Mines Branch Investigation Report IR 70-2

THE APPLICATION OF A PORTABLE X-RAY FLUORESCENCE ANALYSER TO THE CONTROL OF A GRINDING CIRCUIT

by

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SUMMARY OF RESULTS

The experimental use of a portable X-ray fluorescent analyser was examined in the control of feed rate to a grinding mill at Craigmont Mines Limited, Merritt, B.C. The possible use of the instrument for this purpose was suggested by the correlation of iron content of the feed and the grindability of the ore. Test work conducted over a period of 37½ hours demonstrated that when the mill feed rate was changed to correspond to counting rate changes of the instrument, reflecting changing iron content, an increased mill throughput was achieved, compared to a parallel grinding circuit under manual control. In addition, a less variable grind resulted in the product controlled by the X-ray fluorescent unit.

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INTRODUCTION

The results presented in this report are the outcome of a study carried out at the request of Craigmont Mines Limited, at the company property at Merritt, B. C. The test work was done by the author with the assistance of company staff.

Property

The property is located at Merritt, B. C. where 5000 tons per day of copper ore are treated at the company's mill.

Objectives

The objective of the research was to investigate the possibility of controlling a grinding circuit using a portable fluorescence analyser to measure the iron content of the mill feed.

Test Work and Analyses

All test work was carried out at the company's property and chemical analyses were done by the company's assay laboratory. The mathematical treatment was performed by the author and Mr. J. A. W. Anderson at the Mines Branch in Ottawa.

Equipment

The Ekco Mineral Analyser was used for all test work. It was equipped with a 30-millicuries Plutonium 238 source. Filter pairs for iron and copper were used. The unit was run from the local mains supply, utilizing a charger/power-supply unit.

Correlation Between Ore Hardness and Iron Content

The company had found a strong correlation between the hardness of the ore and its iron content. It was felt that by taking advantage of the better grindability of the ore "high in iron", a significant increase could be made in mill throughput without a corresponding increase in capital or running costs. Figure 1 shows a theoretical relationship between mill tonnage and per cent soluble iron. It can be seen that with a one per cent increase in iron content, one hundred and eighty additional tons can be processed in twenty four hours, while maintaining a grind of 55% ± 3% -200 mesh.

PRESENT PROCEDURE

Under the present system, the mill feed rate is controlled manually, using operator experience. Samples are taken regularly for sizing and iron analysis. However, a twenty-four hour delay is experienced in getting these results to the mill operators. The effect of this delay is to cause the mill to lag the changes in feed. Consequently, optimum tonnage is not obtained, and the grind is subject to variability.

TEST PROCEDURE

In order to test the feasibility of operating the grinding circuit under the control of the analyser, the following test was carried out. First, a series of samples were measured for their iron content and the prediction equation associated with the counts was obtained. Since the absolute iron content was not needed, the number of instrument counts associated with a given change in iron content was obtained. This also eliminated, to a large extent, errors caused by matrix, interelement and grain size effects, these factors could be considered constant from one sample to the next.

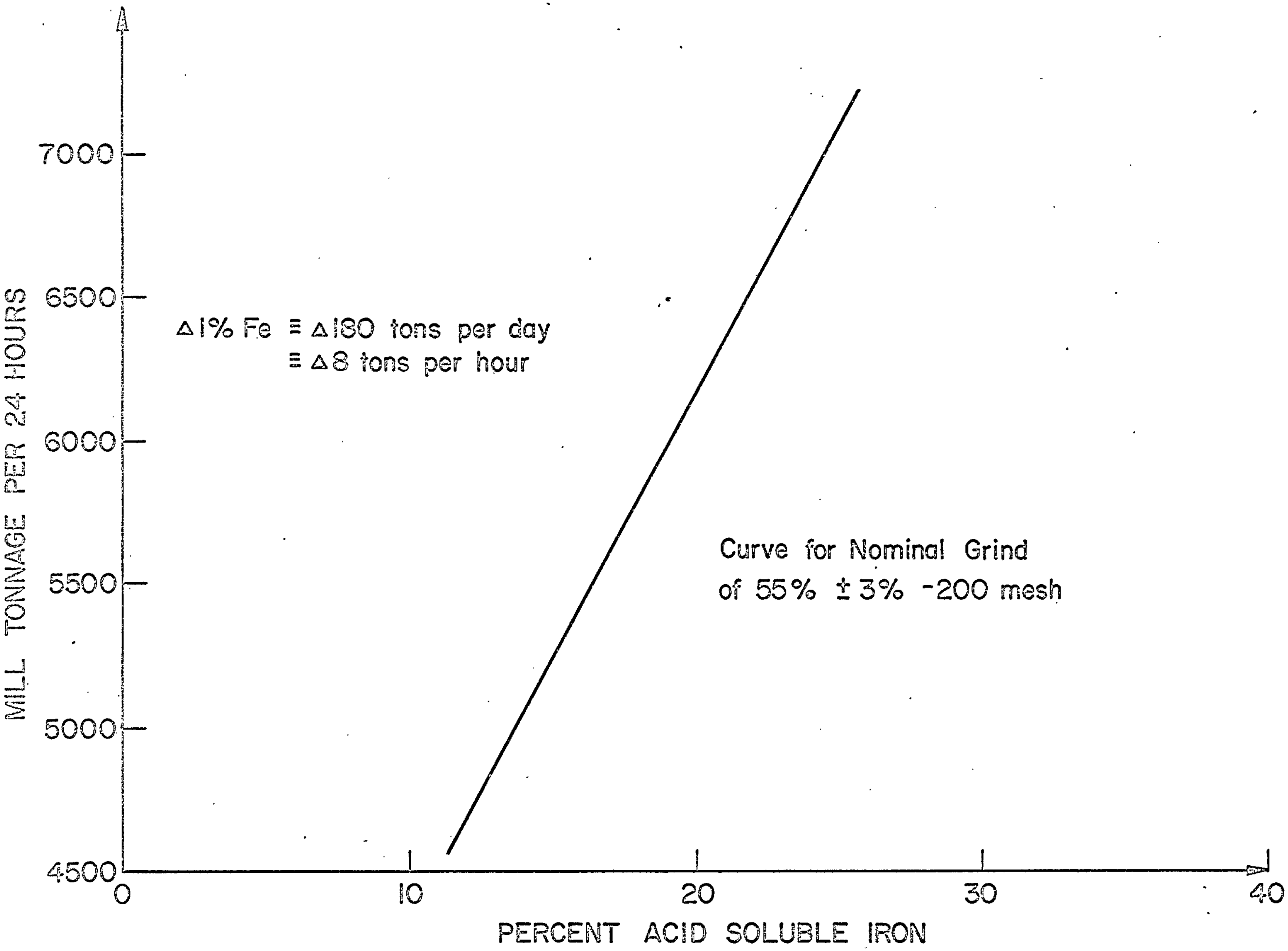

Figure 1. Relationship Between Mill Tonnage and Per Cent Soluble Iron.

The mill feed is divided and fed to two grinding circuits. One of these circuits was sampled by means of the analyser, and the second was continued under the control of the operator. The circuit was sampled at the rod mill discharge.

A preliminary series of samples were taken at five-minute intervals to obtain some representative samples and to get a range of instrument counts. Samples were taken every fifteen minutes in the full test and a running average was computed over four values. This was done to reduce the effect of sampling errors.

It was decided to accept the first value as an optimum. A change in mill feed rate was made where the running average exceeded a limit of ± 1% Fe. After operating for 24 hours these limits were reduced to ±.5% Fe. The test lasted from 9:00 a.m. on January 15th to 10:30 p.m. of January 16th.

On the hour additional samples were taken from each circuit for sizing analysis and the sample used for control was sent for iron analysis.

It should be noted that the correlation is between grindability and soluble iron. The instrument measures total iron. However, it was felt that this would make little difference to the results of the test.

RESULTS

I. Calibration

Table 1 lists the results of iron readings made on four pulp samples, which are plotted on Figure 2.

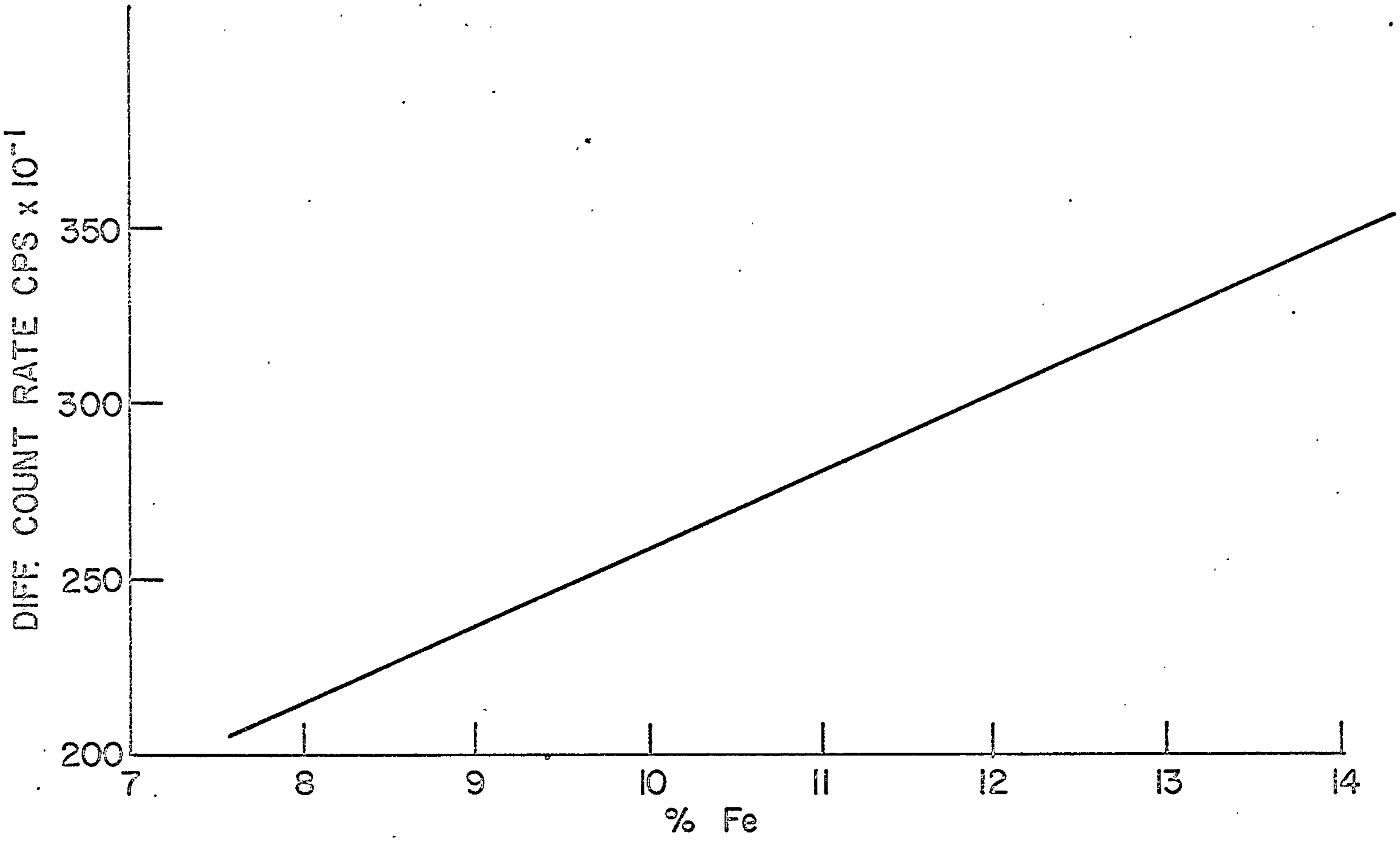

Figure 2. Prediction Line for Iron.

TABLE 1

Results Obtained for Iron in Pulp Samples

Sample No.	% Fe (Total)	Diff. Counts/10 Sec
3800	7.70	208
3730	9.35	250
3711	11.50	286
3712	13.50	342

$\hat{Y} = 36.40 + 22.36X$

$r = 0.995$

$Se^2 = 45.86$

$\hat{V}(m) = 2.39$

Δ 1% Fe = 22.4 Counts/10 Sec

where r = correlation coefficient

Se^2 = error variance

$\hat{Y}$ = estimate of counts

X = per cent iron

$\hat{V}(m)$ = estimate of variance of the slope of regression line.

From this curve a value of 20 Counts/10 sec ≡ 1% was determined. A change in the feed rate of 4 tons per hour was made for a 1% Fe, or 20 Counts per 10 second, change in iron content.

II. Five-Minute Test

Samples were taken at five-minute intervals for a period of one hour. Five readings were taken on each sample from which a running average over three values was calculated. Table 2 contains the results and they are plotted on Figure 3.

TABLE 2

Results of Five-Minute Test

Time	Mean Reading of 5 values	Running Average of 3 Readings
9:15	295	-
9:20	296	-
9:25	292	294
9:30	289	292
9:35	288	289
9:40	285	287
9:45	330	301
9:50	307	307
9:55	298	312
9:60	308	304
10:05	296	300
10:10	288	297
10:15	293	292

III. Main Test

Identical procedures were used, except that the samples were taken every 15 minutes and a running average over four values was used. The results are shown in Table 3 and in Figure 4.

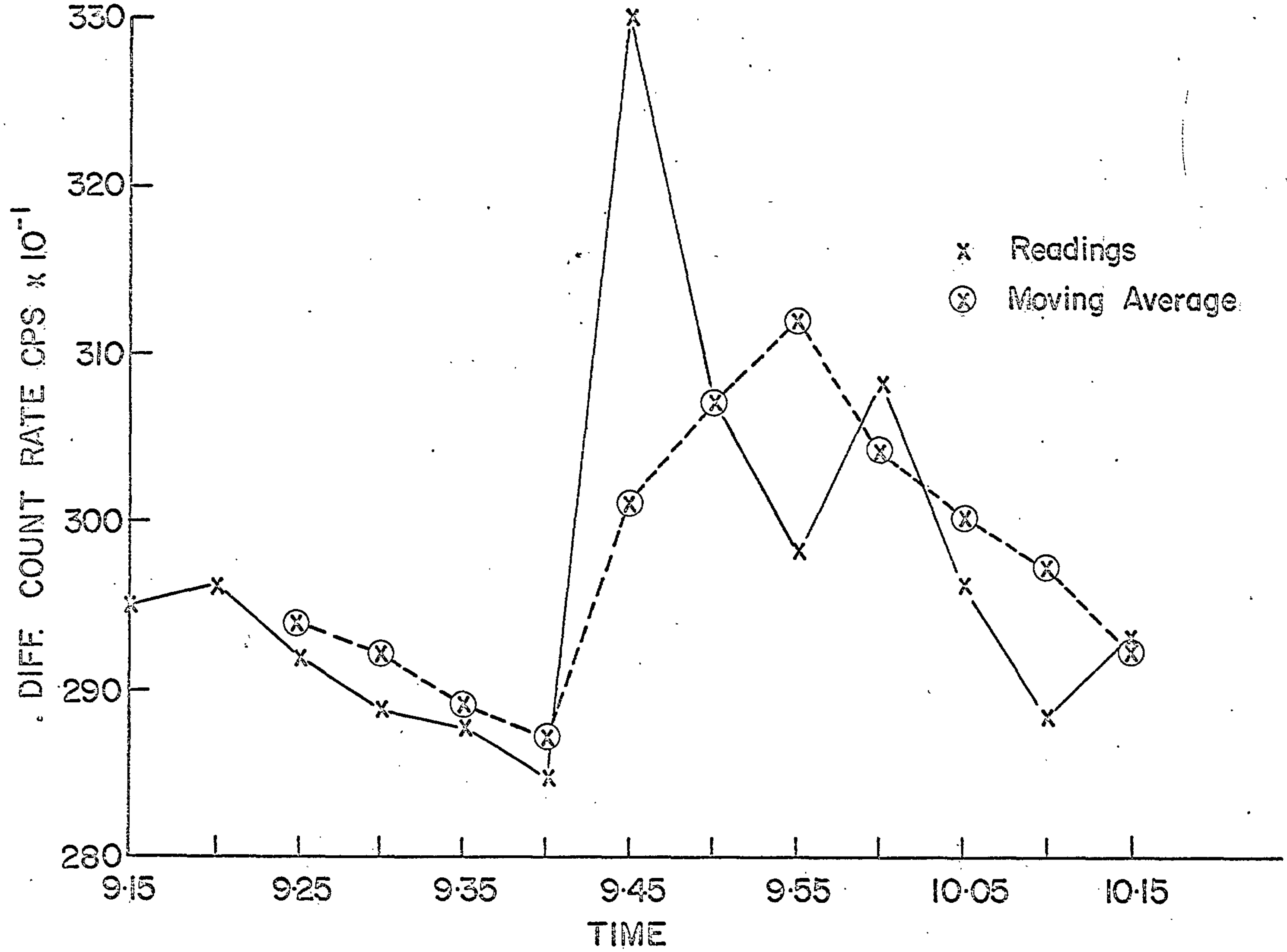

Figure 3. Results of 5-Minute Test.

TABLE 3

Results of Main Test

Time	Mean Reading	Running Average	Change from Set Point 1% Limit
9:00 a.m.	284	-	-
9:15	295	-	-
9:30	189	-	-
9:45	330	299	0
10:00	308	305	+6
10:15	293	305	+6
10:30	312	310	+11
10:45	287	300	+1
11:00	283	293	-6
11:15	282	291	-8
11:30	292	286	-13
11:45	288	286	-13
12:00	286	287	-12
12:15 p.m.	295	290	-9
12:30	288	289	-10
12:45	289	289	-10
1:00	293	291	-8
1:15	299	292	-7
1:30	310	297	-2
1:45	314	304	+5
2:00	313	309	+10
2:15	306	310	+11
2:30	315	312	+13
2:45	325	314	+15
3:00	313	314	+15
3:15	311	316	+17
3:30	303	313	+14
3:45	294	305	+6
4:00	309	302	+3
4:15	296	298	-1
4:30	318	302	+3
4:45	327	310	+11
5:00	321	315	+16
5:15	327	323	+24 ⊕
5:30	319	323	0
5:45	315	320	-3
6:00	326	321	-2
6:15	325	321	-2
6:30	319	321	-2
6:45	323	323	0
7:00	327	323	0

Table 3 cont'd.

Time	Mean Reading	Running Average	Change from Set Point 1% Limit
7:15	328	324	+1
7:30	315	323	0
7:45	313	320	-3
8:00	318	318	-5
8:15	320	316	-7
8:30	323	319	-4
8:45	311	319	-4
9:00	319	319	-4
9:15	331	322	-1
9:30	320	320	-3
9:45	321	322	-1
10:00	330	325	+2
10:15	320	322	-1
10:30	314	321	-2
10:45	312	319	-4
11:00	313	314	-9
11:15	301	310	-13
11:30	305	307	-16
11:45	313	308	-15
12:00 a.m.	327	313	-10
12:15	310	315	-8
12:30	330	322	-1
12:45	330	320	-3
1:00	340	324	+1
1:15	331	324	+1
1:30	310	320	-3
1:45	320	322	-1
2:00	301	317	-6
2:15	324	321	-2
2:30	309	317	-6
2:45	314	317	-6
3:00	325	320	-3
3:15	321	319	-4
3:30	313	317	-6
3:45	310	317	-6
4:00	336	322	-1
4:15	330	322	-1
4:30	327	322	-1
4:45	324	323	0
5:00	336	326	+3
5:15	339	328	+5
5:30	323	325	+2
5:45	341	330	+7

Table 3 cont'd.

Time	Mean Reading	Running Average	Change from Set Point 1% Limit	0.5% Limit
6:00	327	328	+5	
6:15	327	328	+5	
6:30	318	326	+3	
6:45	319	325	+2	
7:00	328	327	+4	
7:15	326	326	+3	
7:30	316	324	+1	
7:45	327	326	+3	
8:00	319	322	-1	
8:15	303	316	-7	
8:30	317	316	-7	
8:45	314	313	-10	
9:00	314	312	-11	
9:15	312	314	-9	
9:30	294	308	-15	
9:45	284	301		-7 *
10:00	290	295		-13 ⊖
10:15	279	287		-8
10:30	289	285		-10
10:45	306	291		-4
11:00	304	294		-1
11:15	331	307		+12 ⊕
11:30	320	315		+8
11:45	325	320		+13 ⊕
12:00	319	324		+4
12:15 p.m.	321	321		+1
12:30	322	322		+2
12:45	305	316		-4
1:00	305	313		-7
1:15	307	310		-10
1:30	307	306		-14 ⊖
1:45	309	307		+1
2:00	317	310		+4
2:15	339	318		+12 ⊕
2:30	329	324		+6
2:45	325	328		+10
3:00	331	331		+13 ⊕
3:15	330	328		-3
3:30	321	326		-5
3:45	324	326		-5

Table 3 cont'd.

Time	Mean Reading	Running Average	Change from Set Point 1% Limit	Change from Set Point 0.5% Limit
4:00	326	325		-6
4:15	360	332		+1
4:30	363	343		+12 ⊕
4:45	367	354		+11 ⊕
5:00	370	365		+11 ⊕
5:15	376	369		+4
5:30	365	369		+4
5:45	347	364		-1
6:00	368	364		-1
6:15	354	358		-7
6:30	378	361		-4
6:45	364	366		+1
7:00	357	363		-2
7:15	369	367		+2
7:30	368	364		-1
7:45	365	364		-1
8:00	370	368		+3
8:15	368	367		+2
8:30	360	365		0
8:45	366	366		+1
9:00	365	364		-1
9:15	359	362		-3
9:30	364	363		-2
9:45	360	362		-3
10:00	349	358		-7
10:15	363	359		-6
10:30	362	358		-7

⊕ or ⊖ indicates a change in feed rate.
* actual control limits changed to ± 0.5% Fe.

Using ± 1% limits from the start until 9:30 a.m. on January 16th, and ± 0.5% limits thereafter resulted in processing 159 additional tons through the grinding circuit under instrument control compared to the other circuit.

From 4:00 p.m. until the end of the test, samples were taken for size analysis. These results are reproduced on Table 4 and Figure 4.

TABLE 4

Size Analysis on Both Grinding Sections

Time		No. 1 Stream with "Inst. Control" % -200 mesh	No. 2 Stream Manual % -200 mesh
16:00 hrs	15/1/69	55.2	55.2
17:00		54.1	53.9
18:00		55.0	53.5
19:00		54.5	54.1
20:00		55.2	55.0
21:00		55.8	55.1
22:00		53.3	54.8
23:00		55.8	54.1
24:00		55.4	56.2
1:00	16/1/69	57.2	55.9
2:00		55.2	53.5
3:00		55.4	54.6
4:00		56.3	55.5
5:00		56.1	56.0
6:00		56.9	53.9
7:00		54.9	52.8
8:00		53.9	54.7
9:00		53.5	58.2
10:00		54.0	58.7
11:00		58.8	53.5
12:00		55.3	52.8
13:00		60.5	54.4
14:00		--	56.1
15:00		55.9	54.6
16:00		54.7	61.2
17:00		57.0	55.4
18:00		55.7	54.7
19:00		55.1	54.3
20:00		55.5	53.9
21:00		55.5	54.0
22:00		53.6	54.0
Mean $\overline{X}$		55.5	55.0
σ		1.60	1.76

$\overline{X}$ = arithmetic average

σ = standard deviation

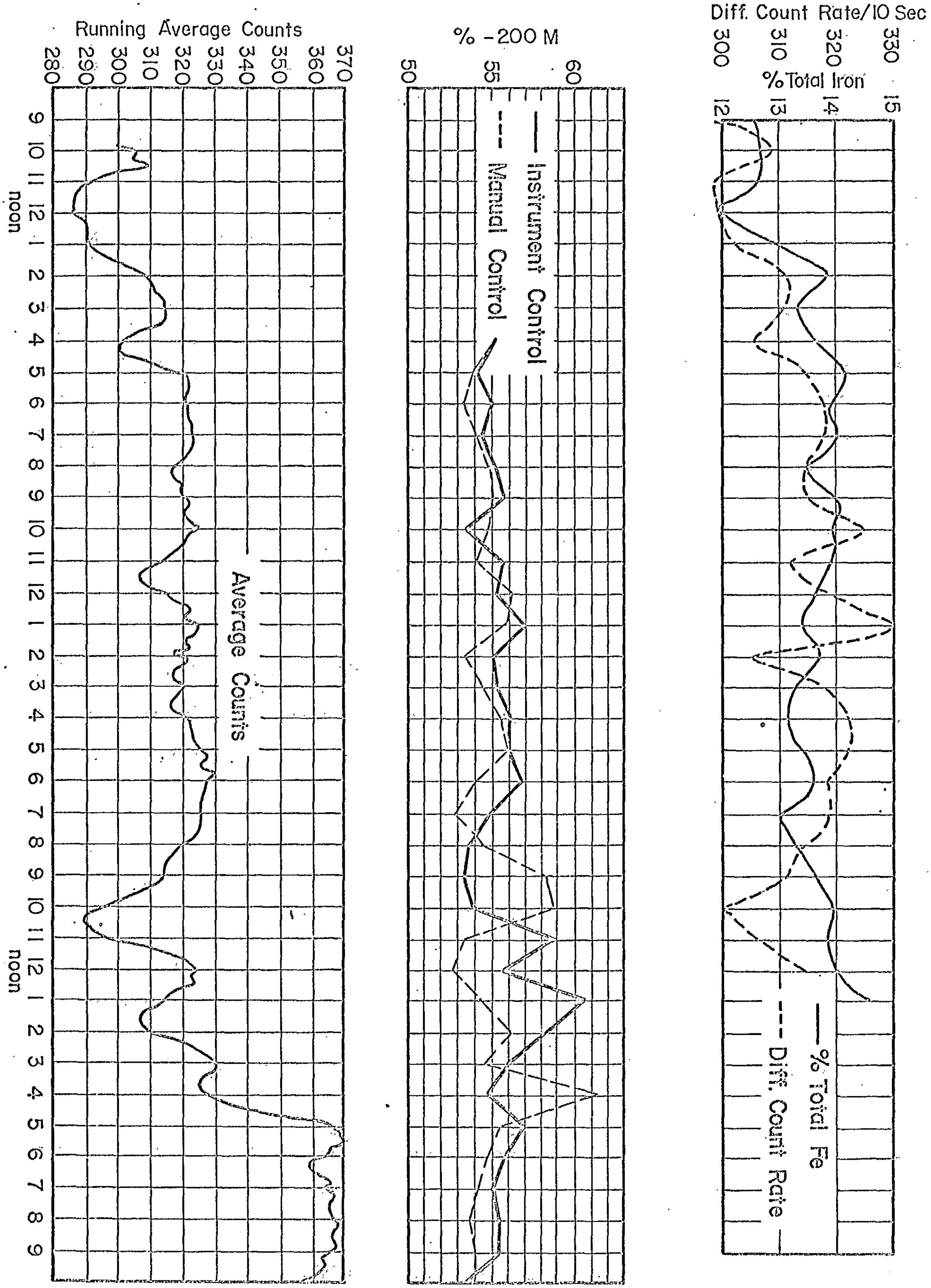
Running Average Counts
280
290
300
310
320
330
340
350
360
370
Average Counts
% -200 M
50
55
60
Instrument Control
Manual Control
Diff. Count Rate/10 Sec
300
310
320
330
% Total Iron
12
13
14
15
% Total Fe
Diff. Count Rate
9
10
11
12
noon
1
2
3
4
5
6
7
8
9
10
11
12
1
2
3
4
5
6
7
8
9
10
11
12
noon
1
2
3
4
5
6
7
8
9

Figure 4.

CONCLUSIONS

The test showed that improved control was obtainable using the Ekco instrument. Increased mill throughput was realised, without any decrease in the control of the size distribution. Additionally, a less variable grind resulted.

In view of the speed of response to changes in iron content that the technique permits, significant increases in profit may be realised without a notable increase in capital cost, and with a saving in operating cost.

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