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TUNGSTEN CONCENTRATION FROM GREY RIVER PROPERTY OF AMERICAN SMELTING AND REFINING COMPANY, NEWFOUNDLAND

by

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Four ore shipments (250 tons) received for the pilot plant investigation assayed: 0.97% WO_3, 0.29% WO_3, 0.30% WO_3, and 0.24% WO_3 respectively.

Scheelite and wolframite are the two tungsten minerals present in the Grey River ore deposit. Due to their fine intergrowth a mixed scheelite-wolframite concentrate was produced by applying jigging, flotation and tabling.

The concentrates obtained from shipment No. 1 assayed about 65% WO_3 with a recovery between 61 and 69% of the WO_3 in the ore.

With a gradual improvement in the operation, particularly in the reduction of fines produced by crushing and grinding, a slightly higher tungsten recovery should be expected from this ore.

The other three shipments had too low tungsten contents for an economic consideration.

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INTRODUCTION

Location of Property

The Grey River tungsten deposit, a property of the American Smelting and Refining Company (ASARCO), is located on the south coast of Newfoundland about 90 miles south of Buchans in the Grey River area near the small town of Grey River.

Ore Characteristics of the Deposit

Scheelite and wolframite ore the two tungsten minerals in the ore. The principal gangue mineral is quartz but fluorite, barite and calcite-aragonite are also present. Pyrite is the main sulphide mineral but a small amount of copper, primarily as chalcopyrite, is also present in the ore. A list of minerals in this deposit identified by infrared spectra (IR) and X-ray diffraction paterns is given in Table 1.

The microscopic examination done on the previous ore samples from this property crushed to minus 10 mesh indicated that approximately half of the scheelite and wolframite minerals are free from the gangue material. In addition between 20 and 30% of the tungsten minerals were present as interlocked scheelite-wolframite particles. Therefore, approximately 80% of the tungsten values were reported to be free from gangue in the minus 10-mesh crushed ore.

It has been reported that by grinding the ore to minus 48 mesh the tungsten minerals essentially become liberated from gangue, but a substantial locking of scheelite-wolframite minerals extends down to micron sizes indicating that a complete separation of scheelite and wolframite minerals into two separate concentrates does not seem possible. More detailed mineralogical examinations of this deposit are reported in ASARCO's reports.

TABLE 1

Minerals Present in Grey River Ore Deposit

	Determined by: Microscope	IR	X-Ray
Tungsten Minerals			
Scheelite, $CaWO_4$	x	x	x
Wolframite, $(Fe, Mn)WO_4$	x	x	x
Sulphide Minerals			
Pyrite, FeS_2	x	x	x
Chalcopyrite, $CuFeS_2$	x		x
Galena, PbS	x		x
Sphalerite, ZnS	x		
Chalcocite, Cu_2S	x		
Covellite, CuS	x		
Molybdenite, MoS_2	x		
Pyrrhotite, $Fe_{11}S_{12}$	Poss		x
Silica-Silicates			
Quartz, SiO_2	x	x	x
Fayalite, $FeSiO_4$			x
Lepidolite, $KLiAl_2Si_3O_{10}(OH, F)_2$		Poss	
Muscovite, $3Al_2O_3.K_2O.6SiO_2.2H_2O$		Poss	x
Orthoclase, $Al_2O_3.K_2O.6SiO_2$		Poss	
Other Minerals			
Fluorite, CaF_2		x	x
Calcite-Argonite, $CaCO_3$		x	x
Barite, $BaSO_4$		x	x
Butlerite, $(Fe, Al)_2O_3.2SO_3.5H_2O$			x
Magnetite, Fe_3O_4			x
Hematite, Fe_2O_3	x		
Copper, Cu	x		

Purpose of Investigation

As a result of a substantial locking of scheelite and wolframite minerals occurring in this ore deposit ASARCO requested Mines Branch to concentrate the two tungsten minerals together in one concentrate rather than into two separate concentrates. No concentration of chalcopyrite in a separate copper concentrate was requested. As a result, the sulphide minerals present in the ore including chalcopyrite, being undesirable in the tungsten concentrate, were floated and rejected prior to final concentration of the tungsten minerals.

Procedure for Tungsten Concentration

The flowsheet developed by the ASARCO's Laboratory and used for this pilot plant investigation consisted of the following steps:

(a) Pre-concentration of minus 10-mesh ore by jigging.

(b) Grinding the jig concentrate to minus 48 mesh and floating the sulphides.

(c) Upgrading the tungsten values after sulphides removal by shaking tables using plus 100-, 100 to 200-, and minus 200-mesh fractions as table feeds.

(d) Regrinding the coarse table middlings and returning them to the feed-sizing operation.

(e) High-Intensity magnetic treatment of the fine tailings to obtain a low-grade WO_3 concentrate.

The ASARCO's laboratory investigation carried out on ore sample assaying 1.2% WO_3 indicated that about 75% of the WO_3 in the ore was recovered in a tungsten concentrate assaying 65% WO_3. The laboratory jigging of this investigation was carried out in a 4-in. x 6-in. Denver mineral jig which has a capacity between 150 and 500 pounds per hour. The ASARCO's feed rate to this jig was kept at 10 pounds per hour, i.e., an extremely low feed rate for the capacity of the jig.

Ore Shipments, Crushing and Analyses

In all seven ore samples were received for the laboratory and pilot plant investigation.

Three ore samples were received for the laboratory test work.

The first sample, designated as sample (a), already ground to 96% minus 48 mesh when received, assayed 0.42% WO_3.

The second sample designated as sample (b) assayed about 1% WO_3 and was already crushed to minus 10 mesh when received.

The third ore sample (about 800 pounds), designated as sample (c), was shipped from the Grey River property and was supposed to be a representative sample of the 250 tons ore sample for the pilot plant operation. This ore sample assayed 1.75% WO_3 and was shipped ahead of the 250-ton pilot-plant sample.

Four ore shipments designated as Shipment No. 1, Shipment No. 2, Shipment No. 3 and Shipment No. 4 were sent from the Grey River property during the months of October and November 1970 in 55-gallon drums. Each shipment as it was received was crushed applying primary and secondary procedure. In the primary crushing, a 10-inch jaw crusher and a 20-inch Symons cone crusher, both set at about one inch, were used. The primary-cone crushed product was then split by a cutter and approximately 60% was loaded into barrels for secondary crushing while 40% of the primary cone product was discarded.

In the secondary crushing, the primary-cone product (less than one inch) was passed through the jaw crusher set at 3/4 inch and then through the cone crusher set at 5/8 inch. The product from the secondary cone crusher was sampled continuously by a Snyder sampler from which about 80% of the secondary-crushing product was collected in barrels and used for pilot plant tests. The remaining 20% was reduced further in size by passing it through a Hazemag impact crusher. The Hazemag product was sampled on another Snyder sampler which took a 10% cut. This final cut was used as the head sample for each shipment.

The remaining portion of the Snyder sampler was used for preliminary testing.

Shipment No. 1 contained 0.97% WO_3 while the next three shipments contained 0.29%, 0.30% and 0.24% WO_3 respectively.

A summary of data regarding each shipment is presented in Table 2.

TABLE 2

Ore Shipments for Pilot-Plant Investigation

Ship No.	Date Rec'd	Wet Weight, Tons	No. of Barrels	Raise Number	Assays - %	
					WO_3	Cu
1	Sept. 25/71	83	195	1-7, 9	0.97	0.24
2	Oct. 14/70	19	41	8, 10	0.82	0.23
		46	110	11 - 14	0.29	0.13
3	Oct. 29/70	70	162	15 - 20	0.30	0.16
4	Nov. 12/70	57	133	21 - 25	0.24	0.20
Totals:		275	641			

OUTLINE OF INVESTIGATION

The investigation was carried out in two parts; one in the laboratory and the other in the pilot plant.

To determine the degree of separability of the tungsten minerals from sulphides and gangue minerals, laboratory heavy liquid separation tests were done on the 10-mesh crushed ore. This was followed by jigging of the crushed ore in a 1-M Denver laboratory jig and in a 4-in. x 4-in. Denver laboratory jig to obtain a scheelite-wolframite pre-concentrate.

The pre-concentration of these minerals on the pilot plant scale was done in a Wemco Remer jig and in a Denver Duplex Mineral jig. The initial tests were run on the low-grade material from shipments Nos. 2, 3 and 4 to set up the equipment and develop the jigging, flotation and tabling conditions. The jigging was carried out on crushed, ground and deslimed ore. Flotation and tabling were run on the combined pre-concentrates from the various jigging tests except Test DJF-10 in which pre-concentrate was directly fed to the mill and ground followed by flotation and tabling.

LABORATORY INVESTIGATION

(i) Heavy Liquid Separation Tests on Shipment No. 1

To observe the degree of liberation between the tungsten minerals and the other ore components in the crushed ore, a few preliminary heavy liquid tests were carried out on the head sample from shipment No. 1 at various specific gravities of the heavy liquid. It was shown that 2.88 specific gravity gave a good separation. When this was established, two head samples were crushed in the laboratory to minus 4 mesh and minus 10 mesh, sized down to minus 200 mesh and each size-fraction coarser than 200 mesh subjected to heavy liquid separation at 2.88 specific gravity. The screen analysis and results of the heavy liquid separation obtained from the minus 4-mesh crushed ore are recorded in Table 3, while the detailed results on the minus 10-mesh crushed ore are recorded in Table 4.

TABLE 3

Results of Screen Analysis and Heavy Liquid Separation of Minus 4-Mesh Crushed Ore - Shipment No. 1

Size, Mesh	Screen Analysis			Sink			Float		
	% Weight	% WO_3		% Weight	% WO_3		% Weight	% WO_3	
		Assays	Distn		Assays	Distn		Assays	Distn
-4+6	19.6	0.63	13.1	12.9	0.92	12.6	6.7	0.07	0.5
-6+10	33.6	0.82	29.0	17.3	1.54	28.1	16.3	0.05	0.9
-10+20	17.0	0.97	17.4	3.5	4.41	16.4	13.5	0.07	1.0
-20+48	14.1	1.08	16.1	2.6	5.64	15.4	11.5	0.06	0.7
-48+65	3.0	1.45	4.6	0.6	6.97	4.4	2.4	0.06	0.2
-65+100	2.5	1.28	3.4	0.5	6.15	3.3	2.0	0.05	0.1
-100+200	4.1	1.47	6.4	0.8	7.18	6.1	3.3	0.08	0.3
+200 (acc)	93.9	0.91	90.0	38.2	2.13	86.3	55.7	0.063	3.7
-200	6.1	1.53	10.0						
Head (calcd)	100.0	0.946	100.0						

TABLE 4

Screen Analysis and Heavy Liquid Separation of Minus 10-Mesh Crushed Ore - Shipment No. 1

Size, Mesh	Screen Analysis			Sink			Float		
	% Weight	% WO_3		% Weight	% WO_3		% Weight	% WO_3	
		Assays	Distn		Assays	Distn		Assays	Distn
-10+14	14.9	0.83	12.5	2.1	5.23	11.6	12.8	0.01	0.2
-14+28	31.9	0.94	30.6	4.1	6.51	28.3	27.8	0.02	0.6
-28+65	27.3	0.96	26.9	4.1	6.15	26.3	23.2	0.07	1.7
-65+100	5.4	1.02	5.7	0.9	6.48	6.4	4.5	0.01	0.1
-100+150	4.3	1.14	5.0	0.8	6.23	5.3	3.5	0.01	0.1
-150+200	3.4	1.24	4.3	0.6	6.23	4.2	2.8	0.05	0.2
+200 (acc)	87.2	0.95	85.0	12.6	6.19	82.1	74.6	0.034	2.9
-200	12.8	1.13	15.0						
Head (calcd)	100.0	0.97	100.0						

Comparing the results from Table 3 and Table 4 showed that a good separation of the tungsten minerals from the other ore components was obtained from minus 10-mesh crushed ore (Table 4). Crushing the ore to minus 4 mesh produced less minus 200-mesh material but the grades of sinks were lower in Table 3 (particularly those from fraction coarser than 48 mesh) than when ore was crushed to minus 10 mesh (Table 4) indicating that crushing the ore to minus 4 mesh did not sufficiently liberate the tungsten minerals from the other ore components.

Based on these results it appeared that ore from Shipment No. 1 had similar characteristics to that used for ASARCO's laboratory investigations and that minus 10-mesh ore would be suitable as jig feed for the pre-concentration.

Pre-concentration at the Mineral Processing Division was carried out using:

(i) 1-M (1-in. x 2-in.) Denver laboratory jig
(ii) 4-in. x 6-in. Denver laboratory jig

Procedure and results for each jig run on two ore samples will be recorded separately.

(ii) Pre-concentration With 1-M Denver Lab Jig

Two ore samples - (b) and (c) - crushed to minus 10 mesh were used for this test work using steel balls for ragging.

The sample (b) - about 400 pounds - assayed about 1% WO_3 while the portion of sample (c) assayed about 1.77% WO_3.

After a few preliminary tests were carried out under various jigging conditions, two jigging tests were then done applying the most favourable conditions. Detailed jigging conditions are shown in Appendix I tests GR-4 and GR-5, page 1 and 2 respectively while the results of these two tests are recorded in Table 5.

TABLE 5

Results of 1-M Denver Laboratory Jig
Ore Sample: (b) - 1% WO_3

Test No. and Products	% Weight	% WO_3	
		Assays	Distn
GR-4			
Hutch	32.0	2.46	83.7
Jig bed	21.9	0.11	2.5
Jig tail	46.1	0.28	13.8
Head (calcd)	100.0	0.94	100.0
GR-5			
Hutch	17.2	4.36	73.5
Jig bed	8.0	0.39	3.1
Hutch + bed	25.2	3.10	76.6
Jig tail	74.8	0.32	23.4
Head (calcd)	100.0	1.02	100.0

When the jig tailings of these two tests were separated into 200-mesh fractions it was found that the minus 200-mesh fraction of the tailings had a considerably higher WO_3 content than the plus 200-mesh fraction. The results of the separation of these tailings are recorded in Table 6.

TABLE 6

Results of Screening Jig Tailings on 200-Mesh

Test No. and Size Fraction	% Weight	% WO_3		
		Assays	Distribution	
			In tail	In ore
GR-4				
Jig tail, -200 m	10.0	0.80	61.5	8.5
Jig tail, +200 m	36.1	0.14	38.5	5.3
Total jig tail	46.1	0.28	100.0	13.8
GR-5				
Jig tail, -200 m	12.7	0.91	47.8	11.2
Jig tail, +200 m	62.1	0.20	52.2	12.2
Total jig tail	74.8	0.32	100.0	23.4

These results showed that the tungsten values contained in the minus 200-mesh fraction of the feed could not be effectively concentrated by jigging. Since the tungsten values of the minus 200-mesh fraction had a reasonable WO_3 grade and the scheelite and wolframite particles were liberated from the gangue material, it was decided to combine the minus 200-mesh fraction of the jig tailings with the hutch product to form the tungsten pre-concentrate, while the plus 200-mesh portion of the jig tailings was discarded. The summarized results from Table 5 and Table 6, where the minus 200-mesh fractions of the jig tailings are added to the jig concentrates (hutch) of these two tests, are given in Table 7.

TABLE 7

Summary of Results from 1-M Denver Laboratory Jig
Ore Sample: (b) - 1% WO_3

Test No. and Products	% Weight	% WO_3	
		Assays	Distn
GR-4			
Hutch	32.0	2.46	83.7
Jig tail, -200 m	10.0	0.80	8.5
Pre-concentrate	42.0	2.05	92.2
Jig bed	21.9	0.11	2.5
Jig tail, +200 m	36.1	0.14	5.3
Head (calcd)	100.0	0.94	100.0
GR-5			
Hutch + bed	25.2	3.10	76.6
Jig tail, -200 m	12.7	0.91	11.2
Pre-concentrate	37.9	2.36	87.8
Jig tail, +200 m	62.1	0.20	12.2
Head (calcd)	100.0	1.02	100.0

Two tests were carried out using a 1-M Denver jig on sample (c) containing about 1.77% WO_3. The sample was crushed to minus 10 mesh and then jigged applying same conditions as in Test GR-5.

The jig tailings were separated into plus and minus 200-mesh fractions as in the previous two tests.

The summarized results are recorded in Table 8.

TABLE 8

Summary of Results from 1-M Denver Laboratory Jig
Ore Sample: (c) - 1.77% WO_3

Test No. and Products	% Weight	% WO_3	
		Assays	Distn
GR-6			
Hutch	21.5	6.61	81.0
Jig bed	8.5	0.72	3.4
Jig tail, -200 m	9.4	1.33	7.1
Pre-concentrate	39.4	4.07	91.5
Jig tail, +200 m	60.6	0.25	8.5
Head (calcd)	10.0	1.76	100.0
GR-7			
Hutch	25.5	5.90	80.4
Jig bed	13.0	0.79	5.6
Jig tail, -200 m	9.6	1.52	7.6
Pre-concentrate	48.1	1.65	93.6
Jig tail, +200 m	51.9	0.23	6.4
Head (calcd)	100.0	1.87	100.0

(iii) Pre-concentration With 4 in. x 6 in. Denver Jig

As the only sample available for preliminary laboratory tests was sample (c) containing 1.77% WO_3, this sample, crushed to minus 10 mesh, was used as jig feed for a 4-in. x 6-in. Denver jig. All jigging tests were carried out in consultation with Mr. E. Martinez, ASARCO's representative from the Central Research Laboratory in South Plainfield, N.J.

Two tests were run applying ASARCO's laboratory procedure in which portion of steel shot (ragging) was replaced by quartz and three tests using steel shot alone as ragging (standard procedure), i.e., without the quartz. The feed rates in the ASARCO's procedure were kept at 10 lb/hr and 75 lb/hr while the feed rates of tests with standard procedure were kept at 75 lb/hr, i.e., one half of the minimum capacity of the jig.

Detailed jigging conditions of these tests are recorded in the Appendix, Tests GR-A, GR-B, GR-C, GR-D, and GR-E, pages 5 to 9 inclusive. The jig tailings from these tests were separated into plus 200-mesh and minus 200-mesh fractions as usual and assayed separately. It was observed again that the tungsten values in the minus 200-mesh fractions of the jig tailings were considerably higher than the values in the plus 200-mesh fractions.

The jigging results of these tests are recorded in Table 9.

TABLE 9

Jigging Results from ASARCO's and Standard Laboratory Procedure
Ore Sample: (c) - 1.77% WO_3

Test No., Procedure and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
GR-A ASARCO's Proc: Ragging: Quartz and steel balls Feed Rate: 10 lb/hr	Hutch	15.9	7.22	60.6
	Jig bed	13.0	3.74	25.8
	Jig tail, -200 m	7.4	1.03	4.2
	Pre-concentrate	36.3	4.74	90.6
	Jig tail, +200 m	63.7	0.20	9.4
	Head (calcd)	100.0	1.90	100.0
GR-B ASARCO's Proc: Ragging: Quartz and steel balls Feed Rate: 75 lb/hr	Hutch	13.8	7.76	60.2
	Jig bed	8.3	4.78	22.4
	Jig tail, -200 m	8.5	1.30	5.7
	Pre-concentrate	30.6	5.16	88.3
	Jig tail, +200 m	69.4	0.26	11.7
	Head (calcd)	100.0	1.78	100.0
GR-C Standard Proc: Ragging: Steel balls Feed Rate: 75 lb/hr	Hutch	13.6	7.63	58.8
	Jig bed	9.3	4.51	23.7
	Jig tail, -200 m	11.0	1.40	8.4
	Pre-concentrate	33.9	4.75	90.9
	Jig tail, +200 m	66.1	0.24	9.1
	Head (calcd)	100.0	1.77	100.0
GR-D Standard Proc: 5 Ragging: Steel balls Feed Rate: 75 lb/hr	Hutch	18.0	6.27	64.6
	Jig bed	9.4	3.23	17.1
	Jig tail, -200 m	11.2	1.23	9.1
	Pre-concentrate	38.6	4.13	90.8
	Jig tail, +200 m	61.4	0.23	9.2
	Head (calcd)	100.0	1.75	100.0
GR-E Standard Proc: Ragging: Steel balls Feed Rate: 75 lb/hr	Hutch	18.2	5.82	67.0
	Jig bed	8.8	2.20	12.3
	Jig tail, -200 m	12.0	1.39	10.7
	Pre-concentrate	39.0	3.57	90.0
	Jig tail, +200 m	61.0	0.25	10.0
	Head (calcd)	100.0	1.54	100.0

The laboratory jigging of the two ore samples (containing 1% WO_3 and 1.77% WO_3) showed that this pre-concentration method gave reasonably good results. The procedure resulted in a rejection of 58 to 66% by weight of the material from the ore with 7 to 10% loss of the WO_3.

The pre-concentrate contained 34 to 42% of the ore by weight and recovered 90 to 93% of the WO_3.

During the pilot plant operation, a few laboratory tests were done on the ore sample from Shipment No. 1. Detailed jigging conditions of the two best tests (GR-F and GR-8) are recorded in the Appendix, page 10 and 11 respectively. The results of these tests are given in Table 10.

TABLE 10

Jigging Results from Pilot Plant Shipment No. 1 - 0.97% WO_3

Test No., Procedure and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
GR-F Standard Proc Feed Rate: 75 lb/hr	Hutch	49.2	1.62	74.8
	Jig bed	8.3	2.15	16.8
	Jig tail, -200 m	4.5	0.70	2.8
	Pre-concentrate	62.0	1.63	94.4
	Jig tail, +200 m	38.0	0.12	5.6
	Head (calcd)	100.0	1.07	100.0
GR-8 Standard Proc Feed Rate: 75 lb/hr	Hutch	31.3	1.77	72.7
	Jig tail, -200 m	14.3	0.71	13.1
	Pre-concentrate	45.6	0.66	85.8
	Jig bed	8.7	0.62	7.1
	Jig tail, +200 m	45.7	0.12	7.1
	Head (calcd)	100.0	0.77	100.0

(iv) Concentration of Wolframite From Jig Tailings

Regardless of the method used to reduce the jig feed to minus 10 mesh, a certain percentage of the tungsten-bearing minerals will be reduced to minus 200 mesh. After jigging,most of the minus 200-mesh particles of scheelite and wolframite present in the jig feed will remain in the jig tailings and, it appears that there is usually slightly more wolframite than scheelite.

Since scheelite has no magnetic characteristics and wolframite is weakly magnetic, the feasibility of concentrating wolframite from the jig tailings was investigated. For this purpose the minus 200-mesh portion of the jig tailing (containing 1.39% WO_3) was fed to a Jones high-intensity magnetic separator applying one-stage (rougher) treatment at 15 amperes.

Results of this test are recorded in Table 11.

TABLE 11

Concentration of Wolframite from Minus 200-Mesh Fraction of Jig Tailing by High-Intensity Magnetic Separator

Products	% Weight		% WO_3		
	In -200 m Jig tail	In Ore	Assays	Distribution	
				In -200 m	In ore
Jones conc @ 15 amp	8.33	0.8	9.68	58.0	4.4
Jones midds and tail	91.67	8.8	0.53	42.0	3.2
-200 m jig tail	100.00	9.6	1.39	100.0	7.6

PILOT PLANT INVESTIGATION

(a) Pre-concentration with Remer Jig

The preliminary tests on this jig were carried out on minus 10-mesh material obtained from screening the crushed ore on 10 mesh. These tests provided necessary information for the general operating conditions of the jig for this relatively fine jig feed.

When tailings from this jig were separated on a 200-mesh screen, it was observed that most of the minus 200-mesh sizes of scheelite and wolframite present in the crushed ore remained in the jig tailings.

A futile effort and a considerable length of time was spent in trying to recover these fine sizes of scheelite and wolframite by jigging the 10-mesh crushed ore. The results showed that this could not be achieved with the Remer jig as also it could not be done with the two laboratory jigs (see "Laboratory Jigging"), i.e., most of the minus 200-mesh particles of scheelite and wolframite present in the feed remained in the jig tailings.

As a result, it was decided to separate the jig tailings into plus and minus 200-mesh fractions and add the minus 200-mesh fraction to the jig concentrate to obtain a maximum tungsten recovery, i.e., the same procedure as applied in the laboratory jigging.

The first test (RJ-1) with the Remer jig was carried out on the minus 10-mesh material from Shipment No. 1 obtained by screening the rejects of the 5/8-inch crushed ore through a 10-mesh screen. This material contained 1.36% WO_3. The screen analysis of this jig feed is recorded in the following Table 12.

TABLE 12

Screen Analysis of Ore Crushed to Minus 10 Mesh

Size	% Weight
+10 mesh	0.3
-10+14 "	5.0
-14+28 "	20.4
-28+65 "	36.1
-65+100 "	6.9
-100+150 "	5.4
-150+200 "	4.2
-200 "	21.7
Jig feed	100.0

The feed rate in this test was 1900 lb/hr. The other operating conditions of Test RJ-1 are recorded on page 12 of Appendix .

The jig tailing was separated into 200-mesh fractions. The fine fraction of tailing (minus 200-mesh) was added to the jig concentrate as before to form the pre-concentrate.

The results of this test are recorded in the following Table 13.

TABLE 13

Jigging Results of Test RJ-1

Jig Feed: Crushed Ore; 1.36% WO_3

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-1 Feed Rate: 1900 lb/hr	Jig concentrate*	56.7	2.08	86.7
	Jig tail, -200 m	16.6	0.90	10.5
	Pre-concentrate	73.3	1.86	97.2
	Jig tail, +200 m	26.7	0.12	2.8
	Jig feed	100.0	1.36	100.0

* 4 hutches.

Test RJ-3 was run under the same operating conditions as RJ-1 but the feed rate was 1800 lb/hr. The material used for this test contained 0.75% WO_3, i.e., a considerably lower tungsten content than in Test RJ-1.

The results of this test are recorded in the following Table 14.

TABLE 14

Jigging Results of Test RJ-3

Jig Feed: Crushed Ore; 0.75% WO_3

Test No. and Feed Rate	Products	% Weight	WO_3	
			Assays	Distn
RJ-3 Feed Rate: 1800 lb/hr	Jig concentrate*	45.5	1.41	86.1
	Jig tail, -200 m	8.5	0.91	10.3
	Pre-concentrate	54.0	1.33	96.4
	Jig tail, +200 m	46.0	0.06	3.6
	Jig feed	100.0	0.75	100.0

* 4 hutches.

As part of the preliminary testing, several tests were run on ground ore. For this purpose the minus 5/8-inch ore was wet-ground in a rod mill to minus 10 mesh and the ground ore used as jig feed. As the per cent solids of the the ground ore was too low for jig operation, the ground ore had to be thickened in order to reach the required density for the jig feed. As no thickeners were available in the pilot-plant to handle this amount of material, the ground ore was treated by the following two techniques to increase the density of the jig feed:

(a) partially thickened, thickener overflow discarded and underflow used as jig feed or filtered prior to jigging;

(b) deslimed by cycloning, cyclone overflow discarded and cyclone underflow used as jig feed.

In both methods considerable difficulty was experienced in obtaining a constant jig feed which caused a variation in the tungsten content in the feed.

The results of two tests (RJ-4 and RJ-5) in which jig feed was prepared as described in (a) are recorded in the following Table 15.

TABLE 15

Jigging Results of Test RJ-4 and RJ-5

Jig Feed: Ground ore

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-4 Feed Rate: 2600 lb/hr	Hutch 1	19.6	2.56	58.0
	2	10.0	1.44	16.7
	3	7.9	0.69	6.3
	Jig concentrate	37.5	1.86	81.0
	Jig tail, -200 m	6.8	1.15	9.0
	Pre-concentrate	44.3	1.75	90.0
	Hutch 4* + jig tail, +200 m (comb)	55.7	0.16	10.0
	Jig feed	100.0	0.86	100.0
RJ-5 Feed Rate: 2100 lb/hr	Hutch 1	9.7	5.58	48.5
	2	5.0	3.85	17.3
	3	8.8	1.14	9.0
	4	4.6	0.81	3.3
	Jig concentrate	28.1	3.09	78.1
	Jig tail, -200 m	10.3	1.05	9.7
	Pre-concentrate	38.4	2.54	87.8
	Jig tail, +200 m	61.6	0.22	12.2
	Jig feed	100.0	1.11	100.0

*Assayed 0.25% WO_3 and thus calculated with the jig tail.

Difficulties were experienced in controlling the feed rate using these ground materials (thickened and filtered) due to small size of the equipment available. The jigging conditions of Tests RJ-4 and RJ-5 are recorded in the Appendix, pages 14 and 15.

For better control of the jig feed rate, it was decided to deslime the ground ore by hydrocyclones prior to jigging and use the cyclone underflow as jig feed. Most of these tests were run on Shipment No. 3 which contained about

0.3% WO_3 and on the material from Raises 8 and 10 from Shipment No. 1 containing about 0.8% WO_3.

Separation of jig tailings on 200-mesh fractions was partially done by a rake classifier. A further recovery of fines from the tailings was done by screening the rake classifier sands on a 200-mesh screen.

The jigging conditions of these tests are recorded on pages 18, 19, 16, and 17 of the Appendix.

Results of tests from Shipment No. 3 (RJ-8 and 9) are recorded in Table 16 while the results from Raises 8 and 10 are recorded in Table 17 (Tests RJ-6 and 7).

TABLE 16

Jigging Results from Shipment No. 3

Jig Feed: Deslimed Ground Ore

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-8 Feed Rate: 2300 lb/hr	2nd cyclone O'Flow	7.4	0.31	6.6
	2nd cyclone U'Flow	5.6	0.26	4.0
	Hutch 1	3.4	3.49	34.0
	2	11.7	0.64	21.3
	3	6.8	0.39	10.5
	Jig concentrate	21.9	1.05	65.8
	Jig tail, -200 m	9.0	0.46	12.0
	Pre-concentrate	30.9	0.88	77.8
	Hutch 4 + jig tail, +200 m	56.1	0.07	11.6
	Head (calcd)	100.0	0.35	100.0
RJ-9 Feed Rate: 2550 lb/hr	1st cyclone O'Flow	13.2	0.24	9.3
	Hutch 1	7.5	1.71	37.1
	2	14.8	0.55	23.8
	Jig concentrate	22.3	0.94	60.9
	Jig tail, -200 m	11.3	0.39	12.7
	Pre-concentrate	33.6	0.76	73.6
	Hutch 3 + 4 and jig tail, +200 m	53.2	0.11	17.1
	Head (calcd)*	100.0	0.345	100.0

*Slightly finer grind than usual.

TABLE 17

Jigging Results from Raises 8 and 10

Jig Feed: Deslimed Ground Ore

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-6 Feed Rate: 2600 lb/hr	2nd cyclone o'flow	6.9	0.63	5.5
	2nd cyclone u'flow	4.2	0.58	3.1
	Hutch 1	4.7	6.40	39.2
	2	7.8	1.85	18.8
	3	4.0	1.43	7.4
	4	1.7	0.76	0.1
	Jig concentrate	18.2	2.75	65.5
	Rake class o'flow	7.4	0.71	6.8
	Pre-concentrate	25.6	2.17	72.3
	Rake class sands 1 + 2	63.3	0.23	19.1
	Head (calcd)	100.0	0.77	100.0
RJ-7 Feed Rate: 2100 lb/hr	2nd cyclone o'flow	5.5	0.61	4.2
	2nd cyclone u'flow	7.5	0.59	5.6
	Hutch 1	12.7	3.44	56.1
	2	11.0	0.85	12.1
	3	4.1	0.67	3.5
	Jig concentrate	27.8	2.01	71.7
	Jig tail, -200 m	9.6	0.75	9.2
	Pre-concentrate	37.4	1.68	80.9
	Hutch 4 and jig tail, +200 m	49.6	0.15	9.3
	Head (calcd)	100.0	0.78	100.0

To investigate the effect in variation of jig feed rates on pre-concentration of tungsten from the minus 10-mesh crushed ore, a series of test was carried out in which the feed rate to the Remer jig was 480 lb/hr, 1000 lb/hr and 1500 lb/hr, under the same jigging conditions. The operating conditions of this series of tests are recorded on pages 21, 22, and 23 of the Appendix.

The results of this series of tests are given in Table 18.

TABLE 18

Effect of Various Jig Feed Rates on Tungsten Pre-concentration

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-13 Feed Rate: 480 lb/hr	Hutch 1	9.0	4.10	50.0
	2	25.0	0.79	26.8
	3	15.9	0.24	5.1
	4	5.1	0.27	1.9
	Jig concentrate	55.0	1.12	83.8
	Jig tail, -200 mesh	15.8	0.52	11.1
	Pre-concentrate	70.8	0.99	94.9
	Jig tail, +200 mesh	29.2	0.13	5.1
	Head (calcd)	100.0	0.74	100.0
RJ-14 Feed Rate: 1000 lb/hr	Hutch 1 + 2	27.7	1.87	68.9
	3	13.4	0.40	7.0
	4	4.2	0.18	1.1
	Jig concentrate	45.3	1.26	77.0
	Jig tail, -200 mesh	10.7	0.64	9.0
	Pre-concentrate	56.0	1.16	86.0
	Jig tail, +200 mesh	44.0	0.24	14.0
	Head (calcd)	100.0	0.76	100.0
RJ-15 Feed Rate: 1500 lb/hr	Hutch 1 + 2	23.9	3.07	63.5
	3	11.1	0.90	8.7
	4	5.5	0.23	1.1
	Jig concentrate	40.5	2.09	73.3
	Jig tail, -200 mesh	20.1	0.98	17.0
	Pre-concentrate	60.6	1.72	90.3
	Jig tail, +200 mesh	39.4	0.28	9.7
	Head (calcd)	100.0	1.17	100.0

To observe the effect of slightly coarser crushed ore, one test (RJ-12) was run on ore crushed to minus 8 mesh, using feed rate of about 1000 lb/hr.

The operating conditions were the same as in the previous series of tests.

The results of this test are recorded in the following Table 19.

TABLE 19

Results of Jigging 8-Mesh Crushed Ore

Test No. and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
RJ-12 Feed Rate: 1000 lb/hr	Hutch 1	4.1	13.04	53.8
	2	14.5	1.15	16.6
	3	19.9	0.38	7.6
	4	4.5	0.34	1.5
	Jig concentrate	43.0	1.86	79.5
	Jig tail, -200 mesh	23.4	0.68	15.8
	Pre-concentrate	66.4	1.44	95.3
	Jig tail, +200 mesh	33.6	0.14	4.7
	Head (calcd)	100.0	0.95	100.0

(b) Flotation and Tabling of Pre-concentrates from Remer Jig

To obtain a marketable grade of tungsten concentrate, the pre-concentrate had to be upgraded to a minimum grade of 65% WO_3. The method used to obtain this final tungsten concentrate consisted of the following steps:

(a) grinding the pre-concentrate to minus 48 mesh;
(b) flotation of sulphides from the ground pre-concentrate, at pH 8.2;
(c) screening the flotation tailing into three size fractions;
(d) tabling each size fraction separately.

To establish flotation and tabling conditions, several preliminary tests were carried out using material from the pre-concentrates produced during the previous jigging operations. Difficulty was experienced in floating the sulphides due to their surface oxidation during the stockpilong period. This required heavier collection of sulphides during flotation, resulting in larger losses of WO_3 to the sulphide rougher concentrates. The addition of the

cleaner and sometimes re-cleaner sulphides circuits reduced the WO_3 losses considerably. The approximate densities in the rougher, cleaner and re-cleaner circuits were 28, 15 and 8 per cent respectively.

Xanthate, sodium silicate, copper sulphate and Dowfroth 250 - pine oil were used for floating the bulk sulphide concentrate (chalcopyrite-pyrite combined). The typical flotation conditions are recorded in the following Table 20.

TABLE 20

Pilot-Plant Flotation Conditions

Flotation reagents	lb/ton	Point of addition
Sodium silicate	1.2	Ball mill discharge
Copper sulphate	0.8	Ball mill feed
Na sec butyl xanthate	0.3	Rougher conditioner
Frother*	0.1	Rougher conditioner
Na sec butyl xanthate	0.1	5th flot ro cell
Frother*	0.05	5th flot ro cell

*1:1 mixture of pine oil and Dowfroth 250

The results from the preliminary tabling tests showed that one-stage (rougher) tabling of the size fractions from the pre-concentrates did not give sufficiently high WO_3 grades of the rougher concentrates and the WO_3 recoveries were low. As a result it was decided to add cleaner tables for upgrading the rougher concentrates. To increase the WO_3 recovery in the rougher concentrates, a much wider cut was taken from the rougher tables. This produced rougher concentrate with low WO_3 grade but increased the tungsten recovery. These low-grade rougher concentrates were upgraded by cleaner tables, which produced the final tungsten concentrate of required WO_3 grade.

The coarsest portion of the middlings was cut during the secondary tabling, (being low-grade and locked particles) in order to prevent the lowering the WO_3 grade of the final tungsten concentrate. These middlings were assayed separately, collected and then a separate treatment carried out to recover a maximum tungsten recovery (see "Treatment of Middlings", page 28). A flowsheet of this procedure is given in Figure 1, while detailed results of the flotation and tabling tests run on various pre-concentrates are recorded in the following Table 21 and summarized in Table 22.

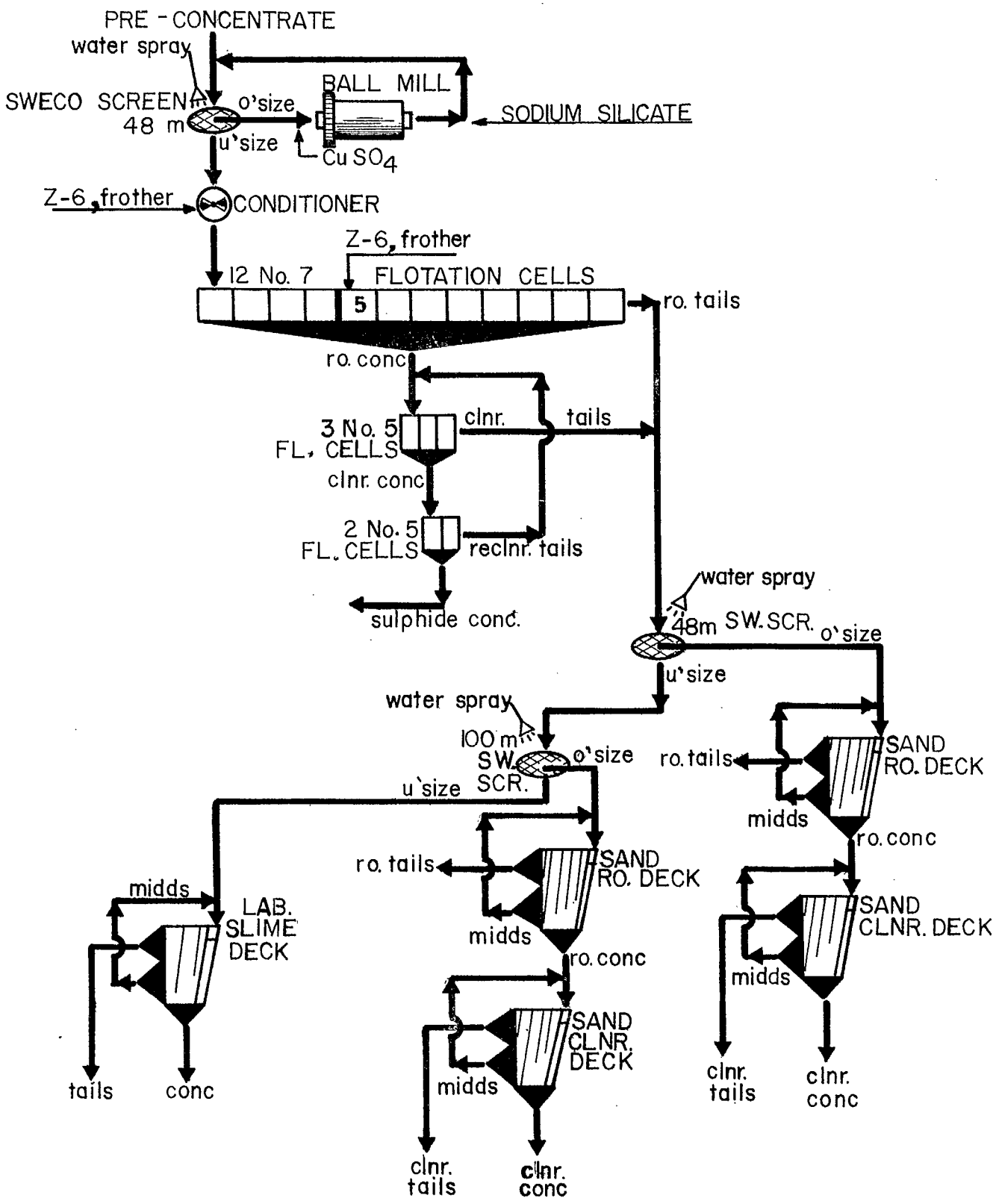

FIGURE 1. PILOT PLANT FLOWSHEET

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TABLE 21

Detailed Flotation and Tabling Results

Feed	Flotation and Tabling Products	% Weight	% WO_3	
			Assays	Distn
Remer Jig conc (Test No. RJF-11)	Sulphide re-cl conc	13.42	0.92	6.1
	Prim cleaner conc	0.19	71.75	6.8
	" " midds	0.32	15.21	2.4
	" " tails	1.13	0.86	0.5
	" rougher tails	16.46	0.14	1.1
	Sec cleaner conc	0.09	72.57	3.2
	" " midds	0.28	9.81	1.3
	" " tails	1.17	0.38	0.2
	" rougher tails	13.58	0.23	1.5
	Slime deck ro conc	1.48	68.06	49.7
	" " " midds	0.98	5.25	2.5
	" "" " tails	50.90	0.98	24.7
	Pre-concentrate (calcd)	100.00	2.02	100.0
Remer Jig conc (Test No. RJF-9)	Sulphide cl conc	15.00	0.52	4.6
	Prim cleaner conc	0.40	68.06	16.2
	" " midds	0.02	17.14	0.2
	" " tails	2.00	2.30	2.7
	" rougher tails	27.10	0.32	5.3
	Sec cleaner conc	0.30	65.40	11.7
	" " midds	0.04	9.06	0.3
	" "" tails	2.50	0.32	0.5
	" rougher tails	12.10	0.28	2.0
	Slime deck ro conc	0.80	64.20	30.6
	" " " midds	1.10	12.80	8.4
	" " " tails	38.64	0.76	17.5
	Pre-concentrate (calcd)	100.00	1.68	100.0
Remer Jig conc (Test No. RJF-6)	Sulphide cl conc	15.65	0.41	5.5
	Prim cleaner conc	0.11	71.55	6.7
	" " midds	0.30	16.65	4.3
	" " tails	1.03	0.08	0.1
	" rougher tails	14.97	0.01	0.1
	Sec cleaner conc	0.35	68.06	20.4
	" " midds	0.10	14.68	1.3
	" " tails	0.90	0.80	0.6
	" rougher tails	30.97	0.03	0.8
	Slime deck ro conc	0.67	64.17	36.8
	" " " midds	0.75	12.79	8.2
	" " " tails	34.20	0.52	15.2
	Pre-concentrate (calcd)	100.00	1.17	100.0

TABLE 22

Summary of Flotation and Tabling Results of Tests RJF-11, RJF-9 and RJF-6 from Table 21 (Remer Jig)

Feed	Flotation and Tabling Products	% Weight	% WO_3	
			Assays	Distn
Remer Jig conc (Test No. RJF-11)	Sulphide re-cl conc	13.42	0.92	6.1
	Prim, sec and slime deck conc (comb)	1.76	68.45	58.7
	Prim, sec and slime deck midds (comb)	1.58	8.15	6.2
	Prim and sec cl tails (comb)	2.30	0.61	0.7
	Prim and sec ro tails (comb)	30.04	0.18	3.6
	Slime deck ro tails	50.90	0.98	24.7
	Pre-concentrate (calcd)	100.00	2.02	100.0
Remer Jig conc (Test No. RJF-9)	Sulphide cl conc	15.00	0.52	4.6
	Prim, sec and slime deck conc (comb)	1.50	65.40	58.5
	Prim, sec and slime deck midds (comb)	1.16	12.75	8.9
	Prim and sec cl tails (comb)	4.50	1.20	3.2
	Prim and sec ro tails (comb)	39.20	0.31	7.3
	Slime deck ro tails	38.64	0.76	17.5
	Pre-concentrate (calcd)	100.00	1.68	100.0
Remer Jig conc (Test No. RJF-6)	Sulphide cl conc	15.65	0.41	5.5
	Prim, sec and slime deck conc comb	1.13	66.00	63.9
	Prim, sec and slime deck midds	1.15	13.95	13.8
	Prim and sec cl tails	1.93	0.43	0.7
	Prim and sec ro tails	45.94	0.024	0.9
	Slime deck ro tails	34.20	0.52	15.2
	Pre-concentrate* (calcd)	100.00	1.17	100.0

*From shipment No. 1 and No. 3 combined.

These results showed that good grades of table concentrates were obtained with a fair recovery but, as expected, a certain amount of tungsten remained in the middlings with a high WO_3 content.

(c) Treatment of Secondary Table-Middlings

Middling particles are a problem in any kind of the ore dressing treatment and the table middlings are no exception. It was observed that middling produced by tabling showed that interlocking of scheelite and wolframite with sulphide and gangue material was extensive and that regrinding of the middlings would be necessary to liberate and recover these locked tungsten minerals.

To obtain a sufficient amount of the middling material for flotation and tabling, the secondary middlings of several tests including those from Tests RJF-11, 9 and 6 were combined, ground to minus 65 mesh, and the two-stage (rougher and cleaner) flotation procedure applied. The rougher and cleaner flotation tailings were combined and separated into two fractions (plus 150-mesh and minus 150-mesh) and each fraction tabled separately.

The results are recorded in the following Table 23.

TABLE 23

Recovery of Tungsten from Middlings

Flotation and Tabling Products	% Weight in Middlings	% WO_3	
		Assays	Distn
Sulphide cl conc	11.6	0.80	0.6
Table rougher conc	9.8	61.50	39.3
" " midds	5.2	25.70	8.8
" " tails	38.4	1.69	6.5
Slime deck ro conc	7.0	62.31	28.2
" " " midds	4.2	24.12	6.5
" " " tails	23.8	6.48	10.1
Middlings	100.0	15.31	100.0

The summarized results from Table 23 are given in Table 24.

TABLE 24

Summarized Results from Table 23

Flotation and Tabling Products	% Weight in Middlings	% WO_3	
		Assays	Distn
Sulphide conc	11.6	0.80	0.6
Table ro conc - combined	16.8	61.87	67.5
Table ro midds - combined	9.4	24.88	15.9
Table ro tails - combined	62.2	4.08	16.6
Middlings	100.0	15.32	100.0

Results in Table 23 showed that 67.5% of the WO_3 present in the middling was recovered in a concentrate of 61.87% WO_3 grade at the minus 65-mesh grind. The new middlings produced assayed 24.88% WO_3 containing 15.9% of the WO_3 present in the original middlings, indicating that a grind of the original middlings finer than minus 65 mesh was necessary in order to obtain a slightly higher-grade tungsten concentrate (about 62% WO_3) with a recovery of about 70 per cent.

Based on these results, calculated tungsten concentrates obtained from the middlings of Tests RJF-11, RJF-9, and RJF-6 shown in Table 22 are recorded in the following Table 25.

TABLE 25

Calculated Results of Tungsten Concentrates from Middlings of Tests in Table 21

Test No.	Prim, sec + slime deck middlings			Tungsten Concentrate*		
	% Weight in pre-conc	% WO_3		% Weight in pre-conc	% WO_3	
		Assays	Distn in pre-conc		Assays	Distn in pre-conc
RJF-11	1.58	8.15	6.2	0.20	62	4.3
RJF-9	1.16	12.75	8.9	0.17	62	6.2
RJ-6	1.15	13.95	13.8	0.26	62	9.6

*Based on 62% WO_3 grade and 70% recovery.

(d) Pre-concentration with Duplex Mineral Jig

Five tests were run with a pilot-plant-size, 8-in. x 12-in., Denver Duplex Mineral jig which had a rated capacity of about 15 to 45 tons per day, i.e., about 0.6 to 1.8 tons per hour or 1250 to 3750 pounds per hour. For the concentration of scheelite-wolframite, the manufacturer recommended about one half of the rated capacity, i.e., about 625 to 1875 pounds per hour. A screen analysis of the minus 10-mesh, dry-crushed jig feed was as follows:

Mesh	% Weight
-10+28	31.8
-28+48	20.5
-48+100	15.0
-100+200	11.0
-200	21.7
Total	100.0

The type of ragging used for this jig was entirely composed of the "Samson shots" (oval steel balls) recommended and supplied by the jig manufacturer.

The feed rate was varied from about 600 lb/hr to about 1000 lb/hr. To ensure that ore was wet before reaching the jig and that the feed rate to the the jig was constant, the dry-crushed ore was fed first to a rake classifier without an overflow and then raked to the jig through the sands discharge. A small amount of water was added with the feed to assure a smooth flow of the feed to the jig.

The two hutch discharges were controlled by Dowsett valves constructed at the Mines Branch machine shop. The pulp densities of the two hutches were kept at about 50% and 20% respectively. The total amount of water used in each test was approximately 8 U.S. gallon/min.

Detail jigging conditions for each test are recorded in the Appendix, Tests No. DJ-1 to 5, pages No. 24 to 28 inclusive.

During the operation of this jig it was observed that most of the tungsten values in the jig tailings was in the minus 200-mesh fraction of the tailings, i.e., this jig also could not recover the fine sizes of the tungsten-bearing minerals present in the minus 10-mesh crushed ore. As a result, the tailings from this jig were separated into plus 200- and minus 200-mesh fractions and the latter combined with the hutch products to form the final pre-concentrate.

The results of these tests are recorded in Table 26.

TABLE 26

Jigging Results From Duplex Mineral Jig

Ore Sample: Shipment No. 1

Test No., Stroke and Feed Rate	Products	% Weight	% WO_3	
			Assays	Distn
DJ-1	Hutch No. 1	34.6	2.53	73.9
Stroke: 3/16 in.	Hutch No. 2	4.2	0.44	1.5
	Jig tail, -200 m	23.7	0.99	19.9
600 lb/hr	Pre-concentrate	62.5	1.80	95.3
	Jig tail, +200 m	37.5	0.15	4.7
	Head (calcd)	100.0	1.25	100.0
DJ-2	Hutch No. 1	31.5	2.64	66.1
Stroke: 1/4 in.	Hutch No. 2	8.3	0.39	3.3
	Jig tail, -200 m	18.7	1.15	21.8
600 lb/hr	Pre-concentrate	58.5	1.53	91.2
	Jig tail, +200 m	41.5	0.21	8.8
	Head (calcd)	100.0	0.98	100.0
DJ-3	Hutch No. 1	19.7	4.81	68.1
Stroke: 1/4 in.	Hutch No. 2	4.3	0.96	2.9
	Jig tail, -200 m	23.1	1.27	21.0
800 lb/hr	Pre-concentrate	47.1	2.72	92.0
	Jig tail, +200 m	52.9	0.21	8.0
	Head (calcd)	100.0	1.39	100.0
DJ-5	Hutch No. 1 + No. 2	23.5	2.67	54.5
Stroke: 1/4 in.	Jig tail, -200 m	22.5	1.82	35.5
950 lb/hr	Pre-concentrate	46.0	2.26	90.0
	Jig tail, +200 m	54.0	0.21	10.0
	Head (calcd)	100.0	1.15	100.0
DJ-4	Hutch No. 1	10.6	4.21	44.9
Stroke: 1/4 in.	Hutch No. 2	12.4	1.34	16.7
	Jig tail, -200 m	22.5	1.19	27.0
1000 lb/hr	Pre-concentrate	45.5	1.93	88.6
	Jig tail, +200 m	54.5	0.21	11.4
	Head (calcd)	100.0	0.99	100.0

(e) Flotation and Tabling of Pre-concentrates from Duplex Mineral Jig

In a flotation and tabling test carried out on a pre-concentrate produced by Duplex Mineral jig, the secondary middlings were ground in a separate circuit and returned to flotation, i.e., the jig pre-concentrate and middling were treated as produced. As in the other tests, the minus 200-mesh fraction of the flotation tailing was tabled on a laboratory-size slime deck because an operating-size slime deck was not available.

Detailed results of this test are recorded in Table 27 and summarized in Table 28.

TABLE 27

Flotation and Tabling Results - Test DJF-10

Feed: Pre-concentrate from Duplex Mineral Jig

Type of Jig and Test No.	Flotation and Tabling Products	% Weight	% WO_3	
			Assays	Distn
Duplex Mineral Jig	Sulphide cl conc	4.25	1.13	4.8
DJF-10	Prim cl conc	0.26	72.47	19.9
	" " midds	0.38	13.69	5.2
	" " tails	0.46	1.91	0.8
	Sec cl conc + midds	0.40	57.0	23.0
	" " tails	0.37	6.02	2.2
	Prim and sec ro tails	17.35	0.21	3.6
	Slime deck ro conc	0.15	66.6	10.1
	" " " midds	0.38	15.5	5.8
	" " " tails	27.00	5.40	14.3
	Pre-concentrate	51.00	1.74	89.7
	Jig tails, +200 mesh	49.00	0.21	10.3
	Head (Shipment No. 1)	100.0	0.996	100.0

TABLE 28

Summary of Results of Test DJF-10 from Table 27

Type of Jig and Test No.	Flotation and Tabling Products	% Weight	% WO_3	
			Assays	Distn
Duplex Mineral Jig DJF-10	Sulphide cl conc	4.25	1.13	4.8
	Prim cl conc, sec cl conc and slime deck ro conc	0.81	64.90	53.0
	Prim cl midds + slime deck midds	0.76	14.86	11.0
	Prim + sec cl tails	0.83	3.74	3.0
	Prim + sec ro tails	17.35	0.21	3.6
	Slime deck ro tails	27.00	5.40	14.3
	Pre-concentrate	51.00	1.74	89.7
	Jig tails (+200 mesh)	49.00	0.21	10.3
	Head (Shipment No. 1)	100.00	0.996	100.0

An additional 7 to 8% of WO_3 in the ore can be recovered from the cleaner middlings and slime-deck middlings as indicated in "Treatment of Middlings". This would result in about 61% tungsten recovery from the ore at a grade of about 64% WO_3.

(f) Final Tungsten Concentrates

The average pre-concentrates from the best tests with Remer and Duplex Mineral jigs (Table 13, 14, 15, 18, 19 and 26) comprized about 60% by weight of the ore with an average recovery of about 94% of the WO_3 in the ore.

Calculated final tungsten concentrates from the summarized results of the tungsten concentrates from Table 22, Table 27 and the tungsten recovery from secondary middling - Table 24 are recorded in Table 29.

TABLE 29

Final Tungsten Concentrates

Test No.	Products	% Weight in pre-conc	% WO_3		
			Assays	Distribution	
				In pre-conc	In ore
RJF-11	Prim, sec + sl deck conc	1.76	68.45	58.7	55.2
	Tungsten conc from midds	0.20	62.00	4.3	4.5
	Final tungsten conc	1.96	67.80	63.0	59.7
RJF-9	Prim, sec + sl deck conc	1.50	65.40	58.5	54.8
	Tungsten conc from midds	0.17	62.00	6.2	5.8
	Final tungsten conc	1.67	64.50	64.7	60.6
RJF-6	Prim, sec + sl deck conc	1.13	66.00	63.9	60.0
	Tungsten conc from midds	0.26	62.00	9.6	9.0
	Final tungsten conc	1.39	65.10	73.5	69.0
DJF-10	Prim, sec + sl deck conc	0.81	64.90	53.0	49.8
	Tungsten conc from midds	0.13	62.00	7.7	7.2
	Final tungsten conc	0.94	64.20	60.7	57.0

(g) Preparation of Separate Scheelite and Wolframite Concentrates by High-Intensity Magnetic Separation

Although mineralogical examination of the previous ore samples from this property showed that a considerable amount of scheelite and wolframite are finely intergrown even at micron sizes, it was decided to treat a combined scheelite-wolframite concentrate with Jones high-intensity magnetic separator to obtain a separate wolframite and a separate scheelite concentrates. As scheelite is not magnetic and wolframite is slightly magnetic in a strong magnetic field (over 10 amperes on the Jones separator), the Jones magnetic concentrate at 15 amperes would contain most of the wolframite (black) and Jones tailing would become the scheelite concentrate (creamish white). The Jones middlings would contain mainly locked scheelite-wolframite particles. The material for this test was composed of several combined scheelite-wolframite concentrates produced during the pilot plant operation. These concentrates, containing between 55 and 72% WO_3 were mixed and treated with the Jones separator at 15 amperes. The results are recorded in the following Table 30.

TABLE 30

Separation of Combined Scheelite-Wolframite Concentrate into Two Separate Concentrates

Product	% Weight	% WO_3	
		Assays	Distn
Wolframite conc	24.2	70.11	25.9
Scheelite-Wolframite midds	33.8	63.55	34.0
Scheelite conc	42.0	60.47	40.1
Scheelite-Wolframite conc combined (Jones feed)	100.0	63.20	100.0

CONCLUSIONS

Jigging of 10-mesh crushed or ground ore containing about 1% WO_3 using a Remer jig or a Duplex Mineral jig produced pre-concentrates which comprized 44 to 73% of the ore by weight and recovered between 90 and 97% of the WO_3 in the ore.

A final tungsten concentrate of about 65% WO_3 grade (scheelite-wolframite combined) were obtained from these pre-concentrates by grinding the pre-concentrates to about minus 48 mesh, removing sulphides by flotation, followed by a primary and secondary tabling of the sized flotation tailings. An additional recovery of a high-grade tungsten concentrate was obtained by re-grinding and re-treating middlings from the secondary tabling. The results of best final concentrates obtained were as follows:

Approx % Weight of ore	% WO_3 Assays	% WO_3 Recovery from ore
1.25	63.0	59.7
1.25	64.7	60.6
1.25	65.1	69.0
0.94	64.2	57.0

With gradual improvement in the operation, particularly in grinding circuits to minimize production of fines and by the use of an additional slime deck, a slightly higher tungsten recovery would be realized from processing the Grey River ore.

/ms

APPENDIX

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- 4

COMPANY ASARCO - Grey River Property

SAMPLE Sample (B)

JIG: 1 - Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	250 RPM	
Stroke	1/4 inch	
Ragging		
Type	Steel balls	Steel balls
Size	3/8 inch	3/16 inch
Weight	60 grams	31 grams

Supporting Screen: 8 mesh

Water:

Top	400 cc/min
Bottom	800 cc/min

Feed Rate : 40 grams/min

PRODUCT:	% Weight
Hutch	32.0
Tail, - 200 mesh	10.0
+ 200 mesh	36.1
Bed	21.9
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR-5

COMPANY ASARCO - Grey River Property

SAMPLE Sample (B)

JIG: 1 - M Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	250 RPM	
Stroke	1/4 inch	
Ragging		
Type	Steel balls	Steel balls
Size	3/8 inch	3/16 inch
Weight	60 grams	45 grams

Supporting Screen: 8 mesh

Water:

Top	400 cc/min
Bottom	800 cc/min

Feed Rate: 40 grams/min

PRODUCT:

	% Weight
Hutch	17.2
Tail, - 200 mesh	12.7
+ 200 mesh	62.1
Bed	8.0
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- 6

COMPANY ASARCO - Grey River Property

SAMPLE Sample (C)

JIG: 1 - M Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	250 RPM	
Stroke	1/4 inch	
Ragging		
Type	Steel balls	Steel balls
Size	3/16 inch	3/16 inch
Weight	60 grams	45 grams

Supporting Screen: 8 mesh

Water:

Top	400 cc/min
Bottom	800 cc/min

Feed Rate: 40 grams/min

PRODUCT:	% Weight
Hutch	21.6
Tail, - 200 mesh	9.4
+ 200 mesh	60.6
Bed	8.5
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- 7

COMPANY ASARCO - Grey River Property

SAMPLE Sample (C)

JIG: 1 - M Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	250 RPM	
Stroke	1/4 inch	
Ragging		
Type	Steel balls	Steel balls
Size	3/61 inch	3/16 inch
Weight	60 grams	45 grams

Supporting Screen: 8 mesh

Water:

Top	400 cc/min
Bottom	800 cc/min

Feed Rate: 40 grams/min

PRODUCT:	% Weight
Hutch	25.5
Tail, - 200 mesh	9.6
+ 200 mesh	51.9
Bed	13.0
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- A

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Sample (One drum - high grade)

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	330 RPM	
Stroke	3/16 inch	
Ragging		
Type	Steel balls	Quartz
Size	3/16 inch	+8 mesh
Weight	2200 grams	1250 grams

Supporting Screen: 2-mm wedge bars

Water:

Top	600 cc/min
Bottom	2260 cc/min
Feed Rate:	10 lb/hr

PRODUCT:	% Weight
Hutch	15.9
Tail, - 200 mesh	7.4
+ 200 mesh	63.7
Bed	13.0
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- B

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Sample (One drum - high grade)

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	330 RPM	
Stroke	3/16 inch	
Ragging		
Type	Steel balls	Quartz
Size	3/16 inch	+8 mesh
Weight	2200 grams	105 grams

Supporting Screen: 2-mm wedge bars

Water:

Top	400	cc/min
Bottom	2260	cc/min

Feed Rate: 75 lb/hr

PRODUCT:	% Weight
Hutch	13.8
Tail, - 200 mesh	8.5
+ 200 mesh	69.4
Bed	8.3
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- C

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Sample (One drum - high grade)

JIG: 4-inch x 6-inch Denver Laboratory jig

OPERATING CONDITIONS:

Speed 330 RPM

Stroke 3/16 inch

Ragging

Type	Steel balls	Steel balls
Size	3/16 inch	1/4 inch
Weight	1400 grams	800 grams

Supporting Screen: 2-mm wedge bars

Water:

Top 600 cc/min

Bottom 2260 cc/min

Feed Rate: 75 lb/hr

PRODUCT:	% Weight
Hutch	13.6
Tail, - 200 mesh	11.0
+ 200 mesh	66.1
Bed	9.3
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- D

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Sample (One drum - high grade)

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	330 RPM
Stroke	3/16 inch

Ragging

Type	Steel balls	Steel balls
Size	3/16 inch	1/4 inch
Weight	1000 grams	1000 grams

Supporting Screen: 2-mm wedge bars

Water:

Top	600	cc/min
Bottom	2260	cc/min

Feed Rate: 75 lb/hr

PRODUCT:

	% Weight
Hutch	18.0
Tail, - 200 mesh	11.2
+ 200 mesh	61.4
Bed	9.4
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- E

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Sample (One drum - high grade)

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed 330 RPM

Stroke 3/8 inch

Ragging

Type	Steel balls	Steel balls
Size	3/16 inch	1/4 inch
Weight	1000 grams	1000 grams

Supporting Screen: 2-mm wedge bars

Water:

Top	600	cc/min
Bottom	2200	cc/min

Feed Rate: 75 lb/hr

PRODUCT:

	% Weight
Hutch	18.2
Tail, - 200 mesh	12.0
+ 200 mesh	61.0
Bed	8.8
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- F

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Shipment No. 1, -10 mesh, laboratory crushing

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed	330 RPM
Stroke	1/4 inch

Ragging

Type	Steel balls	Steel balls
Size	1/4 inch	3/16 inch
Weight	1000 grams	800 grams

Supporting Screen: 2-mm wedge bars

Water:

Top	2500 cc/min
Bottom	2260 cc/min

Feed Rate: 75 lb/hr

PRODUCT:	% Weight
Hutch	49.2
Tail, - 200 mesh	4.5
+ 200 mesh	38.0
Bed	8.3
Total	100.0

JIG TEST REPORT - LABORATORY JIGGING

Test No. GR- 8

COMPANY ASARCO - Grey River Property

SAMPLE Pilot Plant Shipment No. 1, -10 mesh, Pilot-Plant dry crushing

JIG: 4-inch x 6-inch Denver Laboratory Jig

OPERATING CONDITIONS:

Speed 330 RPM

Stroke 3/16 inch

Ragging

Type	Steel balls	Steel balls
Size	3/16 inch	1700 grams
Weight	1/4 inch	300 grams

Supporting Screen: 2-mm wedge bars

Water:

Top 800 cc/min

Bottom 2260 cc/min

Feed Rate: 75 lb/hr

PRODUCT:	% Weight
Hutch	31.3
Tail, - 200 mesh	14.3
+ 200 mesh	45.7
Bed	8.7
Total	100.0

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ-1 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 160 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	8	8	5	5
Water - US gal/min:				
Top - 2.0				
To Hutch -	3.8	4.0	6.0	7.7

Feed Rate: 1900 lb /hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	56.7		56.7	
2				
3				
4				
Tail, - 200 mesh		16.6	16.6	
+ 200 mesh		26.7	-	26.7
Total	56.7	43.3	73.3	26.7

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 3 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 160 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	8	8	5	5
Water - US gal/min:				
Top - 2.0	3.0	3.5	5.9	7.6
To Hutch -				

Feed Rate: 1800 lb /hr

PRODUCT: % Weight in Ore

	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1, 2, 3, 4	45.5		45.5	
Tail, - 200 mesh		8.5	8.5	
+ 200 mesh		46.0	-	46.0
Total	45.5	54.5	54.0	46.0

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 4 SAMPLE: P.P. Shipment No. 1, -10 mesh (ground)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 160 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb. - 1/4 in.	10	10	10	10
- 3/16 in.	8	8	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	3.0	3.5	6.0	7.7

Feed Rate: Approx. 2100 dry lb /hr
(Approx. 2600 wet)

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	19.6		19.6	
2	10.0		10.0	
3	7.9		7.9	
4	5.5		-	5.5
Tail, - 200 mesh		6.8	6.8	-
+ 200 mesh		50.2	-	50.2
Total	43.0	57.0	44.3	55.7

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 5 SAMPLE: P.P. Shipment No. 1, -10 mesh (ground)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 180 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	3.0	3.5	6.0	7.5

Feed Rate: Approx 2100 dry lb /hr as filter cake*

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	9.7		9.7	
2	5.0		5.0	
3	8.8		8.8	
4	4.6		4.6	
Tail, - 200 mesh		10.3	10.3	
+ 200 mesh		61.6	-	61.6
Total	28.1	71.9	38.4	61.6

* Feeding difficulties.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ-6 SAMPLE: P.P. Shipment No. 1, - 10 mesh (ground)*

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 190 RPM

Stroke - 3/16 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb. - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	nil	2.2	8.7	11.6

Feed Rate: Approx 2100 dry lb /hr as filter cake
(Approx 2600 wet)

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	4.7		4.7	
2	7.8		7.8	
3	4.0		4.0	
4	1.7		1.7	
Tail, - 200 mesh		7.4	7.4	
+ 200 mesh		63.3		63.3
Total	18.2	70.7	25.6	63.3

* Deslimed by two-stage cyclones:
Second cyclone o'flow and u'flow had 6.9 and 4.2% weights respectively.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 7 SAMPLE: P.P. Shipment No. 1, -10 mesh (ground)*

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 190 RPM

Stroke - 3/16 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	nil	2.2	8.7	11.6

Feed Rate: Approx 2100 dry lb /hr as filter cake

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	12.7		12.7	
2	11.0		11.0	
3	4.1		4.1	
4	1.4		-	
Tail, - 200 mesh		9.6	9.6	1.4
+ 200 mesh		48.2	-	48.2
Total	29.2	57.8	37.4	49.6

*Deslimed by two-stage cyclones:
2nd cyclone o'flow and u'flow had 5.5 and 7.5% weights respectively.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ-8 SAMPLE: P.P. Shipment No. 1, -10 mesh (ground)*

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1½ in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 200 RPM

Stroke - 3/16 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	nil	2.4	8.9	10.8

Feed Rate: Approx 2300 dry lb /hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	3.4		3.4	
2	11.7		11.7	
3	6.8		6.8	
4	2.1		-	2.1
Tail, - 200 mesh		9.0	9.0	-
+ 200 mesh		54.0	-	54.0
Total	24.0	63.0	30.9	56.1

* Deslimed by two-stage cyclones:
2nd cyclone o'flow and u'flow had 5.6 and 7.4% weights respectively.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 9 SAMPLE: P.P. Shipment No. 1, -10 mesh (ground)*

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1½ in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 200 RPM

Stroke - 3/16 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2 + 1 = 3				
To Hutch -	nil	nil	6.8	7.6

Feed Rate: 2550 dry lb./hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	7.5		7.5	
2	14.8		14.8	
3	5.9		-	5.9
4	1.0		-	1.0
Tail, - 200 mesh		11.3	11.3	-
+ 200 mesh		46.3	-	46.3
Total	29.2	57.6	33.6	53.2

*Ground finer than usual and deslimed by one-stage cyclone: % weight = 13.2.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 12 SAMPLE: P.P. Shipment No. 1, -8 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1/2 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 165 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type: *	Steel balls			
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	13	13	5	5
Water - US gal/min:				
Top - 2.0				
To Hutch -	3.5	4.1	6.8	7.8

Feed Rate: 1000 lb /hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	4.1		4.1	
2	14.5		14.5	
3	19.9		19.9	
4	4.5		4.5	
Tail, - 200 mesh		23.4	23.4	
+ 200 mesh		33.6	-	33.6
Total	43.0	57.0	66.4	33.6

* Small amount of ilmenite (-3/8" + 1/2 inch) in each hutch together with steel balls.

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 13 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1/2 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 165 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	10	10	10	10
Water - US gal/min:				
Top - 2.4				
To Hutch -	1.4	3.2	5.4	10.8

Feed Rate: 480 dry lb /hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	9.0		9.0	
2	25.0		25.0	
3	15.9		15.9	
4	5.1		5.1	
Tail, - 200 mesh		15.8		
+ 200 mesh		29.2	-	29.2
Total	55.0	45.0	70.8	29.2

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ - 14 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1/2 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 165 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:	Steel balls			
Weight, lb - 1/4 in.	10	10	10	10
- 3/16 in.	10	10	10	10
Water - US gal/min:				
Top - 2.4				
To Hutch -	1.4	3.2	5.4	10.8

Feed Rate: 1000 dry lb /hr

PRODUCT: % Weight in Ore

	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	27.7		27.7	
2				
3	13.4		13.4	
4	4.2		4.2	
Tail, - 200 mesh		10.7	10.7	
+ 200 mesh		44.0	-	44.0
Total	45.3	54.7	56.0	44.0

JIG TEST REPORT - PILOT-PLANT JIGGING

TEST NO: RJ-15 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 1-ft x 3-ft Wemco Remer Jig

OPERATING CONDITIONS:

Slope of jig - 1/2 in/ft

Supporting screen - 3/16 inch

Height of check boards - 3 inch

Primary eccentric: Speed - 165 RPM

Stroke - 3/8 inch

Secondary eccentric: Speed - 490 RPM

	Hutch 1,	Hutch 2,	Hutch 3,	Hutch 4.
Ragging:				
Type:		Steel	balls	
Weight, lb: - 1/4 in.	10	10	10	10
- 3/16 in.	10	10	10	10
Water - US gal/min:				
Top - 2.4				
To Hutch -	1.4	3.2	5.4	10.8

Feed Rate: 1500 dry lb /hr

PRODUCT:

	% Weight in Ore			
	Hutch Prod.	Tail	Pre-conc	Final Tail
Hutch 1	23.9		23.9	
2				
3	11.1		11.1	
4	5.5		5.5	
Tail, - 200 mesh		20.1	20.1	
+ 200 mesh		39.4	-	39.4
Total	40.5	59.5	60.6	39.4

JIG TEST REPORT - PILOT-PLANT JIGGING

Test No. DJ- 1 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 8-in x 12-in Denver Duplex Mineral Jig

OPERATING CONDITIONS:

Speed	Standard (fixed)	
Stroke	3/16 inch	
Ragging	Hutch No. 1	Hutch No. 2
Type	Samson shots	
Size	1/4 inch and 3/16 inch, mixed	
Weight	18 lb	18 lb

Supporting Screen: 2-mm wedge bars

Water: US gal/min

Top	2.6
Bottom	6.6

Feed Rate: 600 lb /hr

PRODUCT:	% Weight
Hutch No. 1	34.6
Hutch No. 2	4.2
Tail, - 200 mesh	23.7
+ 200 mesh	37.5
Total	100.0

JIG TEST REPORT - PILOT-PLANT JIGGING

Test No. DJ- 2 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 8-in x 12-in Denver Duplex Mineral Jig

OPERATING CONDITIONS:

Speed	Standard (fixed)	
Stroke	1/4 inch	
Ragging	Hutch No. 1	Hutch No. 2
Type	Samson shots	
Size	1/4 inch and 3/16 inch, mixed	
Weight	18 lb	18 lb

Supporting Screen: 2-mm wedge bars

Water: US gal/min

Top	2.0
Bottom	6.6

Feed Rate: 600 lb /hr

PRODUCT:	% Weight
Hutch No. 1	31.5
Hutch No. 2	8.3
Tail, - 200 mesh	18.7
+ 200 mesh	41.5
Total	100.0

JIG TEST REPORT - PILOT-PLANT JIGGING

Test No. DJ- 3 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 8-in x 12-in Denver Duplex Mineral Jig

OPERATING CONDITIONS:

Speed	Standard (fixed)	
Stroke	1/4 inch	
Ragging	Hutch No. 1	Hutch No. 2
Type	Samson shots	
Size	1/4 inch and 3/16 inch, mixed	
Weight	18 lb	18 lb

Supporting Screen: 2-mm wedge bars

Water: US gal/min

Top	1.2
Bottom	6.5

Feed Rate: 800 lb /hr

PRODUCT:	% Weight
Hutch No. 1	19.7
Hutch No. 2	4.3
Tail, - 200 mesh	23.1
+ 200 mesh	52.9
Total	100.0

JIG TEST REPORT - PILOT-PLANT JIGGING

Test No. DJ- 4 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 8-in x 12-in Denver Duplex Mineral Jig

OPERATING CONDITIONS:

Speed	Standard (fixed)	
Stroke	1/4 inch	
Ragging	Hutch No. 1	Hutch No. 2
Type	Samson shots	
Size	1/4 inch and 3/16 inch, mixed	
Weight	18 lb	18 lb

Supporting Screen: 2-mm wedge bars

Water: US gal/min

Top	1.7
Bottom	5.5

Feed Rate: 960 lb/hr

PRODUCT:	% Weight
Hutch No. 1	10.6
Hutch No. 2	12.4
Tail, - 200 mesh	22.5
+ 200 mesh	54.5
Total	100.0

JIG TEST REPORT - PILOT-PLANT JIGGING

Test No. DJ- 5 SAMPLE: P.P. Shipment No. 1, -10 mesh (dry)

COMPANY: ASARCO - Grey River Property

JIG: 8-in x 12-in Denver Duplex Mineral Jig

OPERATING CONDITIONS:

Speed	Standard (fixed)	
Stroke	1/4 inch	
Ragging	Hutch No. 1	Hutch No. 2
Type	Samson shots	
Size	1/4 inch and 3/16 inch, mixed	
Weight	18 lb	18 lb

Supporting Screen: 2-mm wedge bars

Water: US gal/min

Top	1.7
Bottom	5.5

Feed Rate: 900 lb/hr

PRODUCT:	% Weight
Hutch No. 1	23.5
Hutch No. 2	
Tail, - 200 mesh	22.5
+ 200 mesh	54.0
Total	100.0