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REPORT
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ORE DRESSING AND METALLURGICAL LABORATORIES

Report No.204

Concentration of the zinc-lead ores of Notre Dame des Anges, Quebec

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Shipments: Four separate shipments were received from the property of Dr. J. L. A. Tetreault and associates of 730 Delorimier Ave., Montreal. The shipments were made up as follows:

Shipment No. 1 - consisted of 100 pounds of zinc-iron middling from a dump, produced from the operation of a gravity concentrator. This shipment was received in July 1923

Shipment No. 2 - was a sample of the crude ore taken from the mill feed to the gravity concentrator then in operation. The shipment weighed 42 lbs. and was received in July 1923.

Shipment No. 3 - consisted of 100 pounds of zinc-iron middling from tables in a gravity concentrator then in operation. This was received in July 1923

Shipment No. 4 - was a carload of 27 tons of crude ore representing the mill feed to the gravity concentrator then in operation. This shipment was received in November 1923.

Characteristics & analyses of shipments Nos. 1 and 3: The zinc-iron middling product received consisted of a mixture of zinc and iron sulphides which had been freed by crushing to 40 mesh. Both pyrrhotite and pyrite were present, the pyrrhotite predominating. Analysis:

	Shipment No. 1	Shipment No. 3
Zinc	17.23 %	15.6 %
Lead	2.16	2.2
Iron	37.57	38.0
Gold	0.12 oz/ton	0.12 oz/ton
Silver	4.68 "	4.70 "

Characteristics & analyses of shipments nos. 2 and 4: This is the crude ore. The minerals are probably entirely freed by crushing to 65 mesh

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Tyler standard screen. Mineralogically the ore is composed of galena, a dark zinc blende, pyrite, pyrrhotite, and a small amount of chalcopyrite in a siliceous gangue containing chloritic minerals and calcite. The galena is argentiferous and there is gold present, some of which is apparently in the free state. Analysis:

	Shipment No. 2	Shipment No. 4
Zinc	6.43 %	5.59 %
Lead	1.86	2.53
Iron		6.78
Gold	0.08 oz/ton	0.06 oz/ton
Silver	2.98 "	3.75 "

Object of Experimental work: The property from which these samples were taken has been operated from time to time for a number of years. Numerous attempts have been made to separate and recover both a lead and zinc concentrate which could be marketed. The attempts to produce a zinc concentrate were failures, but the mine was operated, and is being operated at present, to produce a lead concentrate. The lead is concentrated by graded crushing and tabling. Both flotation and magnetic separation have been tried on the ore, and mills were built to use these processes. During the war period a magnetic plant operated for some time but we understand it was not a success. When flotation was used, the iron and zinc were both floated, the bulk of the lead having been previously eliminated by tables. The flotation concentrate of zinc and iron was given a magnetic roast and the iron eliminated. This process was not a commercial success.

The purpose of the experimental work in the case of shipment no. 1, which consisted of zinc-iron table middlings taken from the dump produced by previous milling operations, was to determine whether a successful method could be worked out whereby a high grade zinc concentrate could be produced from the material. Shipment no. 3 is the same material as no. 1, the only difference being that shipment no. 3 contained freshly produced middling, whereas no. 1 shipment was dump material which had lain exposed to the weather for some time. The purpose of submitting shipment no. 3 was to determine whether there was any material difference between the two products with respect to their response to various methods of separation.

Shipments nos. 2 and 4 which consisted of the crude ore, were submitted to determine whether a possible method could be worked out so that both a lead and zinc concentrate could be recovered as marketable products.

EXPERIMENTAL TESTS ON SHIPMENTS 1 & 3

The work done on this material was confined to small scale tests.

Magnetic Separation tests: Two methods of magnetic separation were tried, namely, separation of the raw middlings, and of the middlings which had been given a flash roast to change the pyrite to the magnetic sulphide. The results of these tests are given in table no. 1. The particulars of the tests follow:

Test No. 1 - 26.5 lbs. of middlings fed to an Ullrich magnetic separator. Proper adjustments were made and the ore fed slowly to the separator. The product of each ring was kept separate and analyzed for zinc and iron.

Tests nos. 8, 9, 10, & 11 — 25 lbs of middlings were roasted very carefully in a small laboratory rotating cylindrical roaster fired with gasolene. The temperature was kept under careful control and the efficiency would compare closely with practice.

Test No. 8 — Two products only were made, a magnetic and a non-magnetic product. The machine actually makes four magnetic products and a middling. The middling was repassed to make a final magnetic and non-magnetic product. The magnets were adjusted 3/8" above the feed plates and a current density of 3 amperes, 110 volts was used

Test No. 9 - The rings were set at 3/8" above the feed pan and the amperage lowered to 2 amperes.

Test No. 10- The magnets were set at 3/8" above the feed pan and the applied amperage was reduced to 1.5

Test No. 11- The magnets were raised to 1-3/8" above feed pan and the applied amperage was 10

Conclusions: It is evident from test no. 1 that the separation cannot be obtained on the crude middlings by magnetic separation. On the roasted ore very little difference in either the grade or the recovery was obtained by the various adjustments of the separator. The zinc product, which is the non-magnetic product from the separator, averaged about 39% zinc with a recovery of 93%. An exceptionally good elimination of the iron was obtained, leaving only 10% in the zinc product. The reason why a higher grade zinc concentrate was not obtained was due to gangue minerals in the feed which all reported in the non-ma netic zinc product. These could probably be eliminated by air jigs or tables, and a zinc concentrate containing 44% to 45% zinc obtained.

Remarks: Roasting followed by magnetic separation would, we believe, be satisfactory for the dump material, but we do not consider it advisable as an adjunct to a mill treating the crude ore. The reasons for this opinion are fairly obvious, the method already having been given an exhaustive trial at the mine, and reported to be unsatisfactory.

Flotation Tests: Only small scale batch flotation tests were run on these shipments. The flotation of this middling product was given careful consideration, particularly the dump material. The fact that the product is a dump material was sufficient to cause us to approach the problem with extreme caution. The attempt to float a zinc sulphide from such a product involves a rare problem in selective flotation. A zinc concentrate was required which would contain 42% to 45% zinc, which necessitated the production of a tailing which consisted almost entirely of iron sulphides. The results of these tests are given in table no.2

General procedure: The middlings were ground in a ball mill with iron balls, to pass 65 mesh. The density of the pulp in the mill was 1 : 1. A charge was prepared separately for each test.

Test No. 2 - Ore 1000 grams. Reagents added to ball mill and ground with the ore:

Lime	2 lbs. per ton of ore
Soda ash	4 " " " "
Copper sulph.	2 " " " "
Barretts #634	0.51 " " "

Reagents added directly to the flotation cell: TT, a mixture of 25% thio-carbanilide and 75% ortho-toluodine, 0.15 lbs. per ton.

Test No. 3 - Ore 1000 grams. Reagents added to ball mill and ground with ore:

Soda ash	4 lbs. per ton of ore
Barretts #634	0.5 " " " "

Reagents added to flotation cell: TT, 0.15 lb. per ton.

Test No. 4 - Ore 1000 grams. Reagents added to ball mill and ground with ore:

Soda ash	4 lbs. per ton of ore
Barretts #634	0.75 " " " "

Test No. 5 - Ore 1000 grams. Reagents added to ball mill and ground with ore:

Lime	2 lbs. per ton of ore
Soda ash	4 " " " "
Copper sulphate	2 " " " "
Barretts #634	0.5 " " " "

Reagents added to flotation cell: TT, 0.15 lb. per ton.

Test No. 6 - Ore 1000 grams. Reagents added to ball mill and ground with ore:

Soda ash	4 lbs. per ton of ore
Barretts #634	0.5 " " " "

Reagents added to cell:

Copper sulphate	2 lbs. per ton of ore
TT	0.15 " " " "

Note: Flotation was tried without copper sulphate, but very little float was obtained. Copper sulphate was added and zinc immediately came up.

Test No. 7 - Ore 1000 grams. Reagents added to ball mill and ground with ore:

Lime	4 lbs. per ton of ore
Copper sulphate	2 " " " "
Barretts #634	0.5 " " " "

Reagents added to flotation cell: TT 0.15 lb. per ton.

Flotation tests, shipment 3 This is the freshly produced middling from the mill at present in operation. Only one flotation test was run on this material, the results of which are given in table no. 3, and are identical to those obtained on shipment no. 1

Test No. 1 - Ore 1000 grams. Reagents added to ball mill and ground with the ore:

Lime	2 lbs. per ton of ore
Soda ash	4 " " " "
Copper sulphate	2 " " " "
Barretts #634	0.5 " " " "
TT	0.15" " " "

Summary and conclusions from tests on shipments Nos.1 & 3 The charge in the first test, No. 2, was made up to have the maximum wetting effect on the iron sulphide, and at the same time balanced so that the zinc could still be floated. Lime will prevent both zinc and iron from floating, but copper sulphate and soda ash enhance the floating properties of zinc and at the same time the soda ash has a strong wetting effect on the iron. The oils used were those we have found from experience to have very little collecting power on iron sulphides.

Tests nos. 2 and 5 were run with the same charge, the other tests were run to determine whether any of the reagents used in the first test were unnecessary

In tests nos. 3 and 4, the lime and copper sulphate were left out. The results as shown in table no. 2 were unsatisfactory, an irony concentrate was obtained and a low recovery made. In test no. 6 only the lime was left out. This gave fairly satisfactory results. The concentrate was high grade but the recovery was low. The low recovery may have been due to poor manipulation. In test no. 7 the amount of lime added was doubled, and the soda ash left out. The result was a high grade concentrate, but a low recovery of the zinc.

It would not be advisable to draw any definite conclusions with regard to the possibility of a commercial plant being able to duplicate the results of tests nos. 2 and 5, because we have found that small scale batch tests are not always reliable on material of this character. It would be necessary to run a large scale tonnage test before a definite opinion could be given on this method of treatment for the dump material.

EXPERIMENTAL TESTS ON SHIPMENT 2

Flotation test: Only one test was run on this sample, which represents the crude ore from the mine. The results are given in table no. 4

Test No. 1 - Ore 1000 grams. Reagents added to ball mill and ground with the ore:

Lime	2	lbs per ton of ore
Soda ash	4	" " " "
Copper sulphate	1	" " " "
Barretts #634	0.5	" " " "
TT	0.1	" " " "

Conclusions: A high grade zinc concentrate can be obtained from the crude ore by flotation, and a good recovery made without any apparent difficulty.

SMALL SCALE EXPERIMENTAL TESTS ON SHIPMENT 4

This shipment consists of a carload of crude ore from the mine. A number of small scale tests were run in conjunction with a series of tonnage tests. The results of these tests are given in table no. 5

Test No. 1 - This test was run in conjunction with the large scale tests nos. 2 - 5. In the large scale tests the lead was removed by tabling, and the table tailing dewatered before the flotation of the zinc was attempted. In order to duplicate the conditions for the flotation of the zinc in the small tests, the pulp from the ball mill was allowed to settle and then dewatered. The dewatered pulp was then washed into the flotation machine with fresh water and made up to the required density before the following reagents were added. In subsequent tests this operation is referred to as "ball mill pulp dewatered". Reagents added to flotation cell:

Soda ash	8	lbs per ton of ore
Copper sulphate	2	"
G.N.S. oil #20	0.15	"
P.T.&T.Co #350	0.10	"

Purpose of test: The purpose of this test was to determine whether General Naval Stores oil #20 could be used for the flotation of the zinc.

Conclusions: The oil is not suitable under the above conditions.

Test No. 2 - Ore 1000 grams. Reagents added to ball mill and ground with ore in a 1:1 pulp:

Lime	10 lbs per ton

Ball mill pulp dewatered; reagents added to flotation cell:

Soda ash	8 lbs. per ton
Copper sulphate	2 "
Barretts #634	0.75 "

Purpose of test: To determine the effect of adding a large amount of lime to the ball mill and grinding with the ore, then dewatering the bulk of it before floating the zinc.

Conclusions: More work will have to be done before any conclusions can be drawn from this result.

Test No. 4: Ore 1000 grams. Reagents added to ball mill and ground with ore:

Soda ash	8 lbs. per ton
Copper sulphate	2 "

Oils used - 40% solution of Mexican crude in gasoline.

Frothing oil - Fumol

Ball mill pulp was not dewatered.

Purpose of test: To determine whether the zinc could be floated and the iron dropped by using the Mexican crude and gasoline mixture.

Conclusions: This oil mixture is unsatisfactory under these conditions.

Test No. 5 - Ore 1000 grams. The ball mill pulp dewatered. Reagents added to cells:

Soda ash	4 lbs. per ton
Copper sulphate	1 "
Xylidine and thiocarbanilide mixt.	0.1 "
Barretts #634	0.75 "

Purpose of test: This test was made to duplicate the conditions obtained in the large scale tests 2 -5. The purpose of the test was to obtain a comparison of the results of both operations.

Conclusions: A much lower grade concentrate was obtained from the small test than from the large scale tests. If the results given in table no. 5 are compared with the results of test no. 1 table no. 4, which was run on shipment no. 2, and which is also crude ore, it will be observed that when the ball mill pulp was not dewatered a much higher grade concentrate was obtained. There was not the same tendency for the iron to float. Lime was used in test no. 1, shipment no. 2, but we found that in the large scale work just as good results could be obtained by using soda ash without lime, so that the use of lime is not necessary if other conditions are right.

Test No. 6 - Ore 1000 grams. The ball mill pulp was dewatered. Reagents added to flotation cells:

Soda ash	6 lbs. per ton
Copper sulphate	1 "
YZ mixture	0.1 "

Purpose of test: The soda ash was increased from 4 lbs. in the previous test to 6 lbs. The purpose of the test was to determine the effect, if any, of this increase

Conclusions: Increasing the amount of soda ash apparently has little effect.

Test No. 7 - Ore 1000 grams. The pulp from the ball mill was not dewatered. Reagents added to ball mill and ground with ore:

Soda ash	4 lbs. per ton
Copper sulphate	1 "

Reagents added to flotation cells: The oils used were varied during the test. A few drops of a neutral oil from hardwood creosote was used.

Purpose of test: To determine if neutral oil from hardwood creosote oil could be used.

Conclusions: The oil is not satisfactory under these conditions.

Tests Nos. 9 & 10: These tests are duplicates of test no. 5

Conclusions: The same results were obtained as in test no. 5

Selective Flotation Tests: These tests were run to determine whether it was possible to make a separation between the lead and zinc minerals, and to produce a marketable concentrate of each. The results are given in table no. 6

Test No. 1 - Ore 1000 grams. The ore ground in a ball mill in a pulp of 1:1 to approximately -65 mesh

Flotation of lead: Reagents added to the ball mill for the flotation of the lead:

Lime	5 lbs. per ton
Selecto	2 "
Thio carbanilid	0.125 "

Reagents added to lead flotation cells:

Aldol	0.1 lbs. per ton

After flotation of the lead, the lead tailing was dewatered.

Flotation of zinc: Reagents added to flotation cells for flotation of zinc, after dewatered pulp from lead cell was diluted to 1:3 with fresh water:

Soda ash	5 lbs. per ton
Copper sulphate	1 "
Barretts #634	0.5 "
TT	0.15 "

Note: The zinc concentrate was recleaned, but the lead was not.

Conclusions: A highly selective condition was obtained in this test, and the results are very encouraging.

Test No. 2 - This test is a duplicate of test no. 1

Test No. 3:- Flotation of lead: Reagents added to ball mill and ground wet with the ore:

Soda ash	2 lbs. per ton
Sodium cyanide	0.1 "
Barretts water gas tar	0.2 "
Coal tar creosote	0.2 "
Cresylic acid	0.2 "

The lead concentrate was not dewatered.

Flotation of zinc: Reagents added to zinc cell:

Copper sulphate	1 lb. per ton
Water gas tar	0.2 "

The zinc concentrate was not recleaned.

Conclusions: A highly selective condition was obtained in this test. Comparing the results with those of tests nos. 1 and 2, it will be observed that the lead concentrate in the first method is lower than in the second.

Remarks: The method used in this test is the same as used at the Consolidated Mining & Smelting Co. Traill, B.C.

Test		Weight		Analysis					Percent of values			
No.	Product	grams	%	Zn %	Pb %	Fe %	Au oz	Ag oz	Zn	Pb	Au	Ag
	TABLE NO. 1 - Magnetic Separation Tests, Shipment No. 1											
	Head sample			17.23	2.16	37.57	0.12	4.68				
1	Concentrate											
	Ring 1	8.5	32.1	7.89		50.9			14.4			
	" 2	0.5	1.9	12.08		45.65			1.2			
	" 3	1.0	3.8	11.10		47.47			2.3			
	" 4	4.5	17.0	17.52		41.00			17.7			
	Middling	3.0	11.3	28.22		24.84			18.4			
	Tailing	9.0	33.9	23.41		46.66			46.1			
8	Non-magnetic	471.3	41.0	39.91	4.36	8.3	0.04	4.76	91.2	76.2	35.7	44.6
	Magnetic	678.8	59.0	2.69	0.87	54.5	0.05	4.10	8.8	23.9	64.3	55.4
9	Non-magnetic	209.2	49.2	39.35	4.15	8.95			91.8	76.8		
	Magnetic	287.5	57.8	2.57	0.93	53.70			8.2	23.6		
10	Non-magnetic	454.6	44.2	38.00	4.56	10.50			93.0	84.8		
	Magnetic	577.6	55.8	2.28	0.65	55.70			7.1	15.2		
11	Non-magnetic	593.5	44.0	39.03	4.04	10.50			93.8	78.6		
	Magnetic	754.7	56.0	2.02	0.37	55.50			6.2	21.5		
	TABLE NO. 2 - Flotation tests, shipment No. 1											
	Head sample			17.23	2.16	37.57	0.12	4.68				
2	Concentrate	365.3	36.6	42.08	4.69	13.23	0.16	9.90	90.40		95.0	74.5
	Middling	73.5	7.5	11.60	1.75	45.85	0.02	4.20	5.10		2.3	6.5
	Tailing	558.6	55.9	1.25	tr	52.92	0.03	1.65	4.50		2.7	19.0
3	Concentrate	372.5	36.9	34.0					71.85			
	Middling	103.1	10.2	13.6					7.95			
	Tailing	532.2	53.0	6.64					20.10			
4	Concentrate	493.5	48.8	28.23					78.11			
	Middling	118.0	11.7	9.34					6.14			
	Tailing	399.9	39.5	7.05					15.75			
5	Concentrate	356.0	35.5	44.40			0.02	9.58	93.30		54.6	65.
	Middling	55.0	5.5	12.74			0.10	11.58	4.12		42.35	12.
	Tailing	592.2	59.0	0.72			tr	1.94	2.52		3.06	22.
6	Concentrate	332.2	33.5	42.55			0.06	10.08	84.60		75.6	66.1
	Middling	99.2	9.6	15.34			0.008	8.81	8.72		2.9	16.5
	Tailing	566.5	56.9	1.97			0.01	1.55	6.66		21.4	17.2
7	Concentrate	222	22.3	45.88					68.6			
	Middling	198.9	19.9	18.16					24.6			
	Tailing	575.0	57.7	1.32					7.0			
	TABLE NO. 3 - Flotation test, Shipment No. 3											
	Head Sample			15.6	2.2	38.0	0.12	4.7				
1	Concentrate	382.7	34.1	42.15			0.10	12.74	92.1		64.0	56.2
	Middling	68.0	6.0	7.99			0.12	11.52	3.08		13.5	8.9
	Tailing	672.7	59.9	1.25			0.02	4.48	4.82		22.5	34.8
	TABLE NO. 4 - Flotation test, Shipment No. 2											
	Head Sample			6.43	1.86		0.08	2.98				
1	Concentrate	140.4	14.8	41.3			0.12	16.46	81.6		30.1	62.
	Middling	87.4	9.2	12.5			0.12	10.60	15.4		18.4	24.
	Tailing	719.7	76.0	0.3			0.04	0.66	3.0		51.5	12.
	TABLE NO. 6 - Selective flotation tests, Shipment No. 4											
	Head Sample			5.59	2.53	6.78	0.06	3.75				
1	xLead conc.	87.7	8.6	24.42	7.52		0.32	32.48	93.5	12.9	96.2	87.
	Zinc "	98.2	9.7	0.51	40.45		tr	1.38	2.2	78.4		4.
	Middling	56.0	5.5	0.41	4.43		0.02	1.44	1.0	4.9	3.8	2.
2	xLead conc.	48.9	4.8	25.44	4.12		0.28	34.86	55.5	4.1	42.2	53.
	Zinc "	106.0	10.5	7.5	40.87		0.04	9.08	35.8	86.0	13.1	30.
	Middling	66.2	6.5	1.18	4.92		0.22	5.12	3.5	6.4	44.7	10.
	Tailing	789.5	78.2	0.15	0.21		tr	0.24	5.3	3.4		5.
3	xLead conc.	77.9	7.7	34.47	8.49	6.67			90.5	10.9	7.2	Fe
	xZinc "	152.4	15.1	1.13	34.94	8.18			5.8	83.5	17.4	Fe
	Tailing	781.2	77.2	0.14	0.47	6.97			3.7	5.7	75.4	Fe

x Concentrate not recleaned

Table No. 5 - Flotation tests - Shipment No. 4

Product	Test No. 1 Wt.gms.	Test No. 1 Zn %	Test No. 2 Wt.gms.	Test No. 2 Zn %	Test No. 4 Wt.gms.	Test No. 4 Zn %	Test No. 5 Wt.gms.	Test No. 5 Zn %
Concentrate	118.0	34.5	141.7	32.0	174.0	24.9	134.4	34.5
Middling	72.2	7.13	71.5	9.42	74.0	9.72	56.6	9.37
Tailing	80.3	1.0	796.5	0.51	756.5	0.56	816.5	0.49
Product	**Test No. 6 Wt.gms.**	**Test No. 6 Zn %**	**Test No. 7 Wt.gms.**	**Test No. 7 Zn %**	**Test No. 9 Wt.gms.**	**Test No. 9 Zn %**	**Test No. 10 Wt.gms.**	**Test No. 10 Zn %**
Concentrate	140.9	32.0	88.2	35.55	120.0	33.1	119.0	32.55
Middling	91.6	6.38	57.5	17.35	70.8	6.46	67.0	12.09
Tailing	773.3	0.51	854.0	1.34	811.1	0.26	819.7	0.18

LARGE SCALE TONNAGE CHECK TESTS

Test No. 1

General description of test: The ore was crushed to ½" in a jaw crusher and set of rolls. The ½" material was fed to a 4½' Hardinge ball mill, first passing through a Vezin sampler where a 1/20 was cut out for a head sample. The Hardinge ball mill was operated in closed circuit with a 14" standard Dorr classifier. The classifier overflow went direct to a two 6'x12" Callow flat bottom flotation unit, where a rougher concentrate and final tailing was made. The rougher concentrates were recleaned twice in two 3'x12" cleaners. The cleaner tailings were returned to the head of the rougher cells by an air lift. The heavy tar oil was fed to the ball mill, but the soluble oils and pine oil were fed in at the classifier overflow. The soda ash and lime were added at the ball mill. The final concentrate was passed over a Wilfley table, using a standard deck.

Details of operation:

Amount of ore fed to ball mill	6000 lbs.
Rate of feed per hour	1050 "

Screen test on Classifier Overflow

Mesh	Wt. gms.	Percent	Cumulative percent
+48	1.3	0.26	0.26
-48+65	5.6	1.12	1.38
-65+100	23.3	4.66	6.04
-100+150	63.2	12.64	18.68
-150+200	117.7	23.54	42.22
-200	287.7	57.54	99.76

Explanation of sample numbers and unit used for quantity of reagents: The test was divided into two sections. During the first half of the run soda ash was used, but during the second half, lime, at the rate of 1 lb. per ton was added in addition to the soda ash. Samples marked No. 1 were taken during the first half, and those marked No. 2 during the second half. The reagents used are given in lbs. per ton of ore. Oils used were Barrett Co's water gas tar, General Engineering Co's TT mixture, and steam distilled pine oil from Hercules Powder Co.

Reagents added

Time	Soda ash	Lime	Copper sulph.	TT	Water gas tar	Pine oil
10.15	5		1	0.15	0.20	
11.45	5		1	0.15	0.20	0.02
12.45	5		1	0.15	0.20	0.02
1.15	5	1	1	0.15	0.20	0.02
2.15	5	1	1	0.15	0.20	0.02
3.15	5	1	1	0.15	0.20	0.02

Pulp densities

Sample No.	Time	Solids %	Ratio solids to dilution	Remarks
1	11.45	50	1 : 1	Ball Mill discharge
1	12.14	56	1 : 0.78	"
1	1.15	50	1 : 1	"
2	1.45	51	1 : 0.96	"
2	2.15	52	1 : 0.92	"
2	2.45	45	1 : 1.12	"
2	3.15	43	1 : 1.3	"
2	3.45	41	1 : 1.4	"
1	11.30	17	1 : 4.88	Classifier overflow
1	12.00	29	L : 2.45	"
1	12.30	43	1 : 1.3	"
1	1.00	31	1 : 2.2	"
2	1.30	27	1 : 2.7	"
2	2.00	28	1 : 2.57	"

Sample No.	Time	Solids %	Ratio solids to dilution	Remarks
2	2.30	28	1 : 2.57	Classifier overflow
2	3.00	25	1 : 3.0	"
2	3.30	28	1 : 2.57	"
2	4.00	25	1 : 3.0	"

Analysis of samples

Product	Zinc %	Lead %	Iron %	Gold ozs.	Silver ozs.
Head sample (Vezin sampler)	5.28	2.13	6.93	0.08	3.90
Classifier overflow (feed to cells)	5.78	1.86	4.68	0.03	2.60
Concentrate sample no. 1	30.88	7.61	19.31	0.08	13.68
Tailing " " 1	0.78	0.28	3.05	0.02	0.38
Concentrate " " 2	32.29	11.32	15.26	0.03	13.17
Tailing " " 2	0.58	0.28	4.06	0.02	0.80
Table concentrate (lead)	2.25	68.78		0.36	62.04
" tailing (zinc)	32.48	5.88		0.03	11.31

Summary: A good recovery of the zinc was made but the concentrate obtained was of much too low a grade. The flotation concentrate of zinc and lead was tabled to produce a lead concentrate. A high grade lead concentrate was made, but the recovery obtained was very poor. The discrepancy between the percent of values in the head sample and in the sample of the classifier overflow is explained by the fact that the ball mill was empty at the beginning of the test. The heavy minerals in the ore would remain in the ball mill and classifier circuit until the circuit was built up.

Recapitulation of results using classifier overflow as head sample:

Zinc.	Average grade of concentrate	32.48%
	" " " tailing	0.68
	Total recovery of zinc in feed	90.30
Lead.	Grade of table concentrate	68.78%
	Total recovery of lead in feed	44.9
	Recovery of lead by tabling flotation concentrate	51.0

Summary and distribution of lead in flotation products:

Lead lost in zinc product	43.1 %
" " " flotation tailing	12.0
" recovered in table concentrate	44.9

Conclusions:

1. The low grade zinc concentrate obtained was due to the use of water gas tar

2. The use of lime was not very effective in preventing iron sulphide from floating with the zinc. A slight improvement can be observed in the grade of zinc concentrate, but the effect was not very marked.

3. The production of a flotation concentrate containing both lead and zinc values and the subsequent use of tables to separate these two minerals is unsatisfactory. A very low recovery of lead is obtained and the results of this test which gives a recovery of 51% lead in flotation concentrate represents the best table practice obtainable.

Test No. 2

General description of test: The ore was crushed to ½" and a head sample cut out by a Vezin sampler. The ore after passing through the sampler was fed to a

4½' Hardinge ball mill in closed circuit with a Dorr classifier. The classifier overflow was passed over a Wilfley table where a lead concentrate was made. The table tailing carrying the zinc was dewatered in an 8' Callow cone, and the thickened feed went to two 6'x12"Callow flat bottom cells, each cell receiving half the feed. As in the previous test the final tailing was produced from these two rougher cells and the rougher concentrate was recleaned twice in two 3'x12" cleaner cells, the cleaner tailing being returned to the rougher cells. The final flotation zinc concentrate was tabled on a Wilfley table to remove a second lead concentrate.

Details of operation: Amount of feed to ball mill 6140 lbs.
Rate of feed per hour 1200 "

Screen test on classifier overflow or feed to table

Mesh	Wt.gms	Percent	Cumulative percent
+48	1.1	0.30	0.30
-48+65	4.1	1.00	1.30
-65+100	19.0	4.70	6.00
-100+150	46.0	11.5	17.5
-150+200	89.8	22.5	40.0
-200	240.0	60.0	100.0

Explanation of sample numbers and unit of measurement for reagents: Density samples were taken every hour of the feed to the table from the classifier, and every hour of the thickened feed to the flotation cells. Only one density sample was taken of the ball mill discharge. Two head samples were taken, one of the ore feed to the mill and one of the classifier overflow. The lead concentrate from the table was dried and sampled in a Jones sampler. The table tailing was sampled after thickening. This material also represents the feed to the flotation cells. Two samples were taken of the thickened feed. Sample no. 1 was taken during the first half of the run before lime was used. Sample no. 2 was taken during the last half of the run when lime was used. Four separate samples were taken of both the flotation concentrate and tailing, and indicate the results obtained during different periods of the test. The flotation concentrate from the whole run was sampled before the second tabling. The lead concentrate and zinc tailing from the table were also sampled. A wet sample was taken of the zinc product from the table during operation, but the lead concentrate was dried before being sampled. The samples of the flotation concentrate and tailing were taken at two minute intervals.

Oils used were Barretts #634, TT mixture and YZ mixture. Steam distilled pine oil. Amount of reagents given in lbs. per ton of ore.

Pulp density of ball mill discharge - 56% solids - 1:0.77 solids to solution.

Pulp densities

Sample No.	Time	Solids %	Ratio solids to solution	Remarks
1	10.30	57	1 : 0.74	Classifier overflow
1	11.30	46	1 : 1.16	"
1	12.30	38	1 : 1.6	"
2	1.30	27	1 : 2.77	"
2	2.30	29	1 · 2.4	"
2	3.00	31	1 : 2.18	"
1	12.00	42	1 : 1.35	Feed to flotation cells
1	12.30	34	1 : 1.20	"
1	1.00	22	1 : 3.54	"
2	1.30	33	1 : 2.00	"
2	2.00	38	1 : 1.60	"
2	2.30	45	1 : 1.22	"
2	3.00	28	1 : 2.70	"

Reagents added

Time	Soda ash	Lime	Copper sulph.	TT	YZ	#634	Pine oil
10.30-1.00	5	0	2	0	0.15	0.20	0.02
1.00-3.00	5	5	2	0.15	0	0.20	0.02

Analysis of samples

Time	Product	Zinc %	Lead %	Iron %	gold ozs.	silver ozs.
Whole	Head sample (Vezin sampler)	5.78	2.68		0.05	3.97
"	Classifier overflow (table feed)	5.88	2.15		0.02	3.78
"	Lead table concentrate	1.93	71.41	6.5	0.70	75.60
10.30-1.00	Thickened feed to cells sample 1	5.48	0.72		0.01	1.99
10.30-12.00	Flotation concentrate " 1	25.68	2.58		tr	6.40
10.30-12.00	Flotation tailing " 1	0.46	0.21		tr	0.54
12.00-1.05	Flotation concentrate " 2	45.55	4.78		0.10	10.90
12.00-1.05	Flotation tailing " 2	0.81	0.21		tr	0.60
1.00-3.00	Thickened feed to cells " 2	6.08	1.23		0.01	2.59
1.05-1.30	Flotation concentrate " 3	38.95	4.97		0.10	11.60
1.05-1.30	" tailing " 3	0.25	0.31		tr	0.40
1.30-3.00	" concentrate " 4	36.18	4.92	12.4	0.10	10.70
1.30-3.00	" tailing " 4	0.35	0.31		tr	0.35
Whole	Flotation concentrate sample	35.80	6.20		0.10	11.60
"	Lead table concentrate no. 2	18.19	25.86		0.40	41.60
"	Zinc table product	37.89	3.49		0.04	6.56
	Average of lead table concentrate	7.78	55.0			

Summary: It will be noticed as in the previous test that the lead and gold content of the classifier overflow is lower than the ball mill feed. The classifier overflow or feed to table was much thicker during the first half of the run than in the second half, which would give a coarser product for the table feed. The tailing samples from the table show that a better recovery of the lead was obtained with the coarser feed. A very high grade lead concentrate was produced on the table, but the recovery of the lead was poor. The density of the thickened feed to the flotation cells varied considerably and during the first part of the test the feed to the flotation cells was very thick, approaching 40% solids. The flotation concentrates during this period were very dirty, only containing 25% zinc. The feed to the cells from 12.30 to 1.30 was more dilute, averaging about 25% solids and a sample of the flotation concentrate (sample no. 2) produced from this feed showed a very marked improvement in grade, containing 45% zinc. For the remainder of the test lime was added in addition to the soda ash, and the density of the feed to the cells varied between 28% and 45% solids. Two samples of the concentrates were taken, one running 38.9% zinc and the other 36.1% zinc. All the tailing samples are very low in zinc showing a high recovery. A low grade lead concentrate was made from the tabling of the flotation concentrate, but the combined lead concentrate from the two table operations average 55% lead.

Recapitulation of results using
classifier overflow as head sample:

Average grade of lead concentrate	55.0 %
Total recovery of lead values	72.73
Recovery of lead values from flotation conc.	50.4

Summary of distribution of
lead values in products:

Lead recovered by first tabling	55.6 %
" " " tabling flotation conc.	17.13
" values lost in flotation tailing	10.3
" " " " zinc concentrate	16.97

Average grade of zinc concentrate	37.89 %
" recovery of zinc values	93.75

Conclusions: First - This test indicates clearly that a thick pulp in the flotation cells gives a low grade concentrate. Second - The addition of lime to the pulp is of no advantage, and that just as high grade concentrate can be produced with soda ash alone, provided the proper condition with regard to oiling and density of the pulp in the flotation cells is maintained. Third - The Barrett #634 oil is far superior to the water gas tar for floating the zinc. Fourth - No conclusions can be drawn regarding the use of TT and YZ mixtures.

Test No. 3

General description of test: The same procedure was followed as in test no. 2

Details of operation:

Amount of feed to ball mill	5694	lbs.
Rate of feed per hour	1500	"

Screen test of classifier overflow

Mesh	Weight	Percent	Cumulative percent
+48	0.9	0.18	0.18
-48+65	4.2	0.84	1.02
-65+100	16.1	3.22	4.24
-100+150	52.5	10.50	17.74
-150+200	137.7	27.54	42.28
-200	289.3	57.86	100.00

Explanation of sample numbers and unit for quantity of reagents: Density samples of the ball mill discharge were taken every hour, and of the classifier overflow every half hour. The derity of the thickened feed to the cells was also taken every half hour. The reagents used were measured from time to time and special samples of the flotation producs were taken over periods corresponding to the regulation of the reagents used. Amount of reagents given in lbs. per ton of ore.

Pulp densities

Time	Weight	Ratio	% solids	Remarks
10.50	1375	1 : 1.40	41	Ball Mill discharge
12.00	1462	1 : 1.07	48	
1.05	1462	1 : 1.07	48	
1.30	1460	1 : 1.07	48	
2.00	1454	1 : 1.09	47	
2.10	1400	1 : 1.28	44	
10.45	1367	1 : 1.44	41	Classifier overflow
11.00	1165	1 : 3.60	21	
11.20	1210	1 : 2.77	26	
11.35	1300	1 : 1.84	36	
12.00	1230	1 : 2.48	28	
12.20	1210	1 : 2.77	26	
12.40	1240	1 : 2.36	29	
1.05	1240	1 : 2.36	29	
1.25	1238	1 : 2.36	29	
1.50	1240	1 : 2.36	29	
2.15	1160	1 : 3.76	21	
2.25	1210	1 : 2.77	26	
2.45	1160	1 : 3.76	21	
10.45	1217	1 : 2.70	27)	Thickener discharge
11.00	1145	1 : 4.10	19)	
11.20	1145	1 : 4.10	19)	Sample no. 1
11.40	1115	1 : 5.25	16)	
12.00	1260	1 : 2.17	31)	
12.20	1285	1 : 1.90	34)	Sample no. 2
12.40	1287	1 : 1.94	34)	
1.05	1360	1 : 1.47	40)	
1.25	1345	1 : 1.56	39)	Sample no. 3
1.50	1235	1 : 2.45	29)	
2.10	1230	1 : 2.48	28)	Sample no. 4
2.25	1220	1 : 2.60	27)	
3.10	1265	1 : 2.125	32)	Sample no. 5
3.30	1225	1 : 2.571	28)	

Reagents used

Sample No.	Time	Soda ash	Copper sulph	#634	Pine oil	YZ	Fuel oil
1	10.25			0.30		0.13	
1	11.15	2.8					
1	11.30		1.45	0.13		0.15	
1	11.35	2.8					
1	11.40	1.45					
2	11.45	2.90					
2	12.00	1.95	0.75	0.20			
2	12.05	3.15	0.70				
2	12.15	3.78		0.03		0.15	
2	12.30	3.27		0.15		0.15	
2	12.40	2.08	0.72				0.33
3	12.50	3.60	1.68				0.33
3	1.10	3.27	1.20				0.33
3	1.25	4.10	1.75				0.33
3	1.40	3.78	1.45				0.33
4	1.45	2.40	1.80	0.27		0.15	
4	1.48	3.58					
4	1.50	3.90					
4	2.00	4.40	1.45			0.15	
4	2.01	3.10	1.80				
4	2.05	3.46					
4	2.15	2.52				0.15	
5	2.25	3.78		0.2			
5	2.30	3.78					
5	2.35	4.0	1.80				
5	2.50	2.83					
5	2.51	3.90	1.20				
5	2.55		1.62	0.25			
5	3.05	3.22					
5	3.10	3.78					
5	3.15	2.58	1.28	0.25			
5	3.20	3.47					
5	3.30	2.90	1.22				

Analysis of samples

Time	Product	Zinc %	Lead %	Iron %	Gold ozs	Silver ozs
Whole	Head sample (Vezin sampler)	5.86	2.57		0.05	3.61
"	Classifier overflow	5.56	2.46		0.02	3.68
"	Table concentrate (lead)	3.29	63.62		0.60	66.9
"	Table tailing	6.28	1.23		tr	1.78
10.35-11.40	Flotation conc.(zinc) sample 1	40.58	7.50		0.10	12.9
"	" tailing " 1	1.30	0.41		tr	0.74
11.40-12.40	" conc.(zinc) " 2	42.78	7.39		0.10	14.20
"	" tailing " 2	0.82	0.36		tr	0.62
12.40-1.40	" conc(zinc) " 3	27.95	7.71		0.10	13.80
"	" tailing " 3	2.63	0.31		tr	0.76
1.40-2.10	" conc.(zinc) " 4	41.97	5.85		0.10	11.90
"	" tailing " 4	2.11	0.51		tr	0.92
2.10-3.45	" conc.(zinc) " 5	42.80	7.70		0.10	15.80
"	" tailing " 5	2.26	0.62		tr	1.42
Whole	Combined flotation concentrate	38.75	8.72	9.6	0.10	15.46
	Table conc. no. 2 lead	8.02	62.79		0.55	68.55
	" tailings, final zn conc	41.36	4.92		0.08	10.46

Summary: The feed to the table was ground finer than in the previous test with the result that a lower recovery was obtained of the lead. During the first part of the test the table was operated to produce a high grade lead product, but as it was observed that considerable fine lead was escaping, the table was adjusted to cut out more concentrate. This resulted in a lower grade lead concentrate being produced and as far as could be observed very little, if any, extra saving of lead was effected. The table tailings were thickened in a Callow 8' cone. It was difficult to maintain the thickened discharge of this cone at uniform density. The density varied over quite a wide range.

The reagents were measured from time to time. The amount of soda ash was varied from 2.5 to 3.5 lbs. per ton, but this variation as far as could be judged from the character of operation of the cells, had little effect on the results. The amount of copper sulphate varied slightly from time to time, but no difference in the character of the operation was observed. The quantity of oils used was kept down to a minimum as it was thought that perhaps any excess would tend to lift more iron with the zinc. There is no doubt that the small amount of oil used accounts for the high tailing obtained. A fuel oil manufactured by the G.N.W. oil Co. Cleveland, Ohio, was tried, but was found to be of no use, as both a dirty irony concentrate and a high tailing were made. During the operations, it was noticed that considerable gangue was floating with the zinc. An analysis was made on concentrate sample no. 4 to determine whether it was the iron or the gangue which was reducing the grade of the concentrate.

Recapitulation of results based on
analysis of classifier overflow:

Average grade of lead concentrate	63.4%
Total recovery of lead values	66.7

Distribution of lead in concentration products:

Recovery of lead in first table conc.	51.0 %
" " " " second " "	15.7
Loss " " " zinc concentrate	17.5
" " " " tailing	15.8

The recoveries of the zinc values varied according to the changes made in the use and regulation of the flotation reagents. Recovery based on samples no. 2 obtained with 0.20 lb. #634 and 0.15 lb. YZ :

Zinc concentrate	42.7% Zn
Recovery of zinc	88.6%

Conclusions: First - in order to obtain a high recovery of the lead it will be necessary to table at a coarser size and resort to a classified table feed. Second - The results of the three tests already made show that the gold and silver values concentrate and report with the lead table concentrate. Third - That by using a very small quantity of oil the grade of the zinc concentrate can be raised. Fourth - The analysis made on concentrate sample no. 4 indicates that it is the gangue minerals and not the iron sulphides which were lowering the grade of the concentrate.

Test No. 4

General description of test: The ore was crushed to 1" and a head sample cut by a Vezin sampler. The ore after passing through the sampler was fed to a 4½' Hardinge ball mill in closed circuit with a Dorr classifier. The classifier overflow was passed over a Wilfley table where a lead concentrate was made. The table tailing was thickened in a Callow cone and the thickened feed went to two 6'x12"Callow flat bottom cells. A final tailing and a rougher concentrate were made. The rougher concentrate was recleaned in two 3'x12" cleaner cells, the cleaner tailing being returned with the feed to the rougher cells. This zinc flotation concentrate was tabled to remove as much lead as possible.

Details of operation: Amount of ore fed to ball mill 6000 lbs.
Rate of feed per hour 1000 "

Screen Test of Classifier Overflow

Mesh	Weight	Percent	Cumulative percent
+48	1.7	0.34	0.34
-48+65	4.0	0.80	1.14
-65+100	21.8	4.36	5.50
-100+150	36.3	7.26	12.76
-150+200	116.7	23.34	36.10
-200	318.6	63.78	100.00

<u>Explanation of samples: and unit used for measuring reagents:</u> Density samples were taken of the ball mill discharge, the classifier overflow, and thickened feed to the flotation cells. The amounts of reagents used are given in lbs. per ton of ore. Special samples of the concentration products were taken from time to time during the tests. These samples are numbered and the time of taking is given in the first column of the table showing the analyses of the samples.

Pulp densities

Sample No.	Time	Weight	Ratio	% solids	
1	10.30	1450	1 : 1.20	47	Ball mill discharge
2	11.00	1620	1 : 0.70	58	
3	11.30	1560	1 : 0.81	55	
4	12.00	1450	1 : 1.12	47	
5	12.30	1445	1 : 1.128	47	
6	1.15	1450	1 : 1.12	47	
7	2.00	1500	1 : 0.96	50	
8	2.40	1430	1 : 1.174	47	
9	3.15	1380	1 : 1.381	42	
10	4.10	1385	1 : 1.36	43	
1	10.30	1295	1 : 1.94	34	Classifier overflow
2	11.00	1260	1 : 2.125	32	
3	11.30	1500	1 : 0.961	51	
4	12.00	1395	1 : 1.33	43	
5	12.30	1280	1 : 1.94	34	
6	1.15	1315	1 : 1.203	37	
7	2.00	1490	1 : 1.10	50	
8	2.40	1410	1 : 1.22	45	
9	3.15	1330	1 : 1.63	38	
10	4.10	1380	1 : 1.38	42	
1	10.30	1125	1 : 4.88	17	Thickener discharge
2	11.00	1080	1 : 7.33	12	
3	11.30	1275	1 : 2.03	33	
4	12.00	1160	1 : 3.76	21	
5	12.30	1145	1 : 4.26	19	
6	1.15	1120	1 : 4.88	17	
7	2.00	1128	1 : 4.88	17	
8	2.45	1120	1 : 4.88	17	
9	3.20	1140	1 : 4.26	19	
10	4.15	1150	1 : 4.00	20	

Reagents used

Sample No.	Time	Soda ash	Copper sulphate	#634	YZ
	10.00	3.48	1.14		
	10.15	3.10		0.10	
	10.30	2.82	1.42		
	10.45	3.28			
	11.00			0.31	
	11.15				0.20
1	11.45	2.72	0.95	0.25	
1	12.05	3.0	0.855		
1	12.20	3.0	1.14		
1	12.40			0.25	
1	1.05	2.72	0.855		0.22
2	1.50	3.10	1.14		
2	2.00	2.63			
2	2.15	3.37			
2	2.20				0.22
2	2.35	2.92			
2	2.45	2.92	0.95	0.25	0.20
2	3.20	2.82	1.42		
3	3.45			0.20	
3	3.55			0.45	
3	4.00	2.63	1.33	0.31	
4	4.15	3.67		0.3	

Analysis of Samples

Time	Product	Zinc %	Lead %	Iron %	Insol %	Gold ozs.	Sil ozs.
Whole	Head sample (Vezin sampler)	5.98	2.36	6.46		0.07	3.53
"	" " (classfr overflo)	5.54	2.77	6.77		0.05	3.41
"	Table conc no. 1 - lead	2.27	58.5	13.74		0.90	68.3
"	" tailing after thickng	5.68	1.85	7.37		0.03	2.55
11.50-1.20	Flotation conc. sample no. 1	44.03	7.28	9.09	1.51	0.10	10.80
"	" tailing " 1	1.19	0.36				
1.20-3.30	" conc. " 2	43.9	7.39	8.89	2.76	0.10	13.98
"	" tailing " 2	1.76	0.41				
3.30-4.00	" conc. " 3	42.25	10.18	8.80	4.90	0.10	12.46
"	" tailing " 3	0.95	0.40	6.4		tr	0.58
4.00-4.45	" concentrate 4	43.0	17.25	8.30	4.7	0.12	14.12
"	" tailing " 4	1.08	0.30	6.4		tr	0.08
Whole	" conc. (feed to tabl)	44.0	9.23				
"	Table concentrate no. 2 lead	9.26	63.8	4.85		0.90	76.6
"	" tailing (final zn con)	44.13	7.28	9.4	1.51	0.12	12.36

Summary: It will be noticed that in the three previous tests the lead content of the feed to the ball mill has been higher than the classifier overflow. In this test this condition is reversed and the classifier overflow is higher than the feed to the mill. The reason for this is due partly to the reduction in rate of feed to ball mill from 1500 to 1000 lbs. per hour, and partly to regulation of the classifier overflow, to deliver a thicker overflow. The circuit which had been building up with the heavy lead values now started to discharge part of its accumulated load in adjusting itself to these new conditions. The lead discharged was naturally in a very fine state which made it difficult to recover on the table. The thickened feed to the flotation cells was maintained at a much more constant density than in the previous tests. This no doubt accounts in part for the greatly improved results obtained in the flotation.

The flotation reagents used were kept fairly constant throughout the test, the soda ash being maintained as nearly as possible at 3 lbs. per ton of original feed, and the copper sulphate at approximately 1 lb. per ton. The average for the run, taking actual weights of reagents used, was 3.6 lbs per ton soda ash and 0.91 lb. per ton copper sulphate. The amount of oil used was increased over the quantity used in the previous test. The amount of Barretts #634 averaged approximately 0.25 lb. per ton, and the amount of YZ 0.2 lb. per ton. As far as could be observed the Barretts #634 oil was doing the greater part of the work. The YX gave quite a different bubble from the Barretts oil.

The operation of the flotation cells was regulated to prevent the gangue from lifting and lowering the grade of the zinc concentrate. Special attention was given the operation of the cleaner cells, considerably more wash water being used in them than in the previous test.

Recapitulation of results based
on classifier overflow analysis

Lead	Average grade of lead concentrate		59.1 %
Zinc	The recovery varied during the test:		
	Sample no. 1	Recovery of zinc	80.7 %
	" 2	" "	71.4
	" 3	" "	85.2
	" 4	" "	82.6

The lead in the flotation concentrate fromthis test was so fine that a poor recovery was made on the table.

Conclusions: First - That with reasonably careful operation a 45% zinc concentrate can be obtained with a recovery of 90%. Second - that the gangue which has been lowering the grade of the flotation concentrate in the first three tests can be eliminated by increasing the dilution in the cleaner cells. Third - That a pulp dilution of about 20% appears to give the most favourable flotation conditions in the cells. Fourth - The lead recovery shown in this test does not represent the recovery which could be expected in actual milling operations.

Test No. 5

General description of test: The procedure followed was similar to that of the preceeding tests. The zinc concentrate was not tabled for the removal of the lead as sufficient data had already been collected on this operation. In figuring the recovery of the lead, a recovery of 50% of the lead in the flotation concentrate was assumed as this figure corresponds with the results obtained in the preceeding tests.

Details of operation: Amount of feed to ball mill 5000 lbs.
Rate of feed per hour 1200 "

Screen test of classifier overflow

Mesh	Weight	Percent	Accumulative %
+48	2.5	0.5	
-48+65	4.8	0.96	1.46
-65+100	62.1	12.42	13.88
-100+150	65.6	13.12	27.00
-150+200	115.6	23.12	50.12
-200	250.0	50.00	

Explanation of sample numbers: Density samples were taken of the ball mill discharge and of the classifier overflow. The density of the thickened feed to the cells was also taken. The reagents used were measured and special samples of the concentration products were taken over periods corresponding to the regulation of the reagents.

Pulp Densities

Sample No.	Time	Weight	Ratio	% solids	
1	11.00	1290	1 : 1.94	34	Ball mill discharge
2	11.45	1580	1 : 0.79	56	
3	3.55	1450	1 : 1.13	47	
4	4.15	1490	1 : 1.00	50	
1	10.45	1255	1 : 2.23	31	Classifier discharge
2	11.25	1255	1 : 2.23	31	
3	11.55	1230	1 : 2.45	29	
4	3.35	1425	1 : 1.17	47	
5	3.55	1350	1 : 1.50	40	
6	4.15	1380	1 : 1.38	42	
1	10.45	1110	1 : 5.67	15	Feed to cells
2	11.20	1140	1 : 4.26	19	
3	11.55	1140	1 : 4.26	19	
4	12.15	1215	1 : 2.70	27	
5	12.45	1190	1 : 3.00	25	
6	3.35	1380	1 : 1.38	42	
7	4.00	1210	1 : 2.70	27	
8	4.25	1170	1 : 3.54	22	

Analysis of samples

Time	Product	Zinc%	Lead%	Iron%	
Whole	Head sample (Vezin sampler)	5.68	3.18	6.72	
"	" " (classifier o'flo)	5.17	2.05	6.00	
"	Table conc. no. 1 lead	2.69	59.84	11.00	
"	" tailing (feed to cells)	4.81	0.92	5.30	
11.30-12.45	Flotation conc. sample no. 1	43.53	6.67	9.39	Mill shut do
"	" tailing " 1	0.42			12.45-3.20
3.20-3.45	" conc. " 2	42.39	6.06	10.86	
"	" tailing " 2	0.23			

Time	Product	Zinc%	Lead%	Iron%
3.45-4.10	Flotation conc. Sample No. 3	45.51	5.54	9.29
"	" tailing " 3	0.36		
4.10-4.40	" conc " 4	42.81	6.98	9.24
"	" tailing " 4	0.47		
Whole	Average flot. tailg.(calculatd)	0.37		
"	Final flotation concentrate	42.39	6.78	10.0

Summary: The amount of oils used was considerably increased in this test. Barretts #634 and YZ mixtures were used throughout, and a little pine oil for frothing. The amount of #634 used was approximately 0.70 lb. per ton, compared to 0.25 lb. per ton in test no. 4. The YZ was increased from 0.20 lb. to 0.35 lb. per ton. The results of this increase in oils as can be seen from the table of analyses of the products was a tailing containing an average of 0.35% zinc against 1.70% in test no.4, without any appreciable decrease in the grade of the concentrate.

Recapitulation of results using classifier overflow as head sample

Lead	Average grade of concentrate	59.84 %
	" recovery, assuming 50% lead in flotation concentrate recovered by tabling	78 %
Zinc	Average grade of zinc concentrate (not tabled to remove lead)	42.4 %
	Average recovery for whole test	93.6 %

Conclusions: A high recovery of the zinc can be obtained by increasing, within limits, the amount of oil without reducing the grade of the zinc concentrate

Test No. 6

General description of test: This test is a selective flotation test. The ore was crushed as in the precious tests and the classifier overflow was fed to a 4 cell Ruth flotation machine where the lead was floated. The tailing from the Ruth went direct to the Callow cells where the zinc was floated.

Details of operation: Amount of ore fed to ball mill 7340 lbs.
Rate of feed per hour 1200 "

Screen test of Classifier Overflow

Mesh	Weight	Percent	Cumulative %
+35	0		
-35+48	3.1	0.62	
-48+65	6.7	1.34	1.96
-65+100	45.7	9.14	11.10
-100+150	80.1	16.02	27.12
-150+200	117.2	23.44	50.56
-200	247.2	49.44	100.00

Pulp Densities

Time	Weight	Ratio	% solids	
12.50	1500	1 : 0.96	51	Ball mill discharge
1.25	1504	1 : 0.96	51	
1.45	1462	1 : 1.08	48	
2.50	1485	1 : 1.00	50	
3.20	1487	1 : 1.00	50	
4.10	1486	1 : 1.00	50	
4.40	1490	1 : 1.00	50	
10.10	1370	1 : 1.44	41	Classifier discharge
12.30	1240	1 : 2.33	30	
12.45	1230	1 : 2.45	29	
1.05	1235	1 : 2.45	29	
1.25	1200	1 : 2.85	26	
1.50	1232	1 : 2.45	29	
2.00	1220	1 : 2.57	28	
2.55	1220	1 : 2.57	28	
3.30	1215	1 : 2.70	27	

Time	Weight	Ratio	% solids	
3.50	1240	1 : 2.33	30	Classifier discharge cont.
4.15	1225	1 : 2.45	29	
4.35	1220	1 : 2.57	28	
1.00	1210	1 : 2.70	27	Ruth discharge, feed to Callow
1.40	1282	1 : 1.19	34	
2.15	1175	1 : 3.35	23	
2.45	1230	1 : 2.48	29	
3.20	1155	1 : 3.76	21	
4.30	1175	1 : 3.35	23	

Reagents for flotation of lead

Time	Sod. cyanide	Oil mixture	Cresylic acid	Soda ash
10.15	0.20	0.29	0.24	7.0
	Mill shut down - power off.			
12.15	0.21			
12.20			0.24	
12.25		0.24		
12.35	0.23			
12.55	0.24		0.24	
1.00				5.0
2.15	Sample no. 2			
2.30	0.23			
3.10		0.29	0.24	
3.15	0.23			
4.00	0.24		0.24	
4.20	0.24	0.29	0.24	
4.50	0.24	0.29	0.24	5.0

Note: Soda ash fed to ball mill in solid form, other reagents fed to overflow from Dorr classifier

Reagents for flotation of zinc

Time	Water gas tar	Copper sulphate	#634	Pine oil #5
1.35	0.38	1.2		10 drops pr min
1.45			0.6	
2.30	0.35	1.2	0.53	8
3.00		0.8		
3.10		1.2		
3.40		1.2		
3.45		1.3		
4.25	Cut in TT mixture @ 0.63 lb.per ton			
4.30		0.90		
4.50	0.23	1.2	0.48	5 lb/ton

Analysis of samples

Time	Product		Zinc%	Lead%	Iron%	Insol%
Whole	Head sample (Vezin sampler)		5.65	2.87	6.87	
"	Classifier overflow head sample		6.10	2.36	6.46	
"	Lead concentrate (Ruth machine)		4.65	35.51	6.72	28.3
"	" tailing - feed to zn. flotatn.		5.27	0.21	6.00	
1.15-2.15	Zinc flotation conc. sample no.	1	50.66	0.61	10.91	
"	" " tailing "	1	1.96	0.10		
2.15-3.00	" " conc. "	2	51.18	0.72		
"	" " tailing "	2	7.64	0.11		
3.00-3.45	" " concentra "	3	50.05	0.92		
"	" " tailing "	3	2.53	0.13		
3.45-4.20	" " conc. "	4	48.02	0.92		
"	" " tailing "	4	1.24	0.11		
4.20-4.45	" " conc. "	5	49.32	1.03		
"	" " tailing "	5	1.45	0.10		
Whole	Final zinc concentrate		50.04	0.72		
"	" " tailing, average		1.76			

Summary: Lead flotation The ore was ground in a pulp made slightly alkaline with soda ash. The amount used averaged 5 lbs. per ton of ore, and was fed in the dry form to the ball mill. An oil mixture made up of 50% coal tar creosote from the Dominion Tar & Chemical Co, and 50% water gas tar from the Barrett Co., was also added to the ball mill. To the classifier discharge, which led directly to the flotation cells, approximately 0.24 pounds per ton of sodium cyanide was added, together with 0.25 lb. cresylic acid, which was used as a frother. By the use of these reagents the results shown in the above table were obtained. The tailing from the lead flotation cells was fed directly to the zinc flotation cells.

Zinc flotation - To the head of the cells approximately 1.2 lb. copper sulphate was added, 0.5 lb. Barretts #634, and a little pine oil for frothing. These reagents were fed into an air lift used to elevate the pulp to the Callow cells. It was necessary to use some method of preliminary mixing in order to get the #634 oil into the pulp, as it is of a heavy tarry nature. A remarkable separation of the lead and zinc was obtained in this test. The grade of the lead concentrate was low, but no attempt was made to re-clean it. The zinc tailing was high, due to the moderate use of flotation oils in order to obtain a high grade zinc concentrate

Recapitulation of results using classifier overflow as head sample;

Lead	Average grade of concentrate	35.51 %
	" recovery	90.0
Zinc	Average grade of concentrate	50.09 %
	" recovery	73.8

Note: At times during test, the recovery was over 85%

Conclusions: First - A remarkable separation can be obtained between the lead and zinc by selective flotation. Second - The grade of concentrate from both products is good, especially that of the zinc product. Third - A high recovery of the lead can be obtained. Fourth - From observation of the operating conditions during the test a much better recovery of the zinc canbe expected. Fifth - That the grade of the lead concentrate can be raised by more careful control of the flotation cells without lowering the extraction.

Test No. 8

General description of test: This test, together with test no. 9 were run to demonstrate the two methods of concentration for Messrs. Tetreault and their engineer, who were present by appointment.

The procedure followed in this test is similar to that used in tests nos. 2 to 5

Details of operation:

Amount of ore fed to ball mill	4200	lbs.
Rate of feed per hour	1000	"

Screen test of classifier overflow

Mesh	Weight	Percent	Cumulative %
+48	1.3	0.26	
-48+65	5.3	1.06	1.32
-65+100	39.2	7.84	9.16
-100+150	68.4	13.68	22.84
-150+200	67.8	13.56	36.40
-200	318.0	63.60	100.00

Pulp Densities

Sample No.	Time	Weight	Ratio	% solids	
1	12.40	1415	1 : 1.222	45	Ball mill discharge
2	1.10	1540	1 : 0.852	54	
3	1.35	1550	1 : 0.852	54	
4	1.50	1530	1 : 0.887	53	
5	2.35	1490	1 : 1.0	50	
6	3.00	1485	1 : 1.0	50	
1	12.30	1275	1 : 2.03	33	Classifier discharge
2	1.00	1340	1 : 1.564	39	
3	1.30	1260	1 : 2.125	32	
4	1.45	1300	1 : 1.778	36	
5	2.30	1240	1 : 2.333	30	
6	2.35	1260	1 : 2.125	32	
7	2.45	1295	1 : 1.857	35	
8	3.00	1280	1 : 1.940	34	
9	3.40	1285	1 : 1.940	34	
1	12.45	1105	1 : 5/667	15	Feed to Callow cells
2	1.10	1140	1 : 4.263	19	
3	1.25	1240	1 : 2.333	30	
4	1.45	1205	1 : 2.846	26	
5	2.15	1260	1 : 2.125	32	
6	2.20	1205	1 : 2.846	26	
7	2.35	1150	1 : 4.0	20	

Zinc Reagents

Time	Soda ash	Copper sulph	#634	YZ	Pine oil #5
12.20	2.5				
12.25		1.08			
1.15			0.49	0.23	
2.00	2.5	1.20	0.44	0.23	
2.20				YZ changed to TT	
2.45	2.3			TT	
3.00	2.3	1.20		0.36	
3.20	2.3		0.49	0.27	
3.45	Ball mill shut down.				

Analysis of samples

Time	Product	Zinc %	Lead %	Iron %
Whole	Head sample (Vezin sampler)	4.92	1.96	7.02
"	Classifier overflow (feed to table)	4.87	1.62	
"	Table concentrate (lead)	10.85	68.26	
"	Table tailing (feed to cells)	4.42	0.45	
12.20-2.30	Flotation concentrate sample no. 1	38.65	5.12	
	" tailing " 1	0.48	0.22	
Whole	" concentrate	37.65	4.76	

Recapitulation of results using classifier overflow as head sample:

(Assuming that by retabling the zinc concentrate 50% of the lead in it would be recovered)

Lead	Average grade of concentrate	68.26 %
	" recovery of lead	78.80
Zinc	Average grade of concentrate	37.65 %
	" recovery of zinc	91.4

Summary: The crushing in this test was coarser than in any of the preceeding tests. The advantage of coarse crushing is clearly exemplified in the results by the increase in the recovery of the lead. The first table separation alone recovered 70.8% of the lead in the feed.

The amount of soda ash used was approximately 2.5 lb/ton. The oil averaged 0.45 lb/ton of the Barretts #634 and 0.25 lb/ton YZ and TT mixtures. The YZ was used during the first half of the test and TT during the latter half. The density of the feed to the flotation cells was thicker than in test no. 5, and this no doubt accounted for the lower grade of concentrate made.

Conclusions: First - The results of this test emphasize the point that coarse crushing recovers more lead on the table. Second - That the density of the pulp in the flotation cells should not be allowed to get thicker than 1:3

Test No. 9 T

General description of test: This is a selective flotation test. The object was to produce a high grade lead and zinc concentrate. The classifier overflow was fed directly to a four-cell Ruth flotation machine where a lead concentrate was made in one operation, no cleaner cell being used. The concentrate from the last two cells of the Ruth were returned to the feed end of the machine, a finished concentrate being taken from the first two cells. The tailing was pumped to Callow cells consisting of two rougher cells operated in parallel, and two cleaners in parallel. The middling product from the two cleaners was returned to the feed end of the rougher cells.

Details of operation: Amount of feed to ball mill 7700 lbs.
Rate of feed per hour 1400 "

Screen test of Classifier Overflow

Mesh	Weight	Percent	Cumulative %
+48	3.2	0.64	
-48+65	8.7	1.74	2.38
-65+100	40.9	8.21	10.59
-100+150	62.5	12.51	23.10
-150+200	49.4	10.0	33.10
-200	334.0	66.9	100.00

Pulp Densities

Time	Weight	Ratio	% solids	
11.15	1480	1 : 1.0	50	Ball mill discharge
12.15	1520	1 : 0.923	52	
1.20	1497	1 : 0.961	51	
2.10	1510	1 : 0.923	52	
2.30	1500	1 : 0.961	51	
3.10	1500	1 : 0.961	51	
4.00	1550	1 : 0.852	54	
4.20	1510	1 : 0.923	52	
11.20	1255	1 : 2.226	31	Classifier overflow
12.00	1320	1 : 1.703	37	
12.15	1207	1 : 2.846	26	
12.30	1235	1 : 2.448	29	
1.15	1305	1 : 1.778	31	
1.30	1255	1 : 2.226	31	
2.10	1297	1 : 1,857	35	
2.30	1240	1 : 2.333	30	
3.10	1260	1 : 2.125	32	
3.45	1270	1 : 2.125	32	
4.20	1270	1 : 2.125	33	
4.40	1220	1 : 2.571	28	
11.30	1105	1 : 5.667	15	Feed to Callow cells
11.45	1155	1 : 3.762	21	
12.00	1170	1 : 3.525	22	
12.45	1185	1 : 3.167	23	
1.15	1175	1 : 3.348	23	
1.40	1205	1 : 2.846	26	
1.55	1195	1 : 3.000	25	
2.40	1192	1 : 3.000	25	
3.05	1190	1 : 3.000	25	
3.50	1215	1 : 2.704	27	
4.15	1245	1 : 2.333	30	
4.40	1180	1 : 3.167	24	

Lead Reagents

Time	Soda ash	Sod. cyanide	Cresylic acid	Oil mixture
10.50		0.12	0.21	0.43
11000		0.12	0.23	0.48
12.30	3.44	0.11	0.23	0.55
1.30	3.44	0.11	0.23	0.72
2.00	3.44	0.11	0.23	0.72
2.45	3.44	0.11	0.23	0.72
3.15	3.44	0.11	0.23	0.60
4.00	3.44	0.11	0.23	0.72

Zinc Reagents

Time	Soda ash	Copper sulph.	#634	TT	Pine oil #5
11.30	no further soda	1.08	0.49	0.25	
12.15	ash used	1.62			
12.50		1.48	0.49	0.27	2 dr.per min.
1.15		1.62	0.49	0.27	
1.40		1.82	0.49	0.25	
2.50			#634 added to tailing cell		
3.20		1.08	0.73	0.27	
		Fumol #6, 2 dr. per min. to froth			
3.50		1.62	0.37		

Analysis of Products

Time	Product	Zinc %	Lead %	Iron %	Insol %	Gold ozs.	Silve ozs.
Whole	Classifier overflo (head smple)	5.52	1.96	7.42		0.02	3.28
"	Lead concentrate sample no. 1	4.17	51.09	2.60	16.13	0.30	
	" tailing " " 1	5.12	0.22	6.16	49.04	tr	0.70
	Zinc concentrate " " 1	41.46	2.72				
	" tailing " " 1	0.15	0.22	9.39			
	" concentrate " " 2	47.18	1.15				
	" tailing " " 2	0.53	0.17				
	" concentrate, total sample	46.19	1.09				
	" tailing " "	0.30	0.15				
Special	sample first cleaner Zinc concentrate	20.86	1.29	11.92	11.30		
Special	sample of table concentrate by tabling final flotation tailing		3.64			0.06	6.44

Screen Analysis of Lead Concentrate

Mesh	Weight	% weight	Lead %
+100	27.5	5.50	17.67
-100+150	6.1	1.22	18.47
-150+200	2.4	0.48	11.00
-200	464.0	92.80	54.26

Summary: A remarkable separation was obtained between the lead and zinc. No difficulties were encountered during the test and the operation was smooth and easily controlled. The regulation of the lead cells producing the final concentrate required rather careful attention, but nothing out of the ordinary. The zinc cells operated smoothly and produced the typical froth which had been observed to give good results during the whole run without any change in character. One special sample was taken of the first cleaner concentrate to determine if it was necessary to use the two cleaners. This sample shows that the second cell is dropping considerable gangue mineral. A special test was made on the zinc flotation or final tailing going to waste. Part of this tailing was tabled and a narrow band of iron concentrate near the top of the table was cut out. The object of this test was to determine if the iron sulphides carried any appreciable gold or silver. The concentrate made was a very clean pyrite carrying some lead. An analysis was made for lead, gold, and silver, which quite conclusively shows that the iron pyrite does not carry the gold and silver, and that they are associated with the galena, as there is enough present to account for all the gold and silver present. The lead content in this sample bears practically the same ratio to gold and silver content as the lead content in the head sample.

Recapitulation of results using classifier overflow as head sample:

Average grade of lead concentrate	51.09 %
" recovery of lead	89.4
Average grade of zinc concentrate	46.17 %
" recovery of zinc	94.8

Conclusions: First - The ore is amenable to concentration by selective flotation. A fair grade of lead concentrate is obtained with a high recovery of the lead values. A very good grade of zinc concentrate is produced with a very high recovery of the zinc values. Second - This test would indicate that a second cleaning operation on the zinc concentrate is necessary to reduce the percentage of insoluble in the concentrate, and hence raise the grade. Third - The gold and silver practically all report in the lead concentrate and a high recovery is obtained, the tailing running only a trace in gold.

GENERAL SUMMARY & CONCLUSIONS: Two methods of concentration are suggested for the treatment of this ore, namely - tabling to recover the lead followed by flotation of the table tailing to recover the zinc, and re-tabling the flotation zinc concentrate to recover additional lead. The alternative method is selective flotation, where a slightly lower grade lead concentrate is obtained, but with a much higher recovery than in the first method, and a higher grade zinc concentrate, lower in lead, with approximately the same recovery as in the first method.

By the first method, provided that a system of graded crushing, screening, and classification is used, and a classified product fed to the tables, and the flotation concentrate is re-tabled, 80% of the lead values should be recovered in a high grade lead concentrate containing 65% to 70% lead. The gold and silver values in the ore are practically all recovered, and chiefly report in the lead concentrate. The zinc concentrate consistently contains only 0.10 oz. of gold, and approximately 12.0 ozs. silver per ton. The zinc recovery is high, and 90% can be expected with a grade of concentrate assaying around 43% to 45% Zn. The chief difficulty in obtaining a high grade zinc concentrate is due to the tendency of the chloritic gangue mineral to float. This may not be so marked in a larger flotation unit.

By the second method of selective flotation, a 50% lead concentrate can be obtained with a 90% recovery of the lead values, and containing, from figures obtained in small scale selective flotation test no. 1, 95% of the gold and 87% of the silver. A 50% zinc concentrate can be obtained, having a lead content of less than 1.5%, and with a recovery of better than 90% of the zinc values.