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CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 66-77

UPGRADING SILVER CONCENTRATES FROM COBALT REFINERY LIMITED, COBALT, ONTARIO

by

A. J. BOISONNAULT

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Pilot plant investigations on two samples of high grade silver table concentrates produced five grades of product. One of the products from each test, containing between 53 and 66 percent of the silver, was suitable for direct treatment in the silver refinery. The treatment of these fractions could result in more efficient operation and a quicker return of a considerable percentage of the silver.

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INTRODUCTION

Most of the silver concentrates, both gravity and flotation, produced in the Cobalt area of Ontario are shipped to Cobalt Refinery Ltd. These concentrates contain large amounts of sulphide and gangue minerals and are not of a high enough silver grade for direct treatment in the silver refinery. It is necessary to employ a costly initial treatment including electric furnace smelting and chemical extraction before treatment in the silver refinery.

Purpose of Investigation

Mr. J.N. Cram, Vice President and General Manager of Cobalt Refinery Ltd., wished to determine the feasibility of using conventional mineral processing methods to produce, from purchased table concentrates, a high grade silver concentrate suitable for direct silver refining.

In a letter dated January 27, 1966 to Dr. John Convey, Mr. Cram requested the use of the Mines Branch facilities to corroborate the results of laboratory investigations carried out by Mr. Ramon Champetier at Cobalt Refinery Ltd.

Shipment

Five drums containing approximately two tons of table concentrate were received at the Mines Branch on January 31, 1966. Approximately one ton of Silverfield table concentrate and one ton of Agnico table concentrate were received on March 21, 1966.

The head sample analyses of the shipments are given in Table No. 1.

TABLE NO. 1

Analyses of Table Concentrates

Element	Composite Sample	Langis Silver Mines	Hi Ho Silver Mines	Silverfield Silver Mines
Silver	1980 oz/ton	1114 oz/ton	2822 oz/ton	2304 oz/ton
Cobalt	8.6 %	5.4 %	8.5 %	9.3 %
Arsenic	35.4 %	21.9 %	35.2 %	39.5 %
Iron	10.0 %	14.6 %	7.2 %	10.2 %
Sulphur	8.0 %	10.2 %	3.5 %	10.2 %
Nickel	3.1 %	1.4 %	3.5 %	2.4 %
Copper	0.4 %	0.42 %	0.24 %	0.50 %

OUTLINE OF INVESTIGATIONAL PROCEDURE

Laboratory investigations had been carried out in Cobalt so the present project consisted of four pilot plant runs comprised of screening, grinding, gravity concentration by means of shaking tables and flotation. The mill feed used in the first two mill runs was a composite sample of concentrate from various mills in the Cobalt area. These two tests were of an exploratory nature with inconclusive results. However, the experience and information gained led to the third and fourth tests which confirmed the laboratory findings.

The material used in the third test run was a composite sample from the Silverfield mine. A sample of Agnico mine concentrate was treated in the fourth test run.

Equipment Used

1. One No. 12 Rotex screening machine
2. One Sweco 30 inch double deck separator
3. One Hardinge universal test rod-ball mill 20" x 30" with 500 pounds 1" to 1 1/2" steel balls
4. One Deister No. 15-S diagonal deck concentrating table
5. One standard size Wilfley concentrating table

6. One Denver 12" x 18" conditioner
7. Four Denver No. 7 flotation cells
8. Five Denver No. 5 flotation cells
9. Feeders, pumps, holding tanks etc.

DETAILS OF INVESTIGATION

Mill Run No. 1

Sixteen hundred and thirty-four pounds of composited table concentrate was screened on a Rotex screen fitted with an 80 mesh Tyler wire cloth. The minus 80 mesh material was stockpiled for later treatment. The plus 80 mesh fraction was fed to the ball mill at a rate of 350 pounds per hour. Water was added at a rate to give a ball mill pulp discharge of 50-60% solids. The ball mill discharge was pumped to the Sweco separator which was fitted with 60 and 80 mesh screens. Sufficient water was added to allow wet screening.

The plus 60 mesh fraction and the minus 60 plus 80 mesh fraction were collected individually in tubs to determine if coarse silver flakes were retained at these sizes. These fractions were combined later, and tabled to produce a concentrate and tailing. These products were collected, dried and sampled for assay.

When all the plus 80 mesh material had been fed to the ball mill, the mill run was continued with the minus 80 mesh material. This minus 80 mesh material was fed directly to the Sweco separator, by-passing the ball mill. All other treatment was the same.

The minus 80 mesh underflow from the Sweco separator was pumped to a Deister table on which a concentrate and tailing were produced. These products were collected in holding tanks and tubs.

The Deister concentrate was fed from a Pulva disc feeder to a Denver 12" x 18" conditioner at a rate of 360 pounds per hour at 20-25% solids which overflowed to a No. 7 Denver flotation cell where a concentrate and tailing were collected for analysis.

A 200 pound portion of the Deister tailing was passed over a standard Wilfley concentrating table at a rate of 400 pounds per hour at 20-25% solids. A concentrate, middling and tailing were collected for analysis.

The remaining Deister table tailing was fed at a rate of 360 pounds per hour at 25-30% solids to a Denver 12" x 18" conditioner which overflowed to four No. 7 Denver flotation cells. The first cell produced a silver concentrate, the second cell an iron concentrate and the last two a cobalt concentrate.

The desired pH was not attained during flotation because the acid being used was too dilute and the feed had been run through the circuit before the correct pH could be achieved. The material still in the conditioner and flotation cells at the end of the run was not removed but was left in place for Mill Run No. 2. Estimated weight was 125 pounds.

The ball mill was operated for one hour after all the ore had been fed to the mill. At the end of this hour, the material remaining in the mill was screened on a 60 mesh screen and the plus and minus 60 mesh fractions were dried and assayed.

Figure 1 shows the flowsheet used in Mill Run No. 1. The reagents used and conditions are shown in Table No. 2 and the results obtained are shown in Table No. 3.

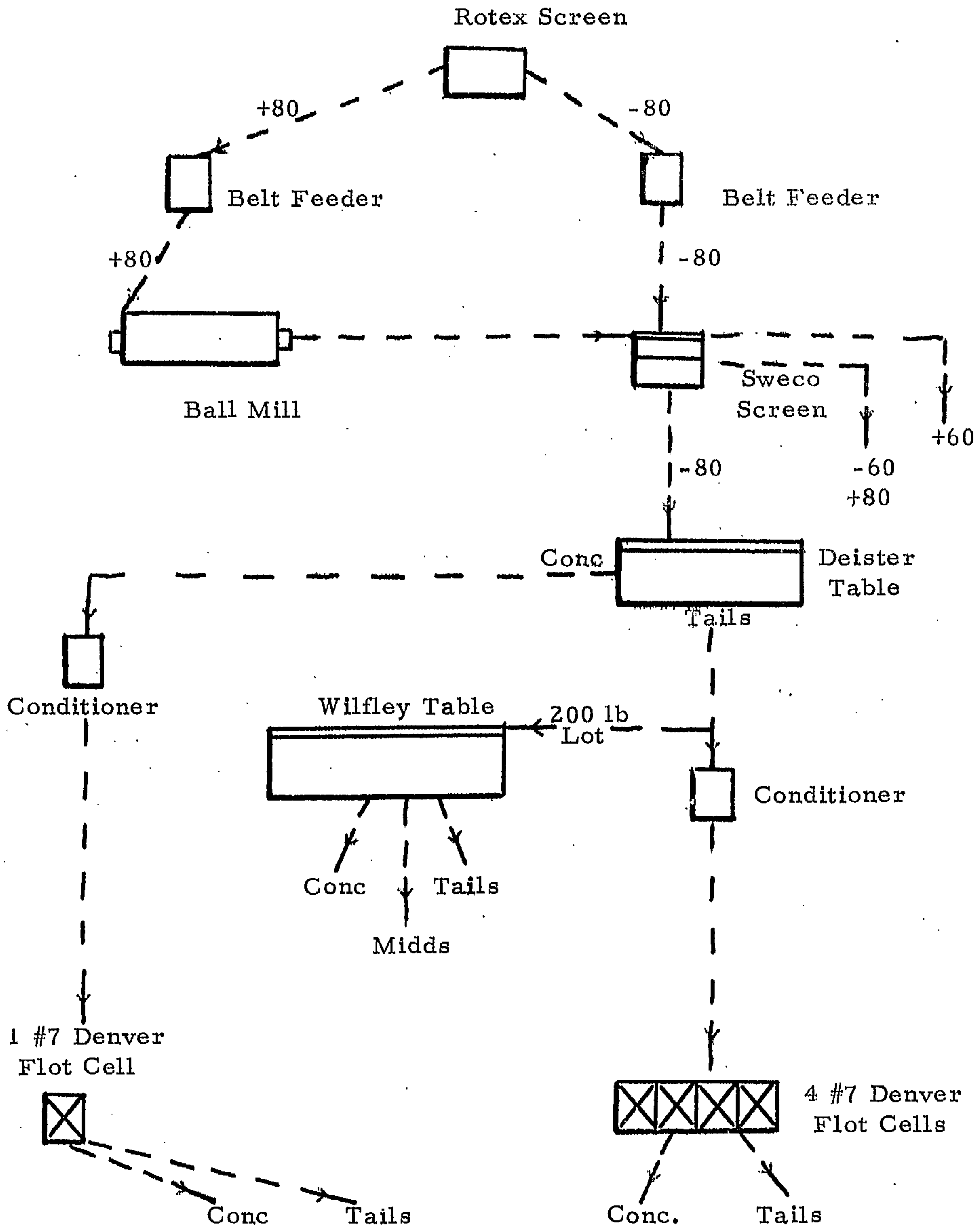

Figure 1. Flowsheet for Mill Run No. 1

TABLE NO. 2

Reagents and Conditions for Mill Run No. 1

Material	Operation	Reagent	pH	lb/ton of Feed
Deister	Conditioner	Lime	11	1.50
Conc		Cyanide		0.375
	Flot Cell	Aerofroth 60	11	0.05
		Z6		0.450
Deister	Conditioner	Lime	11	1.50
Tails		Cyanide		0.375
	1st Flot Cell	Aerofroth 60	11	0.05
		Z6		0.450
	2nd Flot Cell	Acetic Acid	6	10.50
	3rd Flot Cell	Sulphuric Acid	5	9.00
	4th Flot Cell		5	

TABLE NO. 3

Results of Pilot Plant Run No. 1

Grinding

Product	Weight %	Assays Ag oz/ton	Co %	Fe %	Distribution % Ag	Co	Fe
Metallics	12.5	10,278	10.50	6.8	45.7	13.0	8.7
Sweco -80M	75.3	1,195	10.60	10.7	37.3	79.2	82.6
Sweco +80M	12.2	3,362	6.48	6.9	17.0	7.8	8.7
Mill Feed	100.0	2,595	10.08	9.7	100.0	100.0	100.0

Product	Weight % This Test	Weight % Total	Assays oz/ton Ag	Assays % Co	Assays % Fe	Distribution % This Test Ag	This Test Co	This Test Fe	Total Ag	Total Co	Total Fe
Metallics Screened											
+60 Mesh	88.0	11.0	10,800	-	-	95.0	-	-	43.4	-	-
-60+80M	12.0	1.5	6,450	-	-	5.0	-	-	2.3	-	-
Metallics	100.0	12.5	10,278	10.5	6.8	100.0	-	-	45.7	13.0	8.7
+80 Mesh Tabled											
Conc	51.7	6.3	6,116	10.3	8.6	93.8	82.0	64.4	16.0	6.4	5.6
Tails	48.3	5.9	422	2.4	5.0	6.2	18.0	35.6	1.0	1.4	3.1
Sweco+80M	100.0	12.2	3,362	6.5	6.9	100.0	100.0	100.0	17.0	7.8	8.7
-80 Mesh Tabled											
Conc	44.0	33.2	1,783	14.27	10.0	65.9	59.6	41.5	24.6	47.2	34.3
Tails #1	23.0	17.3	656	7.84	11.5	12.9	16.9	24.6	4.8	13.4	20.3
Tails #2	33.0	24.8	784	7.60	11.0	21.2	23.5	33.9	7.9	18.6	28.0
Sweco-80M	100.0	75.3	1,195	10.60	10.7	100.0	100.0	100.0	37.3	79.2	82.6
Flotation of -80 Mesh Table Conc											
Conc	13.6	4.5	9,044	8.0	8.0	68.8	7.6	10.8	16.9	3.6	3.7
Cell Cleanings	11.1	3.7	1,892	14.3	9.4	11.8	11.0	10.5	2.9	5.2	3.6
Tails	75.3	25.0	460	15.4	10.5	19.4	81.4	78.7	4.8	38.4	27.0
Conc	100.0	33.2	1,783	14.3	10.0	100.0	100.0	100.0	24.6	47.2	34.3
Retabling of -80 Mesh Table Tails No. 1											
Conc	17.3	3.0	1,240	12.5	9.6	31.5	27.6	14.3	1.5	3.7	2.9
Midds	67.1	11.6	638	8.1	13.2	66.4	69.4	77.4	3.2	9.3	15.7
Tails	15.6	2.7	85	1.6	6.1	2.1	3.0	8.3	0.1	0.4	1.7
No. 1 Tails	100.0	17.3	656	7.8	11.5	100.0	100.0	100.0	4.8	13.4	20.3
Flotation of -80 Mesh Deister Table Tails No. 2											
No. 1 Cell Conc	21.0	5.2	2,216	7.3	12.5	60.7	19.9	23.9	4.8	3.7	6.7
No. 2 Cell Conc	3.0	0.7	4,000			13.4			1.1		
No. 3 Cell Conc	0.7	0.2	262	8.1	10.0	0.3	13.4	11.5	0.0	2.5	3.2
No. 4 Cell Conc	8.9	2.2	1,520			17.4			1.4		
Tails	66.4	16.5	95	7.6	10.7	8.2	66.7	64.6	0.6	12.4	18.1
No. 2 Tails	100.0	24.8	784	7.6	11.0	100.0	100.0	100.0	7.9	18.6	28.0

Mill Run No. 2

Two thousand three hundred and sixty-four pounds of the composite table concentrate was fed at a rate of 360 pounds per hour to a Sweco separator fitted with a 60 mesh wire cloth. The plus 60 mesh fraction was fed to the ball mill. Water was added to give a ball mill pulp discharge density of 50-60% solids. Water was also added to the mill discharge which was pumped back to the 60 mesh Sweco separator to close the grinding circuit.

The minus 60 mesh fraction from the Sweco separator was fed to a Deister table which made a concentrate and a tailing. The tailing was pumped to a Wilfley table where a concentrate, a middling and a tailing were collected.

The Deister concentrate was fed at a rate of 360 pounds per hour and 25-30% solids to a conditioner and a No. 7 Denver flotation cell. A concentrate and a tailing were collected, dried and analysed. The Wilfley table concentrate was fed at a rate of 360 pounds per hour and 25-30% solids to a conditioner and a No. 7 Denver flotation cell. The concentrate was cleaned in a No. 7 cell to produce a cleaner concentrate and a cleaner tailing.

The Wilfley tailing was given no further treatment and was collected, dried and analysed.

The Wilfley middlings were fed from a Pulva disc feeder at a rate of 360 pounds per hour at 25-30% solids to a conditioner and four No. 7 flotation cells with the first cell producing a silver concentrate, the second cell an iron concentrate and the third and fourth cells a cobalt concentrate. The desired pH was not attained so the flotation tailings were re-run through number 2, 3 and 4 cells with stronger acid. The desired pH was still not attained.

The ball mill was operated for two hours after the feed was finished. At the end of this period the material remaining in the mill was screened on a 200 mesh screen. The plus and minus fractions were dried and assayed.

Figure No. 2 shows the flowsheet for Mill Run No. 2. Table No. 4 gives the reagents and conditions and Table No. 5 the results. Table No. 6 shows a possible grouping of the various products of the mill run, their projected further treatment, assays and metal distribution.

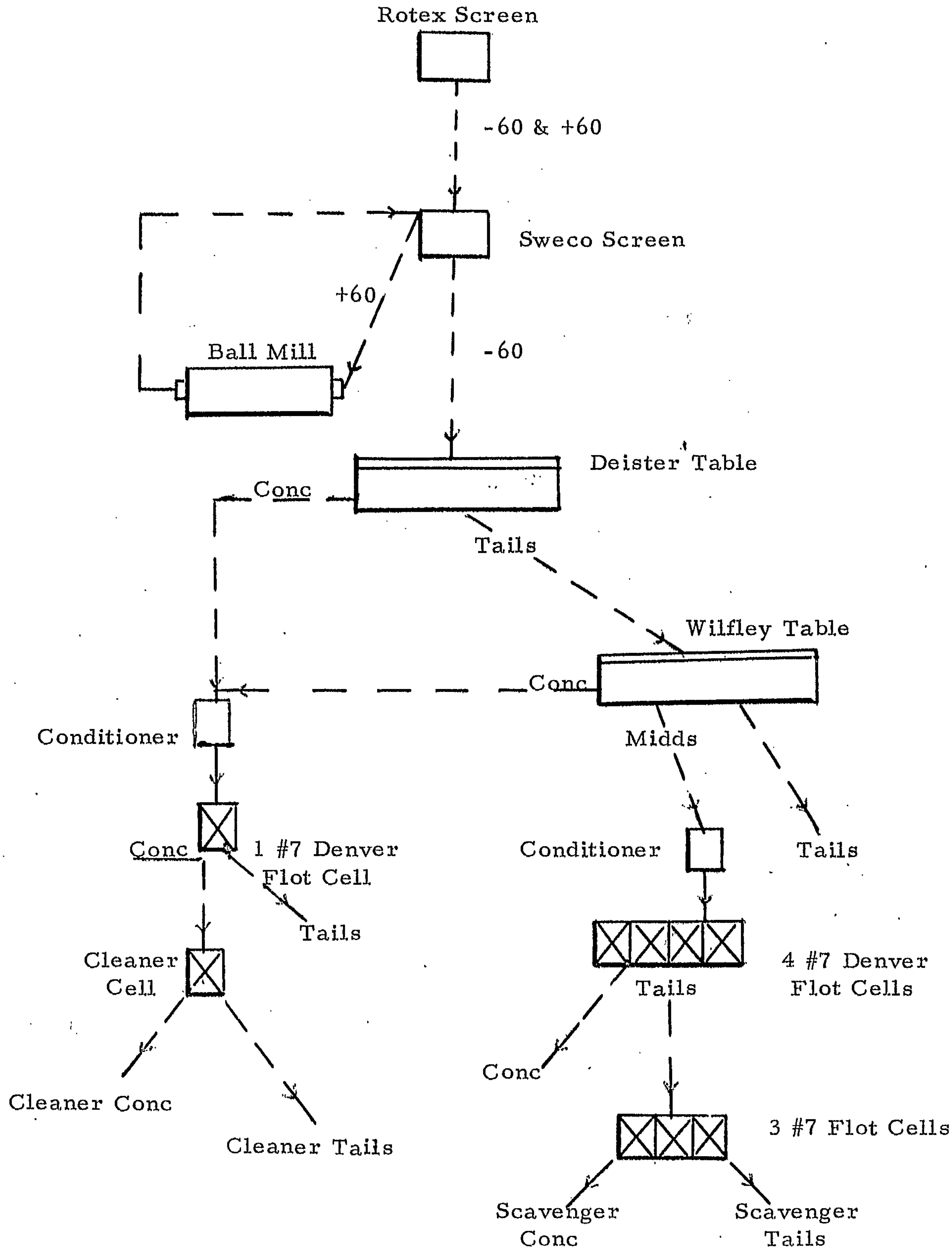

Figure 2. Flowsheet for Mill Run No. 2

TABLE NO. 4

Reagents and Conditions for Mill Run No. 2

Material	Operation	Reagent	Lb/Ton of Feed	pH
Deister Table Conc	Conditioner	Lime	1.50	11
		Cyanide	.375	
	Flot Cell	Aerofroth 60	0.05	11
		Z6	.450	
Wilfley Table Conc	Conditioner	Lime	1.50	11
		Cyanide	.375	
	Flot Cell	Aerofroth 60	0.05	11
		Z6	.450	
	Recleaner Cell	None		
Wilfley Table Middling	Conditioner	Lime	1.50	11
		Cyanide	.375	
	1st Flot Cell	Aerofroth 60	0.05	11
		Z6	.450	
	2nd Flot Cell	Acetic Acid	10.5	6
	3rd Flot Cell	Sulphuric Acid	9.0	5
Flot Tailing Scavenger Flot	2nd Flot Cell	Acetic Acid	11.5	6
	3rd Flot Cell	Sulphuric Acid	10.0	4.5
		Z6	0.20	

TABLE NO. 5

Results of Pilot Plant Run No. 2

Grinding

Product	Weight %	Assays Ag oz/ton	Assays Co %	Assays Fe %	Distribution % Ag	Distribution % Co	Distribution % Fe
Metallics	3.5	20,155	2.63	3.6	39.1	1.2	1.5
-60 Mesh	96.5	1,133	7.90	8.8	60.9	98.8	98.5
Mill Feed	100.0	1,779	7.67	8.5	100.0	100.0	100.0

Metallics Screened

Product	Weight % This Test	Weight % Total	Assays oz/ton Ag	Assays % Co	Assays % Fe	Distribution % This Test Ag	This Test Co	This Test Fe	Total Ag	Total Co	Total Fe
+200 Mesh	82.9	2.9	23,500	1.43	2.6	96.4	41.7	59.5	37.7	0.5	0.9
-200 Mesh	17.1	0.6	3,990	8.40	8.5	3.6	58.3	40.5	1.4	0.7	0.6
Metallics	100.0	3.5	20,155	2.63	3.6	100.0	100.0	100.0	39.1	1.2	1.5
-60 Mesh Deister Tabled											
Conc	21.0	20.2	2,600	10.53	9.24	48.6	27.2	22.1	29.6	26.9	21.8
Tails	79.0	76.3	719	7.10	8.60	51.4	72.8	77.9	31.3	71.9	76.7
-60 Mesh	100.0	96.5	1,133	7.90	8.80	100.0	100.0	100.0	60.9	98.8	98.5
Flotation of Deister Conc											
Conc	19.3	3.9	9,916	7.0	8.5	73.6	13.0	17.8	21.8	3.5	3.9
Tails	76.2	15.4	848	11.3	9.4	25.0	81.8	77.5	7.4	22.0	16.9
Cell Cleanings	4.5	0.9	864	12.8	9.7	1.4	5.2	4.7	0.4	1.4	1.0
Deister Conc	100.0	20.2	2,600	10.5	9.2	100.0	100.0	100.0	29.6	26.9	21.8
Wilfley Tabling of Deister Tailings											
Conc	25.1	19.2	1,284	11.9	10.3	44.1	40.2	30.0	13.8	28.9	23.0
Midds	43.7	33.3	590	6.0	8.5	36.7	39.5	43.3	11.5	28.4	33.2
Tails	31.2	23.8	440	4.9	7.5	19.2	20.3	26.7	6.0	14.6	20.5
Deister Tails	100.0	76.3	719	7.1	8.6	100.0	100.0	100.0	31.3	71.9	76.7
Flotation of Wilfley Table Conc											
Cl Conc	7.3	1.4	10,240	6.1	6.7	58.0	3.8	4.8	8.0	1.1	1.1
Cl Tails	14.6	2.8	1,340	11.6	10.7	15.2	14.2	15.2	2.1	4.1	3.5
Ro Tails	74.0	14.2	438	12.5	10.5	26.8	82.0	80.0	3.7	23.7	18.4
Cell Cleanings	4.1	0.8	438	12.5	10.5						
Wilfley Conc	100.0	19.2	1,284	11.9	10.3	100.0	100.0	100.0	13.8	28.9	23.0
Flotation of Wilfley Table Middlings											
#1 Cell Conc	2.4	0.8	4,280	7.2	10.3	20.0	2.8	3.0	2.3	0.8	1.0
#2 Cell Conc	5.7	1.9	3,100	7.0	10.1	29.6	6.0	6.6	3.4	1.7	2.2
#3 Cell Conc	6.3	2.1	932	9.5	8.9	9.5	8.8	6.6	1.1	2.5	2.2
#4 Cell Conc	16.2	5.4	904	3.7	9.8	23.5	20.4	18.7	2.7	5.8	6.2
Tailings	69.4	23.1	152	6.1	8.0	17.4	62.0	65.1	2.0	17.6	21.6
Middlings	100.0	33.3	590	6.0	8.5	100.0	100.0	100.0	11.5	28.4	33.2

TABLE NO. 6

Summary of Results of Mill Run No. 2

Products	% Weight	Assays*		Distribution %	
		Ag oz/ton	% Co	Ag	Co
Ag Conc to Refinery	8.0	14,276	4.9	67.5	5.1
Co Conc to Chemical Plant	34.7	765	11.8	15.0	51.8
Conc to Electric Furnace	57.3	529	5.5	17.5	43.1

*Calculated

Mill Runs Nos. 3 and 4

The Silverfield's concentrate was used in Mill Run No. 3 and the Agnico concentrate in Mill Run No. 4.

The flowsheet used in each mill run was identical, but differed from that used in Mill Runs Nos. 1 and 2 as follows:

1. Elimination of Rotex screen and Deister table
2. Combining of Wilfley table middling and tailing to flotation
3. A different combination of flotation cells
4. Acids at full strength for desired pH

The material was fed from a Denver belt feeder at a rate of 420 pounds per hour to a 30" Sweco separator fitted with a 60 mesh wire cloth. The plus 60 mesh fraction was fed to a Hardinge 20" x 30" universal mill charged with 500 pounds of 1" to 1 1/2" steel balls. Water was added to the mill to give a discharge pulp of 50 to 60% solids which was pumped to the Sweco separator. Water was also added to the ball mill discharge pump and to the original feed hopper to allow wet screening. The minus 60 mesh material was pumped to a standard Wilfley concentrating table. The table concentrate was collected in settling tanks. The middling and tailing were combined and dewatered in a 9 foot thickening cone. The cone underflow was pumped to a conditioner and fed to four No. 7 Denver flotation cells where a silver concentrate was floated in the first cell, an iron concentrate in the second and a cobalt concentrate in cells 3 and 4. These products were dried and analysed.

The table concentrates were fed by a Pulva disc feeder at a rate of 360 pounds per hour at 20 to 25 percent solids through the same circuit. The silver concentrate from the first cell was cleaned in three No. 5 Denver cells. The cleaner tailing was returned to the No. 7 cell feed. The cleaner concentrate was recleaned in two No. 5 Denver cells. The recleaner tailing were returned to the recleaner cell feed. The various products were collected dried and analysed.

The ball mill was run for two hours after the feed was finished. When the mill was shut down, the material remaining in the mill was screened on a 200 mesh and the plus and minus fractions were dried and analysed.

Figure No. 3 shows the flowsheet for Mill Runs Nos. 3 and 4. Table No. 7 shows the reagents and conditions. Table Nos. 8 and 9 show the results of Mill Runs Nos. 3 and 4 respectively. Table Nos 10 and 11 show the silver distribution and assays when the recleaned flotation concentrate from floating the Wilfley table concentrate was screened on a 150 mesh screen in Mill Runs Nos. 3 and 4 respectively.

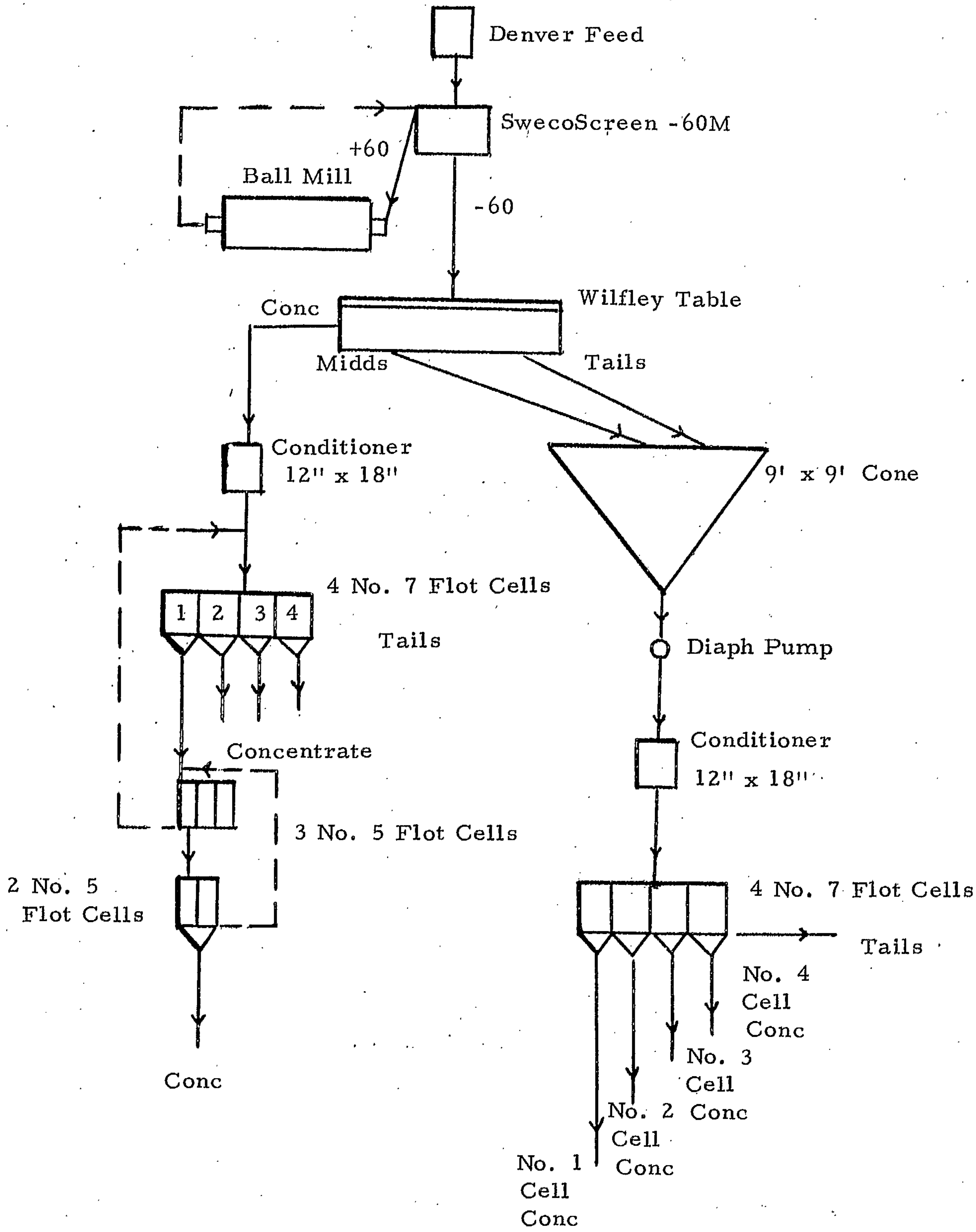

Figure 3. Flowsheet for Mill Runs Nos. 3 and 4.

TABLE NO. 7

Reagents and Conditions for Mill Runs Nos. 3 and 4

Material	Operation	Reagent	pH	Lb/Ton of Feed
Wilfley Table Mids & Tails (Combined)	Conditioner	Lime		1.02
		Cyanide		0.375
		Z6		0.360
	#1 Flot Cell	Aerofroth 60	9-10	0.05
	#2 Flot Cell	Acetic Acid	4-5	71.5
		Z6		0.360
	#3 Flot Cell	Sulphuric Acid	1.5-2	73.0
		Z6		0.360
		Aerofroth 60		0.05
Wilfley Concentrate: Same As Above				

Note: High acid consumption.

TABLE NO. 8

Results of Mill Run No. 3

Grinding

Product	Weight %	Assays			Distribution %		
		Ag oz/ton	Co %	Fe %	Ag	Co	Fe
Metallics	7.3	21,014	2.3	2.3	58.3	1.7	1.6
-60 Mesh	92.7	1,181	10.3	11.2	41.7	98.3	98.4
Mill Feed	100.0	2,684	10.0	10.6	100.0	100.0	100.0

Metallics Screened

Product	Weight %		Assays			Distribution %					
	This Test	Total	oz/ton Ag	% Co	% Fe	This Test			Total		
						Ag	Co	Fe	Ag	Co	Fe
+200 Mesh	95.9	7.0	21,800	2.0	2.0	99.4	82.4	81.2	58.0	1.4	1.3
-200 Mesh	4.1	0.3	2,684	10.0	10.0	0.6	17.6	18.8	0.3	0.3	0.3
Metallics	100.0	7.3	21,014	2.3	2.3	100.0	100.0	100.0	58.3	1.7	1.6
Wilfley Tabling of -60 Mesh											
Conc	58.3	54.0	1,567	12.9	10.2	77.2	72.5	53.0	32.2	71.3	52.2
Tails	41.7	38.7	642	6.8	12.6	22.8	27.5	47.0	9.5	27.0	46.2
-60 Mesh	100.0	92.7	1,181	10.3	11.2	100.0	100.0	100.0	41.7	98.3	98.4
Flotation of Wilfley Table Conc											
ReCl Conc	13.3	7.2	8,940	8.3	7.1	76.1	8.6	9.2	24.5	6.1	4.8
#2 Cell Conc	2.8	1.5	1,204	10.6	11.3	2.2	2.2	3.1	0.7	1.6	1.6
#3 Cell Conc	33.3	18.0	212	13.5	11.0	4.3	34.9	36.0	1.4	24.9	18.8
#4 Cell Conc	18.6	10.0	264	14.4	10.6	3.1	20.8	19.1	1.0	14.8	10.0
Tails	32.0	17.3	693	13.5	10.4	14.3	33.5	32.6	4.6	23.9	17.0
Table Conc	100.0	54.0	1,567	12.9	10.2	100.0	100.0	100.0	32.2	71.3	52.2
Flotation of Wilfley Table Tails											
#1 Cell Conc	18.3	7.1	2,616	7.2	13.7	74.7	19.3	19.9	7.1	5.2	9.2
#2 Cell Conc	19.9	7.7	380	8.8	18.3	12.6	25.9	28.8	1.2	7.0	13.3
#3 Cell Conc	25.6	9.9	240	9.7	13.2	9.5	36.7	26.8	0.9	9.9	12.4
#4 Cell Conc	9.6	3.7	200	8.5	12.0	2.1	11.8	9.1	0.2	3.2	4.2
Tails	26.6	10.3	23	1.6	7.3	1.1	6.3	15.4	0.1	1.7	7.1
Table Tails	100.0	38.7	642	6.8	12.6	100.0	100.0	100.0	9.5	27.0	46.2

TABLE NO. 9

Results of Mill Run No. 4

Grinding

Product	Weight %	Assays Ag oz/ton	Assays Co %	Assays Fe %	Distribution % Ag	Distribution % Co	Distribution % Fe
Metallics	2.9	23,613	2.28	2.28	43.5	0.7	0.5
Table Feed	97.1	944	9.22	13.42	56.5	99.3	99.5
Mill Feed	100.0	1,601	9.02	13.09	100.0	100.0	100.0

Product	Weight % This Test	Weight % Total	Assays oz/ton Ag	Assays % Co	Assays % Fe	Distribution % This Test Ag	This Test Co	This Test Fe	Total Ag	Total Co	Total Fe
Screening Metallics											
+200 Mesh	96.6	2.8	24,360	2.00	2.00	99.5	85.7	80.0	43.3	0.6	0.4
-200 Mesh	3.4	0.1	2,700	10.00	10.00	0.5	14.3	20.0	0.2	0.1	0.1
Metallics	100.0	2.9	23,613	2.28	2.28	100.0	100.0	100.0	43.5	0.7	0.5
Wilfley Tabling											
Conc	37.6	36.5	1,486	11.69	11.50	61.1	47.6	32.2	34.5	47.3	32.1
Midds & Tails	62.4	60.6	617	7.74	14.57	38.9	52.4	67.8	22.0	52.0	67.4
Table Feed	100.0	97.1	944	9.22	13.42	100.0	100.0	100.0	56.5	99.3	99.5
Flotation of Wilfley Table Conc											
Cl Conc	12.9	4.7	9,876	7.5	6.8	85.5	8.2	7.5	29.5	3.9	2.4
#2 Cell Conc											
#3 Cell Conc	32.0	11.7	140	10.6	14.1	2.9	29.2	39.3	1.0	13.8	12.6
#4 Cell Conc	34.3	12.5	224	13.3	12.0	5.2	38.9	35.8	1.8	18.4	11.5
Tails	20.8	7.6	448	13.3	9.6	6.4	23.7	17.4	2.2	11.2	5.6
Table Conc	100.0	36.5	1,486	11.7	11.5	100.0	100.0	100.0	34.5	47.3	32.1
Flotation of Wilfley Table Midds & Tails											
#1 Cell Conc	26.6	16.1	1,580	9.1	18.3	73.2	31.1	33.4	16.1	16.2	22.5
#2 Cell Conc	18.5	11.2	536	9.8	15.4	17.3	23.5	19.6	3.8	12.2	13.2
#3 Cell Conc	11.1	6.7	168	10.6	17.2	3.2	15.2	13.0	0.7	7.9	8.8
#4 Cell Conc	13.5	8.2	180	10.6	13.6	4.1	18.5	12.6	0.9	9.6	8.5
#1 Tails	5.4	3.3	88	7.0	11.5	0.9	5.0	4.3	0.2	2.6	2.9
#2 Tails	24.9	15.1	30	2.1	10.0	1.3	6.7	17.1	0.3	3.5	11.5
Table Midds & Tails	100.0	60.6	617	7.7	14.6	100.0	100.0	100.0	22.0	52.0	67.4

TABLE NO. 10

Results of Screening Flotation Concentrate from Mill Run No. 3

Product	Weight %		Assay	Distribution %	
	This Test	Total	Ag oz/ton	This Test	Total
Plus 150 Mesh	22.2	1.6	14,100	35.1	8.6
Minus 150 Mesh	77.8	5.6	7,300	64.9	15.9
Flot Conc	100.0	7.2	8,940	100.0	24.5

TABLE NO. 11

Results of Screening Flotation Concentrate from Mill Run No. 4

Product	Weight %		Assay	Distribution %	
	This Test	Total	Ag oz/ton	This Test	Total
Plus 150 Mesh	17.0	0.8	16,500	34.6	10.2
Minus 150 Mesh	83.0	3.9	8,500	65.4	19.3
Flot Conc	100.0	4.7	9,876	100.0	29.5

DISCUSSION AND CONCLUSIONS

The concentrates as received had a high silver, cobalt, arsenic, iron and sulphur content with minor amounts of copper, nickel, silicates and other gangue minerals (See Table No. 1).

The main objective of the pilot plant work was to recover metallic silver from this material. However, of equal importance while doing this, was the feasibility of making the following products:

(1) A tailing for sale to a copper smelter or low enough grade to discard.
(2) A high grade cobalt concentrate suitable for roasting and treatment in the cobalt plant.

(3) A concentrate similar to the flotation concentrates being purchased and suitable for smelting in the electric furnace.
(4) Metallics suitable for direct smelting in the silver refinery.
(5) A concentrate similar to the table concentrate being purchased which would require retreatment.

The results of Mill Runs Nos, 3 and 4 shows that the investigation was successful in making the above products as illustrated by the following tables.

TABLE NO. 12

Summary of Results of Mill Run No. 3

Product	Weight %	Assays		Distribution %	
		Ag oz/ton	Co %	Ag	Co
Tails to Copper Smelter	10.3	23	1.6	0.1	1.7
Co Conc - Roast & Chemical Plant	45.3	407	13.7	7.0	63.6
Conc - Electric Furnace	21.3	284	9.1	2.3	20.1
Metallics - Silver Refinery	8.6	20,367	3.2	66.6	2.7
Conc - Retreatment	14.5	4,284	8.0	24.0	11.9
Table Concentrates	100.0	2,684	10.0	100.0	100.0

TABLE NO. 13

Summary of Results of Mill Run No. 4

Product	Weight %	Assays		Distribution %	
		Ag oz/ton	Co%	Ag	Co
Tails to Copper Smelter	15.1	30	2.1	0.3	3.5
Co Conc - Roast & Chemical Plant	31.3	390	12.1	7.8	41.8
Conc - Electric Furnace	29.9	239	10.2	2.8	33.9
Metallics - Silver Refinery	3.6	22,614	3.2	53.5	1.3
Conc - Retreatment	20.1	2,928	8.8	35.6	19.5
Table Concentrates	100.0	1,601	9.0	100.0	100.0

The most significant feature of the pilot plant investigation was the recovery of 53.5 to 66.6 percent of the silver in a concentrate grading over 20,000 oz per ton. For the most part this was recovered in the grinding mill itself. The ball mill was a 20 x 30 in. Universal mill with a grate about 6 inches from the discharge end (See Figure 4). There are no lifters between the grate and the trunnion discharge so that the metallic silver which is liberated in the mill is trapped between the grate and the discharge end when the mill is operated at high discharge with the peripheral discharge ports plugged. At the end of each mill run, the ball mill was run for one to two hours after the feed was shut off. The metallic silver was then drawn from the mill by opening all of the peripheral discharge ports.

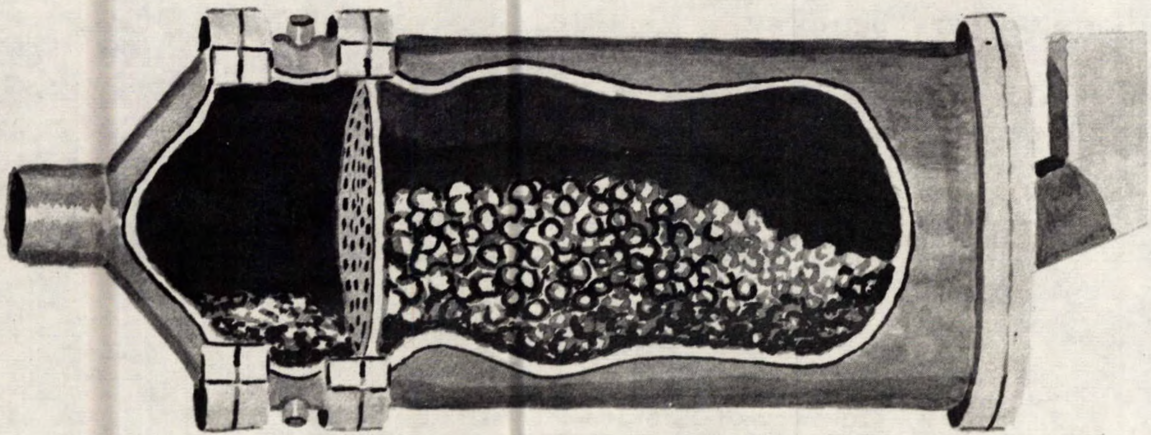

Figure 4. Diagram of 20 x 30 in. Universal Mill
Used to Trap Metallic Silver.

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AJB:rlm