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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 61-41

RECOVERY OF IRON FROM SAMPLES SUBMITTED BY CAN-FER MINES LIMITED, TORONTO, ONTARIO

by

D. E. PICKETT & P. D. R. MALTBY

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

From the results of small and large scale testing, it has been shown that the samples of Can-Fer ore submitted could be concentrated to approximately 66.5% Fe and 6% SiO_2 using standard procedures. To obtain this grade, a grind of 90% minus 325 mesh or finer was required. The ratio of concentration would be in the order of 2.75 tons of ore to one ton of concentrate. Filter cake can be obtained from this concentrate containing 9.5 to 10% moisture. Phosphorus and sulphur content of the concentrate was 0.02% and 0.029% respectively, well within required limits. Analyses on other elements showed them to be present in negligible amounts. It is understood that pelletizing tests on the concentrate produced satisfactory results.

Cobbing tests were carried out and it was found that on normal grade ore, good tailing rejection was obtained at 20 mesh. Leaner ore could be upgraded by cobbing at 1/4 in. and treating in the normal flowsheet.

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INTRODUCTION

The purpose of the investigation was to determine the recovery of iron by magnetic separation, and the methods necessary to make a premium grade concentrate for blast furnace feed, on the samples submitted.

Shipments

Three carload shipments of iron ore were received from the Central Onaman range property of Can-Fer Mines Limited, in the Nakina Mining Division of Ontario, at Kowkash, 20 miles from Nakina:

Shipment No.	Date Rec'd	Weight, Tons
1	May 4, 1960	54
2	Aug. 26, 1960	42
3	Oct. 28, 1960	80

The material was minus 10 in. as mined from an open cut across the orebody.

Description of Property

The property from which the ore was taken was the Jeffries Lake orebody in the Central Onaman range, and is part of a large iron formation. Drilling is not completed but a large tonnage of ore is indicated and said to be similar to the sample shipped. The samples submitted represent a complete cross section about 240 feet long from a pit 15 feet wide and 6 feet deep totalling 2000 tons of ore.

Sampling and Analysis

Approximately five tons of shipment No. 1 was crushed to minus 1/4 in., mixed and sampled to obtain the following head analysis:

Total Fe	26.12%
Soluble Fe	25.30%
TiO_2	0.29%
P	0.14%
SiO_2	46.40%
S	0.134%
Insol.	52.96%

Samples of mill feed were taken during the continuous test runs to obtain the calculated analyses in Table 1 below.

TABLE 1

Head Analysis of Pilot Plant Runs

Run No.	Head Assay % Sol Fe
1	26.48
3	28.4
4	28.4
5	19.65
6	30.4
6A	29.82
7 (Mean)	30.04

All chemical analyses in this investigation were made by the Analytical Chemistry Sub-Division, Mineral Sciences Division, Mines Branch.

Characteristics of the Ore*

A small sample of the ore from shipment No. 1 was submitted for microscopic examination. Four polished sections were prepared and studied microscopically. Three of the polished sections appear to be typical banded-iron formation. The widest of the parallel layers of metallics and gangue is approximately 1/2 in. across, but the majority are much narrower and range down to bands less than 1 mm wide. The fourth polished section is not banded and, to the unaided eye, appears to be uniformly well mineralized.

Microscopically, magnetite preponderates as medium to fine disseminated grains in gangue. It is distributed abundantly and evenly throughout the whole of one polished surface. In the other three, however, bands range from those which are well mineralized to those which are sparsely mineralized. No band of gangue is completely mineralized. While the magnetite is generally free of inclusions, it does enclose a few small particles of gangue and, more rarely, of sulphide minerals.

Relatively small amounts of pyrrhotite, pyrite and chalcopyrite are visible as small unevenly scattered particles in gangue and, very rarely, in magnetite. Pyrrhotite is by far the most abundant sulphide mineral; particles of pyrite and chalcopyrite are comparatively rare.

*Microscopic Examination of a Sample of Magnetic Iron Ore From Can-Fer Mines Limited, Toronto, Ontario, by W. E. White, Internal Report MS 60-55, Mineral Sciences Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

Dense grey quartz is the chief gangue mineral in the polished sections with minor amounts of admixed garnet, chlorite, and clay. Calcite is also present in one polished surface as narrow veinlets which cut obliquely across the parallel iron-rich bands.

A very small amount of a hard, grey, anisotropic mineral, possibly ilmenite, is present in one polished section. It occurs in gangue as tiny sparsely-disseminated blades or laths, all too minute to obtain a satisfactory powder sample for X-ray diffraction.

OUTLINE OF INVESTIGATION

Preliminary laboratory tests were carried out on the 5-ton head sample, described above, to obtain preliminary data on the wet magnetic concentrating characteristics of the ore. (Dry concentration tests had been carried out at the Ontario Research Foundation, Rexdale, Toronto, on a 55-ton shipment similar to shipment No. 1).

Preliminary continuous tests were conducted to obtain information on the stages of processing likely to be necessary and the characteristics of a product resulting from continuous closed circuit grinding.

Pilot plant tests were carried out on the three shipments with laboratory tests for process control. These pilot plant tests were carried out in co-operation with Mr. T. B. Counselman, of Behre Dolbear & Co., New York, metallurgical consultants for Can-Fer Mines Limited. Tests were also observed occasionally by Mr. H. L. Isaacs and Mr. B. Allen, president and metallurgist of Can-Fer Mines, Ltd.

RESULTS OF INVESTIGATION

Preliminary Investigation

In the laboratory cobbing tests, over 42% of the feed was rejected as tailing, with a loss in magnetic iron of less than 2% at 10 and 20 mesh, and 4.7% at 1/4 in. The tailing assayed about 9% iron mainly due to non-magnetic iron, not recoverable except by magnetic roasting. As the loss of iron units was under 19% in all three cases, it would not be economical to give the ore a magnetizing roast to recover this small amount of iron. From the results of the cobbing tests, it was decided to carry out the preliminary magnetic separation of the pilot plant tests at about 10 mesh or finer.

The overall results from Tests 1 and 2 showed a ratio of concentration of 3.16:1. The magnetic iron unit recovery was 96.5% and the overall iron unit recovery 80%, the difference being due to non-magnetic iron oxides and silicates present in the feed. In the first stage a product assaying 48.10% iron was made at 50% minus 325 mesh which would be suitable as feed for the Strategic Udy process. In the second stage, by discarding the siliceous middling with hydraulic classification in the hydroseparator, a concentrate of premium grade was made, suitable for pelletizing.

Pilot Plant Investigation

It was found possible by fine grinding and wet magnetic separation to produce a concentrate assaying better than 66.5% iron with approximately 6% silica and 0.02% phosphorus, with a magnetic iron recovery of 94%. It was found that the critical fineness of grind was about 90% minus 325 mesh, the concentrates produced at this grind making excellent material for pellets.

The chief problem in treating this ore was the removal of siliceous middling particles from the magnetic concentrates. These relatively coarse particles, instead of being returned to the ball mill in the cyclone spigot product for regrinding, were light enough to collect in the cyclone overflow and go from there to the final cleaning stage. Apart from using a fine screen to trap this middling for regrinding, the only way to remove it and thus produce a premium grade concentrate was by hydroseparation.

The final flowsheet developed for treatment of the ore is shown as Appendix 3. The important features of this flowsheet are:

(1) The optimum sizes of crusher stage products and rod mill feed and discharge would have to be determined by large-scale pilot plant testing. The tests carried out at the Mines Branch would indicate that the product of open circuit rod milling at minus 10 mesh could be cobbed efficiently in the first stage of magnetic separation.

(2) Crusher product cobbing has been omitted from the flowsheet since it was not necessary on the representative sample treated. Cobbing might be necessary on marginal ore mined in development of the pit.

(3) Grinding to 90% minus 325 mesh appeared necessary. Although this was done in one ball mill stage it is probable that two stage grinding would be more efficient with the second stage in the finishing circuit ahead of the 3-drum finishing separation. This final stage could be open or closed circuit.

(4) Ball mill density control would require a thickener or similar equipment where the Akins classifier is shown in the pilot plant. Other thickeners would be required in the flowsheet

for density control.

(5) Classification in the small cyclone was not satisfactory as too much fine liberated magnetite was returned to the ball mill while coarse siliceous middling which should have been ground finer was classified into the cyclone overflow and to the separation stage. More efficient classification would be highly desirable.

(6) Hydroseparation is necessary to remove the siliceous middling in both the cleaning and finishing circuits. Although the syphon sizer was too large to perform effectively on a continuous basis it did give good results in semi-continuous operation which indicated that a full-scale continuous operation in a machine of proper size would give the required performance.

(7) Although a pilot size finishing type separator was not available for the tests it is shown in the final flowsheet on the basis of superior separating performance by the laboratory size Jeffrey-Steffensen finishing type separator used in small-scale tests.

(8) Although demagnetization was employed before classification and filtering, no tests were made to check to what extent it was necessary.

DETAILS OF PRELIMINARY INVESTIGATION

Although, as a result of laboratory results elsewhere, a standard wet treatment scheme for the magnetite ore had been planned, it was necessary to determine the optimum size of ground feed for the cobbing and magnetic separation steps before a pilot plant flow sheet could be designed. Preliminary laboratory and continuous tests were conducted to obtain this information and to determine the probable grade and yield of concentrate which could be recovered.

Throughout the investigation soluble iron was determined by the bisulphate fusion method which gave a result close to total iron as determined by standard fusion methods. Magnetic iron was determined by calculation from the results of a Davis tube test with soluble iron analysis of the products.

Magnetic Cobbing at 10 Mesh

In order to determine how the ore could be cobbed, 2000 g was ground to minus 10 mesh and screened. The plus 35 mesh fractions were each treated separately by a Ball-Norton dry belt separator. The minus 35 mesh fraction was treated by a Crockett wet belt separator and the concentrate was screened after separation. The results are combined in Table 2.

TABLE 2

Cobbing at 10 Mesh

	Concentrate		Tailing		
Fraction	Weight %	Analysis % Sol Fe	Weight %	Analysis % Sol Fe	Mag Fe
+ 14 M	7.9	34.4	4.8	9.7	1.04
+ 20 M	12.3	34.6	7.8	9.5	0.94
+ 28 M	10.1	35.4	6.4	9.2	1.35
+ 35 M	7.8	35.6	5.3	9.2	0.92
+ 48 M	2.8	32.5	↑	↑	↑
+ 65 M	2.8	31.9	*17.3	8.8	1.64
+100 M	2.3	33.0			
+150 M	1.8	37.0			
+200 M	1.8	44.9			
-200 M	8.8	57.1	↓	↓	↓

*The minus 35 M tailings were not screened.

From the results shown in Table 2 it seems that there will be only a small difference in iron recovery cobbing at 10 M as opposed to 35 M.

Magnetic Cobbing at 20 Mesh

A similar test was done in which 2000 g of ore was ground to minus 20 mesh. The ground product was then fed to the Crockett belt separator where it was cobbed. A screen test on the Crockett feed is shown in Table 3.

TABLE 3

Screen Test on Crockett Feed

Mesh	Weight %	Cum. Weight % Retained
+ 28	15.2	
+ 35	16.6	31.8
+ 48	11.4	43.2
+ 65	9.2	52.4
+ 100	6.8	59.2
- 100	40.8	

The Crockett concentrate was ground for 30 min in a steel ball mill and treated by a Jeffrey-Steffensen separator. The results are shown in Table 4. Concentrate and tailing were 97.3% and 97.2% minus 325 mesh, respectively.

TABLE 4

Results of Magnetic Separation

Product	Weight %	Analysis %			Distn %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
Feed*	100.0	25.8	20.6		100.0	100.0
Jeffrey Conc	25.9	69.1	69.1	3.70	69.4	86.7
Jeffrey Midd	4.4	45.84	43.98	28.76	7.9	9.4
Jeffrey Tail	27.5	7.82	2.04		8.3	2.7
Crockett Tail	42.2	8.78	0.56		14.4	1.2

*Calculated

The results show that besides obtaining a satisfactory concentrate, 42.2% of the original feed can be rejected at 20 mesh with a loss of 1.2% of the original magnetic iron. Also a premium grade concentrate can be produced from the cobbed concentrate by regrinding to 97.2% minus 325 mesh.

Preliminary Pilot Plant Tests 1 and 2

The object of these tests was to establish a continuous flowsheet for grinding and concentrating the ore, and to find out at what grind a premium grade blast furnace feed could be made. The ore used in this test was from the 5-ton head sample from shipment No. 1 and was crushed to 1/4 in. The test had to be divided into two stages as only single units including one Dings separator, one ball mill, and auxiliary equipment were available.

In the first stage, the ore was fed to a ball mill at rates gradually increased from 200 to 400 lb/hr.

The ball mill product was pumped to the Dings magnetic separator, only one drum of which was used. The concentrate was pumped to a Dorr P50 wet cyclone classifier, the oversize being returned to the ball mill. The cyclone overflow was accumulated as feed to the second stage of the flowsheet.

In the second stage, the thickened solids from the cyclone overflow of the first stage operation were fed to the ball mill, the discharge being pumped to a Dorr P50 wet cyclone. The coarse product was returned to the ball mill while the overflow, at 96% minus 325 mesh, went to a Dings separator, which produced a concentrate of 60% Fe. In order to raise the grade of concentrate, it was retreated in the 6 in. diameter Wade hydroseparator to discard siliceous middling which went to tailing. The underflow, the final concentrate, assayed 67% Fe.

During this run no tonnage samples were taken, so that all recoveries are calculated from analyses. Magnetic Fe analyses were obtained by running Davis tube tests on the various products and analyzing the results. The flowsheet and results are shown in Figures 1 and 2, and Tables 5, 6 and 7.

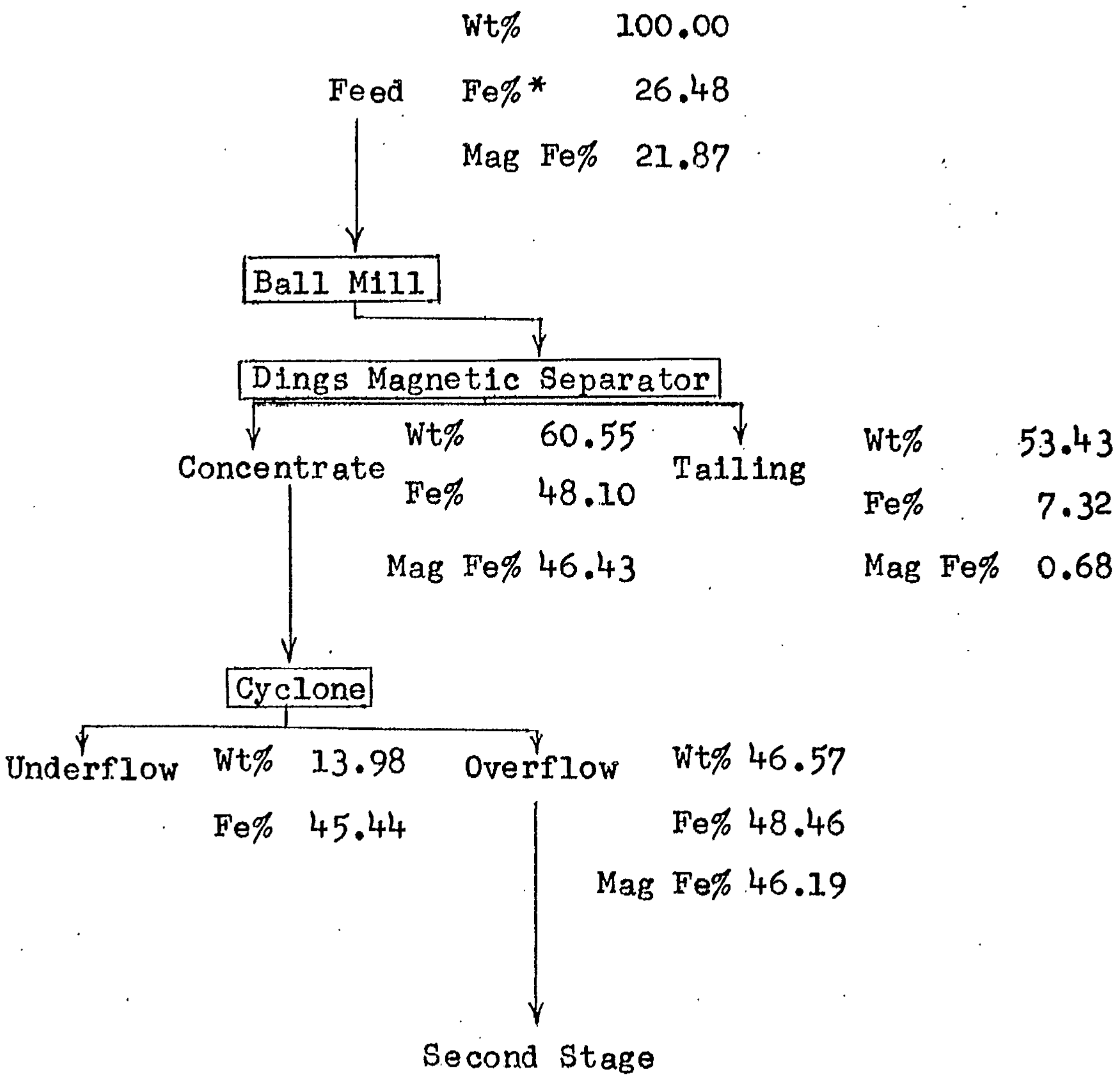


Figure 1

First Stage Metallurgical Flowsheet

*Fe analyses have been balanced to correct unit Fe discrepancies; compare Table 5 which is not balanced.

Figure 2 - Second Stage Metallurgical Flowsheet

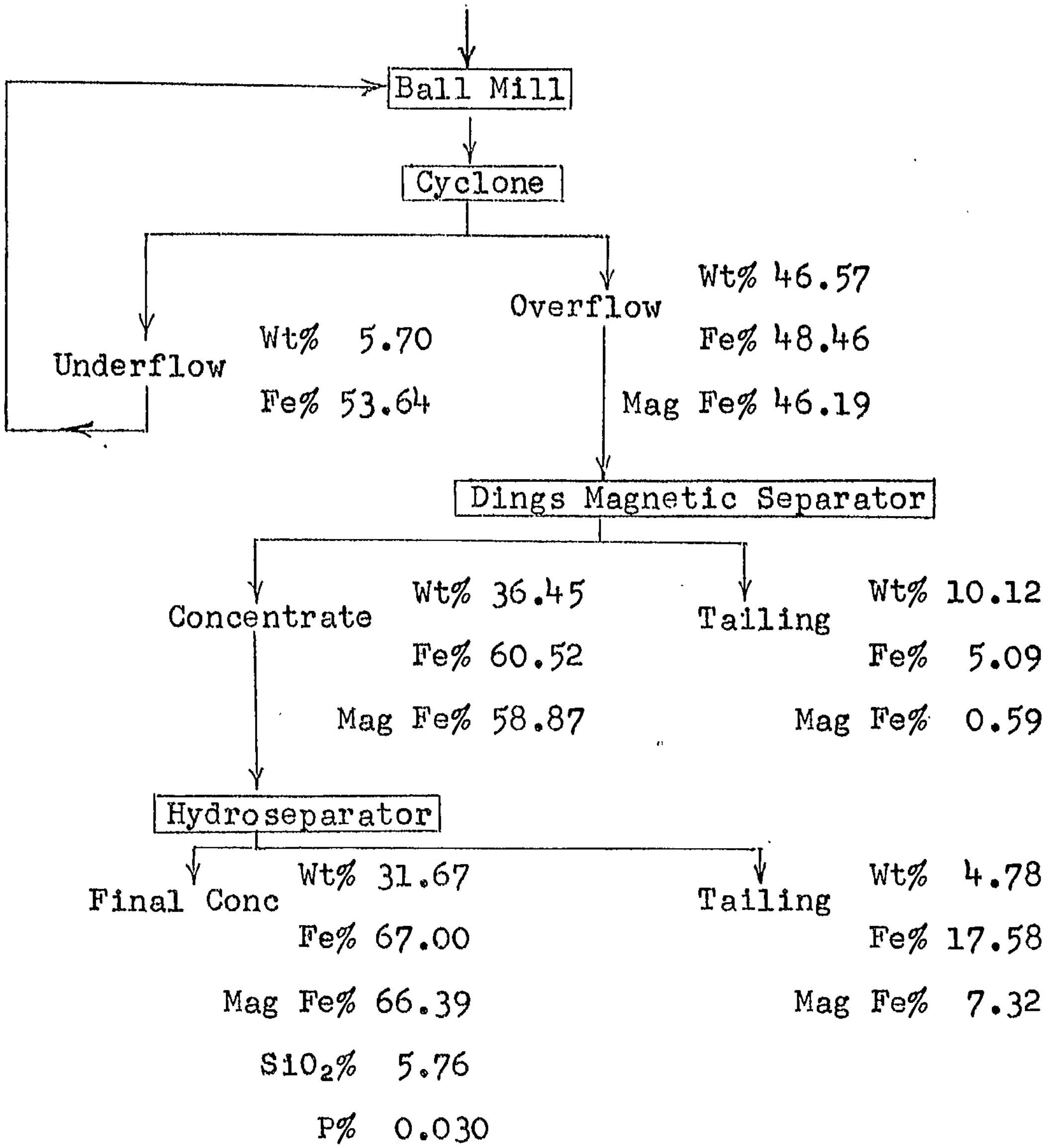


Figure 2

Second Stage Metallurgical Flowsheet

TABLE 5

Tabulation of Results of Tests 1 and 2

Test 1	Weight %	Analysis % Sol Fe	Analysis % Mag Fe	Distn % Mag Fe
Feed	100.00	26.49*	21.87*	100.00
Dings Conc	60.55	47.76	46.43	128.53
Dings Tail	53.43	7.31	0.68	1.65
Cyclone Overflow	46.57	48.46	46.19	98.35
Test 2				
Dings Conc	36.45	60.52	58.87	98.08
Dings Tail	10.12	5.09	0.59	0.27
Hydroseparator Underflow	31.67	67.00	66.39	96.48
Hydroseparator Overflow	4.78	17.58	7.32	1.60
Combined Tail	68.33	7.70	0.67	3.52

*Calculated

TABLE 6

Size Distribution - First Stage Products

Mesh	Ball Mill Feed		Ball Mill Discharge		Dings Conc		Dings Tail		Cyclone Underflow		Cyclone Overflow	
	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %
+ 4	0.5											
+ 6	1.8	2.3										
+ 8	5.0	7.3										
+ 10	18.5	25.8										
+ 14	16.9	42.7					0.3					
+ 20	12.8	55.5	0.2				0.9	1.2				
+ 28	7.6	63.1	0.2	0.4	0.3		2.0	3.2	0.2			
+ 35	5.8	68.9	0.6	1.0	0.4	0.7	5.9	9.1	0.9	1.1		
+ 48	4.0	72.9	2.2	3.2	1.0	1.7	8.4	17.5	3.2	4.3		
+ 65	3.4	76.3	5.4	8.6	3.2	4.9	9.0	26.5	10.0	14.3	0.6	
+100	3.1	79.4	8.3	16.9	6.6	11.5	9.8	36.3	16.6	30.9	2.6	3.2
+150			9.4	26.3	10.0	21.5	6.1	42.4	18.6	49.5	4.8	8.0
+200	20.6		8.2	34.5	11.4	32.9	5.2	47.6	15.5	65.0	8.4	16.4
+325			16.0	50.5	24.0	56.9	10.0	57.6	22.0	87.0	21.0	37.4
-325			49.5		43.1		42.4		13.0		62.6	

TABLE 7

Size Distribution - Second Stage Products

Mesh	Ball Mill Feed		Ball Mill Discharge		Cyclone Underflow		Cyclone Overflow		Dings Concentrate		Dings Tailing	
	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %	%	Cum %
+ 20	0.1											
+ 28	0.2	0.3										
+ 35	0.3	0.6										
+ 48	0.8	1.4										
+ 65	1.4	2.8			0.3							
+100	3.2	6.0	1.3		0.9	1.2						
+150	5.4	11.4	3.2	4.5	3.0	4.2	0.1		0.1		0.1	
+200	8.6	20.0	7.7	12.2	8.9	13.1	0.3	0.4	0.3	0.4	0.2	0.3
+325	21.6	41.6	31.3	43.5	35.6	48.7	3.8	4.2	3.6	4.0	8.1	8.4
-325	58.4		56.5		51.3		95.8		96.0		91.6	

Additional Laboratory Tests

Two more tests were run using as feed, in one, the first stage Dings concentrate and, in the other, the second stage Dings concentrate. Of each feed 2000 g was passed through the Jeffrey-Steffenson 3-drum separator at 30 lb/hr with 1 amp intensity on each drum. The concentrate produced was cleaned by a hydroseparator using an upflow of 45 ft/hr. Results are shown in Tables 8 and 9.

TABLE 8

First Stage Dings Concentrate Cleaning

	Weight %	Analysis % Sol Fe	Analysis % Mag Fe	Distn % Sol Fe
Jeff midds	8.4	28.26		4.7
Jeff tail	7.6	11.69		1.7
Hydroseparator feed	84.0	55.80		93.6
" overflow	6.6	16.75	15.38	2.2
" underflow	77.4	60.04	59.61	91.4
Feed	100.0	50.84*		100.0

* Calculated

Feed 50% minus 325 M

TABLE 9

Second Stage Dings Concentrate Cleaning

Product	Weight %	Analysis % Sol Fe	Analysis % Mag Fe	Distn % Sol Fe
Jeff midds	4.6	29.44		2.3
Jeff tail	4.0	12.20		0.8
Hydroseparator feed	91.4	62.32		96.9
" overflow	4.7	15.05	11.43	1.2
" underflow	86.7	64.98	64.84	95.7
Feed	100.0	58.89*		100.0

*Calculated
Feed 96% minus 325 mesh

Cobbing of 1/4 in. Feed

Prior to the pilot plant run, a laboratory test was done to find out what recovery and grade could be made when 1/4 in. ore was treated. A sample of 4000 grams of minus 1/4 in. feed was taken and screened on 35 mesh. The plus 35 mesh fraction was treated on the Ball-Norton belt separator and the minus 35 mesh fraction was treated on the Jeffrey-Steffensen separator. Results are shown in Table 10.

TABLE 10

Magnetic Cobbing at $\frac{1}{4}$ in.

Product	Weight %	Analysis % Sol Fe	Analysis % Mag Fe	Distn % Sol Fe	Distn % Mag Fe
B - N conc	34.6	33.98	29.72	46.7	52.4
B - N tail	17.1	10.71	1.45	7.3	1.3
Jeff conc	18.2	48.21	46.25	34.8	42.9
Jeff tail	30.1	9.40	2.27	11.2	3.4
Feed	100.0	25.19*	19.63*	100.0	100.0

*Calculated

DETAILS OF PILOT PLANT TESTS

Test 3

The purpose of this test was to investigate a pilot plant flowsheet at a feed rate of 2 tons/hr. The test was divided into two stages due to shortage of magnetic separators. The ore was crushed dry to approximately ¼ in. size. It was then fed at rates of 4000 to 4500 lb/hr, to a 36 x 61 in. rod mill operating at 30 rpm, containing a charge of 3000 lb of 2½ in. rods. The product was screened at 10 mesh, the oversize being returned to the rod mill. The minus 10 mesh material was fed to the 2-drum Dings separator which discarded about 45% of the weight of crude ore.

The primary Dings concentrate was densified in an Akins classifier and fed to a 44 x 38 in. ball mill, operating at 32 rpm, containing a 3000 lb ball charge of 2½ to ½ in. balls. The ball mill discharge was fed to the 3-drum Dings separator. An additional discard, as tailing, of 15.6% of the weight of crude ore was made. The concentrate was washed, classified with about 4% of the weight returned for regrinding, and finally filtered. The flowsheet for this stage of the test appears as Appendix 1 to the report. The filter cake was repulped and ground in the ball mill, the product being fed to the 3-drum Dings separator. After various pumping and dewatering steps, the concentrate was demagnetized and classified in a wet cyclone, the spigot fraction being returned to the ball mill. The overflow was demagnetized and fed to a Denver cone, acting as a hydroseparator. The underflow of this cone was the second stage concentrate which was filtered. Appendix 2 shows the flowsheet for this second stage of treatment.

Analysis of the final filter cake showed 7.70% SiO_2; and microscopic observation showed grains of practically free SiO_2. It was, therefore, repulped, remagnetized, and treated by further hydroseparation in two Denver cones. The overflow of these, while small in quantity, was the troublesome middling material. The final concentrate was upgraded to 66.76% Fe, 6.18% SiO_2, and 0.02% P.

Results of this test are shown in Tables 11, 12, 13, 14, 15 and 16.

TABLE 11

Tabulation of Results - First Stage Test 3

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Crude ore	100.00	28.4	19.24	100.00	100.00
Dings rougher conc	54.2	38.8	34.7	85.2	97.9
Dings rougher tail	45.8	8.1	0.88	14.8	2.1
Akins spiral sands	48.8	40.4	-	79.4	-
Akins spiral overflow	5.4	25.7	-	5.8	-
Ball mill discharge	52.9	39.8	35.6	85.2	97.9
Dings cleaner conc	37.3	53.4	49.5	80.4	95.9
Dings cleaner tail	15.6	7.3	2.46	4.8	2.0
Denver cone spigot	38.8	54.0	-	84.8	-
Denver cone overflow	3.9	9.0	2.03	1.4	0.4
Collecting cone o'flow	0.1	10.2	-	-	-
Dorr classifier sands	4.1	54.2	-	-	-
Dorr classifier o'flow	38.8	54.0	47.5	84.8	95.5
Filter cone overflow	0.5	8.4	-	0.2	0.2
First stage filter cake	38.2	54.9	49.4	84.6	95.3
First stage tail	61.8	6.20	1.5	15.4	4.7
Ratio of concentration 2.62:1					

The first stage run was carried out on July 6, 1960, the second stage on July 14, 1960, and the third stage on July 15, 18 and 19, 1960.

TABLE 12

Tabulation of Results - Second Stage of Test 3

Product	Weight %	Analysis % Sol Fe	Analysis % Mag Fe	Distn % Sol Fe	Distn % Mag Fe
Ball mill feed	38.2	54.9	49.4	84.6	95.3
Ball mill discharge	38.2	59.04		84.6	
Dings cleaner tail		7.80	4.0		
Desliming cone o'flow	6.2	8.9 {12.20	7.8 } 5.3	2.2	1.7
Collecting cone "		7.86	4.1		
Cyclone agitator feed		64.44			
Cyclone spigot		65.44			
Cyclone overflow	32.0	63.86		82.4	
Dings remagnetizer tail	0.7	18.26		0.5	
Hydroseparator feed	31.3	64.86		81.9	93.5
Hydroseparator o'flow	0.4	33.48	15.4	0.5	0.4
Hydroseparator spigot	30.9	65.40		81.4	
Filter cone overflow	0.1	27.40		0.1	
Second stage filter cake	30.8	65.5	59.23	81.3	93.1

Ratio of concentration 3.25:1

Filter cake analysis % SiO_2 7.70

% P 0.021

TABLE 13

Tabulation of Results - Third Stage of Test 3

Product	Weight %	Analysis % Sol Fe	Analysis % SiO_2	Analysis % Mag Fe	Distn % Sol Fe	Distn % Mag Fe
Dings feed	30.8	65.5	7.70	59.2	81.3	93.1
Dings tail	0.3	22.5			0.3	
Hydroseparator feed	30.5	65.85	6.91		81.0	
Hydroseparator o'flow	0.6	28.01		24.6	0.7	0.8
Hydroseparator spigot	29.9	66.62			80.3	
Filter cone o'flow	0.1	19.6			0.1	
Filter cake	29.8	66.76	6.18	59.9	80.2	92.3

Ratio of concentration 3.36:1

TABLE 14

Size Distribution - First Stage of Test 3

Mesh	Rod Mill		Dings Rougher	Akins Classifier		Ball Mill	
	Feed	Dis-charge	Conc	Sands	O'flow	Feed	Dis-charge
+3/8"	0.4						
+3	28.2						
+4	19.2						
+6	12.8						
+8	7.5						
+10	7.0	0.3	0.1	0.2			
+14	2.7	2.3	1.6	4.6		2.0	
+20	3.8	8.4	6.6	13.7		7.9	
+28	2.8	11.5	10.3	13.6		12.0	
+35	2.3	12.0	12.1	11.6		13.8	
+48	1.7	9.2	9.8	8.2		10.7	0.9
+65	1.4	7.7	8.0	6.4		9.0	1.8
+100	1.4	5.8	6.2	5.2	0.3	6.8	3.2
+150 }		4.6	5.0	4.2	0.3	5.3	4.9
+200 }	8.8	4.2	5.0	3.8	0.8	4.8	7.5
+325 }		7.4	9.4	8.2	10.0	8.8	16.4
-325 }		26.6	25.9	20.3	88.6	18.9	65.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Mesh	Dorr Classifier Overflow	Filter Cake	
		Wt %	% Fe
+48	0.6	0.6	21.8
+65	1.8	1.8	27.6
+100	3.3	3.5	31.8
+150	5.3	4.8	34.4
+200	7.8	8.0	38.4
+325	18.7	20.2	47.0
-325	62.5	61.1	61.8
Total	100.0	100.0	54.8

Filter Cake moisture = 7.0%

TABLE 15

Size Distribution - Second Stage of Test 3

Mesh	Ball Mill		Cyclone			Hydro-Separator	Filter Cake
	Feed	Dis-charge	Feed	Spigot	O'flow	Spigot	
+48	0.4						
+65	1.1		0.2	0.2			
+100	2.8	0.2	0.4	1.2			
+150	4.7	0.9	1.0	1.8	0.2		0.2
+200	6.6	2.8	2.8	6.2	0.4	0.4	0.5
+325	20.0	17.0	19.0	33.2	5.5	4.6	5.6
-325	64.4	79.1	76.6	57.4	93.9	95.0	93.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 16

Size Distribution - Third Stage of Test 3

Mesh	Dings Feed	Hydroseparator		Filter Cake
		Feed	Spigot	
+200	0.5	0.4	0.4	0.3
+325	4.9	4.6	4.7	4.8
-325	94.6	95.0	94.9	94.9
Total	100.0	100.0	100.0	100.0

<u>Test 4</u>

The results from Test 3 showed that it was possible to produce a premium grade product from Can-Fer ore suitable for blast furnace feed after pelletizing. However, there was no satisfactory hydroseparator equipment to classify out the siliceous middling. The purpose of Test 4 was (1) to discover if the ore could be concentrated in a single stage, followed by recleaning, and (2) to test a new 24 in. diameter hydroseparator that had been built at the Mines Branch.

The rod and ball loads were increased for the test, the flowsheet being similar to Test 3 except for the following modifications:

1. The concentrate from the 3-drum Dings cleaner after hydroseparation in the Denver cone and partial dewatering in the collecting cone was classified in a 3 in. Dorr wet cyclone.
2. The cyclone spigot product was returned to the ball mill feed by way of the Akins classifier to obtain the correct density.
3. The Akins classifier overflow, now much greater in volume than in Test 3, was added to the ball mill discharge for treatment in the Dings cleaner.
4. The cyclone overflow was remagnetized on the old Roche belt magnetic separator before final hydroseparator treatment in the 30 in. hydroseparator.

Results of the test are shown in Tables 17, 18, 19 and 20. The grind was 91% minus 325 mesh, slightly on the coarse side and as a result the filter cake assayed only 62.4% Fe and contained 12.4% SiO_2. Laboratory tests demonstrated that, without further grinding, the filter cake could be cleaned to 67.0% Fe with about 6% SiO_2 using a magnetic separation step and better hydroseparation. The mill run was carried out on August 11, 1960 with laboratory tests on the filter cake carried out on August 15 and 16, 1960.

TABLE 17

Tabulation of Results - First Stage of Test 4

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Crude ore	100.0	28.4	24.7	100.0	100.0
Dings rougher conc	60.2	42.5	39.7	90.1	97.0
Dings rougher tail	39.8	7.0	1.89	9.9	3.0
Akins feed	88.5	48.5	46.6	151.1	167.1
Dings cleaner conc	72.6	57.7	56.6	147.5	166.4
Dings cleaner tail	15.9	6.4	1.1	3.6	0.7
Denver cone spigot	69.3	60.0	59.1	146.4	165.9
Denver cone overflow	3.3	9.2	3.9	1.1	0.5
Collecting cone spigot	69.2	60.0	59.2	146.2	165.9
Collecting cone o'flow	0.1	8.2	1.3	0.2	-
Cyclone spigot	28.3	61.2	61.2	61.0	70.1
Cyclone overflow	40.9	59.6	57.8	85.2	95.8
Roche concentrate	40.0	60.4	58.6	85.1	94.9
Roche tail	0.9	27.0	22.3	0.1	0.9
Hydroseparator spigot	38.4	62.4	60.5	84.4	94.2
Hydroseparator o'flow	1.6	13.2	10.7	0.7	0.7
Filter cake	38.4	62.4	60.5	84.4	94.2

Ratio of concentration 2.60:1
Filter cake % SiO_2, 12.4; % P, 0.025

TABLE 18

Laboratory Tests on Filter Cake of Test 4

Product	Weight %	Sol Fe %	Distn % Sol Fe
Feed	100.0	62.3	100.0
Wade hydroseparator spigot	89.0	66.4	94.9
Wade hydroseparator overflow	11.0	29.0	5.1
Feed	100.0	62.1	100.0
Jeffrey-Steffensen conc	89.0	66.0	94.6
Jeffrey-Steffensen midd + tail	11.0	30.6	5.4
Wade hydroseparator spigot	85.8	67.0	92.6
Wade hydroseparator overflow	3.2	39.0	2.0

A sample of filter cake was fed to the Jeffrey-Steffensen magnetic separator, the concentrate being pumped to the hydroseparator for further cleaning.

TABLE 19

Laboratory Tests on the Cyclone Spigot of Test 4

Product	Weight %	Sol Fe %	Distn % Sol Fe
Feed	100.0	57.5	100.0
Wade hydroseparator spigot	87.5	62.6	95.3
Wade hydroseparator overflow	12.5	21.4	4.7
Feed			
Jeffrey-Steffensen conc	84.0	63.8	93.3
Jeffrey-Steffensen midd + tail	3.5	33.4	2.0

TABLE 20

Size Distribution - Test 4

Mesh	Rod Mill Feed	Sweco Screen Undersize	Dings Rougher Conc	Dings Rougher Tailing	Akins Classifier O'size	Ball Mill Discharge
+1/2"	0.3					
+3/8	6.1					
+3	23.5					
+4	13.3					
+6	10.4					
+8	7.7					
+10	6.5					
+14	3.7					
+20	4.4					
+28	3.2	1.2	1.2	0.8	0.7	
+35	2.6	7.2	8.2	5.0	5.0	0.3
+48	1.9	9.4	9.4	7.1	7.4	0.4
+65	1.7	9.2	9.7	7.6	8.2	0.8
+100	1.6	8.6	8.2	7.9	7.6	2.0
+150 }		7.6	7.2	6.8	7.0	3.2
+200 }	13.1	6.1	7.0	5.1	7.2	5.2
+325 }		11.2	14.2	7.9	18.6	15.8
-325 }		39.5	34.9	51.8	38.3	72.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Mesh	Cyclone Feed	Cyclone Spigot	Cyclone O'flow	Hydroseparator Spigot	Filter Cone Spigot
+65		1.2	0.8		
+100		2.0	1.5		
+150	0.1	4.8	3.2		
+200	0.9	10.4	5.0	0.6	0.4
+325	7.7	29.2	18.0	7.4	8.2
-325	91.3	52.4	71.5	92.0	91.4
Total	100.0	100.0	100.0	100.0	100.0

Dry cobbing tests were also run on a small sample of rod mill feed (-3/8 in.) with the results shown in Table 21. Recovery was too low to permit cobbing prior to rod milling on this sample.

TABLE 21

Results of Cobbing Rod Mill Feed at Minus 3/8 in.

Product	Weight, %	% Sol Fe	Distn, % Fe
Feed	100.0	20.0	100.0
Ball-Norton conc	44.6	33.0	73.5
Ball-Norton tail	55.4	9.6	26.5

Tests 5 and 5A

This run was carried out on the second carload of ore. In Test 5, lean ore, which had been purposely separated and shipped in one end of the car, was treated. During this test there was spillage on the floor of several tons of rod mill product. Test 5A is a record of the treatment of this spillage.

The purpose of the run was (1) to learn if the leaner ore could be upgraded by dry cobbing at a relatively coarse size, and (2) to learn if the upgraded magnetic fraction could be treated by the same flowsheet as used in the previous mill runs.

Approximately 20 tons of lean ore was first crushed to 3/4 in. size and fed to the dry magnetic cobber consisting of a magnetic head pulley, connected by an 18 in. belt to a tail pulley. The field strength was adjusted so that the tailing rejected was obviously low in magnetite. The magnetic fraction, being about one-third of the 20 tons of lean material, was crushed to 3/8 in. and treated by the same flowsheet as used in Test 4. Only one stage of concentration could be used. Due to a relatively coarse grind (80% minus 325 mesh) the concentrate analyzed only 62.3% Fe, but this was brought to desired grade by reconcentration with some regrinding.

During the test, the bucket elevator, raising the rod mill discharge to the 20 mesh Sweco screen, was out of service. A Wilfley pump was used which gave some trouble due to insufficient intake head and caused several tons spillage. Test 5A is a record of treatment of this spillage as it was fed back to the Wilfley pump, when it operated normally. Results of these tests are shown in Tables 22, 23, 24 and 25.

TABLE 22

Tabulation of Results - Test 5

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Crude ore	100.0	19.65	11.22	100.0	100.0
Cobber conc	34.4	33.50	29.30	58.7	89.8
Cobber tail	65.6	12.38	1.74	41.3	10.2
Rod mill feed	34.4	33.36	29.30	58.7	89.8
Dings rougher conc	29.3	38.00	-	56.7	89.5
Dings rougher tail	5.1	7.40	0.87	2.0	0.3
Ball mill discharge	64.0	48.70	-	158.5	-
Dings cleaner conc	55.4	55.20	-	155.6	-
Dings cleaner tail	8.6	6.70	1.52	2.9	1.2
Denver cone spigot	51.6	57.22	-	150.2	-
Denver cone o'flow	3.8	28.22	1.42	5.4	4.8
Collecting cone spigot	51.0	57.80	-	150.0	-
Collecting cone o'flow	0.6	9.40	-	0.2	-
Cyclone spigot	34.7	57.60	-	101.8	-
Cyclone overflow	16.3	58.10	57.60	48.2	83.2
Roche concentrate	15.9	59.0	-	47.8	82.7
Roche tail	0.4	17.20	12.00	0.4	0.5
Hydroseparator spigot	13.9	63.10	62.60	44.8	73.2
Hydroseparator o'flow	2.0	54.40	53.60	3.0	9.5
Filter cone overflow	-	13.30	-	-	-
Filter cone spigot	-	62.4	-	-	-
Filter cake	-	62.3	61.90	-	-
Ratio of concentration 7.20:1 Filter cake % SiO_2, 12.07					

The test was carried out on September 11, 1960

TABLE 23

Product Size Distribution - Test 5

Mesh	Ball Mill		Sweco Screen	Akins	Dings Rougher		Cyclone		Hydro-Separator	Filter Cone	
	Feed	Discharge	Under-size	Sand	Conc	Tail	Spigot	Overflow	Spigot	Spigot Wt %	Spigot Fe %
+1/2 "	12.5										
+3/8	27.8										
+3	16.5										
+4	9.3										
+6	5.9										
+8	4.8										
+10	2.8										
+14	2.8										
+20	2.5										
+28	2.0		1.5	1.4	1.5	1.1					
+35	1.8		9.5	9.0	10.2	6.2					
+48	1.4	0.8	11.6	11.4	11.8	8.8					
+65	1.3	1.8	10.4	10.1	10.8	8.7	3.0				
+100	1.2	3.6	8.6	9.0	8.5	7.5	6.0		0.4	0.5	26.0
+150		5.4	6.6	8.4	7.0	5.7	9.6	1.1	1.8	2.2	23.7
+200	7.4	7.6	5.8	8.9	6.2	4.8	12.2	4.2	4.6	5.3	31.6
+325		22.6	10.2	19.2	11.7	7.3	38.2	12.8	12.5	14.5	33.6
-325		58.2	35.8	22.6	32.3	49.9	31.0	81.9	80.9	77.5	66.6

Test 5A was carried out on September 12 and 13, 1960. Feed rate was 1600 lb/hr, and 1150 lb/hr respectively.

TABLE 24

Tabulation of Results - Test 5A

Product	Analysis %			
	Sol Fe		Mag Fe	
	Sept. 12	Sept. 13	Sept. 12	Sept. 13
Cyclone overflow	61.6	64.4		
Thickener spigot	61.9	65.6		
Thickener overflow	7.6	10.4		
Hydroseparator spigot	64.4	66.8		
Hydroseparator o'flow	20.4	20.4		
Filter cake	63.6	66.2	63.0	66.0

TABLE 25

Size Distribution - Test 5A

Mesh	Sept. 12		Sept. 13	
	Cyclone Overflow	Filter Cake	Cyclone Overflow	Filter Cake
+100	0.1	0.4	0.1	0.3
+150	0.4	0.9	0.4	0.5
+200	0.7	1.8	0.4	0.7
+325	6.4	8.8	3.3	3.4
-325	92.4	88.1	95.8	95.1

Tests 6 and 6A

In these tests, the balance of ore in the second shipment was treated. It had been intended to use a 3 ft diameter test Syphon Sizer, obtained from Dorr Oliver Inc. It had been stated by Jones and Laughlin representatives that the Syphon Sizer had given very satisfactory results in removing siliceous middlings, and thus upgraded this type of fine concentrate. However, the Sizer was delayed in transit and did not arrive until after the first stage of the test had been completed. An attempt was made to use it for recleaning the first stage concentrate in tests 6B and 6C.

The feed for this test was said to be representative of the main tonnage of the Jeffries Lake ore body.

Tests 6 and 6A followed the flowsheet of Test 4. As concentration could not be completed in one stage, the grind was kept coarser than 90% minus 325 mesh deliberately, to define more accurately the mesh of grind required. The only difference between the two tests was that the feed rate was slightly higher in Test 6, resulting in a coarser grind. The Mines Branch hydroseparator was used, the overflow being found to consist of particles of grey silica, with specks of magnetite attached or included inside the silica grains. The highly siliceous middling could not have been discarded magnetically, but only by a combination of magnetic and gravity concentration. As expected, the concentrate was too high in silica and it was combined with the concentrate from Tests 5 and 5A for a recleaning treatment in Tests 6B and 6C.

Test 6 was carried out on September 14; Test 6A on September 15 and 16; Test 6B on September 22; and Test 6C on September 23, 1960. Results of Tests 6 and 6A are shown in Tables 26, 27, 28, and 29.

TABLE 26

Tabulation of Results - Test 6

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Crude ore	100.0	30.4	27.5	100.0	
Dings rougher conc	67.8	42.0		93.7	
Dings rougher tail	32.2	5.96		6.3	
Akins overflow		40.24			
Akins sands		47.8			
Ball mill discharge	120.0	49.8	48.4	196.6	
Dings cleaner conc	101.7	57.36		191.9	
Dings cleaner tail	18.3	7.8		4.7	
Denver cone spigot	96.4	59.8		189.7	
Denver cone overflow	5.3	12.5	7.8	2.2	
Collecting cone o'flow	0.2	9.12		0.4	
Cyclone feed	52.2	59.8	59.1	102.9	
Cyclone spigot	44.0	59.92		86.4	
Cyclone overflow		59.70	59.4		
Thickener overflow		7.44			
Hydroseparator feed	44.0	59.7		86.4	
Hydroseparator o'flow	4.8	46.0		7.3	
Hydroseparator spigot	39.2	61.37		79.1	
Filter cone overflow	0.5	13.8		0.2	
Filter cone spigot	38.7	62.0		78.9	
Filter cake	38.7	62.0	61.5	78.9	86.5
Ratio of concentration 2.58:1					

TABLE 27

Product Size Distribution - Test 6

Mesh	Rod Mill	Sweco	Akins		Ball Mill	Cyclone		Filter
	Feed	U'size	Sands	O'flow	Dis-charge	Spigot	O'flow	Cake
+3/8"	1.2							
+3	24.4							
+4	16.4							
+6	13.0							
+8	7.9							
+10	6.8							
+14	5.2							
+20	4.5							
+28	3.2	0.6	0.8					
+35	2.6	4.0	4.8					
+48	1.7	8.6	10.5					
+65	1.4	10.0	11.4	0.8	1.3	1.8		
+100	1.2	9.4	10.0	3.0	2.8	5.2	0.8	0.6
+150		7.6	8.8	6.4	4.3	9.0	2.0	2.2
+200	10.5	6.8	9.0	9.5	6.6	12.2	4.5	4.5
+325		11.6	19.4	26.2	22.4	40.0	14.0	12.8
-325		41.4	25.3	54.1	62.6	31.8	78.7	79.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 28

Tabulation of Results - Test 6A

Product	Weight %	Analysis %		Distn %	
		Sol Fe	Mag Fe	Sol Fe	Mag Fe
Crude ore	100.0	29.82	27.50	100.0	100.0
Dings rougher conc	64.1	42.70	40.60	91.8	94.62
Dings rougher tail	35.9	6.80	0.87	8.2	1.13
Akins overflow	-	39.60	-	-	-
Akins sands	130.0	50.76	49.60	221.3	234.47
Ball mill discharge	-	51.60	-	-	-
Dings cleaner conc	113.1	57.20	57.00	216.9	234.44
Dings cleaner tail	16.9	7.80	5.70	4.4	3.49
Denver cone spigot	109.8	58.60	57.80	215.8	230.76
Denver cone overflow	3.3	10.24	5.30	1.1	0.62
Collecting cone o'flow	0.9	7.60	-	0.2	-
Cyclone feed	-	59.10	-	-	-
Cyclone spigot	65.9	58.60	58.40	129.5	139.96
Cyclone overflow	43.0	59.70	59.30	86.1	92.73
Thickener overflow	0.1	9.50	-	0.1	
Thickener spigot	42.9	59.80	-	86.0	
Hydroseparator o'flow	2.3	23.04	20.30	1.8	1.71
Hydroseparator spigot	40.6	61.80	-	84.2	
Filter cone o'flow	-	14.30	-	-	
Filter cone spigot	-	61.00	-	-	
Filter cake	-	61.70	61.40	-	90.87

Filter cake % SiO_2, 12.92

Ratio of concentration 2.46:1

TABLE 29

Product Size Distribution - Test 6A

Mesh	Akins Sands	Ball Mill Discharge	Dings Rougher Feed	Cyclone Overflow	Filter Cake Sept.15	Filter Cake Sept.16
+28	0.8		0.6			
+35	3.3		3.0			
+48	7.0	0.4	5.8			
+65	9.4	1.5	8.3			
+100	10.2	2.4	9.2	0.3	0.6	0.4
+150	9.3	3.7	8.0	0.8	1.4	1.0
+200	9.2	6.1	7.2	2.8	3.9	3.0
+325	19.7	20.1	13.0	10.4	11.6	10.4
-325	31.1	65.8	44.9	85.7	82.5	85.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Comparing the results above with those of Test 5, it can be seen that the weight discarded after the Dings rougher was less than the sum of the weights discarded by dry cobbing and the Dings rougher in Test 5. Higher magnetic iron recovery was attained with the former method. This raises the question as to the relative economics of the two treatment methods. In Test 5 the tailing discarded was 10.5% of the magnetic iron as opposed to only 1.13% correspondingly in Test 6A. Cost estimates would have to be made to determine the more economical treatment method.

Tests 6B and 6C

After preliminary tests with the Dorrco Syphon Sizer, concentrate from Tests 5, 5A, 6 and 6A was repulped and fed to the Dings cleaner, the concentrate from this being fed to the Syphon Sizer. Unfortunately, it was not possible to adjust the Syphon Sizer accurately so that it would stay in balance without surging. Also, without re-grinding, the grade of concentrate was not sufficiently improved to meet premium grade requirements.

The principle of the Syphon Sizer is that a bed of concentrate, in teeter, accumulates in the tank of the Syphon Sizer, with an overflow, but no underflow discharge. The teeter bed of material continues to build up until its density is sufficient to start the discharge syphon operating. In the test it was aimed to maintain a slight syphon discharge practically all the time and to hold a balanced circuit. The difficulty was that when the syphon discharge started, it would continue to syphon until it had discharged most of the accumulated bed of concentrate. At this time the overflow was negligible, despite the feed remaining steady. When most of the accumulated bed had been discharged, the automatic float supposed to regulate the operation would break the syphon. There would then be no underflow discharge until the teeter bed accumulated again. When the teeter bed had accumulated sufficiently to reach the overflow level, and before syphoning recommenced, considerable high grade magnetite would overflow as tailing product.

After two days of closed circuit testing, Test 6B was started on September 22nd. However, with the cyclic action encountered (and not overcome) and the consequent periodic unloading of the teeter bed, a vortex was formed.

This vortex tended to entrain middling grains and pull them down into the bed. From the results of Test 6B it was concluded that finer grinding was necessary for the desired grade after recleaning, and that steadier operation of the Syphon Sizer was required. In Test 6C the recleaning operation was repeated after regrinding, and the hydroseparator used as well as the Syphon Sizer. However, it was not possible to balance this test as the capacity of the hydroseparator was much below that of the Syphon Sizer. Due to this, the results were not satisfactory and losses in the Syphon Sizer overflow were high due to its cyclic action. The grade of the final concentrate, however, was excellent at 67.40% Fe and 5.78% SiO_2.

The feed in Test 6C was repulped and fed to the cyclone, the spigot discharge being dewatered in the Akins classifier and fed to the ball mill at a low feed rate. The ball charge was decreased to avoid overgrinding, the product being about 90% minus 325 mesh. The cyclone overflow went to the 3-drum Dings cleaner which rejected a tailing. The concentrate went to the hydroseparator whose purpose was to reject middling in the overflow. This machine worked well at a feed rate of about 1300 lb/hr - as in Test 5. However, the feed rate to it, in the recleaning operation, was about 2200 lb/hr, which resulted in high losses in the overflow.

The hydroseparator spigot product was pumped to the Syphon Sizer. One of the reasons for the 2200 lb feed rate was to try to feed enough material to the Syphon Sizer to minimize its cyclic operation. This was not completely achieved, although the operation was more uniform than Test 6B. Results of Tests 6B and 6C are shown in Tables 30, 31, 32 and 33.

TABLE 30

Tabulation of Results - Test 6B

Product	Analysis % Sol Fe	SiO_2
Feed	62.0	12.92
Dings cleaner conc	63.2	
Dings cleaner tail	20.0	
Dorrco Syphon Sizer spigot	65.6	
Dorrco Syphon Sizer overflow	42.1	
Filter cake	65.3	

TABLE 31

Size Analysis - Final Concentrate Test 6B

Mesh	Weight %	Analysis % Sol Fe	Distn % Sol Fe
+100	0.4	51.70	0.3
+150	1.1	37.25	0.6
+200	3.0	24.15	1.1
+325	9.3	48.00	6.9
-325	86.2	69.00	91.1
Total	100.0	65.30	100.0

TABLE 32

Tabulation of Results - Test 6C

Product	Analysis %	
	Sol Fe	SiO_2
Akins sands	65.00	
Akins overflow	64.46	
Ball mill discharge	64.84	
Collecting cone overflow	8.28	
Cyclone feed	65.32	
Cyclone spigot	65.16	
Cyclone overflow	64.96	
Hydroseparator overflow	51.60	
Hydroseparator spigot	66.20	
Dings cleaner conc	65.78	
Dings cleaner tail	12.64	
Dorrco Syphon Sizer spigot	67.40	
Dorrco Syphon Sizer overflow	50.98	
Filter cone overflow	20.82	
Filter cake	67.40	5.78

TABLE 33

Product Size Distribution - Test 6C

Mesh	Ball Mill Feed	Cyclone		Hydro-separator	Dings Cleaner	Syphon Sizes
		Spigot	O'flow	Spigot	Conc	Spigot
+100	0.6	0.8	0.3	0.4	0.4	-
+150	0.7	0.8	0.7	0.8	0.7	0.6
+200	2.4	2.7	2.0	2.9	2.2	2.2
+325	7.9	8.1	6.6	15.3	7.4	7.0
-325	88.4	87.6	90.4	80.6	89.3	90.2
Total	100.0	100.0	100.0	100.0	100.0	100.0

Test 7

A third carload of ore arrived in November so that a test run could be made over several days using the flowsheet developed in the previous tests. Other reasons for running the test were:

(1) To produce a large quantity of concentrate averaging 6 to 7% SiO_2 for pelletizing and other testing by potential customers.

(2) To obtain a good average analysis of the carload of ore.

(3) To learn if dry magnetic cobbing was feasible at a relatively coarse size.

(4) To learn the optimum fineness of grind.

(5) To learn the best method for recleaning the first stage concentrate to bring it up to optimum grade.

(6) To discover if the Dorrco Syphon Sizer could be made to operate satisfactorily.

Concentration tests were run from November 28 to December 7 as continuously as possible.

A preliminary cobbing test was done on November 23 in which three tons of feed was cobbed dry at 3/4 in. using the magnetic head pulley. After the test the fractions were recombined for the main mill run. Results of dry cobbing are shown in Tables 34 and 35.

TABLE 34

Dry Cobbing at 3/4 in.

Product	Weight %	Analysis %			Distn %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
Crude ore	100.0	31.1*	28.1*	42.8	100.0	100.0
Cobber conc	76.5	35.3	32.8	38.5	86.8	89.1
Cobber tail	23.5	17.4	12.65	61.1	13.2	10.9

*Calculated

TABLE 35

Davis Tube Results on Dry Cobbing Products

Product	Head	Davis Tube Conc		Davis Tube Tail		%
	% Fe	Weight %	% Fe	Weight %	% Fe	Mag Fe
Crude ore	31.1	52.5	54.82	47.5	6.12	28.1
Cobber conc	35.3	53.1	52.16	46.9	6.80	32.8
Cobber tail	17.4	15.1	55.90	84.9	6.14	12.65

Comparing the results obtained with those using a wet magnetic cobbing procedure at 20 mesh, the conclusion is that the latter is preferable due to the greater weight of tailing removed with lower iron loss.

Test procedure for the pilot run was similar to that followed in previous tests. A first stage concentrate was produced and then recleaned at a later date. Operating data for the tests are shown in Tables 36 and 37.

TABLE 36

Tabulation of Operating Data - Test 7

Product	Dec. 1		Dec. 2		Dec. 5		Dec. 6		Dec. 7	
	% S*	lb/hr	% S	lb/hr	% S	lb/hr	% S	lb/hr	% S	lb/hr
Ball mill discharge			81.7		34.0		55.4		49.0	
Sweco undersize	68.0		59.5	28.40		2526		2644	46.6	1802
Dings rougher conc			42.1		36.1		30.9		37.8	
Denver cone overflow			2.4	78.5	2.6	63.4	2.8	73.7	2.6	116
Denver cone spigot			42.1		39.8		36.3		35.5	
Collecting cone o'flow			0.5	0.6	2.6	3.2	0.6	6.9	0.8	7.4
Collecting cone spigot			51.8		41.1		30.8		24.2	
Comb.#1 and #2 tail			3.8		17.3	999	16.8	509	15.9	
Comb.#3 tail	8.8		4.7		15.5	642	7.7	904	7.1	405
Dings cleaner feed			41.8							
Dings cleaner conc			43.9		40.4		37.3		46.4	
Cyclone overflow	14.9		15.0		16.0		11.8		11.5	
Cyclone spigot			79.5		71.9		68.2		66.9	
Filter cone overflow			0.1		0.4		0.1		0.1	
Filter cone spigot			57.0		39.7		45.1		46.5	
#2 Recleaner conc	28.6	1349	29.6		26.0		27.3		26.3	
#2 Recleaner tail	0.5				0.6		0.4		0.1	
Dings rougher tail	17.8									
Syphon sizer o'flow	2.9	47.5	1.2		3.5	72.5	0.3	25.2	10.9	49.0
Syphon sizer spigot	35.2	952	38.8		38.7	1485	32.2	901	45.0	648
Filter cake % H_2O	9.9		9.7		11.3		9.9		12.2	

	Dec. 8		Dec. 9		
	% S	% H_2O	% S	lb/hr	% H_2O
Feed	24.2		56.5		
Dings cleaner conc	28.4		39.8		
Syphon sizer o'flow	1.7		0.6	118	
Syphon sizer spigot	44.6		43.2	2448	
Filter cone spigot	63.0		59.8		
Filter cake		9.8			11.5
Denver cone o'flow			1.8	12	
Denver cone spigot			28.1		
Dings cleaner tail			0.3		
Filter cone overflow			2.4		

* % S = % solids by weight in ore-water pulp

TABLE 37

Results of Screen Tests - First Stage Products, Test 7

Date	Mesh	Cyclone Overflow	Syphon Sizer Feed		Syphon Sizer Overflow		Syphon Sizer Spigot		Filter Cake	
		Weight %	Weight %	% Fe	Weight %	% Fe	Weight %	% Fe	Weight %	% Fe
Dec. 1	+100	0.4								
	+150	1.2	0.4	34.8			0.9	40.0	0.5	22.72
	+200	2.6	3.8	34.8	0.1		0.8	30.7	2.2	25.42
	+325	8.4	9.1	41.0	3.6	10.8	8.3	39.9	8.7	38.60
	-325	87.4	86.7	65.7	96.3	10.6	90.0	68.0	88.6	68.00
	Feed	100.0	100.0	62.4	100.0		100.0	65.4	100.0	64.52
Dec. 2	+150	0.3							0.8	29.6
	+200	1.6							1.6	26.6
	+325	7.8							7.1	38.4
	-325	90.3							90.5	67.4
	Feed	100.0							100.0	64.6
Dec. 5	+150	0.5					0.4	26.5	0.3	29.2
	+200	2.2			0.2		2.2	23.0	1.8	23.2
	+325	10.3			27.0	10.2	11.7	42.4	8.0	32.0
	-325	87.0			72.8	10.4	85.7	66.6	89.9	66.4
	Feed	100.0			100.0	10.28	100.0	63.5	100.0	63.4
Dec. 6	+150	0.6					0.5	45.4	0.6	43.9
	+200	1.4			0.2		1.8	32.9	2.0	31.0
	+325	8.8			35.0	11.0	10.1	44.6	9.7	44.8
	-325	89.2			64.8	20.0	87.6	67.1	87.7	67.6
	Feed	100.0			100.0	17.0	100.0	64.6	100.0	65.0
Dec. 7	+150	0.2					0.1		0.2	
	+200	1.4					1.3	35.5	1.0	30.48
	+325	5.4					6.5	43.2	5.2	34.44
	-325	93.0					92.1	68.34	93.6	68.00
	Feed	100.0					100.0	66.10	100.0	65.70
Dec. 8	+150		0.6						0.4	34.22
	+200		1.2						1.5	28.00
	+325		6.0						9.0	47.22
	-325		92.2						89.1	68.64
	Feed		100.0	64.70					100.0	66.04
Dec. 9	+150						0.8	30.84	0.2	
	+200						1.8	27.40	1.0	35.9
	+325						6.6	43.26	6.0	42.7
	-325						90.8	68.44	92.8	68.6
	Feed						100.0	65.74	100.0	66.7

A summary of results of the first stage of concentration is shown in Table 38.

TABLE 38

Results of First Stage Concentration

Date	Feed Rate	Grind	Concentrate		Filter Cake
	lb/hr	% -325 M	% Fe	% SiO_2	% Moisture
Nov.28	4000		64.4		
Dec. 1	3000	87.4	65.4		9.9
Dec. 2	3000	90.3	64.6	8.96	9.7
Dec. 5	3000	87.0	63.5	10.32	11.3
Dec. 6	2700	89.2	64.6	8.88	9.9
Dec. 7	2880	93.0	66.1	7.70	12.2

The plant was run on an average of 6.7 hours per operating day treating a total of 51 tons of crude ore. Samples were taken at 15 min intervals.

Detailed results of the daily pilot tests are shown in Table 39. The balanced results for the 5 day test are shown in Table 40, in which the partial results obtained in the startup on November 28 have not been included.

TABLE 39

<u>Tabulation of Results - First Stage Test 7</u>

Product	Dec. 1 Weight %	Dec. 1 Sol Fe %	Dec. 1 Mag Fe %	Dec. 1 Distn % Sol Fe	Dec. 2 Weight %	Dec. 2 Sol Fe %	Dec. 2 Mag Fe %	Dec. 2 SiO_2 %	Dec. 2 Distn % Sol Fe	Dec. 5 Weight %	Dec. 5 Sol Fe %	Dec. 5 Mag Fe %	Dec. 5 SiO_2 %	Dec. 5 Distn % Sol Fe
Crude ore	100.0	30.26	26.7	100.0	100.0	29.72	25.4	-	100.0	100.0	30.04	27.1		100.0
Dings rougher conc	68.4	42.25		95.5	68.7	41.32		-	95.5	71.2	39.95			94.7
Dings rougher tail	31.6	4.26	3.53	4.5	31.3	4.24	0.0	-	4.5	28.8	5.50	0.81		5.3
Ball mill discharge	-	52.64	-	-	-	53.82	-	-	-	-	-	-	-	-
Dings cleaner feed	123.8	50.05	-	204.8	149.2	51.70	-	-	259.7	135.2	50.01	-	-	225.1
Dings cleaner conc	105.2	58.00		201.7	128.5	59.04	-	-	255.1	113.6	58.50	-	-	220.4
Dings cleaner tail	18.6	5.04	2.45	3.1	20.7	6.38	0.22	-	4.6	21.6	5.40	1.88	-	4.7
Denver cone overflow	6.3	30.02	-	6.5	3.0	10.40	2.42	-	1.5	2.4	8.40	-	-	0.7
Denver cone spigot	98.9	59.74	-	195.2	125.5	60.20	-	-	253.6	111.2	59.60	-	-	219.5
Collecting cone o'flow	1.0	9.82	-	0.3	0.8	9.68	-	-	0.3	0.9	7.76	-	-	0.2
Collecting cone spigot	97.9	60.20	-	194.9	124.7	60.50	-	-	253.3	110.3	60.00	-	-	219.3
Cyclone overflow	42.5	60.96	-	85.6	43.2	60.56	-	-	88.1	46.3	57.30	-	-	88.9
Cyclone spigot	55.4	59.66	-	109.3	80.5	60.00	-	-	165.2	64.0	61.20	-	-	130.4
Dings recleaner conc	41.2	62.40	-	85.1	43.0	60.76	59.9	13.14	88.0	44.3	58.84	-	-	86.8
Dings recleaner tail	1.3	10.20	9.80	0.5	0.2	16.00	7.93	-	0.1	2.0	13.94	2.21	-	1.1
Syphon sizer overflow	3.0	23.74	9.70	2.5	2.9	15.80	8.6	61.28	1.6	3.9	10.28	3.27	72.6	1.4
Syphon sizer spigot	38.2	65.40	-	82.6	40.1	64.02	64.0	10.06	86.4	40.4	63.50	63.50	10.4	85.4
Filter cone spigot	-	-	-	-	39.7	64.60	-	-	-	-	-	-	-	-
Filter cone overflow	0.7	12.42	-	0.1	0.4	11.40	-	-	0.1	-	8.93	-	-	-
Filter cake	-	64.52	63.34	-	39.7	64.60	-	8.96	86.3	40.4	63.40	-	10.32	85.4
Ratio of Concentration	2.67:1				2.52:1					2.48:1				

(cont'd)

TABLE 39 (cont'd)

Tabulation of Results - First Stage Test 7

Product	Dec. 6					Dec. 7					Arithmetical Mean				
	Weight %	Sol Fe %	Mag Fe %	SiO_2 %	Distn % Sol Fe	Weight %	Sol Fe %.	Mag Fe %	SiO_2 %	Distn % Sol Fe	Weight %	Sol Fe %	Mag Fe %	SiO_2 %	Distn % Sol Fe
Crude ore	100.0	29.44	25.3	-	100.0	100.0	31.10	-	-	100.0	100.0	30.04	26.17	-	100.0
Dings rougher conc	65.7	41.94	-	-	93.5	65.7	44.40	-	-	93.8	67.94	41.98	-	-	94.6
Dings rougher tail	34.3	5.54	0.0	-	6.5	34.3	5.60	-	-	6.2	32.1	5.05	-	-	5.4
Dings cleaner feed	118.5	51.10	-	-	205.7	118.3	53.12	-	-	202.1	129.0	51.3	-	-	-
Dings cleaner conc	99.6	59.56	-	-	201.5	102.1	60.60	-	-	199.0	109.8	58.4	-	-	-
Dings cleaner tail	18.9	6.46	0.70		4.2	16.2	5.82	-	-	3.1	19.2	6.09	-	-	3.94
Denver cone overflow	3.5	11.70	4.78	-	1.5	3.4	13.40	-	-	1.5	3.1	10.5	4.5	-	1.35
Denver cone spigot	96.1	61.30	-	-	200.0	98.7	62.24	-	-	197.5	106.1	59.8	-	-	213.3
Collecting cone overflow	1.1	9.42	-	-	0.2	0.6	11.00	-	-	0.2	0.9	9.5	-	-	0.2
Collecting cone spigot	95.0	61.90	-	-	199.8	98.1	62.54	-	-	197.3	105.2	60.3	-	-	213.0
Cyclone overflow	42.2	61.10	-	-	87.6	45.5	60.82	-	-	89.0	43.9	59.7	-	-	87.8
Cyclone spigot	52.8	62.50	-	-	112.2	52.6	64.00	-	-	108.3	61.1	59.6	-	-	104.1
Dings recleaner conc	41.0	62.40	-	-	86.9	43.4	62.76	-	11.32	87.6	42.6	61.2	59.9	-	86.9
Dings recleaner tail	1.2	17.90	-	-	0.7	2.1	20.80	-	-	1.4	1.2	14.0	8.9	-	0.6
Syphon sizer overflow	1.9	17.00	13.5	63.0	1.1	19.1	58.52	58.5	-	36.0	2.9	15.5	8.8	-	1.65
Syphon sizer spigot	39.1	64.60	-	8.92	85.8	24.3	66.10	66.10	7.20	51.6	39.4	64.4	64.0	10.0	85.0
Filter cone spigot	-	-	-	-	-	-	65.80	-	-	-	-	65.3	-	-	-
Filter cone overflow	0.3	11.04	-	-	0.1	-	21.8	-	-	-	0.4	11.6	-	-	-
Filter cake	38.8	65.0	-	8.88	85.7	-	65.70	-	7.70	-	39.2	64.4	-	9.4	86.9
Ratio of Concentration	2.58:1										2.55:1				

TABLE 40

Test 7 - First Stage Concentration - Balanced Results

Product	Weight %	Analysis %			Distn %	
		Sol Fe	Mag Fe	SiO_2	Sol Fe	Mag Fe
Crude ore	100.0	30.04	26.17		100.0	100.0
Dings rougher conc	67.9	41.82	37.92		94.54	98.40
Dings rougher tail	32.1	5.11	1.31		5.46	1.60
Dings cleaner tail	19.2	9.28	1.05		5.93	0.77
Denver cone o'flow	3.1	10.48	4.5		1.08	0.53
Collecting cone overflow	0.9	9.55			0.29	
Cyclone overflow	43.9	59.69			87.24	97.10
Dings recleaner conc	42.6	61.20	59.38		86.79	96.68
Dings recleaner tail	1.2	11.42	8.90		0.46	0.42
Syphon sizer o'flow	2.9	15.50	8.80		2.60	0.99
Syphon sizer spigot	39.4	64.19	63.55	10.0	84.19	95.69
Filter cone o'flow		11.50			0.15	
Filter cake, first stage	39.4	64.07	64.0	9.4	84.04	95.64

The filter cake from the first stage was stored and recleaned on December 8 and 9, with some further small-scale cleaning tests after assays were received a few days later.

The Dorrco Syphon Sizer could not be made to operate satisfactorily at the test feed rates, due to intermittent operation of the syphon similar to that experienced in Test No. 6. The concentrate was placed in numbered drums and assayed. The assays and size distribution of composite samples are shown in Tables 41 and 42. The overall ratio of concentration obtained was 2.75:1, with a concentrate assaying about 66.5% Fe and 6.5% SiO_2. (See Table 43).

In the recleaning stage, the results of which are shown in Tables 43 to 47, two operations were tried. In the first, the concentrate was recleaned by an additional step using magnetic separation and hydroseparation without further grinding. In the second operation, the concentrate was ground from 89 to 93% minus 325 mesh, followed by a similar cleaning step. Concentrate grade without regrinding was 66% Fe as opposed to 66.7% Fe with regrinding. Filter cake moisture, however, rose from 9.9% to 11.5%.

The Roche separator was used as a means of upgrading a composite of certain concentrate drums, and the results of this test are shown in Table 46. Special samples taken at the Syphon Sizer are shown in Tables 48 and 49. These include time samples of feed, syphon discharge and overflow, with screen analyses of products, and assays and Davis tube tests of screened samples.

Altogether, 69 drums of concentrate were produced (approximately 24 tons). Of these, approximately 35 assayed 65% Fe or better and were stored. The others have been recleaned to 66% Fe or better by magnetic separation and hydroseparation after regrinding, and the products are now in storage.

TABLE 41

Analysis of Composite Concentrate Samples

Product	Analysis %	
Composite Drums	Sol Fe	SiO_2
107 to 112	64.0	9.55
113 to 118	63.6	9.50
119 to 124	63.1	10.50
125 to 131	64.2	9.07
132 to 135	65.60	7.86
136 to 147	65.82	7.54
148 to 155	66.70	6.56
174 to 179	66.80	5.69
180 to 183	67.00	6.38

TABLE 42

Screen Analyses of Composite Samples of Drums of Concentrate

Mesh	Composite Drums 101-106		Drums 107-112		Drums 113-118	
	Weight %	Analysis % Sol Fe	Weight %	Analysis % Sol Fe	Weight %	Analysis % Sol Fe
+150	0.6	21.2	0.6	37.1	0.6	31.5
+200	2.4	23.4	1.6	21.9	1.6	26.5
+325	8.4	33.6	7.8	30.6	6.6	36.1
-325	88.6	66.8	90.0	67.4	91.2	66.8
Total	100.0	62.7	100.0	64.0	100.0	63.6
Mesh	Composite Drums 119-124		Drums 125-131		Drums 132-135	
+150	0.4	38.8	0.6	44.0	0.2	-
+200	2.2	24.1	1.5	27.2	1.0	33.2
+325	6.5	29.5	6.7	35.8	4.6	32.32
-325	90.9	66.6	91.2	67.1	94.2	67.30
Total	100.0	63.1	100.0	64.2	100.0	65.60
Mesh	Composite Drums 136-147		Drums 148-155		Drums 180-183	
+150	0.5	34.96	0.3	48.16	0.7	34.06
+200	1.4	27.64	0.8	30.4	1.6	26.04
+325	5.3	38.82	6.0	41.88	6.0	43.74
-325	92.8	69.0	92.9	68.86	91.7	69.0
Total	100.0	65.82	100.0	66.70	100.0	67.0

TABLE 43

Results of Recleaning First Stage Concentrate

Product	Dec. 8 Without Regrinding					Dec. 9 With Regrinding				
	Weight %	Analysis %		O'all Distn %		Weight %	Analysis %		Overall Distn%	
		Sol Fe	SiO_2	Sol Fe	Mag Fe		Sol Fe	SiO_2	Sol Fe	Mag Fe
First stage conc	39.3	64.09	9.4	86.0		39.3	63.12	9.4	84.0	-
Denver cone overflow	-	-	-	-	-	0.8	21.66	-	0.6	-
Denver cone spigot	-	-	-	-	-	38.5	64.0	-	83.4	-
Dings conc	38.8	64.70	-	86.0	-	37.1	66.0	-	82.9	-
Dings tail	0.5	20.90	-	-	-	1.4	9.9	-	0.5	-
Syphon sizer o'flow	1.4	31.40	-	2.2	-	0.8	32.4	-	0.9	-
Syphon sizer spigot	37.4	65.90	-	83.8	-	36.3	66.70	-	82.0	-
Filter cone overflow	0.1	16.44	-	0.1	-	-	64.80	-	-	-
Filter cone spigot	37.3	66.06	-	83.7	-	-	67.44	-	-	-
Filter cake	37.3	66.06	-	83.7	-	36.3	66.70	-	82.0	-
Overall ratio of concentration	2.68:1					2.75:1				

TABLE 44

Laboratory Recleaning of Reground Concentrate

Product	Weight %	Analysis % Sol Fe	Analysis % SiO_2	Overall Distn% Sol Fe	Overall Distn% Mag Fe
Filter cake (regrind conc)	36.3	67.3*	-	82.0	-
Hydroseparator spigot	33.7	69.4	4.02	-	-
Hydroseparator o'flow	0.2	40.08	-	-	-
Jeffrey midd	1.8	56.80	-	-	-
Jeffrey tail	0.6	48.40	-	-	-
Hydroseparator spigot + Jeff. midd	35.5	68.8	-	-	-
Overall ratio of concentration		2.82:1			
*calculated					

TABLE 45

Laboratory Recleaning of Composite of Drums 133 to 140

Product	Weight %	Analysis % Sol Fe	Analysis % SiO_2	Distn % Sol Fe	Distn % Mag Fe
Feed	100.0	65.4*	-	100.0	100.0
Hydroseparator spigot	91.0	68.2	4.54	94.0	94.9
Hydroseparator o'flow	1.2	29.64	-	0.5	-
Jeffrey midd	5.6	49.02	-	4.2	-
Jeffrey tail	2.1	41.2	-	1.3	-
Hydroseparator spigot + Jeffrey midd	96.6	67.1	-	-	-
*calculated					

TABLE 46

Recleaning Concentrate on Roche Separator

Product	Feed (Dec. 28) Drums 110-115 Analysis %		Feed (Dec.29) Drums 149-151 Analysis %	
	Sol Fe	SiO_2	Sol Fe	SiO_2
Roche feed	67.0	-	65.82	7.70
Roche conc	67.6	-	66.50	7.18
Roche tail	56.3	17.15	40.36	35.64
Hydroseparator feed	66.7			
Hydroseparator spigot	66.8			

TABLE 47

Analysis of Concentrate

Fraction	%
Sol Fe	67.3
SiO_2	5.68
TiO_2	trace
S	0.023
P	0.017
Mn	0.02
Al_2O_3	0.20
CaO	0.31
MgO	0.30
Cu	0.005
Ni	0.005
Zn	0.05
Cr_2O_3	0.03

Drum 180, recleaned

TABLE 48

Results of Special Syphon Sizer Sampling

2:20 p.m. Set Product	Feed	Syphon Discharge	Overflow
Time of samples	30 sec	30 sec	30 sec
Net wet weight	39 lb	16.5 lb	34 lb
Net dry weight	10.17 lb	5.81 lb	0.14 lb
% Solids	26.1	35.2	0.4
lb/hour (dry)	1220	697	17
3:00 p.m. Set			
Time of samples	60 sec	60 sec	60 sec
Net wet weight	76 lb	41 lb	78 lb
Net dry weight	22.5 lb	15.87 lb	0.78 lb
% Solids	29.6	38.7	1.0
lb/hour (dry)	1350	952	46.8

TABLE 49

Results of Screen Tests on Special Syphon Sizer Samples

2:20 p.m.

Mesh	Feed Weight %	Feed Analysis % Sol Fe	Feed Analysis % Mag Fe	Feed Analysis % SiO_2	Syphon Discharge Weight %	Syphon Discharge Analysis % Sol Fe	Syphon Discharge Analysis % Mag Fe	Syphon Discharge Analysis % SiO_2	Overflow Weight %	Overflow Analysis % Sol Fe	Overflow Analysis % Mag Fe	Overflow Analysis % SiO_2
+150	0.8				0.9							
+200	2.1				2.0				0.2			
+325	9.1				8.5				17.7			
-325	88.0				88.6				82.1			
Total	100.0	62.20		11.28	100.0	65.2		7.54	100.0	12.82		68.88

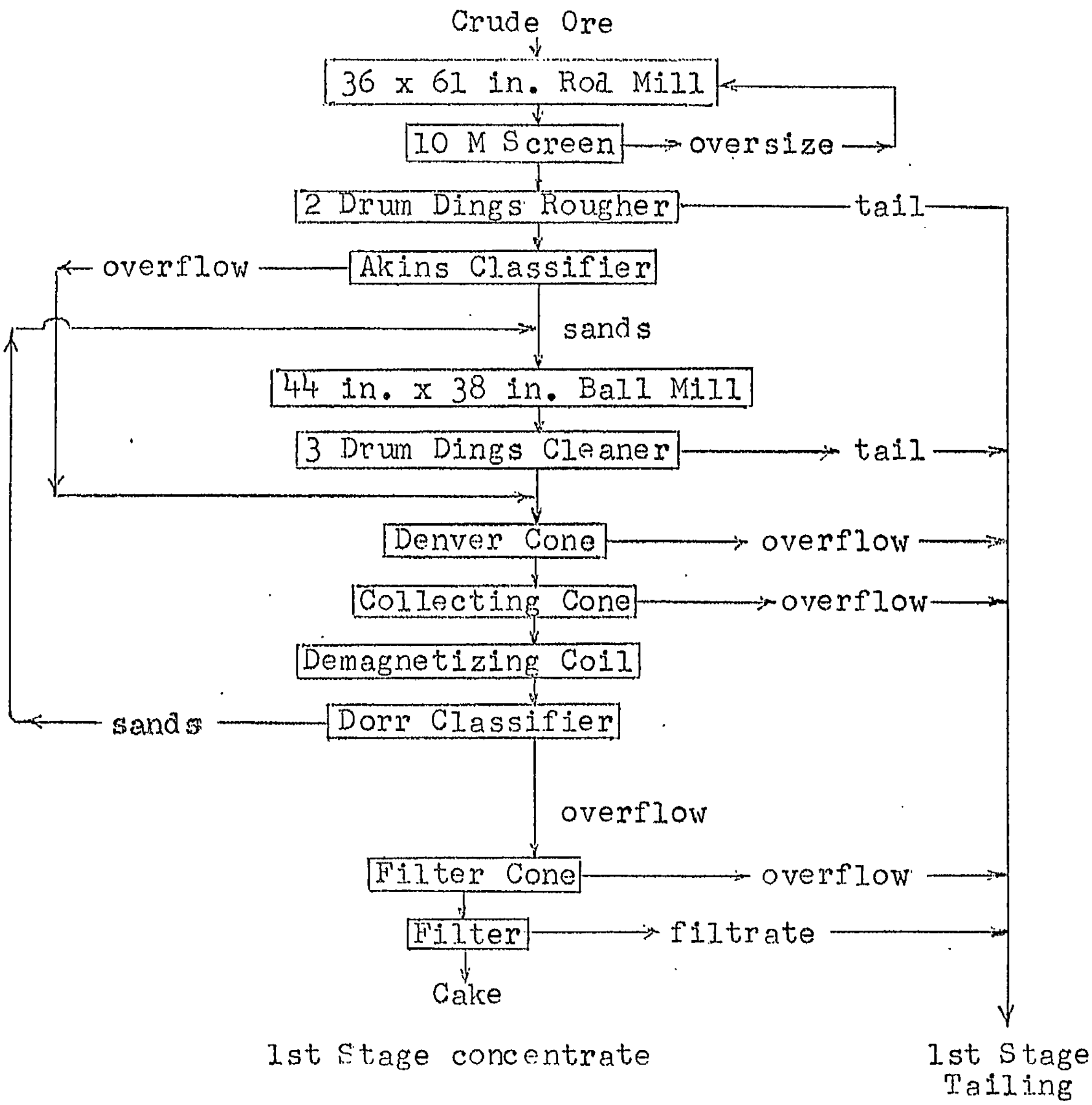
3:00 p.m.

Mesh	Feed Weight %	Feed Analysis % Sol Fe	Feed Analysis % Mag Fe	Feed Analysis % SiO_2	Syphon Discharge Weight %	Syphon Discharge Analysis % Sol Fe	Syphon Discharge Analysis % Mag Fe	Syphon Discharge Analysis % SiO_2	Overflow Weight %	Overflow Analysis % Sol Fe	Overflow Analysis % Mag Fe	Overflow Analysis % SiO_2
+150	0.4	34.8	-		0.9	40.0	37.3					
+200	3.8	34.8	25.3		0.8	30.7	29.5		0.1	13.9		
+325	9.1	41.0	40.3		8.3	39.9	39.8		3.6	10.8	5.7	
-325	86.7	65.7	65.2	-	90.0	68.0	68.0	-	96.3	10.6	2.1	
Total	100.0	61.8		11.83	100.0	64.6		8.36	100.0	10.84		72.60

APPENDIX 1

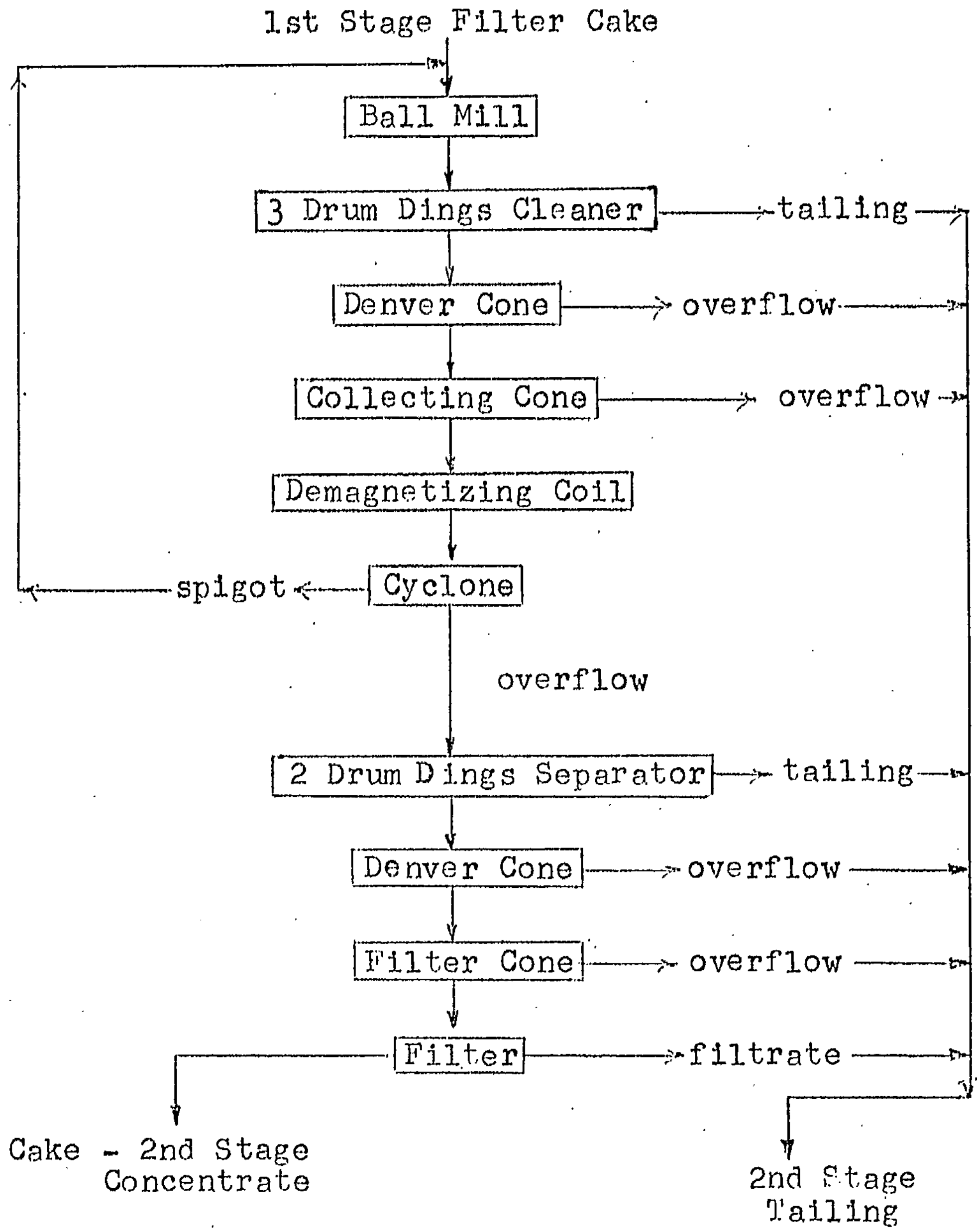
Pilot Plant Flowsheet - First Stage

Flowsheet developed for treating Can-Fer ore in Test 3



APPENDIX 2

Pilot Plant Flowsheet - Second Stage



APPENDIX 3

Final Pilot Plant Flowsheet