLE 1

Reagents and Conditions for Molybdenite-Lead Separation

Test		Time min	Reagents (g) *					
			SO_2	$KMnO_4$	$K_2Cr_2O_7$	Ker	Frother**	pH
1 $KMnO_4$	Rougher separation No. 1	6		2.0				9.5
	Rougher separation No. 2	4		2.0				9.4
	MoS_2 cleaner flotation	3		0.1				9.4
1A $K_2Cr_2O_7$	Rougher separation No. 1	6			2.0			9.1
	Rougher separation No. 2	4			2.0			9.2
2 SO_2 + $KMnO_4$	Conditioning	3	50					4.3
	Rougher separation No. 1	6		2.0		0.03	0.02	4.6
	Rougher separation No. 2	4	10	1.0				4.0
	MoS_2 cleaner flotation	3		0.1				4.5
2A SO_2 + $K_2Cr_2O_7$	Conditioning	3	50					4.5
	Rougher separation No. 1	6			2.0	0.03	0.02	4.7
	Rougher separation No. 2	4	10		2.0			4.2
	MoS_2 cleaner flotation	3			0.1			4.6

* Except SO_2 addition which is expressed in ml of saturated solution.

** 1:1 Pine oil - Dowfroth 250.

All the products of Test 1 and 2 were analyzed for MoS_2, Bi, and Pb. Because no separation was obtained in Tests 1A (i.e., almost all the material reported in the floated concentrate), no chemical analysis was required in this test. Only the molybdenite concentrate was analyzed in Test 2A in order to reduce the analytical work. The metal content of the other product of this test was calculated by difference from the average feed analyses of Tests 1 and 2. The pertinent results of this series of tests are given in Table 2.

TABLE 2

Results of MoS_2-Pb Separation Using $KMnO_4$ and $K_2Cr_2O_7$

Test	Product	Weight %	Analysis %			Distribution %		
			MoS_2	Bi	Pb	MoS_2	Bi	Pb
1 ($KMnO_4$)	MoS_2 conc	9.2	11.2	2.44	38.5	36.8	5.6	43.9
	Cl tailing	45.6	1.4	2.77	3.3	22.8	28.8	18.6
	Pb conc	45.2	2.5	6.38	6.7	40.4	65.6	37.5
	Feed (calcd)	100.0	2.8	4.39	8.1	100.0	100.0	100.0
2 ($KMnO_4$ + SO_2)	MoS_2 conc	9.3	4.2	4.00	41.3	12.5	8.5	45.4
	Cl tailing	48.5	2.4	2.28	2.4	37.4	25.6	13.7
	Pb conc	42.2	3.7	6.81	8.2	50.1	65.9	40.9
	Feed (calcd)	100.0	3.1	4.36	8.5	100.0	100.0	100.0
2A ($K_2Cr_2O_7$ + SO_2)	MoS_2 conc	12.3	10.9	5.78	22.1	45.9	16.2	32.6
	Pb conc +Cl tail (calcd)	87.7	1.8	4.18	6.4	54.1	83.3	67.4
	Feed(Average)	100.0	2.9	4.38	8.3	100.0	100.0	100.0

Part 2 - Flotation of Arsenic Minerals Tests 3 to 9

While waiting for the chemical analyses of the first series of laboratory tests, it was decided to investigate the possibility of recovering by flotation the large amount of arsenic which reported in the mill tailing. The feed for this series of tests was the arsenopyrite table concentrate produced from the mill tailing. Several 1000-g samples were cut for this purpose. Procedures and results of typical tests are shown in Table 3 and 4.

TABLE 3

Reagents and Conditions for Flotation of Arsenic Minerals

Operation	Test	Reagents (g)*					pH
		Z-6	R-250	$CuSO_4$	SO_2	Na_2CO_3	
Rougher Flotation (5 min)	3	0.03	0.03				8.4
	4	0.03	0.03	0.25			7.5
	5	0.03	0.03	0.25	14		4.8
	6	0.03	0.03	0.25		7.5	9.6

TABLE 4

Results of Arsenic Flotation

Test	Product	Weight %	Analysis % As	Distribution % As
3	As conc	3.2	12.8	7.5
	Flot tailing	96.8	5.8	92.5
	Feed (calcd)	100.0	5.4	100.0
4 ($CuSO_4$)	As conc	4.8	22.3	20.0
	Flot tailing	95.2	4.5	80.0
	Feed (calcd)	100.0	5.4	100.0
5 ($CuSO_4$ + SO_2)	As conc	4.1	35.1	24.6
	Flot tailing	95.9	4.6	75.4
	Feed (calcd)	100.0	5.8	100.0
6 ($CuSO_4$ + Na_2CO_3)	As conc	4.0	22.4	14.1
	Flot tailing	96.0	5.7	85.9
	Feed (calcd)	100.0	6.4	100.0

Two additional tests were made using the technique of Tests 4 and 5, except that the collector (Z-6), conditioning, and the flotation time were increased by 50%. When the products of these tests were weighed, it was found that none of the concentrates accounted for more than 6% of the weight of the total feed. With such a ratio of concentration, it was concluded that the arsenic recovery would necessarily be very low, and that chemical analyses of the products were not worthwhile. The only reason found to explain the low arsenic recovery is the nature of its occurrence, mainly as loellingite, which seems resistant to flotation.

Part 3 - Molybdenite-Copper Separation Tests 9 to 19

A series of tests was undertaken to find if the molybdenite contained in the copper concentrate could be removed by selective flotation. The various depressants investigated for the depression of copper were potassium permanganate, arsenic trioxide, and potassium dichromate. The details of the tests are shown in Table 5.

In tests 9, 10, and 11, no significant molybdenite-copper separation was achieved and the products were not analyzed. The results of Tests 12, 13, and 14 are shown in Table 6.

TABLE 5

Reagents and Conditions for Molybdenite-Copper Separation

Test	Operation	Time min	Reagents (g)* SO_2	$KMnO_4$	$K_2Cr_2O_7$	As_2O_3	pH
9	Rougher separation No. 1	5		2.0			8.5
	Rougher separation No. 2	4		1.0			8.4
10	Conditioning	3	20				4.5
	Rougher separation	5		2.0			4.7
11	Rougher separation	5			1.5		8.6
12	Conditioning	3	20				4.4
	Rougher separation	5			1.5		4.5
13	Rougher separation No. 1	6				4.0	4.5
	" " No. 2	5				3.0	4.7
	" " No. 3	4				2.0	5.1
14	Conditioning	3	20				4.6
	Rougher separation No. 1	6				2.0	5.0
	Rougher separation No. 2	5				2.0	5.2
	Cleaner flotation	4				1.0	5.1
	Recleaner flotation	3				0.5	6.0

*Except SO_2 addition which is expressed in ml of saturated solution.

TABLE 6

Results of MoS_2-Cu Separation Using $K_2Cr_2O_7$ and As_2O_3

Test	Product	Weight %	Analysis %					Distribution %				
			MoS_2	Bi	Cu	Pb	Zn	MoS_2	Bi	Cu	Pb	Zn
12 ($K_2Cr_2O_7$)	MoS_2 conc	8.6	3.74	0.94	18.0	17.7	4.58	20.5	5.8	32.1	28.6	2.1
	Cu conc	91.4	1.37	1.54	3.59	4.16	19.8	79.5	94.2	67.9	71.4	97.9
	Feed (calcd)	100.0	1.57	1.49	4.82	5.32	18.5	100.0	100.0	100.0	100.0	100.0
13 (As_2O_3	MoS_2 conc	39.4	19.5*	1.68	8.69	4.15	8.74	86.9	27.3	48.2	26.6	24.6
	Cu conc	60.6	1.91	2.91	6.08	7.43	17.4	13.1	72.7	51.8	73.4	75.4
	Feed (calcd)	100.0	8.84	2.42	7.11	6.13	14.0	100.0	100.0	100.0	100.0	100.0
14 (SO_2 + As_2O_3)	MoS_2 conc	25.1	5.59	0.97	10.9	1.27	9.70	55.0	13.3	46.9	4.8	15.4
	Cl + Recl tailings	15.1	2.76	2.10	7.95	7.33	18.7	16.4	17.3	20.6	16.6	17.9
	Cu conc	59.8	1.22	2.13	3.17	8.74	17.6	28.6	69.4	32.5	78.6	66.7
	Feed (calcd)	100.0	2.55	1.83	5.83	6.65	15.8	100.0	100.0	100.0	100.0	100.0

*This analysis appears to be erratic.

Supplementary tests 15 to 19 were performed in which the quantities of $K_2Cr_2O_7$ and As_2O_3 were varied. The products (particularly the molybdenite concentrates) were examined under the microscope and, when it was found that no significant molybdenite-copper separation was achieved, they were discarded.

Part 4 - Molybdenite-Lead Separation after Mineral Surface Alteration. Tests 20 to 30

It was thought that the poor separation of molybdenite and lead obtained in Tests 1 and 2 could be due to the presence of an excess of reagents in the pulp and on the surface of the minerals. This prompted a second series of tests in which attempts were made to remove these reagents by the following steps prior to flotation: (Test 20) wash and filter the pulp three times using hot water; (Test 21) after washing and filtering as in (a), regrind for 10 minutes; (Test 22) heat and boil the pulp for 40 minutes.

The flotation-separation procedure was the same in each of the three tests and was as follows:

TABLE 7

Reagents and Conditions of Flotation

Operation	Time min	Reagents (g)			pH
		$KMnO_4$	Ker	Frother	
Rougher separation	5	2.0			8.9
Scavenger flotation	3		0.03	0.02	8.8

All the samples were analyzed for molybdenite, bismuth, and lead with the following results.

TABLE 8

Results of Molybdenite Flotation from Lead Concentrate

Test	Product	Weight %	Analysis %			Distribution %		
			MoS_2	Bi	Pb	MoS_2	Bi	Pb
21 (Wash)	MoS_2 conc	12.1	11.4	4.56	13.9	49.1	10.4	20.3
	Scav conc	13.8	4.62	5.19	20.9	22.7	13.4	34.7
	Pb conc	74.1	1.07	5.48	5.04	28.2	76.2	45.0
	Feed (calcd)	100.0	2.81	5.33	8.30	100.0	100.0	100.0
22 (Wash + Regrind)	MoS_2 conc	9.2	11.5	4.75	10.1	38.6	7.6	10.7
	Scav conc	20.0	4.55	7.54	17.8	33.2	26.1	41.1
	Pb conc	70.8	1.09	5.38	5.89	28.2	66.3	48.2
	Feed (calcd)	100.0	2.74	5.75	8.66	100.0	100.0	100.0
23 (Boil)	MoS_2 conc	7.7	12.8	4.88	6.82	35.5	7.1	6.2
	Scav conc	24.0	5.00	6.81	15.3	43.2	31.0	43.7
	Pb conc	68.3	0.87	4.78	6.17	21.3	61.9	50.1
	Feed (calcd)	100.0	2.78	5.28	8.41	100.0	100.0	100.0

Other tests (Nos. 24 to 29) were made using various combinations of washing, regrinding, and boiling but no significant improvement in the separation could be noticed.

Part 5 - Molybdenite Selective Flotation Using Na_2S Tests 30 and 31.

At this point of the investigation, it was realized that a better technique for the selective flotation of molybdenite should be found. Preliminary testwork using sodium sulphide appeared encouraging. Two tests were then conducted with this reagent on a lead concentrate containing 2.7% MoS_2. The detailed procedure and the results obtained are shown below.

TABLE 9

Reagents and Conditions for Molybdenite-Lead Separation

Test	Operation	Time min	Reagents (g) Na_2S	pH
30	Separation No. 1	8	2.0	10.3
	Separation No. 1	7	1.0	10.4
	MoS_2 cleaner flotation	5	0.5	10.1
31	Separation No. 1	8	3.0	10.6
	Separation No. 2	7	1.5	10.9
	MoS_2 cleaner flotation	5	0.4	10.5
	MoS_2 recleaner flotation (twice)	4	0.3	10.2

TABLE 10

Results of MoS_2-Pb Separation Using Na_2S

Test	Product	Weight %	Analysis %			Distribution %		
			MoS_2	Bi	Pb	MoS_2	Bi	Pb
30	MoS_2 conc	15.7	13.34	0.92	1.59	75.4	2.5	3.1
	Cl tailing	11.5	1.49	0.36	8.51	6.2	0.7	12.3
	Pb conc	72.8	0.70	7.61	9.53	18.4	96.8	84.6
	Feed (calcd)	100.0	2.77	5.72	7.97	100.0	100.0	100.0
31	MoS_2 conc	8.8	17.48	1.39	1.53	59.2	2.3	3.4
	Cl + Recl tail	18.3	2.57	0.95	8.56	18.1	3.3	18.8
	Pb conc	72.9	0.81	6.83	7.93	22.7	94.4	77.8
	Feed (calcd)	100.0	2.59	5.28	7.35	100.0	100.0	100.0

In an attempt to increase the molybdenite recovery, an additional test was made in which kerosene and 1:1 pine oil-Dowfroth 250 (in amounts of 0.02 g and 0.01 g) were added prior to the rougher separation stages of the procedure of Test 30. Only the lead concentrate was analyzed with the following results: MoS_2 - 0.34%, Bi - 6.50%, and Pb - 10.3%. These analysis indicated that, at least, 90% of the molybdenite reported in the rougher flotation concentrate and that about 85% of the galena was depressed. It was then concluded that the method with sodium sulphide was by far the best among those investigated for the separation of molybdenite and galena. These encouraging results prompted a trial of the same technique for separation of molybdenite and chalcopyrite. Because the mill run was nearly completed, only a rapid test was made to assess the method and only the molybdenite concentrate was analyzed. The results were as follows:

MoS_2	Bi	Cu	Pb	Zn	As
33.0%	1.70%	2.22%	1.83%	3.99%	3.09%

On comparing these results with those of Tests 12 and 14, it is evident that the Na_2S method again proved to be the most effective for molybdenite-copper separation.

It appeared then advisable to incorporate it in the pilot plant operation for both the molybdenite-lead and molybdenite-copper separations.

APPENDIX V - Bench Scale Tests After Pilot Plant

(by E. W. J. Thornton)

Part 1 - Flotation

Flotation Test A

Recleaning of copper concentrate with lime at a pH of 10.4 with 2 drops of Z-200.

Assays %

	Cu	Pb	Zn	Bi	MoS_2	F	Insol
Copper Recl Conc	17.6	2.13	15.8	.608	2.50	1.31	2.64
Copper Recl Tail	11.9	4.31	11.8	1.50	7.39	2.01	15.50
Pilot Plant Copper Conc	15.7	2.84	14.5	.90	4.10	1.54	6.85

Distribution %

	Wt	Cu	Pb	Zn	Bi	MoS_2	F	Insol
Copper Recl Conc	67.3	75.2	50.3	73.4	45.6	40.9	57.3	26.0
Copper Recl Tail	32.7	24.8	49.7	26.6	54.4	59.1	42.7	74.0
Pilot Plant Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test B

Reclean lead concentrate with 2 drops of MIBC. Separate the molybdenite from it with 2 ml of saturated Na_2S and reclean the molybdenite with 1 drop of fuel oil.

Assays %

	Cu	Pb	Zn	Bi	MoS_2	F	Insol
Molybdenite Cl Conc	3.72	36.6	7.2	1.18	9.94	2.00	16.50
Molybdenite Cl Tail	2.86	28.0	15.3	3.82	6.27	2.01	8.48
Molybdenite Ro Conc	3.15	30.8	12.6	2.93	7.50	2.01	11.15
Lead Conc	2.29	26.8	21.1	5.56	3.22	1.58	5.85
Lead Cl Conc	2.47	27.6	19.3	5.01	4.11	1.67	6.95
Lead Cl Tail	1.58	4.3	20.0	3.86	3.45	3.95	7.69
Pilot Plant Lead Conc	2.20	20.4	19.6	4.66	3.91	2.37	7.18

Distribution %

	Wt	Cu	Pb	Zn	MoS_2	Bi	F	Insol
Molybdenite Cl Conc	4.83	8.2	8.6	1.8	12.3	1.20	4.1	11.1
Molybdenite Cl Tail	9.58	12.5	13.1	7.5	15.4	7.9	8.1	11.3
Molybdenite Ro Conc	14.41	20.7	21.7	9.3	27.7	9.1	12.2	24.4
Lead Conc	54.90	57.3	71.9	59.2	45.2	65.6	36.7	44.7
Lead Cl Conc	69.31	78.0	93.6	68.5	72.9	74.7	48.9	69.1
Lead Cl Tailing	30.69	22.0	6.4	31.5	27.1	25.3	51.1	30.9
Pilot Plant Lead Conc	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test C

Recleaning of the zinc concentrate without lime.

	Assays %						
	Cu	Pb	Zn	Bi	MoS_2	As	F
Zinc Cl Conc	1.70	.79	33.4	.89	.54	17.0	0.73
Zinc Cl Tail	0.75	.38	5.0	1.23	.60	32.9	1.61
Pilot Plant Zinc Conc	1.57	.73	29.6	.93	.55	19.1	.85

	Distribution %							
	Cu	Pb	Zn	Zn	Bi	MoS_2	As	F
Zinc Cl Conc	86.6	93.5	93.1	97.7	82.3	85.3	76.8	74.6
Zinc Cl Tail	13.4	6.5	6.9	2.3	17.7	14.7	23.2	25.4
Pilot Plant Zinc Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test D - Recleaning of the zinc concentrate with lime at a pH of 11.3

This float tended to be very fast.

	Assays %						
	Cu	Pb	Zn	Bi	MoS_2	As	F
Zinc Cl Conc	1.70	.88	30.5	.72	.527	18.0	.76
Zinc Cl Tail	0.40	.42	3.5	2.14	.627	35.6	1.58
Pilot Plant Zinc Conc	1.57	.83	27.9	.86	.537	19.7	.84

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Zinc Cl Conc	90.4	97.6	95.2	98.8	76.2	88.8	82.6	82.0
Zinc Cl Tail	9.6	2.4	4.8	1.2	23.8	11.2	17.4	18.0
Pilot Plant Zinc Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test E - In this test, a sample of arsenic rougher tailings was taken and the fluorspar floated at a pH of 10.4 with 2.0 g. of soda ash and 2 drops of double distilled oleic acid.

	Wt%	F%	F Distribution %
Fluorspar Cl Conc	1.95	35.9	11.35
Fluorspar Cl Tail	1.54	11.6	2.91
Fluorspar Ro Conc	3.49	25.1	14.26
Fluorspar Ro Tail	96.51	5.47	85.74
Arsenic Ro Tail	100.00	6.16	100.00

Flotation Test F - This test is to be compared withTest No. E. The arsenic rougher tailing was filtered and repulped with hot water before indentical fluorspar flotation.

	Wt %	F %	F Distribution %
Fluorspar Cl Conc	1.44	33.4	11.73
Fluorspar Cl Tail	1.33	5.47	1.78
Fluorspar Ro Conc	2.77	20.00	13.51
Fluorspar Ro Tail	97.23	3.65	86.49
Arsenic Ro Tail	100.00	4.104	100.00

Flotation Test No. G - A sample of the fluorine cleaner concentrate was taken from the pilot plant on August 18th and cleaned five times with no reagent.

	Wt %	F %	F Distribution %
Fluorspar Final Conc	16.4	37.7	38.3
Fluorspar 5th Cl Tail	8.3	23.7	12.2
Fluorspar 4th Cl Conc	24.7	33.0	50.5
Fluorspar 3rd Cl Tail	24.3	17.6	26.5
Fluorspar 2nd Cl Conc	49.0	25.4	77.0
Fluorspar 2nd Cl Tail	18.7	10.0	11.5
Fluorspar 1st Cl Conc	67.7	21.15	88.5
Fluorspar 1st Cl Tail	32.3	5.78	11.5
Pilot Plant Fluorspar Conc	100.0	16.16	100.0

Flotation Test H - This test is to be compared with test No. G and shows the beneficial effect of adding 1/2 g of Dextrin for the first stage - 0.3 g of Dextrin for the 2nd. stage and 0.1 g of Dextrin for the final stage. The concentrate looked quite good and when this concentrate was panned no monazite was noticed.

	Wt %	F %	F Distribution %
Fluorspar Final Conc	13.6	38.3	37.6
Fluorspar 3rd Cl Tail	6.6	24.3	11.6
Fluorspar 2nd Cl Conc	20.2	33.6	49.2
Fluorspar 2nd Cl Tail	23.6	15.2	26.0
Fluorspar 1st Cl Conc	43.8	23.72	75.2
Fluorspar 1st Cl Tail	56.2	6.08	24.8
Pilot Plant Fluorspar Conc	100.0	13.80	100.0

Flotation Test L - Cleaning the pilot-plant arsenic concentrate with 12 lb of sodium silicate/ton and recleaning without further addition of reagent.

Product	Wt %	Assays %			Distribution %		
		Bi	Insol	As	Bi	Insol	As
Arsenic Re Cl Conc	16.5	.975	18.5	29.3	62.2	72.4	4.5
Arsenic Re Cl Tail	5.8	.376	68.2	5.30	8.5	4.6	5.9
Arsenic Cl Conc	22.3	.820	31.4	23.05	70.7	77.0	10.4
Arsenic Cl Tail	77.7	.098	78.1	1.97	29.3	23.0	89.6
Pilot Plant Arsenic Conc	100.0	.259	67.6	6.67	100.0	100.0	100.0

Flotation Test I - This test was performed to see if the sonic bath would help eliminate insolubles from the respective concentrates. No reagent was added. These concentrates looked fairly clean, but the froth texture was much different. The zinc was vibrated for 25 min, the copper concentrate for 30 min and the lead concentrate for 45 min. The zinc concentrate was the most responsive.

	Assays %								
	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Cl Conc	4.35	14.9	2.46	22.7	.82	1.93	5.69	1.31	11.6
Copper Cl Tail		6.7	4.58	27.1	1.46	2.12	5.46		
Pilot Plant Copper Conc		13.0	2.96	23.7	.97	1.97	5.63		

	Distribution (%)						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Copper Cl Conc	76.5	88.0	63.6	73.2	64.8	74.7	77.2
Copper Cl Tail	23.5	12.0	36.4	26.8	35.2	25.3	22.8
Pilot Plant Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sonic Vibration of Zinc Conc

	Assays %								
	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Zinc Cl Conc	.08	1.51	.46	54.7	.45	.097	3.6	.33	2.27
Zinc Cl Tail		1.21	.30	27.1	4.19	.487	19.0		
Pilot Plant Zinc Conc		1.49	.44	53.4	.64	.095	4.4		

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Zinc Cl Conc	95.0	96.0	99.6	97.6	67.3	97.0	78.2
Zinc Cl Tail	5.0	4.0	0.4	2.4	32.7	3.0	21.8
Pilot Plant Zinc Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Sonic Vibration of Lead Concentrate

	Assays %								
	Sn	Cu	Pb	Zn	Bi	Mos_2	As	F	Insol
Lead Cl Conc	2.48	2.05	29.7	12.70	3.94	7.09	5.69	1.52	9.67
Lead Cl Tail		1.15	10.0	7.43	4.47	4.63	8.94		
Pilot Plant Lead		1.78	23.7	11.10	4.10	6.34	6.68		

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Lead Cl Conc	69.6	80.4	87.2	79.6	66.9	77.5	59.3
Lead Cl Tail	30.4	19.6	12.8	20.4	33.1	22.5	40.7
Pilot Plant Lead Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test J - Separation of the molybdenum from the lead concentrate by using 12 lb/ton of sodium sulphide (.020 gm).

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Molybdenite Conc	4.14	9.84	6.49	1.86	19.3	2.80
Lead Conc	3.86	16.5	19.5	3.08	4.0	5.23
Lead-Moly Conc	3.88	16.0	18.6	2.99	5.0	5.06

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Molybdenite Conc	6.6	7.1	4.1	2.3	4.1	25.6	3.7
Lead Conc	93.4	92.9	95.9	97.7	95.9	74.4	96.3
Lead-Moly Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test K - This was a repeat of Test No. J except that the concentrate was filtered and repulped with hot water before being conditioned with 0.2 g of sodium sulphide.

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Molybdenite Conc	4.67	11.2	6.5	2.31	18.90	4.01
Lead Conc	3.77	18.4	19.0	2.88	3.27	5.46
Lead-Moly Conc	3.86	17.7	17.8	2.82	4.77	5.32

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Molybdenite Conc	9.6	11.6	6.07	3.5	7.8	38.1	7.24
Lead Conc	90.4	88.4	93.93	96.5	92.2	61.9	92.76
Lead-Moly Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Because, Dextrin was good for depressing topaz, the following tests were performed to see if Dextrin could depress the fluorine and insol contents of the sulphide concentrates. However, nothing of significance was noted. Samples used were from Pilot Plant No. 27.

Flotation Test M - Cleaning of the copper concentrate with 0.2 g of Dextrin.

	Assays %				
	Cu	Pb	Zn	Bi	MoS_2
Copper Cl Conc	13.2	5.88	13.9	1.34	8.49
Copper Cl Tail	13.3	8.42	15.4	1.67	6.93
Pilot Plant Copper Conc	13.2	7.68	14.9	1.57	7.37

	Distribution %					
	Wt	Cu	Pb	Zn	Bi	MoS_2
Copper Cl Conc	28.8	28.6	22.0	26.7	24.5	33.1
Copper Cl Tail	71.2	71.4	78.0	73.3	75.5	66.9
Pilot Plant Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0

Test No. N - Cleaning copper concentrate without Dextrin.

	Assays %				
	Cu	Pb	Zn	Bi	MoS_2
Copper Cl Conc	12.0	6.0	14.4	1.98	9.85
Copper Cl Tail	12.7	2.7	25.1	.97	1.93
Pilot Plant Copper Conc	12.2	4.9	18.2	1.62	7.04

	Distribution %					
	Wt	Cu	Pb	Zn	Bi	MoS_2
Copper Cl Conc	64.5	63.2	80.3	50.9	79.0	90.3
Copper Cl Tail	35.5	36.8	19.7	49.1	21.0	9.7
Pilot Plant Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0

	Assays %							
	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Zinc Cl Conc	1.51	.42	26.8	.66	.30	17.8	.61	3.93
Zinc Cl Tail	.39	.47	3.5	1.34	1.18	32.0	2.25	
Zinc Pilot Plant Conc	1.29	.44	22.3	0.79	.47	20.5	.93	

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Zinc Cl Con	80.6	94.1	76.7	97.1	67.3	51.4	69.8	53.1
Zinc Cleaner Tail	19.4	5.9	23.3	2.9	32.7	48.6	30.2	46.9
Zinc Pilot Plant Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test P - Cleaning of "Pilot Plant Zinc Conc" without Dextrin.

	Assays %							
	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Zinc Cl Conc	1.32	.50	20.9	.94	.76	23.8	1.31	8.45
Zinc Cl Tail	.68	.53	4.51	1.71	1.27	18.2	4.41	
Pilot Plant Zinc Conc	1.28	.50	19.91	.98	.78	23.4	1.49	

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Zinc Cl Conc	94.1	97.0	94.0	98.6	89.7	90.4	95.4	82.6
Zinc Cl Tail	5.9	3.0	6.0	1.4	10.3	9.6	4.6	17.4
Zinc Pilot Plant	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test S - A repeat of Test M with 0.2 gm of Dextrin.

	Assays %							
	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Cl Conc	14.7	.87	17.2	.820	4.14	4.62	2.55	9.17
Copper Cl Tail	6.48	2.34	20.0	1.51	3.71	3.64	6.69	
Pilot Plant Copper Conc	12.19	1.32	18.0	1.03	4.02	4.33	3.82	

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Cl Conc	69.4	83.6	45.7	66.2	55.2	71.7	74.2	46.3
Copper Cl Tail	30.6	16.4	54.3	33.8	44.8	28.3	25.8	53.7
Pilot Plant Copper	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Flotation Test T - A repeat of Test No. N - but without Dextrin.

	Assays %								
	Sn	Cu	Pb	Zn	Bi	MoS_2	As	F	Insol
Copper Cl Conc	4.99	12.5	1.43	19.1	.925	3.62	4.32	3.80	8.96
Copper Cl Tail		6.41	2.30	18.7	1.63	3.88	4.70	4.26	
Copper Pilot P Plant Copper Conc		11.62	1.56	19.0	1.03	3.58	4.37	3.86	

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	F
Copper Cl Conc	85.7	92.1	78.8	85.7	77.3	86.5	84.7	84.4
Copper Cl Tail	14.3	7.9	11.2	14.3	22.7	13.5	15.3	15.6
Pilot Plant Copper Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Wilfley Table Test B (Tabling of Zinc Flotation Concentrate)

Tabling of plus 400-mesh material.

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc No. 1	.28	.24	1.08	1.52	.320	45.8
Table Conc No. 2	1.76	.37	35.0	.405	4.44	4.58
Table Tail	1.59	.45	39.8	.323	3.22	3.91
Plus 400 mesh	1.37	.37	29.5	.62	3.05	13.4

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc No. 1	21.9	4.5	14.2	0.80	54.1	2.3	75.2
Table Conc No. 2	38.2	49.4	37.8	45.30	25.0	55.6	13.1
Table Tail	39.9	46.1	48.0	48.90	20.9	42.1	11.7
Plus 400 mesh	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Tabling of minus 400-mesh material

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc No. 1	.25	.40	10.6	5.13	.167	38.8
Table Conc No. 2	.42	.40	17.5	2.34	.494	32.3
Table Tail	1.56	1.10	49.1	4.75	1.84	4.85
Minus 400 mesh	1.43	1.02	45.5	4.54	.212	7.99

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc No. 1	1.9	0.3	0.7	0.4	2.1	1.4	9.0
Table Conc No. 2	9.1	2.7	3.5	3.5	4.7	21.3	36.9
Table Tail	89.0	97.0	95.8	96.1	93.2	77.3	54.1
Minus 400 mesh	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	Assays (%)					
	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	.369	.367	13.248	2.55	.415	35.90
Table Tail	1.572	1.031	47.892	4.307	2.04	4.80
Zinc Flot Conc	1.43	.95	43.62	3.81	1.84	8.59

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	12.2	3.2	4.7	3.7	0.8	2.8	51.0
Table Tail	87.8	96.8	95.3	96.3	99.2	97.2	49.0
Zinc Flot Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Part 2 - Gravity Concentration Wilfley Table Test A

(Tabling of Copper Flotation Concentrate)

Tabling of plus 400-mesh material:

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	0.30	2.16	4.00	.813	.214	36.2
Table Tail	6.70	.54	20.7	.255	2.790	31.3
Plus 400 mesh	5.90	.742	18.6	.325	2.467	31.02

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	12.5	0.6	36.4	2.7	31.4	1.1	14.6
Table Tail	87.5	99.4	63.6	97.3	68.6	98.9	85.4
Plus 400 mesh	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Tabling of minus 400-mesh material:

	Assays %						
	Cu	Pb	Zn	Bi	MoS_2	As	Sn
Table Conc	2.20	9.50	5.83	2.01	0.500	34.8	1.64
Table Tail	6.09	4.42	20.6	2.43	3.06	12.8	2.00
Minus 400 mesh	5.52	5.08	18.7	2.38	2.73	15.7	1.95

	Distribution %							
	Wt	Cu	Pb	Zn	Bi	MoS_2	As	Sn
Table Conc	13.1	5.19	24.5	4.1	11.1	2.4	29.1	11.0
Table Tail	86.9	94.81	75.5	95.9	88.9	97.6	70.9	89.0
Minus 400 mesh	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	Assays %					
	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	2.13	9.25	5.76	1.97	.490	34.9
Table Tail	6.11	4.27	20.61	2.34	3.04	13.5
Flotation Conc	5.58	4.91	18.60	2.29	2.29	16.3

	Distribution %						
	Wt	Cu	Pb	Zn	Bi	MoS_2	As
Table Conc	13.1	5.0	24.6	4.1	11.3	2.4	28.1
Table Tail	86.9	95.0	75.4	95.9	88.7	97.6	71.9
Flotation Conc	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Part III - Magnetic Separation

Concentration of Wolframite from Pilot Plant Flotation Tailing, Cyclone Overflow and Arsenic Rougher Tailing.

Magnetic Test No. 1

A sample was passed through the Jones Separator set at 10 amperes. The magnetic concentrate was then tabled. The table concentrate contained much coarse waste material (chlorite) that the concentrate was screened into plus and minus 325-mesh fractions. This concentrate was repassed in the Jones Separator at 5 amperes but both the magnetic and non-magnetic fractions contained visible chlorite and wolframite.

Tabling of Magnetic Concentrate

	Wt	WO_3	WO_3 Distribution
Jones Magnetics	3.16	4.582	49.6
Jones Non-Magnetics	96.84	0.15	50.4
Plate Wash	nil		
Flotation Tailing	100.0	.2875	100.0

Screening of Table Concentrate

	Wt %	WO_3 %	WO_3 Distribution %
Table Conc (325 mesh)	66.4	9.0	22.2
Table Conc(325 mesh)	33.6	52.0	77.8
Combined Table Conc	100.0	22.45	100.0

Magnetic Test No. 2

A repeat of the same test, but set at 20 amperes and screening the magnetic concentrate before tabling.

	Wt %	WO_3 %	WO_3 Distribution %
Jones Magnetics (+ 325 mesh)	1.67	1.726	10.4
Jones Magnetics (-325)	2.11	7.390	56.6
Plate Wash	0.06	1.99	0.4
Jones Non-Magnetics	96.16	.093	32.6
Flotation Tailing	100.0	.2754	100.0

Magnetic Test No. 3

Passing of Cyclone Overflow of July 31, 1970, through Jones Magnetic Separator set at 20 amp.

	Assays %							
	Fl	Cu	Pb	Zn	Bi	MoS_2	WO_3	
Jones Magnetics	3.89	.23	.13	.72	.090	.084	1.45	2.60
Jones Middlings	4.40	.085	.014	.54	.088	.090	1.55	
Jones Non-Magnetics	4.50	.068	.13	.44	.086	.079	1.45	
Cyclone O'flow	4.43	.0816	.134	.49	.087	.084	1.492	

	Distribution %						
	Wt	Fl	Cu	Pb	Zn	MoS_2	As
Jones Magnetics	3.82	3.4	10.8	3.7	5.6	3.8	3.7
Jones Middlings	43.38	43.1	45.3	45.2	47.5	46.5	45.1
Jones Non-Magnetics	52.80	53.5	43.9	51.1	46.9	49.7	51.2
Cyclone O'flow	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Magnetic Test No. 4

Passing of Cyclone Overflow of Pilot Plant Test No. 19 through Jones Magnetic Separator at 30 amp.

	Assays %						
	Cu	Pb	Zn	Bi	MoS_2	As	WO_3
Jones Magnetics	.24	.140	.62	.106	.096	1.36	3.67
Jones Middlings	.07	.125	.43	.084	.083	1.36	0.10
Jones Non-Magnetics	.065	.120	.39	.095	0.78	.138	.13

Magnetic Test No. 5

The feed of Magnetic Tests No. 1 and No. 2 was produced when the ball mill was in closed circuit with the classifier only. A test was repeated at 28 amp when the feed was produced with the ball mill in closed circuit with the cyclone and the classifier. This work was done on arsenic rougher tailing from Pilot Plant Test No. 23.

	Wt %	WO_3 %	WO_3 Distribution %
Jones Magnetics	3.23	3.78	66.2
Jones Middlings	41.80	.07	15.9
Jones Non-Magnetics	54.97	.06	17.9
Arsenic Rougher Tailing	100.0		100.0

Tabling of the minus 325-mesh material

	Assays %					
	Bi	MoS_2	As	Insol	WO_3	F
Table Conc	.043	.062	4.22	74.2	34.7	13.35
Table Tail	.026	.029	0.62	76 5	2.6	
Magnetics (-325 mesh)	.0285	.0339	1.158	76.08	7.39	

	Distribution %					
	Wt	Bi	MoS_2	As	Insol	WO_3
Table Conc	14.92	22.5	27.1	54.4	14.5	70.1
Table Tail	85.08	77.5	72.9	45.6	85.5	29.9
Magnetics (-325 mesh)	100.00	100.0	100.0	100.0	100.0	100.0

Tabling of the plus 325-mesh material

	Assays (%)					
	Bi	MoS_2	As	Insol	WO_3	F
Table Conc	.041	.077	1.77	66.8	10.1	10.64
Table Tail	.023	.028	.34	85.2	.13	4.43
Magnetics (+325 mesh)	.026	.036	.577	82.1	1.783	5.455

	Distribution %						
	Wt	Bi	MoS_2	As	Insol	WO_3	F
Table Conc	16.6	26.1	35.6	50.9	13.5	94.0	32.3
Table Tail	83.4	73.9	64.4	49.1	86.5	6.0	67.7
Magnetics (+ 325 mesh)	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Screen Analysis and Assays of Jones Non-Magnetic Fraction at 20 Amp

	Assays %						
Product	Cu	Pb	Zn	Bi	MoS_2	As	WO_3
+ 150 mesh	.013	.008	.032	.013	.025	.65	.05
+ 200	.014	.008	.013	.019	.019	.41	.04
+ 270	.006	.006	.014	.017	.018	.52	.04
+ 325	.006	.006	.016	.016	.014	.61	.04
+ 400	.010	.012	.033	.010	.015	1.59	.06
- 400	.02	.015	.031	.014	.013	1.23	.13
Total Feed	.015	.012	.025	.015	.015	.95	.093

	Distribution %							
Product	Wt	Cu	Ph	Zn	Bi	MoS_2	As	WO_3
+ 150 mesh	2.05	2.0	1.6	2.8	2.0	3.3	1.3	1.2
+ 200	10.8	9.9	7.7	5.7	13.7	13.7	4.7	4.6
+ 270	13.45	5.2	6.8	7.7	15.1	15.7	7.4	5.8
+ 325	13.35	5.2	6.8	7.7	15.0	15.7	7.3	5.8
+ 400	2.25	1.4	2.6	2.9	1.3	2.0	3.8	1.4
- 400	58.10	76.3	74.5	73.2	52.9	49.6	75.5	81.2
Total Feed	100.00	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Magnetic Test No. 6 - Jones Separator at 20 amp on Arsenic Rougher Tailing.

Product	Wt %	WO_3 %	WO_3 Distribution %
Jones Magnetics	3.46	2.52	50.0
Jones Middlings	50.80	0.13	37.9
Jones Non-Magnetics	45.74	0.05	12.1
Arsenic Rougher Tailing	100.00	.1744	100.0

Magnetic Test No. 7 - Jones Separator operating at 10 amps.

Produce	Wt %	WO_3 %	WO_3 Distribution %
Jones Magnetics	2.48	2.96	44.7
Jones Middlings	33.20	0.10	20.2
Jones Non-Magnetics	64.32	0.09	35.1
Arsenic Rougher Tailing	100.00	.1644	100.0

This last series of tests indicate that higher amperage is beneficial, but 28 amperes is the highest that is possible on our Jones Separator. Newer models have amperages up to 40.

Magnetic Test No. 8

The Jones Magnetic Tailing from Test No. 1, which assayed 0.15% WO_3, was subjected to the following treatment:

(1) repassed through the Jones Separator at 10 amp;

(2) repassed through the Jones Separator at 28 amp:

(3) the sample was ground for 15 minutes and then repassed through the separator at 28 amp.

The following table shows the effect of these operations.

Magnetic Separation (Jones)

Product	Wt	WO_3	WO_3 Distribution (%)
Jones Magnetics at 10 amps	3.0	1.19	37.7
Jones Magnetics at 28 amps	3.1	0.50	16.4
Jones Magnetics at 28 amps (After a 15-min regrind)	4.0	0.19	8.0
Plate wash (28 amps)	0.1	0.13	0.1
Jones Final Tailing	89.8	.04	37.8
Feed (Calculated)	100.0	.095	100.0

Screen Analysis of the Magnetic Tailings after the 15-Min. Regrind

Screen Product	Wt
+ 150 mesh	0.5
- 150 mesh + 200 mesh	5.2
- 200 mesh + 270 mesh	9.0
- 270 mesh + 325 mesh	11.7
- 325 mesh + 400 mesh	4.1
- 400 mesh + 500 mesh	23.8
- 500 mesh	45.7

Forecast of WO_3 Recovery on Basis of Tests No. 1 and No. 8

	Wt	WO_3	WO_3 Distribution (%)
Jones Magnetics	9.08	2.13	81.4
Jones Non-Magnetics	90.92	.04	18.6
Flotation Tailing	100.00	.24	100.0