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UNITED STATES ATOMIC ENERGY COMMISSION

NYO-1161

PILOT PLANT BATCH FLOTATION TESTS ON LOT
A-200 RADIOACTIVE ORE AT MIDDLESEX WARE-
HOUSE, MIDDLESEX, NEW JERSEY

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July 30, 1952

American Cyanamid Company

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PILOT PLANT BATCH FLOTATION TESTS ON LOT A-200 RADIOACTIVE ORE
AT MIDDLESEX WAREHOUSE, MIDDLESEX, NEW JERSEY

By J. S. Kennedy and D. M. Kentro

Introduction:

During February, 1950 flotation tests were made at the Stamford Laboratory on Samples A-108 and A-116 of sulfur-bearing uranium ores, which were received from the United States Atomic Energy Commission. Flotation removed concentrates of sulfide minerals containing little uranium and concentrates of uranium (flotation underflow) containing 0.5 % S or less.

From the preliminary laboratory flotation tests it was decided to set up a pilot plant flotation laboratory in the "Old Laundry Room" at the U.S.A.E.C. Middlesex Warehouse, Middlesex, New Jersey. During August 1950 a flotation laboratory was installed at the Middlesex Warehouse to recover the flotation underflow containing 1.0 % sulfur or less from 400 pounds of Lot A-200 high sulfur bearing uranium ore.

Object of Investigation:

To remove sulfide minerals from 400-pounds of Lot A-200 ore by flotation and recover a uranium concentrate (flotation underflow) containing 1.0 percent sulfur or less.

Summary and Conclusions:

The results of this investigation were summarized as the work progressed and were reported by letter periodically to the Atomic Energy

Commission (NYOO).

Pilot Plant batch flotation tests were effective in recovering uranium concentrates containing less than 1.0 % sulfur.

Sulfide minerals were floated from 25.0 # batches and similar products from four - 25 # batches were combined. Uranium concentrates containing 0.77, 0.91, 1.99, and 2.28 % S were recovered. The composite uranium concentrate (flotation underflow) from 400 # of Lot A-200 ore assayed 1.75 % S and 55.4 % U_3O_8 which represented 7.4 % of the total sulfur and 44.4 % of the U_3O_8 in the ore.

The flotation feed was overground to minus 92.5 # minus 200 mesh in the ball mill used for dry grinding which was the only equipment available at the Warehouse. The fine dry grind made excess slime which persisted in floating with the sulfide concentrate. The sulfide concentrate composite assayed 17.3 % S and 20.4 % U_3O_8 and contained 56.3 % of the total sulfur and 12.5 % of the total U_3O_8 .

Preliminary Laboratory Flotation Tests - Stamford Laboratory

Two samples of sulfur-bearing radio-active ore were received February 27, 1950 from the USAEC. The samples were designated Lot A-108 and Lot A-116 and the net weight of each sample was 25.0 pounds. The size of the ore samples received was minus 10-mesh to fines.

The samples were received for flotation tests to remove the sulfide minerals and recover a flotation tailing (underflow) with a low sulfur content.

Preliminary Investigation:

Microscopic Analysis.

A letter from Mr. P. L. Merrit of February 18, 1950 shows the sulfide minerals included are those of Co, Ni, Cu, Mo, and Fe as follows:

Linnaeite - Co_3S_4	Chalcopyrite
Carrollite - CuCo_2S_4	Bornite
Siegenite - $(\text{Co}, \text{Ni}_3)\text{S}_4$	Covellite
Vaesite	Molybdenite
Cattierite	Pyrite
Pentlandite	

Chemical Analyses.

Letters of 2-10-50 and 2-27-50 to Mr. S. J. Swainson from Mr. J. J. Koenig of the U.S.A.E.C. showed the chemical analyses of the ore samples as follows:

Table I

Chemical Analyses Of Lot A-108 and Lot A-116 Ore

Ore Sample	Analyses %										
	U_3O_8	SO_4	SiO_2	PbO	Mo	Fe	Ca	Cu	Ni	Co	Sb
Lot A-108	42.51	32.69	9.26	4.23	.16	.01	.70	.79	4.57	-	<100 PPM
Lot A-116	50.07	15.75	11.87	4.84	0.5	1.0	-	0.5	2.5	1.5	-

Grinding Tests.

Five hundred grams of Lot A-108 and Lot A-116 were ground separately at 62.5 % solids with 2.0 #/Ton Tetrasodium Pyrophosphate for 5 minutes in a laboratory rod mill. The screen analyses of the ground ore to flotation tests are shown as follows:

Table II
Screen Analyses of Ore To Flotation Tests

<u>Lot A-108</u>		<u>Lot A-116</u>	
<u>Tyler Screen</u>		<u>Tyler Screen</u>	
<u>Size</u>	<u>% Wt.</u>	<u>Size</u>	<u>% Wt.</u>
+100	1.2	+100	2.5
+200	23.5	+200	30.5
-200	75.3	-200	67.0
	<u>100.0</u>		<u>100.0</u>

Flotation Tests:

The ground 500-gram charges of ore were conditioned with 0.4 #/Ton Reagent 301 and 0.12 #/Ton Frother 70 at 20 % solids for 3-minutes. The conditioned pulp was floated for 5-minutes at 20 % solids to remove sulfide minerals, but the rougher sulfide concentrates were not cleaned.

Flotation of Lot A-108 recovered on underflow product containing 0.56 % S representing 3.2 % of the sulfur in the ore. The sulfide concentrate assayed 41.81 % S and represented 96.8 % of the total sulfur. The results of flotation are shown in Table III.

Flotation of Lot A-116 recovered an underflow product containing 0.21 % S, representing 2.5 % of the sulfur in the ore. The sulfide concentrate assayed 36.75 % S and represented 97.5 % of the total sulfur. The results of flotation are shown in Table IV.

Abbreviations used for reagents in the flotation test**sheets are designated as follows:**

R-301	American Cyanamid Company Flotation Reagent 301
F-70	American Cyanamid Company Frother 70
Pine Oil	Pine Oil - G.N.S. #5
TSPP	Tetrasodium Pyrophosphate
CuSO_4	Copper Sulfate
Na_2SiO_3	Sodium Silicate - "N" Brand

TABLE No. IIITEST No. 4INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

Sample A-108

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	TSPP	R-301	Fr.70						
Grind	5	62.5		2.0								
Cond.	3	20	9.1		.40	.12						
Flotation	5	20				.04						

REMARKS:

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS			
		% S	% U ₃ O ₈				S	U ₃ O ₈		
Feed	100.0	12.33	42.5				100.0	100.0		
Sulfide Conc.	28.5	41.81	4.20				96.8	2.8		
Flot. Tail	71.5	.56					3.2			

RATIO OF CONCENTRATION

REMARKS: The sulfide concentrate was not cleaned.

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9TABLE No. IVTEST No. 5INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	TSPP	R-301	Fr.70						
Grind	5	62.5		2.0								
Cond.	3	20			.40	.12						
Flotation	5	20				.04						

REMARKS:

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS			
		% S	% U ₃ O ₈				S	U ₃ O ₈		
Feed	100.0	6.88	50.1				100.0	100.0		
Sulfide Conc.	18.2	36.75	7.36				97.5	2.7		
Flot. Tail	81.8	.21					2.5			

RATIO OF CONCENTRATION

REMARKS: The sulfide concentrate was not cleaned.

Pilot Plant Batch Flotation Tests - Middlesex WarehousePreliminary Investigation:

Lot A-200 ore was a gray color and contained a heavy black non-sulfide fraction and a gray non-sulfide fraction. The sulfides were principally bluish-gray with a small amount of brass-yellow colored sulfide minerals. A microscopic examination of the ore was not made to identify the minerals components.

Preparation of Ore for Testing:

Approximately 1300 pounds of ore was crushed to minus 1/8 inch at the Middlesex Warehouse crushing plant. The only equipment available to grind the ore for flotation at the Warehouse was a ball mill for dry grinding of ore. The ore was dry ground in 325-pound batches for two hours, discharged into a blending machine for 1 hour, and discharged from the blender to a sample splitter. A screen analysis of the ground ore showed the following distribution of sizes;

Table VScreen Analysis - Lot A-200 Flotation Feed

<u>Tyler Screen Size</u>	<u>Weight %</u>
+ 65)	
+ 80)	
+100)	5.0
+150)	
+200	2.5
-200	92.5

The ore was overground for flotation, as a greater distribution of plus 200-mesh sizes would be required with 60 - 70 % minus 200-mesh material.

Assay of Head Sample.

The partial analysis of Lot A-200 ore to flotation is shown in Table VI.

Table VIAnalysis of Lot A-200 Ore

<u>% S</u>	<u>% U₃O₈</u>	<u>% Co</u>	<u>% Ni</u>
7.00	39.4	4.00	4.50

Pilot Plant Flotation Procedure:

The ground ore was conditioned with reagents in 25-pound batches at 35 % solids. Conditioning was done by stirring the pulp in a 15-gallon drum with a 4-bladed impeller driven by a drill press. Sulfides were floated from the conditioned ore in an 18-inch Fagergren batch machine. The flotation underflow from two 25-pound batches were combined, conditioned with more reagents at 46 % solids, and a scavenger sulfide float was made. The rougher sulfide concentrates and scavenger sulfide concentrate were combined and cleaned three times, and each cleaner underflow was kept separate. Similar flotation products from four 25-pound batches (100 pounds of ore) were combined for sampling as requested by Mr. A. B. Babcock of U.S.A.E.C. Four-hundred pounds of ore was floated as described and similar flotation products were combined into final composites of Sulfide Concentrate, #1 Cleaner Underflow, #2 Cleaner Underflow, #3 Cleaner Underflow, and Rougher Underflow. A batch flotation flow sheet is shown in Table VII.

Table VII

Batch Pilot Plant Flow Sheet - Lot A-200 Ore

Flotation Test Work:Test 1.

Twenty-five pounds of ore were pulped with water in the Fagergren batch flotation machine and reagents were added without conditioning prior to flotation. The heavy non-sulfide minerals were difficult to hold in suspension and settled to the bottom of the machine trapping sulfide minerals. The charge was removed from the flotation machine.

Test 1A

Twenty-five pounds of ore were pulped with the underflow from Test 1 and conditioned for 1-minute with reagents to determine if a higher percent solids would hold the solids in suspension. Sanding was observed on the cell bottom trapping sulfides, and excess quantities of collector and frother were required. The sulfide rougher concentrate was cleaned 3 times.

Tables VIII and IX show the operating data for Test 1 and Test 1A.

TABLE No. VIIITEST No. 1INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

Sample A-200

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON							
	TIME MINS.	% SOLIDS	PH	R-301	Fr.70						
Rougher Float	35	27		0.5	0.40						

REMARKS: 25.0 # of ore was pulped in an 18" x 18" Fagergren "Batch" machine. The reagents were added to the machine and no conditioning was used prior to flotation.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS				% DISTRIBUTIONS			
Feed									
Sulfide Conc.									
#1 Cl. Tail									
#2 Cl. Tail									
#3 Cl. Tail									
Rougher Tail									

RATIO OF CONCENTRATION

REMARKS: The heavy non-sulfides sanded the flat bottom of the machine and trapped the sulfides, causing hindered flotation of the sulfides.

TABLE No. IXTEST No. 1AINVESTIGATION No. 58
PROBLEM No. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	R-301	Fr. 70							
Condition	1	42		0.3	0.08							
Rougher Float	50	42		0.1	0.08							
#1 Cleaner	52			0.1	0.12							
#2 Cleaner	55			0.05	0.08							
#3 Cleaner	32			-	-							

REMARKS: 25.0 # of ore was conditioned with reagents and added to the underflow from Test 1 to determine if a higher percent solids would assist flotation of the sulfides. The rougher concentrate (Underflow) was cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS			
Feed										
Sulfide Conc.										
#1 Cl. Tail										
#2 Cl. Tail		SIMILAR PRODUCTS FROM TEST 1 AND TEST 2 WERE COMBINED.								
#3 Cl. Tail										
Rougher Tail										

RATIO OF CONCENTRATION

REMARKS: Sanding was observed on the cell bottom and flotation of the sulfides was difficult, requiring excessive quantities of collector and frother.

The rougher tailing was low in sulfides and the cleaned sulfide concentrate contained fine non-sulfides.

Test 2

Fifty pounds of ore were pulped with water and conditioned for 10-minutes with Tetrasodium Pyrophosphate to disperse the solids, then for 10-minutes with collector and frother. The 50 pound batch was too large for the flotation machine and settled non-sulfides trapped sulfide minerals on the cell bottom. Mechanical agitators at each end of the machine assisted in suspending the solids, but excess frother was used to assist in floating the sulfides. The sulfide rougher concentrate was cleaned 3 times. Similar products from Test 1 and Test 2 were combined for sampling, and the results of flotation are shown in Table X.

TABLE No. XTEST No. 2INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

Sample A-200

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON							
	TIME MINS.	% SOLIDS	PH	TSP	R-301	Fr.70					
#1 Condition	10	42		2.0							
#2 Condition	10	42			0.4	0.06					
Rougher Float	50	42				0.09					
#1 Cleaner	30										
#2 Cleaner	45					0.03					
#3 Cleaner	45					0.03					

REMARKS: 50 pounds of A-200 ore was conditioned and a sulfide rougher concentrate was floated and cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS				
		% S									
Feed											
Sulfide Conc.											
#1 Cl. Tail											
#2 Cl. Tail											
#3 Cl. Tail											
Rougher Tail		0.91									

RATIO OF CONCENTRATION

REMARKS: The 50 pound batch was excess for the Fagergren machine. The heavy minerals settled to the bottom and trapped sulfide minerals. The rougher tailing was slightly high in sulfides.

Silimar products from Test 1 and Test 2 were combined.

Tests 3 and 4

The clearance between the stator and cell bottom was 1 inch for Tests 1 and 2. The cell bottom was raised with cement to allow 1/2 inch clearance under the stator (3/4" under the rotor) to determine if less clearance would assist in keeping the heavy minerals in suspension.

Two 25-pound batches were conditioned and floated separately. The two rougher tailings were combined, reconditioned, and a scavenger sulfide concentrate was floated. The total sulfide rougher concentrate was cleaned 3 times. Similar products from Tests 3 and Test 4 were combined for sampling. Sanding during rougher flotation and the scavenger flotation was observed, but was less than in Tests 1 and 2.

The operating data for Tests 3 and 4 are shown in Table XI and XII. The combined flotation results are shown in Table XII.

TABLE No. XITEST No. 3INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

Sample A-200

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON							
	TIME MINS.	% SOLIDS	PH	TSPP	R-301	Fr.70					
#1 Condition	10	30		1.0							
#2 Condition	10	30			0.4	0.09					
Rougher Float	32	30				0.06					
Scavenger Condition	10	46			0.2	0.06					
Scavenger Float	30	46									
#1 Cleaner	34										
#2 Cleaner	32										
#3 Cleaner	30										

REMARKS: Two 25 # batches of ore were conditioned and floated separately. The two rougher tailings were combined, reconditioned and a scavenger sulfide concentrate was floated. The total sulfide concentrates from the two 25 pound batches were combined and cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS				
Feed	100.0										
Sulfide Conc.											
#1 Cl. Tail		SIMILAR PRODUCTS FROM TEST 3 AND TEST 4 WERE COMBINED.									
#2 Cl. Tail											
#3 Cl. Tail											
Rougher Tail											

RATIO OF CONCENTRATION

REMARKS: A small amount of sulfides were observed in the rougher tailings. The cleaned sulfide concentrate contained fine non-sulfides.

TABLE NO. XIITEST NO. 4INVESTIGATION NO. 58PROBLEM NO. 3021

CONDITIONS AND REAGENTS

SAMPLE A-200

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	TSP	R-301	Fr.70						
#1 Condition	10	30		1.0								
#2 Condition	10	30			0.4	0.12						
Rougher Float	20	30										
Scavenger Condition	10	46			0.2	0.06						
Scavenger Float	15	46										
#1 Cleaner	33											
#2 Cleaner	20											
#3 Cleaner	20											

REMARKS: Two 25 pound batches of ore were conditioned and floated separately. Each rougher tailing was reconditioned separately and a scavenger sulfide concentrate was floated. The sulfide concentrates from the two 25 pound batches were combined and cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS				
		% S									
Feed											
Sulfide Conc.											
#1 Cl. Tail											
#2 Cl. Tail											
#3 Cl. Tail											
Rougher Tail		2.38									

RATIO OF CONCENTRATION

REMARKS: Sulfide minerals were observed in the rougher tailings. The cleaned sulfide concentrates contained fine non-sulfide minerals.

Similar flotation products from Test 3 and Test 4 were combined.

Tests 5 and 6

Cement was poured into the flotation machine to make a cell bottom with about a 30° angle sloping down from the sides to the center of the bottom. The sloped bottom was made to assist the suspension of heavy minerals by the circulatory action of the pulp.

Two 25-pound batches were conditioned and floated separately. Copper sulfate was used in the first conditioner for activating the brassy yellow sulfide minerals which tended to float last. The two rougher tailings were combined, reconditioned, and a scavenger concentrate was floated. The total sulfide concentrate was combined and cleared 3 times. The sloped bottom prevented sanding and operating conditions appeared good. Similar products from Test 5 and Test 6 were combined for sampling.

The operating data for Test 5 and 6 are shown in Tables XIII and XIV. The combined flotation results are shown in Table XIV.

TABLE No. XIIITEST No. 5INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	CuSO ₄	R-301	Fr.70						
#1 Condition	10	35		2.0								
#2 Condition	10	35			0.4	0.12						
Rougher Float	20	35										
Scavenger Condition	10	46			0.2	0.06						
Scavenger Float	15	46										
#1 Cleaner	27											
#2 Cleaner	23											
#3 Cleaner	26											

REMARKS: Two 25 pound batches of ore were conditioned and floated separately. The two rougher tailings were combined, reconditioned and a scavenger sulfide concentrate was floated. The total sulfide concentrates from the two batches were combined and cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS				
Feed											
Sulfide Conc.											
#1 Cl. Tail		SIMILAR PRODUCTS FROM TEST 5 AND TEST 6 WERE COMBINED									
#2 Cl. Tail											
#3 Cl. Tail											
Rougher Tail											

RATIO OF CONCENTRATION

REMARKS: Sulfide minerals were observed in the rougher tailings. The cleaned sulfide concentrate contained fine non-sulfides.

TABLE No. XIVTEST No. 6INVESTIGATION No. 58
PROBLEM No. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON								
	TIME MINS.	% SOLIDS	PH	CuSO ₄	R-301	Fr.70						
#1 Condition	10	35		2.0								
#2 Condition	10	35			0.4	0.12						
Rougher Float	20	35										
Scavenger Condition	10	46			0.2	0.06						
Scavenger Float	15	46										
#1 Cleaner	27											
#2 Cleaner	26											
#3 Cleaner	24											

REMARKS: The flotation procedure was the same as that used in Test 5.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS				% DISTRIBUTIONS			
		% S							
Feed									
Sulfide Conc.									
#1 Cl. Tail									
#2 Cl. Tail									
#3 Cl. Tail									
Rougher Tail		1.99							

RATIO OF CONCENTRATION

REMARKS: Observations were the same as those in Test 5.

Similar flotation produces from Test 5 and Test 6 were combined.

Tests 7 and 8

Two 25 pound batches were conditioned and floated separately. The two underflows were combined, reconditioned and a scavenger sulfide concentrate was floated. Sodium silicate was used as dispersant in the first conditioner, and Pine Oil frother was used. The total sulfide rougher concentrate was combined and cleaned 3 times. Conditions were good. Similar products from Test 7 and Test 8 were combined for sampling.

The operating data for Tests 7 and 8 are shown in Tables XV and XVI. The combined flotation results are shown in Table XVI.

TABLE NO. XVTEST NO. 7INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON							
	TIME MINS.	% SOLIDS	PH	Na ₂ SiO ₃	R-301	Pine Oil					
#1 Condition	5	35		2.0							
#2 Condition	10	35			0.6	0.12					
Rougher Float	20	35									
Scavenger Condition	10	46			0.2	0.06					
Scavenger Float	15	46									
#1 Cleaner	24										
#2 Cleaner	21										
#3 Cleaner	18										

REMARKS: Two 25 pound batches were conditioned and floated separately. The two rougher tailings were combined, reconditioned and a scavenger sulfide concentrate was floated. The total sulfide concentrates from the two batches were combined and cleaned 3 times.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS				% DISTRIBUTIONS			
Feed									
Sulfide Conc.									
#1 Cl. Tail		SIMILAR PRODUCTS FROM TEST 7 AND TEST 8 WERE COMBINED.							
#2 Cl. Tail									
#3 Cl. Tail									
Rougher Tail									

RATIO OF CONCENTRATION

REMARKS: Conditions were good. A small amount of sulfides were observed in the rougher tailings. The cleaned sulfide concentrates contained fine non-sulfides.

TABLE NO. XVITEST NO. 8INVESTIGATION NO. 58
PROBLEM NO. 3021

CONDITIONS AND REAGENTS

POINT OF ADDITION	CONDITIONS			REAGENTS POUNDS PER TON							
	TIME MINS.	% SOLIDS	PH	Na ₂ SiO ₃	R-301	Pine Oil					
#1 Condition	5	35		2.0							
#2 Condition	10	35			0.6	0.12					
Rougher Float	20	35									
Scavenger Condition	10	46			0.2	0.06					
Scavenger Float	15	46									
#1 Cleaner	23										
#2 Cleaner	18										
#3 Cleaner	20										

REMARKS: The flotation procedure was the same as that used in Test 7.

METALLURGICAL RESULTS

PRODUCT	% WEIGHT	ASSAYS					% DISTRIBUTIONS			
		% S								
Feed										
Sulfide Conc.										
#1 Cl. Tail										
#2 Cl. Tail										
#3 Cl. Tail										
Rougher Tail		0.77								

RATIO OF CONCENTRATION

REMARKS: Observations were the same as those in Test 5.

Similar flotation products from Test 7 and Test 8 were combined.

Composite of Test 1 Through Test 8.

Similar flotation products from Tests 1 through Test 8 were combined into final composites of Sulfide Concentrate, #1 Cleaner Underflow, #2 Cleaner Underflow, #3 Cleaner Underflow, and Rougher Tailing.

The composite results of flotation are shown in Table XVII. The weights of products shown are not actual weights of filtered and dried products, but were calculated by Mr. A. B. Babcock of the U.S.A.E.C. from the wet weight and percent solids of the total wet pulp of each product before filtering and drying.

The sulfide concentrate assayed 17.3 % S and 20.4 % U_3O_8 and contained 56.3 % of the total sulfur and 12.5 % of the total U_3O_8 .

The uranium underflow (rougher tailing) assay 1.75 % S and 55.4 % U_3O_8 which represented 7.4 % of the total sulfur and 44.4 % of the total U_3O_8 .

Over grinding in the dry ball mill at the Middlesex, Warehouse which reduced 92.5 percent of the ore to minus 200 mesh, caused excess slime which persisted in concentrating with the sulfide minerals. Also, excess sulfide slimes consumed excess reagent which caused insufficient promotion of sulfide minerals as shown by the 1.75 % S assay of the composite rougher tailing. Preliminary laboratory tests indicate that the flotation feed should be ground to about 65 % minus 200 mesh.

Operating Costs For Flotation Of 50 Tons Per 8 Hours

The summary of costs for crushing, grinding, flotation, and filtering 50 tons of the high sulfur pitchblende ore in 8 hours (6.25 tons per hour) is shown in Table XVIII.

Table XVIII

<u>Item</u>	<u>Cost Per dry Short Ton of Feed</u>
Crushing & Grinding Labor	\$0.480
Crushing & Grinding Power	0.213
Flotation Reagents	0.149
Flotation & Filtering Labor	0.480
Flotation & Filtering Power	0.150
Maintainance	0.030
Total	<u>\$1.502</u>

Note: This milling cost does not include drying, packaging, assaying, supervision, amortization and other items which may be necessary to insure the health and safety of personnel.

The list of equipment, operating cost, and flow sheet for crushing and grinding 50 tons of ore per 8 hours are shown in Tables XIX, XX, and XXI.

The list of equipment, operating cost, and flow sheet for flotation and filtering of 50 tons of ore per 8 hours are shown in Tables XXII, XXIII, and XXIV.

Table XIXDry Crushing & Wet Grinding-Equipment List

	<u>H.P. Req'd.</u>
1. Jaw Crusher - 24" x 16" - 10 Tons/Hr.	20
2. Symons Cone Crusher - 2' Diam. Cone - 10 Tons/Hr.	25
3. 1/2" Screen - Single Deck	2
4. Belt Conveyor - Ball Mill Feed	2
5. Ball Mill - 7' x 36" Hardinge Mill	125
6. Spiral Classifier - 24" Akins	5
Total =	179

Table XX

Estimated Operating Costs
Dry Crushing & Wet Grinding Circuits
50 Tons/8 Hours

Labor:

Day Shift Only	1 Crusher Operator at	\$1.50 per hour
Day Shift Only	1 Ball Mill Operator at	1.50 per hour
	Average Total Hourly Cost =	\$3.00
	Cost per ton of Feed =	\$0.48

Power:

The connected horsepower for the crushing and grinding circuits is 179 per hour, or 21.3 Kw per ton of Feed. At 1.0 ¢ per Kw the power cost would be 21.3 ¢ per ton of feed.

Summary of Crushing & Grinding Costs:

<u>Item</u>	<u>Cost per day Short Ton of Feed</u>
Labor	\$0.480
Power	0.213
Total	\$0.693

Table XXIFLOW SHEETDry Crushing & Wet Grinding of Nickel-Cobalt Sulfide Ore

Table XXII
Flotation Equipment Lost
50 Tons Per 8 Hours

	<u>Connected Horse Power</u>
1. Conditioner Tank 107.2 Cuft. To cond'n. 10 Min's.	20
2. Rougher Flotation Machines 5 - 44" Fagergren	25
3. Cleaner Flotation Machine 1 - 44" Fagergren	5
4. Recleaner Flotation Machines 2 - 44" Fagergren	10
5. Rougher Tailing Pump 1 - Size 2 - Denver Centrifugal Sand Pump	3
6. Cleaner Tailing Pumps 3 - Size 1 - Denver Centrifugal Sand Pumps	2-1/4
7. Sulfide Concentrate Pump 1 - Size 1 Denver Centrifugal Sand Pump	3/4
8. 2 Thickeners - Drive Motors (Concentrate and Tailing Thickeners)	20
9. 2 Thickeners - Diaphragm Pumps	20
10. Concentrate Vacuum Filter	5
11. Tailing Vacuum Filter	5
12. Vacuum Pumps for Filters	10
Total =	126 Horse Power

Table XXIII

Estimated Operating Costs
Flotation & Filtering Circuit
50 Tons Per 8 Hours

<u>Reagents</u>			
Reagent	<u>Lbs./Short Ton</u>	<u>Est. Delivery Cost Cents Per Lb.</u>	<u>Cost Per Ton of Feed</u>
Sodium Silicate	2.0	1.65	\$0.033
Reagent 301	0.4	25.00	0.100
Pine Oil (G.N.S. #5)	0.06	11.70	0.007
Frother 70	0.06	15.00	0.009
		Total	= \$0.149

Labor

1 Flotation Operator at	\$1.50 per hour
1 Filter Operator at	1.50 per hour
Average Total Hourly Cost	= \$3.00
Cost Per ton of Feed	\$0.48

Power

The connected horse power for the flotation circuit is 125 per hour, or 15.0 Kw per ton of feed. At 1.0 ¢ per Kw the power cost would be 15.0 ¢ per ton of feed.

Summary of Flotation Costs:

<u>Item</u>	<u>Cost Per day Short Ton of Feed</u>
Reagents	\$0.149
Labor	0.480
Power	0.150
Total	= \$0.779

Table XXIV

FLOW SHEET

FLOTATION OF NICKEL-COBALT SULFIDES FROM GROUND ORE