EFFECT OF CHANGES IN THE DESIGN & ADJUSTMENTS OF CONCENTRATING TABLES OF THE WIFLEY TYPE

THESIS

for the

DEGREE OF MASTER OF SCIENCE

April 20, 1920. C. E. Anderson

The Effect of Changes in the Design and Adjustments of Concentrating Tables of the Wilfley Type and the Relation of Such Changes to the Character and Efficiency of Operation.

Introduction

Modern water concentration of sand sizes is practically confined to riffled jerking tables of the Wilfley type. The original Wilfley table was invented in 1895, but long before this time, the essential elements, riffling and jerking, were known to the art of concentration. Tables such as Rittinger's and Lampert's had one or other of these factors, but were never of paramount importance, and it was the combination of these factors by Wilfley, which completely revolutionised table concentration.

Since the introduction of the Wilfley table, many experimenters have investigated more or less thoroughly, numerous problems relating to the efficient operation of tables of this type. As a result of many of these investigations, several new tables were developed, all having the same underlying principles as the Wilfley, but slightly different in their design. Among the more important of these may be mentioned the Deister, and the Butchart.

Notwithstanding the developments which have been made, and the researches which have been undertaken, to partially overcome difficulties appertaining to the original Wilfley table, and to table concentration in general, no successful analysis, of the effects of the different adjustments which may be made to a table in relation to its efficiency, have as yet been published.

Following a consultation with Dr.J.B. Porter, Professor of Mining at McGill University, and Mr. J.W. Bell, Assistant Professor of Mining, it was thought that an investigation of this type might yield some information, both of a practical and theoretical nature, more so since some doubt was expressed, as to whether the results of Cox and Gibbins, and other experimenters had not been affected more or less by these different adjustments. A series of tests were carried out in the Ore Dressing Laboratory of the University, under Dr. Porter's and Mr. Bell's direct supervision.

The character of the investigation necessitated its division into the following parts:-

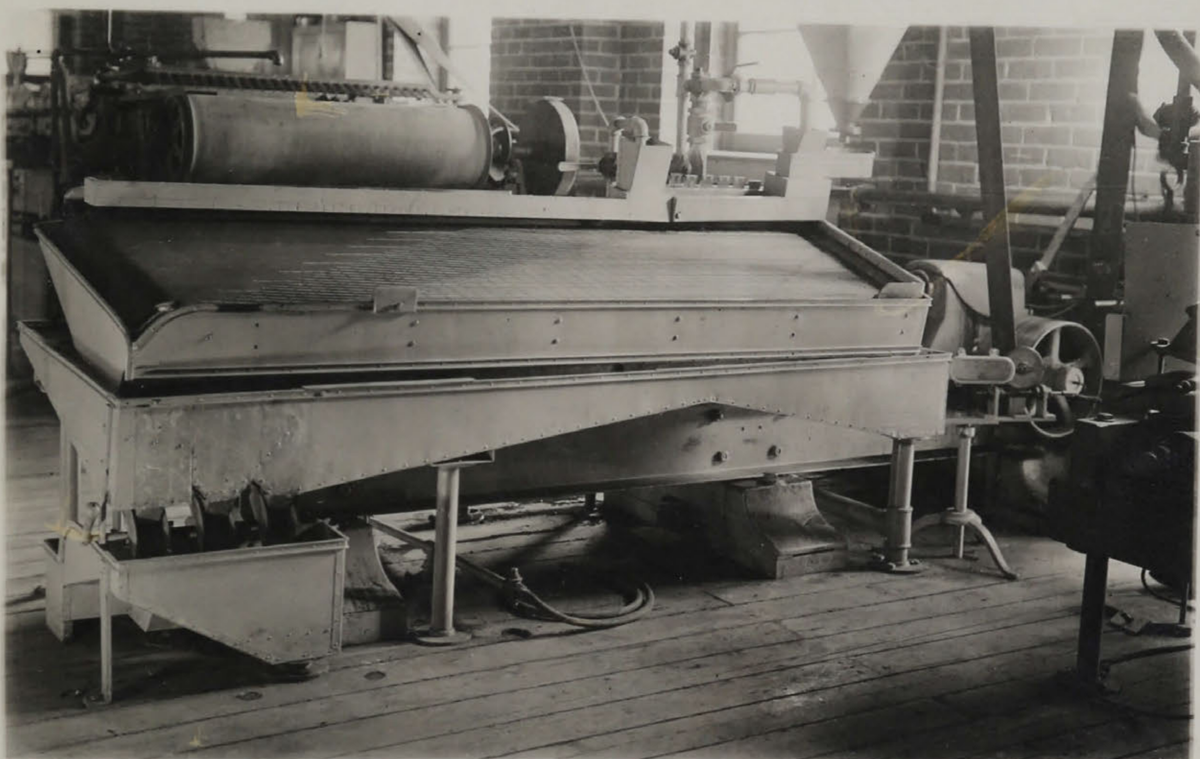
(a) The selection and preparation of an ore suitable for table concentration.

(b) Improvements made to the table to insure a perfect duplication of operating conditions.

(c) The concentration of the various lots of ore and their analysis.

(d) The interpretation of the results obtained.

The actual experimental work could not be very easily divided between the investigators, as both had to work together on all the tests made. In the preparation of this



PHOTOGRAPH SHOWING

½ SIZE BUTCHART TABLE

ORE DRESSING LABORATORY MCGILL UNIVERSITY thesis however, every effort has been made to individualize the work as far as possible, and although the results of the investigation have been discussed freely, with the exception of this introduction and section 1, which are joint work, the remainder of this thesis is of my own composition.

In conclusion of this introduction, the authors wish to thank Dr. Porter and Mr. Bell for their helpful and much needed advice on the work undertaken. Much appreciation is also due the laboratory staff, who rendered us very material assistance in the carrying out of the tests.

Section 1.

Principles of Action of Tables of the Wilfley Type, with a Description of the Table used in all the Tests

The principles of action of tables of the Wilfley type, are four in number and are as follows:-

(1) Agitation. The effect of agitation is to stratify the ore, the heavy mineral constituents forming a lower layer, while the gangue or lighter material forms the upper layer.

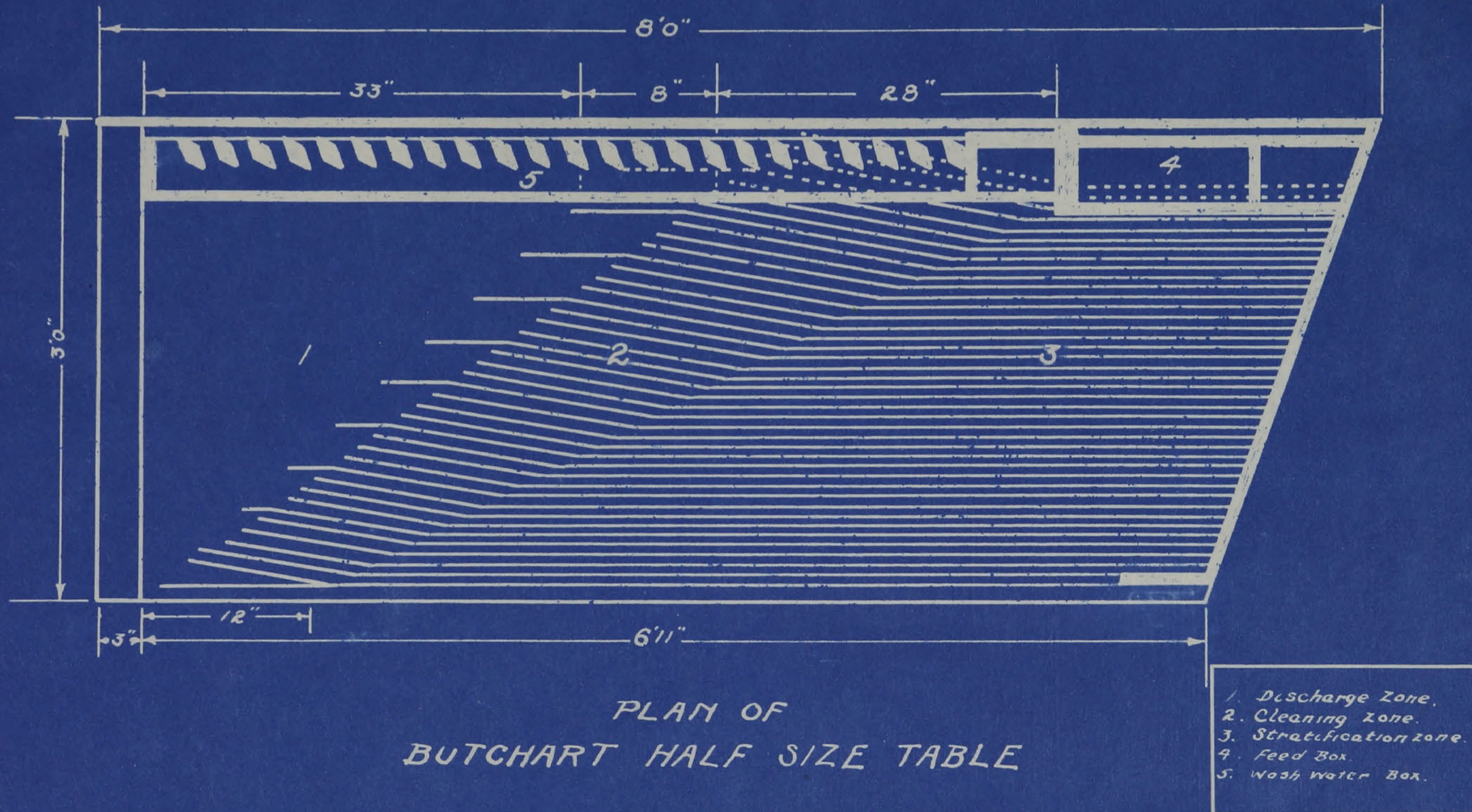
(2) The use of long and narrow riffle grooves.

(3) A jerking motion usually parallel to the riffle grooves. The effect of the jerk is to impel the feed across the table towards the concentrate end, giving a greater momentum to the heavy particles than to the light.

(4) The use of a current of water flowing across the riffle grooves. The effect of this wash water is to force the upper layers of waste material down the sloping table much faster than the under layers of heavy concentrates.

The table used throughout the investigation was a half size Butchart contractor. This table is one of the most recent, having appeared on the market within the last six years, but it has already proved itself to be a very efficient concentrating machine. A detailed description of the mechanical features of this table is deemed unnecessary and only a general statement of these will be made. It is simply although strongly constructed, has a heavy steel base, fully enclosed drive, and throughout the tests, has operated in a very satisfactory manner.

The primary difference between the Butchart and the Wilfley tables lie in the system of riffling. In the latter table the riffles are straight and terminate in a diagonal line. The riffles of the former concentrator are straight for part of their length, and then have an upward sloping curve. They then straighten out and continue to the concentrate end of the table, the whole surface being riffled, with no smooth washing plane, as in the Wilfley. The system on the half size table that was used in these tests, was intermediate between the ordinary Wilfley and Butchart systems, and instead of the riffles covering the whole surface of the table, they ended in a diagonal line, with the exception of every fourth riffle, which was extended a short way beyond the others. Plate 1 shows a detailed plan of the riffling on the table used.



PLAN OF
BUTCHART HALF SIZE TABLE

The table top may be divided into three zones:

(1) The Stratification Zone, in which the riffles are straight and parallel to the head position, being deepest at the head end of the table, here the heavy mineral settled to the bottom of the grooves.

(2) The Cleaning Zone, where the riffles curve towards the higher side of the table and are therefore not parallel to the head motion. This causes a transverse agitation which stratifies the ore more perfectly. This oblique shaking, combined with the backward flow of water caused by the upward curves, tends to wash the upper layer or lighter portion of the feed away from the concentrate end of the table.

(3) The Discharge Zone, which is a plane surface and serves to transport the cleaned concentrates across the table into the concentrate launder.

Section 2.

Selection and Preparation of the Ore.

A manufactured ore was decided to be used. This was done as there was no suitable ore on hand, and the ore used must be easily analysed and have hard constituents so that it could be used continually without appreciable difference in the screen analysis, due to the reduction in size, from the wear and tear of the different operations.

The ore decided upon was a mixture of magnetite and tinguaite, the percentages being ten percent and ninety percent respectively. Magnetite was about the most suitable mineral to be used as a concentrate as it is both hard and heavy and the products from the table could be analysed very easily. Quartz would have been an excellent constituent to be used as a gangue, but at the time of manufacturing the ore sufficient quartz was not obtainable, so it was decided to use tinguaite.

Five bags of very clean magnetite which had already been crushed were screened through a twenty mesh screen. This magnetite contained quite an appreciable quantity of slimes and as slimes are not suitable for table work it was deslimed. It was deslimed in a classifier and the spigot was then dried and passed through the Weatherill Magnetic separator with a very slow feed. This was done to do away with all the impurities and to have all the magnetite of the same magnetic intensity in order to insure good separations after the tests were finished.

Classifier Detail

Total Feed	=	366.50#
Feed Water	=	119 lbs. per minute
Rate of Feed	=	9.2 lbs. " "
Wt. of slimes produced	=	24.80 " " "
" " Weatherill Concentrate	=	253.75 lbs.
" " Middlings)	=	53.05 "
" " Tailings) Discarded	=	34.90 "
" " Classifier Slimes)	=	24.80 "
Total Weight		366.50 "

The following table is a screen analysis of the classifier overflow.

Mesh	Wt. of sampes = 5.00 grams.			% B.
	Wt. A.	% A.	Wt. B	
-200	4.67	93.6	4.49	89.8
+200	0.17	3.2	0.31	6.2
+150	0.15	3.0	0.20	4.2
+100	4.99	0.2	0.00	00.0
	5.00	100.0	5.00	100.

When the magnetite was passed through the magnetic separator the heads became very highly polanized and would stick together in clots. With the magnetite in this condition a proper mixture with the tinguaite gangue, so as to make a uniform grade of ore, could not be very well obtained, so it was necessary to demagnetize it before proceeding.

After numerous experiments in quest of demagnetizing the magnetite were tried, a method was finally devised which proved to be very satisfactory.

A brass pipe one inch in diameter and 1½ ft. long and tapered to a ½" opening at the bottom was wound with insulated copper wire of 1/8" diameter over about three-quarters of its length. This was then supported in an upright position and connected with an alternating current generator, a current of 60 amperes at 20 volts being used. It was connected in series with a small electric furnace which was used as resistance as no calculations were made as to the amount of wire necessary. This prevented the coil from overheating and burning the insulation off the wire. The magnetite was fed through the top of the coil by means of a glass funnel which acted as a hopper. The lines of force were concentrated inside the brass pipe, the field becoming weaker at the bottom as it was not wound with wire throughout its whole length.

When the magnetite entered the pipe it was acted upon by this strong A.C. field, the polarity of the different grains being continually changed. As it came to the discharge end it passed through a gradually weakening field, which finally came to zero in intensity. As the field weakened and became zero the pole strength of the different grains of magnetite also weakened and as a result the magnetite was demagnetized; being discharged through the end of the pipe at the rate of three pounds per minute.

Preparation of the Gangue

About 3,500 lbs. of tignaite were crushed in the stamp battery with a 20 mesh discharge screen. It was discharged from the stamp battery to a cone and from here was pumped into a classifier. The majority of the slime was removed in the classifier, and the spigot was pumped to a feed cone, above the Butchart table, by means of a hydraulic elevator. It was practically all deslimed on the table and a band of concentrates was also cut out which contained a little pyrite and magnetite. The tinguaite was then dried and was passed through the Weatherill Magnetic Separator with a very strong magnetic field, to do away with all magnetic material, so that no error could enter into the results later on. The amount of tinguaite finally obtained was about 2,400#. The magnetite which had previously been demagnetized was thoroughly mixed and cut down into ten lots of about twenty-five pounds each. The tinguaite was then mixed and cut down in the same manner to ten lots of about 225#.

The different lots of magnetite were then mixed with the different lots of tingnaite. Each lot then weighed approximately 250 lbs. and contained approximately 10% magnetite and 90% tingnaite. Samples were taken for screen analysis from and magnetite and tinguaite before and after they were mixed.

The results of screen analyses are shown in the following tables:

Tyler Standard Mesh
Screen Analysis of Tinguaite

Size of opening	Mesh	Gms.A	% A	Gms.B	% B	Av.%
.0238"	20	0.00	0.00	0.00	0.00	0.00
.0232"	28	0.94	1.45	1.04	1.62	1.53
.0164"	35	12.88	20.17	13.67	21.30	20.74
.0116"	48	12.60	19.73	12.67	19.75	19.74
.0082"	65	12.50	19.56	12.74	19.90	19.73
.0058"	100	9.78	15.31	9.33	14.55	14.93
.0041"	150	9.45	14.79	9.09	14.20	14.50
.0029"	200	3.47	5.44	3.33	5.70	5.32
	-200	2.14	3.36	2.27	3.54	3.45
	Total	63.76	100.00	64.14	100.00	

Screen Analysis of Magnetite

Mesh	Gms.A	% A	Gms.B	%BB	Av. %
20	0.99	1.66	1.09	1.91	1.78
28	15.11	24.50	14.55	25.50	25.00
35	13.33	21.51	12.54	22.20	21.86
48	7.95	12.84	7.21	12.61	12.72
65	6.96	11.22	6.11	10.71	10.97
100	5.34	8.66	4.73	8.30	8.48
150	5.38	8.71	4.65	8.17	8.44
200	2.75	4.46	2.40	4.20	4.33
-200	3.99	6.44	3.65	6.40	6.42
Total	61.80	100.00	56.93	100.00	

Screen Analysis of Mixed Feed

Mesh	Gms.A	% A	Gms. B	% B	Av. %
20	0.08	0.15	0.09	0.18	0.17
28	2.04	3.90	2.00	3.68	3.79
35	11.42	21.87	11.68	21.90	21.88
48	10.15	19.43	10.59	19.57	19.50
65	9.87	18.90	10.19	18.75	18.82
100	7.24	13.86	7.68	14.13	14.00
150	6.97	13.34	7.24	13.32	13.31
200	2.55	4.88	2.65	4.87	4.87
-200	1.92	3.67	1.96	3.60	3.64
Total	52.24	100.00	54.08	100.00	

Table No. 1

Section 3.

Before commencing any tests it was thought advisable to make several changes in, and additions to, the design of the table in order to simplify and improve its operation.

The following are the changes or additions made:-

(1) Automatic adjustment of slope of table.

(2) Change in Design of feed box and arrangement of feed Water.

(3) Change in adjustment of spring pressure.

(4) Division of table.

(5) Regulation of wash water launder.

(6) Discharge launders.

Automatic Adjustment of slope of table

The tilting mechanism of the table consists of two pairs of right and left hand screws, actuated by a hand wheel fixed to a small shaft connecting the two pairs of screws. On this shaft a steel disc 11" in diameter was mounted, the shaft fitting into a hole drilled through the centre of the disc. The circumference of this disc was divided into one hundred parts every tenth part being numbered. Opposite this disc and attached to the foundation of the table was a pointer, which registered zero on the disc when the table was level. A cord was then fastened on the shaft so that it wound or unwound as the table was raised or lowered. To the lower end of the cord a small weight with a pointer was attached which moved up or down in a slide divided into parts numbering from one to three corresponding to revolutions of the hand wheel. When the table was elevated the number of revolutions of the hand wheel would be recorded on this slide and any fraction of a revolution would be read on the graduated disc. Actual slopes of the table for revolutions or fractions of revolutions of the hand wheel were recorded by means of a clinometer and a curve was plotted. By means of this curve any required slope could be set or any unknown slope could be determined from a reading.

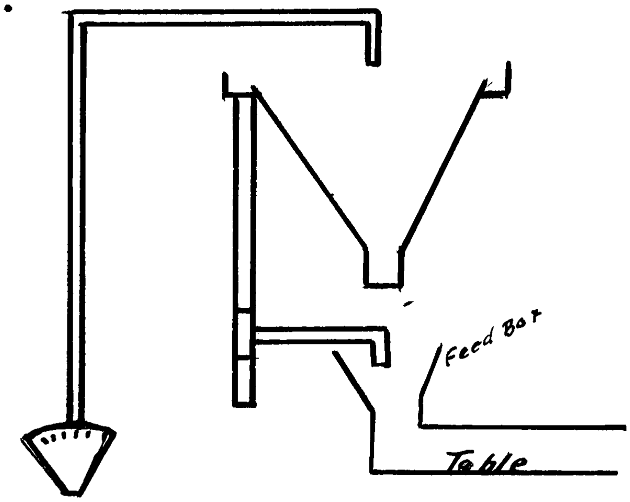
Change in Design of Feed Box and Arrangement of Feed Water.

The feed box is twenty-one inches long, three inches wide, two inches deep on one side and it tapers down to three inches at the discharge side.

On the side nearest the upper edge of the table or discharge side are nine holes one inch in diameter equally spaced and flush with the bottom, through which the feed runs out onto the table. In running a preliminary test it was found that the greater part of the feed water would run out of the first few holes, while the ore when small amounts of feed water were used, had a tendency to pack at the other end of the box and not run out or distribute satisfactorily.

A copper plate was rivetted to the side of the feed box, with square holes cut in it to coincide with the original holes. Sliding copper gates with a 90° notch in the bottom were then fitted over each hole in the copper plate. The result was, that by raising or lowering these slides the sizes of the discharge holes could be regulated until a proper distribution of feed on the table was maintained.

The feed water and wash water were always kept under a constant head. The feed water would flow into the feed cone, which was always full, and the overflow was piped into the feed box.

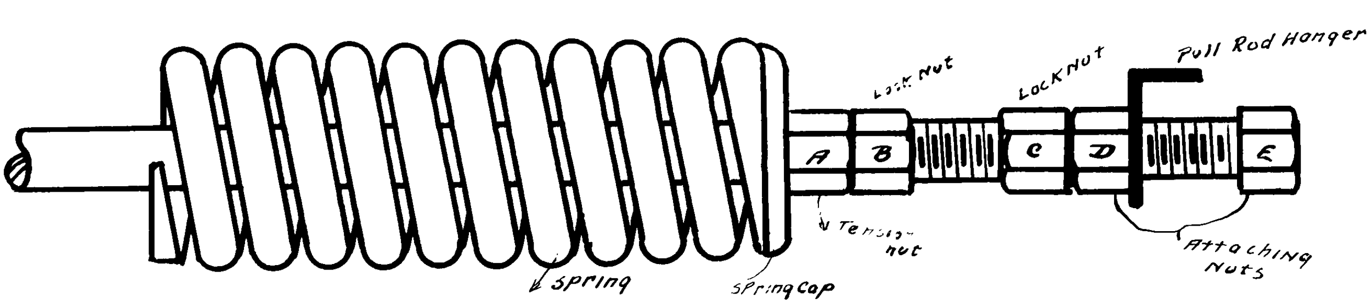


In a test the water would come out in the sand feed. and some of it also overflow into the feed box, consequently the feed water equals the quantity as per calibration /67.

On the feed and wash water valves graduated cocks were attached. These cocks were calibrated and curves drawn, so that for any reading on the cock the corresponding number of lbs. of water per minute could be ready from the curve.

Change in Adjustment of Spring Pressure

Diagram:



In order to make tests on the effect of spring pressure as a variable it was necessary to make a slight change in adjustment.

Originally there were three nuts, A, D and E, as shown in the diagram on the pull rod. The tension nut A as its name implies is used to hold the compression in the spring. The table was set in motion and the tension nut was screwed up against the spring cap until the knock was just taken out of the table. A graduated nut B was then put on to serve as a lock nut and it reads zero when there is just enough compression in the spring to do away with the knock. By tightening A and B more pressure is placed on the spring and the number of turns of the nut is recorded.

Nuts D and E are screwed tight against the pull rod hanger which is attached rigidly to the table. In order to insure that the pull rod would at all times be tightly clamped to the table a split pin was put in nut E and a lock nut was placed before D.

Division of Table

During the different tests the widths of the bands of concentrates, middles and tails were recorded. To facilitate this work the table was graduated in inches, along the side, the end nearest the head motion andalong the side of the wash water launder. A slide was fixed along the table, which could be adjusted so as to cut off any width of middle band required.

Regulation of Wash Water Launder

The wash water launder runs from the feed box to the concentrate end of the table, and has diamond shaped blocks of wood placed side by side along its upper edge. Each block is screwed to the bottom of the launder, and by loosening the screws may be turned in any direction. A preliminary test was run and the upper side of the concentrate line was made straight by regulating the openings between the different blocks, and thus assured a proper distribution of water over the table. These blocks were kept in the same position throughout the tests.

Discharge Launders

A set of discharge launders for the table was designed by Mr. J. W. Bell. These were designed so that during a test the three products, heads, middles and tails, were all discharged into one cone while the table was being adjusted for that test. Then by throwing a lever the three products were discharged into three separate cones, and while at the end of a test when sufficient quantities had been drawn off the lever was thrown back and the ore was discharged into the first cone.

Section 4.

The Concentration of the Various Lots of Ore, Together with Their Analysis.

Throughout the investigation 42 tests were made, of which thirty-four were run with the following adjustments as variables:-

Tests 1-4	inclusive,	Spring Pressure as Variable
5-8	"	Feed Water " "
9-13	"	Wash Water " "
14-15	"	Feed and Wash Waters as Variables
16-28	"	Rate of Feed as Variable
29-30	"	Strokes of Table per minute as Variable
31-34	"	Length of Stroke as Variable

The grade of the table was changed whenever necessary, to make a proper division between concentrates and middlings in each test.

In the last few tests, namely from 35 to 42, runs were made with variable amounts of magnetite in the feed to determine how the extraction was effected.

Analysis:

It was first attempted to analyse the different samples chemically, but as the magnetite was very difficult to get into solution and the time taken was so long this method was abandoned. Much more rapid and very accurate analysis could be made magnetically, so a small magnetic separator was constructed. By this method the Fe_3O_4 was determined and not the Fe as in the chemical analysis.

An electro magnet was set up in a stout wooden framework and was connected up with a 110 volt circuit. The two poles of the magnet were enclosed in a copper box. This was done so that after a sample had been put under the magnet, the magnetite would fall off the pole pieces when the current would be turned off. Underneath the pole pieces was a sheet of copper which was slightly inclined from the horizontal. This copper was fixed between two guides and was about 1/8" from the bottom of the poles.

This plate of copper could be slid to and fro between the guides and the guides themselves could be slid back from underneath the magnet. In order that the same current would be used for analysing all the samples the magnet was connected up with a resistance board. The same number of lamps were kept in the board at all times.

To analyse a sample it was placed on the copper slide and moved up under the magnet. An aluminum disc which is not acted upon by a magnet was placed under one end of the slide. The slide was then shaken by hand so that the sample spread out in a very thin layer and passed beneath the magnet. The non-magnetic material, or tinguaite, would pass underneath the magnet and fall in the aluminum disc. The magnetite, of course, would cling to the magnet. The slide was then moved back and a disc placed under the magnet and the current would then be turned off and the magnetite thus collected. The magnetite and tinguaite would then be weighed.

General Method of Running a Test:

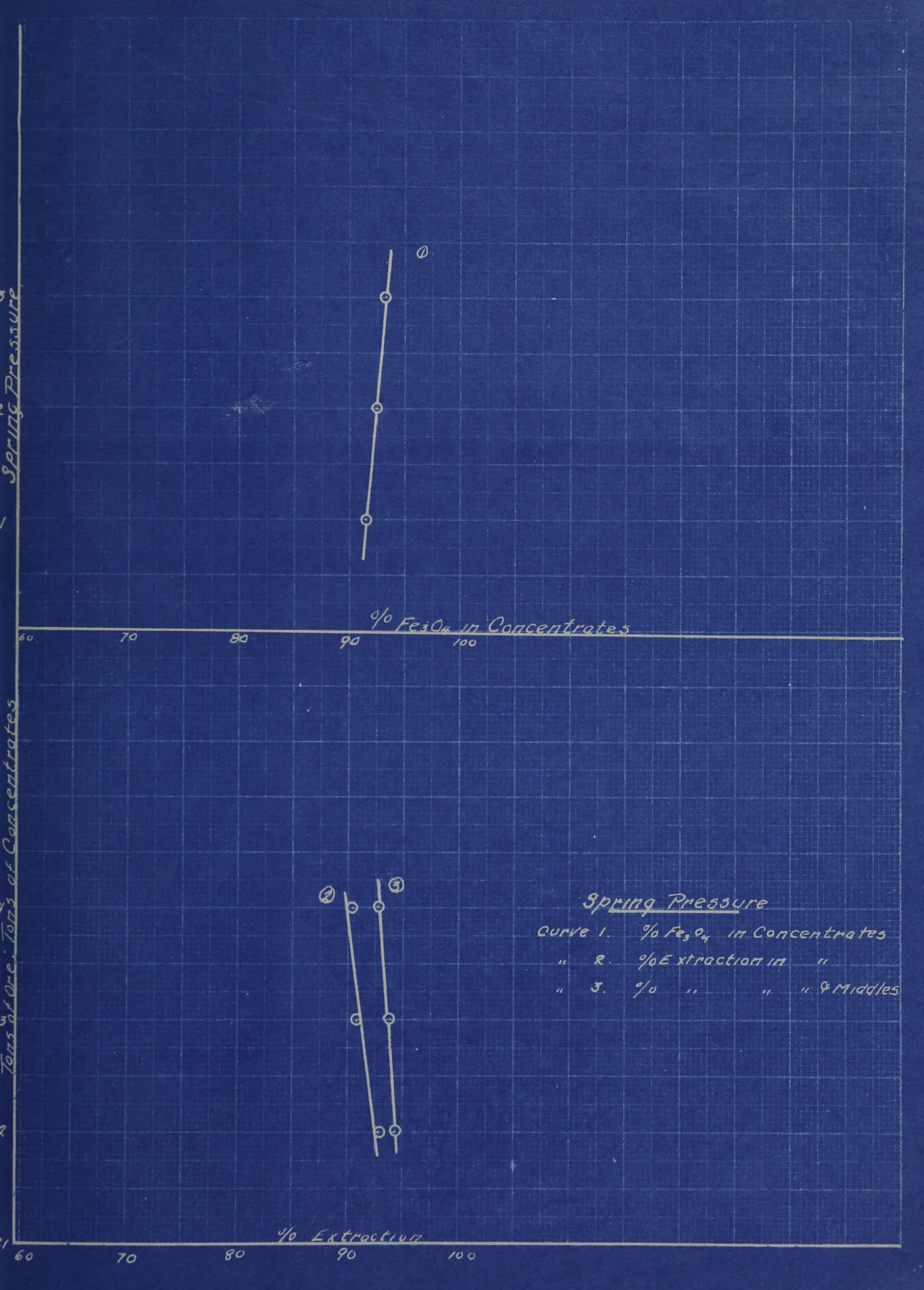
A lot of ore was weighed, placed in the feed cone above the table and then fed to the table. The table was allowed to run a few minutes in order to adjust itself, all the ore running into the same cone. Then the products, heads, middles and tails were collected separately for a certain time. These products were then dried and weighed and samples taken from them for screen and magnetite analysis. The sample would be put in the screening machine and then the machine would run for thirty minutes. The screens were then cleaned out and the different products ranging from 20 mesh to -200 mesh were weighed and each one analysed magnetically.

Spring Pressure

Test	Spring Pressure	% Mag.	Tons/ 24 hrs.	Ratio Tons ore to tons conc.	Conc. % Fe	% $Si O_2$	% Ex. in heads % Fe_3O_4	% $Si O_2$	% Ex. in heads and tails % Fe_3O_4
3	-1	10.8	6.5	9.4	94.7	5.3	91.0	0.6	92.4
1	1	10.1	6.4	9.2	91.5	8.5	92.8	1.0	94.4
4	2	10.5	6.4	9.4	92.4	7.6	90.4	0.9	92.7
2	3	10.7	7.1	9.3	93.0	7.0	90.8	0.8	93.9

In the four tests on spring pressure as a variable the grade of the table was kept constant. The amounts of feed water and wash water were also kept constant except in test 4. owing to an error in the reading of the graduated valve. In test 1 when a good concentrate cut off was being obtained the grade of the table was set and kept the same for the other three tests. In test 3 there was no spring pressure which made a bad knock in the table and although the results are good, they will not be discussed as the table should not be run under this condition.

It will be noticed that with an increase in the spring pressure there is a corresponding increase in the percentage grade of the concentrates, but this may be due to the increase in the percentage of magnetite in the ore. In test No. 1 a cleaner grade of concentrate was obtained than in tests 2 and 4 but a higher ratio of tons of ore to that of concentrates was obtained in the latter two tests. The extraction in tests 2 and 4 is lower than in test 1 which seems obvious owing to the increase in the ratio of ore to concentrates. In tests 2 and 4 yhr percentage of extraction in the heads is about the same and there is little difference in the percentage grade of the heads, but there is an increase of ore to concentrates from 9.3 to 9.4 and from this you would imagine that there should be a decrease in percentage extraction. If, however, the percentage extraction


Spring Pressure
Tons of Ore: Tons of Concentrates
% Fe_3O_4 in Concentrates
60
70
80
90
100
% Extraction
60
70
80
90
100
1
2
3
Spring Pressure
Curve 1. % Fe_3O_4 in Concentrates
" 2. % Extraction in "
" 3. % " " " & Middles

is taken in the heads and middles together it shows a decrease of 1%.

Test No. 1 shows the highest percentage extraction in the heads and the lowest ratio of tons of ore to tons of concentrates and is the most efficient test.

The results of the tests seem to indicate that spring pressure has little to do with the efficiency of operation.

Feed Water Variable

In the tests on feed water as a variable the amount of wash water was kept constant and the grade of the table was adjusted in each test, in order to obtain a good concentrate cut off.

Test	Feed Water	% Mag.	Tons/ 24 hrs	Ratio tons ore tons con.	Grade of Table	Conc. % Fe	Conc. % SiO_2	% Ex. Ton H.	% Ex. Ton M.	Loss -200
6	20	10.5	6.8	9.1	6.8	87.2	12.8	91.8	1.9	20.8
5	30	10.5	6.5	9.25	6.8	89.7	10.3	90.0	3.7	28.4
1	40	10.1	6.4	9.2	7.6	91.5	8.5	92.8	1.6	29.7
8	50	10.2	6.8	9.6	7.4	91.5	8.5	91.5	1.9	33.6
7	60	10.0	6.9	10.0	7.4	91.6	8.4	91.1	1.8	32.8

The first thing noticeable from the table is that as the feed water increases from 20 pounds up to 40 there is a corresponding increase in the extraction in heads and middles. When the feed water is increased over 40# there is a decrease in the extraction of heads and middles which would indicate that the maximum extraction was obtained at 40# of feed water. The cause of this may be due to the following facts:-

With a small amount of feed water the bed is not very loose and the intermediate grains have not a good opportunity of settling, but as the bed gets looser, by using more feed water, the grains have a good opportunity of settling. With an increase in feed water over 40# per minute excessive currents are formed on the table which sweep some magnetite away before it has a chance to settle.

It will also be noticed that the middle band in test 1 was $2\frac{1}{4}$" while in the other tests it was 3". You would also expect there to be a higher extraction in tests 5 and 6 due to the decrease in size of middle band and the greater percentage of magnetite in the feed. This bears out the statement that with the small amounts of feed water the intermediate grains have not a good opportunity to settle. Cleaner concentrates are obtained in tests 1, 7 and 8 than in tests 5 and 6, where small amounts of feed water were used and this is due to poor settling. The best results are obtained with a feed water sufficient to allow proper settling yet providing no rushing currents.

In the -200 mesh magnetite the largest saving was 79.2% with 20# wash water and as the feed water increases the saving becomes smaller until with 60# feed water the saving is 67.2%. This is due to the finer grains being washed away when the bed is loose and settling better in a moderately tight bed.

Wash Water Variable

Test	Wash Water	% Mag.	Feed Rate tons/ 24 hrs.	Ratio tons ore to tons conc.	% grade	Analysis % Fe_3O_4	% Extraction Heads	% Extraction Middles
9	20	10.5	6.7	9.3	8.3	89.0	90.2	3.1
10	30	10.0	6.4	10.0	8.3	91.8	91.3	3.0
5	40	10.5	6.5	9.25	6.8	89.7	90.0	3.7
11	50	10.5	6.9	9.0	6.7	87.6	91.1	2.1
12	60	10.6	6.9	9.7	6.4	92.0	88.9	2.3
13	70	10.0	7.2	10.4	5.9	93.0	91.3	3.4

These tests were run with a constant feed water of 30#. The extractions in these tests do not differ greatly with the exception of test 12, where the extraction falls to 88.9%. It ~~would~~ should seem since test 12 has the highest percentage of magnetite present that the extraction ~~would~~ should be much higher and especially as grade is between that of tests 11 and 13. It will be seen from the table that with an increase in ~~feed~~ wash water the grade ~~in~~decreases which is natural in order to get the cut off of the concentrate correct.

There is quite a drop in the grade in test 5 compared with test 10 which gives a good extraction but low % Fe_3O_4 which would appear that the grade is not large enough.

From these tests it appears that the differences in wash water have not much to do with efficiency, as one test is about as good as another.

Feed Water and Wash Water

Test	% Mag.	Wash Water	Feed Water	Rate of Feed	Grade %	Ore to Conc.	% Fe_3O_4 Heads	% Extraction Heads	% Extraction Middles	Loss -200
14	10.5	50	20	6.5	7.1	9.1	88.0	92.2	2.6	17.7
15	10.0	60	20	6.0	6.7	10.1	92.5	91.5	3.1	23.8
6	10.5	40	20	6.8	6.8	9.1	87.2	91.8	1.9	20.8

The saving in the -200 mesh in test 14 is higher than in tests 15 and 6 and also higher than in tests with higher feed water. This goes to show that with a fairly tight bed, that is, a small amount of feed water, the -200 mesh has a better chance to settle. With a low wash water in test 6 the concentrate is poor but as the wash water is increased the grade of concentrates increase, without much difference in extraction. When the feed water is moderate, say about 40#, the wash water has not much of an effect but when the feed water is low a high wash water has a marked effect in cleaning the concentrates.

If a low amount of feed water is used and it makes poor stratification then a large amount of wash water should be used as it makes a good clean concentrate with little change in the extraction. A lower wash water would make a good extraction butt poorer concentrates. As it is the aim in practice to get a high extraction with clean concentrates, it would appear that a low feed water and a high wash water are the best to use.

Rate of Feed

A 7/16 inch orifice was used.

Test	Rate of Feed	Grade of Ore	% Grade	F.W. Feed	W.W. Feed	Ore Conc.	% Fe_3O_4 Conc.	Ext. Heads	Middles
16	12.8	10.6	7.3	1.7	2.3	9.8	91.0	88.1	3.2
17	12.7	10.5	6.6	2.3	3.4	9.8	93.0	88.7	2.4
18	13.2	10.5	5.9	2.2	3.8	9.6	91.2	89.8	2.3
25	13.7	9.7	5.7	2.4	2.6	10.8	88.9	85.9	2.1
24	13.5	10.5	6.5	2.9	3.7	9.6	89.0	89.0	1.8

The same conclusion may be drawn in these tests as in the others, namely that the feed rate is higher in these tests and the extraction is lower, but the grade of concentrates and the extraction are still good enough to warrant this faster feed rate.

Feed Rate

Tests on 3/8" outfit.

Test	Rate of Feed	% Mag.	% Grade	F.W. Feed	W.W. Feed	Ore Conc.	% grade Conc.	Ext Heads	Middles
22	10.9	9.9	8.2	2.0	2.6	10.8	92.3	88.8	2.5
23	10.5	9.8	6.3	2.1	4.1	10.5	90.0	90.8	2.8
21	10.7	10.2	7.6	2.7	3.4	9.6	91.0	90.1	2.6

In tests 22, 23 and 5 the amount of feed water to feed is practically the same and this bears out the conclusion that with a low feed water, a high wash water is necessary. In test 22 the ratio of wash water to feed is 2.6 with an extraction of 92.3 and when the ratio is larger as in 23 the extraction is raised. The ratio of feed water to feed in test 27 is much higher than in the other two tests although there is not much difference in extraction. A good extraction is obtained in these tests which is only slightly lower then with a lower feed rate and also good grades of concentrates were obtained.

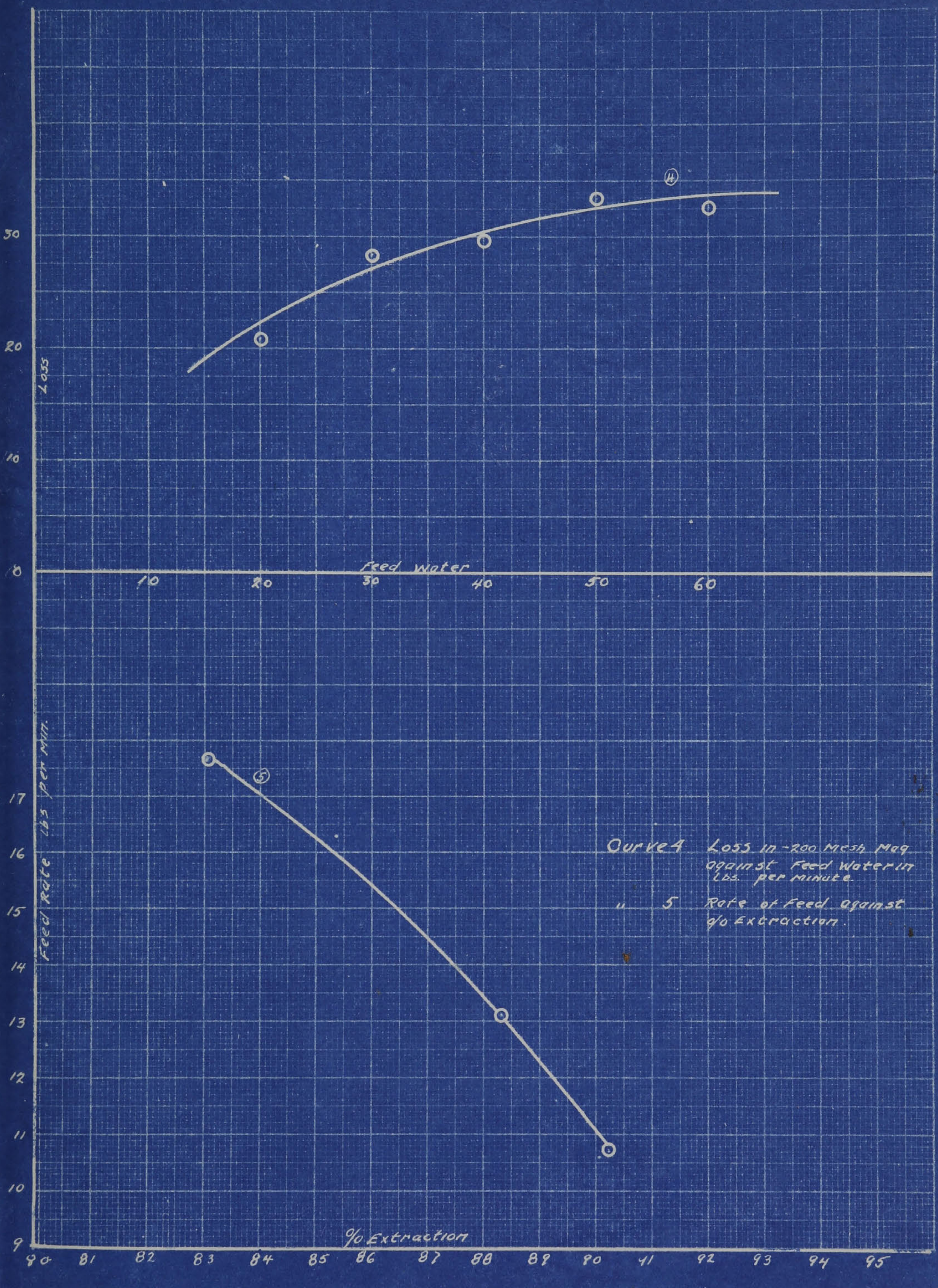
Feed Rate

Orifice used = $\frac{1}{8}$"

Test	Rate of Feed	% Mag.	Grade %	F.W. Feed	W.W. Feed	Ore Conc.	% Fe_3O_4 Conc.	Extraction Heads	Extraction Middles
20	17.9	9.6	5.9	1.6	2.8	12.4	91.5	79.8	3.3
28	17.5	10.4	6.7	1.6	2.5	10.7	90.5	80.6	3.7
27	17.6	10.3	5.6	2.0	2.4	9.3	87.6	89.8	2.0
26	17.7	10.6	5.5	2.4	2.8	9.8	87.3	85.3	2.5

It will be seen from these results that the extractions decrease considerably with the high rate of feed, except in the case of test 27, which seems to be a freak test. The ratios of feed water and wash water to feed in these tests are low due to the high rate of feed, although high amounts of water were used.

In test 26 the extraction has improved over the extractions in tests 20 and 28 and this is due to higher ratio of feed water, although the grade of the concentrates is lower, which is very likely due to the rushing currents of water from the 60# feed water that was used.



Loss
Feed water
Feed Rate lbs per Min.
% Extraction
Curve 4 Loss in -200 Mesh Mag against Feed Water in lbs. per minute.
" 5 Rate of Feed against % Extraction.

The results of these series of tests on the rate of feed are difficult to compare because of the wash and feed water being varied. The extraction with the high rate of feed is poor and to improve this, greater volumes of water would have to be used which, however, would be too much for the table. Fairly good results can be obtained up to a capacity of 13 tons per 24 hours which is about the greatest capacity with which it can be operated efficiently. With a better arrangement on the table for spreading a high feed better extractions and very likely a greater capacity could be obtained.

Speed Tests

Test	Feed Rate	% Grade	% Mag.	Conc. % Mag.	Extraction Heads	Extraction Middles	Speed	Tons ore to Tons Conc
29	10.4	7.2	10.4	91.5	90.7	2.2	241.5	9.4
30	10.4	7.7	10.1	92.2	91.0	2.5	251.5	10.4

Two tests were run on the change in speed. The feed and wash waters were 30 and 50 lbs. respectively and were kept constant in the two tests. The grade of the table was adjusted to suit the concentrate cut off.

The results from these tests do not differ very greatly from tests with higher speed but it seems that an increase in speed may be slightly beneficial, but as the speed could not be reduced under 240 or raised over 260, no definite conclusion can be drawn.

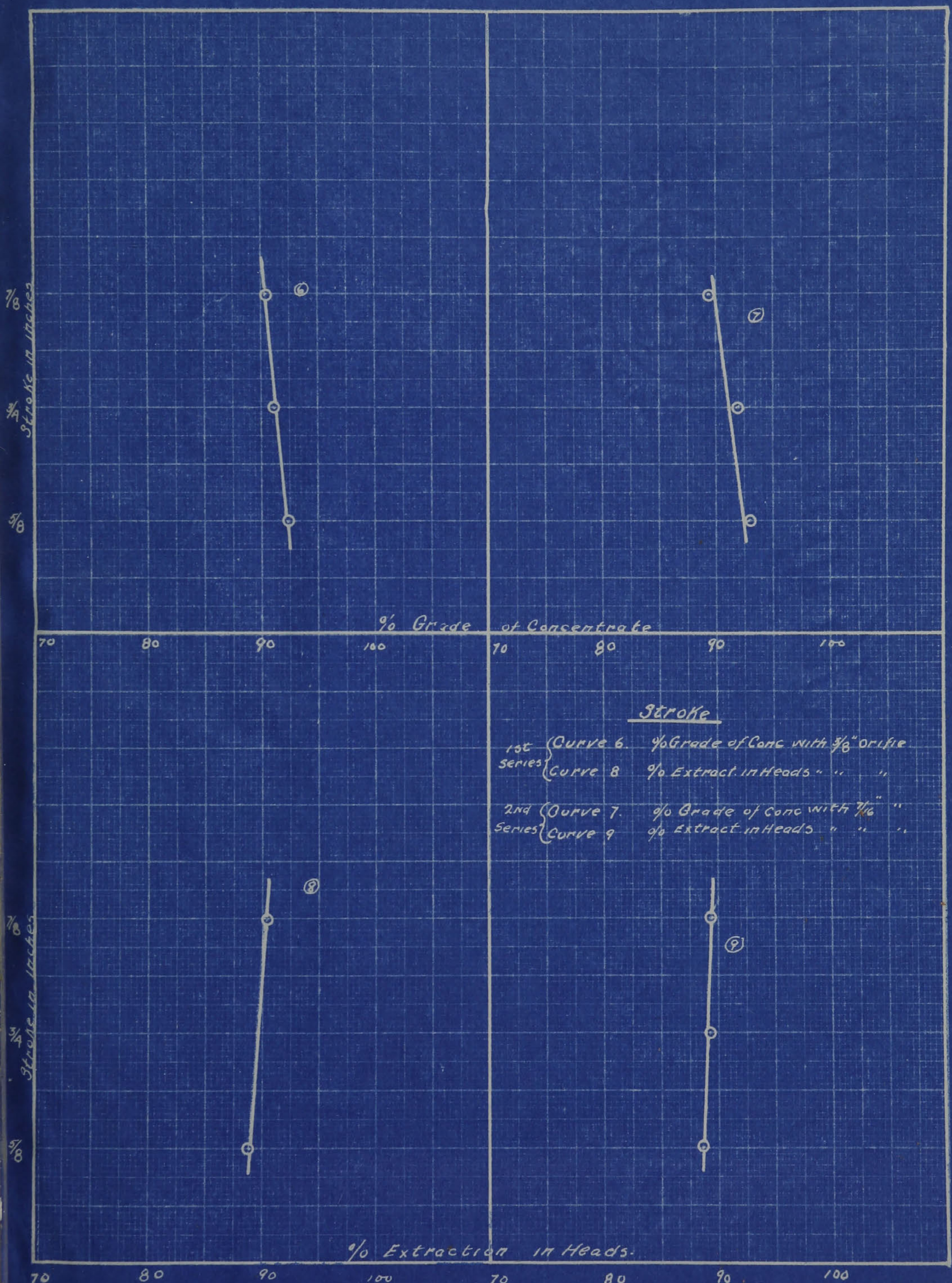
Stroke

Test	Feed Rate	Stroke	% Grade	% Mag. in Ore	% Mag. in Conc.	Extraction Heads	Extraction Middles	Speed	% SiO_2
22	10.9	5/8	8.2	9.9	92.3	88.8	2.5	267	7.7
31	10.9	3/4	7.9	10.1	91.1	91.1	2.9	244	8.9
33	11.0	7/8	8.0	10.1	90.3	90.3	2.6	265	9.7
17	12.7	5/8	6.6	10.5	93.0	88.7	2.4	264	7.0
32	13.6	3/4	6.7	10.2	92.1	89.2	1.7	260.5	7.9
34	13.3	7/8	6.6	10.3	89.4	89.4	2.2	262.5	10.6

Two series of tests were run on the length of stroke; the first series including tests 22, 31 and 33 were run with feed water at 30 lbs. per minute and wash water at 40 lbs. per minute. In the second series, including tests 17, 32 and 34, 40 and 60 lbs. of feed water and wash water were used respectively.

Test 31 does not quite conform to the rest of the series, as the grade is 7.9, and probably the high extraction is influenced by this. If this grade was 8.1 more magnetite would have been lost and the extraction would have been more like the others.

In comparing tests 22 and 33 it will be seen that with the larger stroke the grade of concentrate is decreased and there is a slight increase in extraction. This can also be seen in comparing tests 17 and 34. The stroke does not seem to have much effect, but if anything the larger stroke is favored.


Stroke in Inches
7/8
3/4
5/8
% Grade of Concentrate
70
80
90
100
⑥
⑦
Stroke
1st Series {Curve 6. % Grade of Conc with 3/8" orifice
Curve 8 % Extract. in Heads " " "
2nd Series {Curve 7. % Grade of Conc with 7/16" "
Curve 9 % Extract in Heads " " "
⑧
⑨
% Extraction in Heads.

Variation of % of Mag. in Feed

Test	% Mag.	Conc. Grade	Extraction	
			Heads	Middles
35	8.2	92.7	89.0	3.0
37	6.7	93.2	82.5	8.8
39	4.6	89.8	84.7	3.6
41	2.2	75.7	79.9	4.9
36	8.6	92.4	92.6	2.7
38	6.7	92.0	85.4	3.6
40	4.5	88.0	84.3	3.4
42	2.7	78.8	78.5	4.7

Two series of tests were run. In the first series including tests 35, 37, 39 and 41, 30 and 50 pounds of feed and wash water were used respectively, while in the second series including tests 36, 38, 40 and 42, 40 lbs. of feed water and 60 lbs. of wash water were used.

The extractions in the two series of tests do not differ very greatly although they seem to be slightly better in the first series where 30 lbs. of wash and 50 lbs. of feed water were used. The high extraction in the middles in test 37 is likely due to not enough concentrate being cut off, some of it entering the middles. It can be seen from the curve plotted from the extraction of magnetite in the middles against the percentage of magnetite in the feed that in test 37 the extraction is too high, and that it should be about 3.3. It will also be noticed that the high concentrate extraction in test 36 is due to the low extraction in the middles. It will also be seen from these tests that the magnetite loss in the tailings is not constant with a decrease of magnetite in the feed.

The % mag. in the middles does not decrease in as big proportion as the % mag. in the feed, and as the % mag. in the middles decreases the extraction in the middles decreases. The amount of silica in the heads in proportion to the amount of magnetite increases as the size of the head band or the % of magnetite.

Deductions

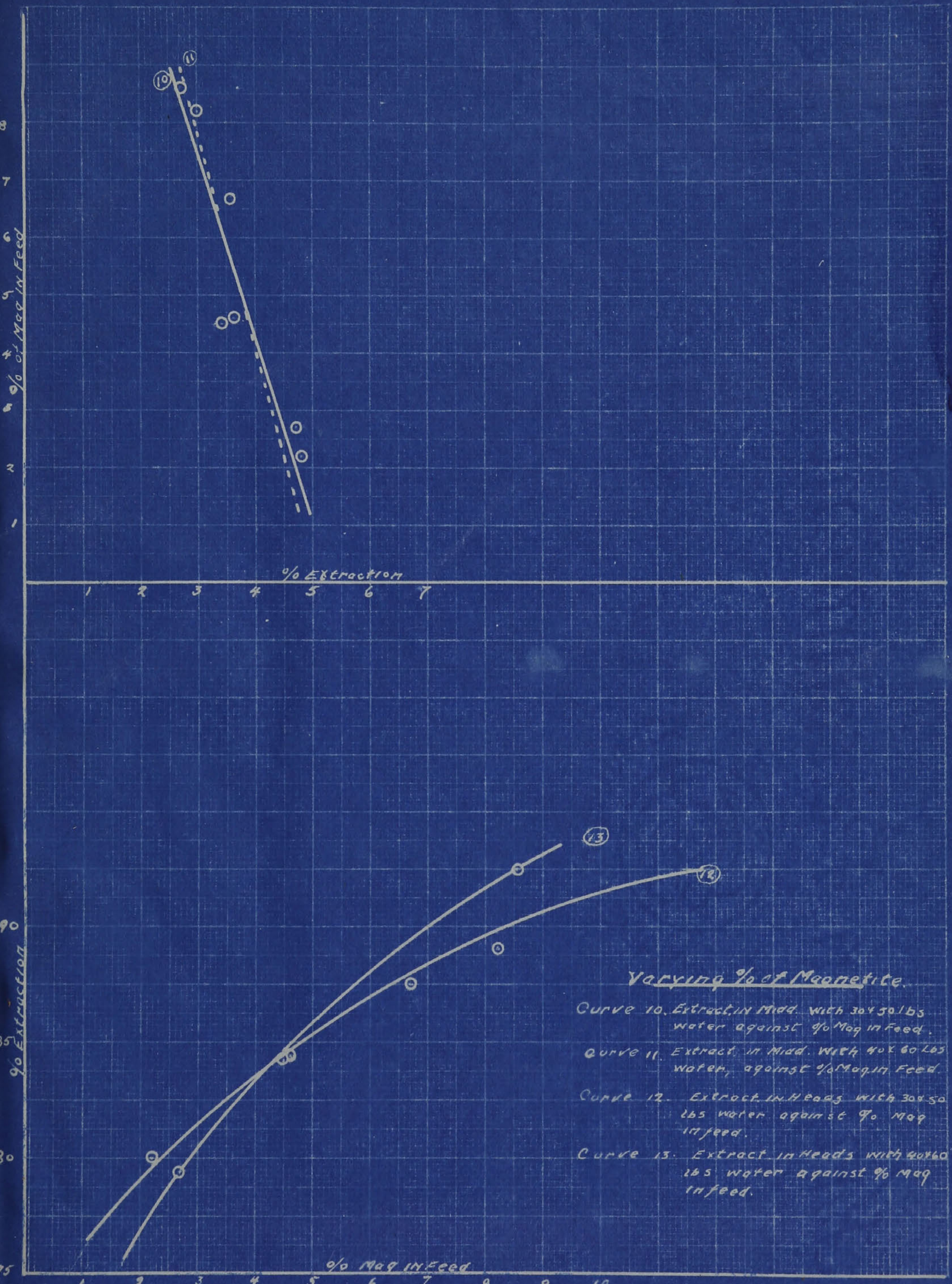
1. A decrease in the % of magnetite in the feed decreases the extraction.

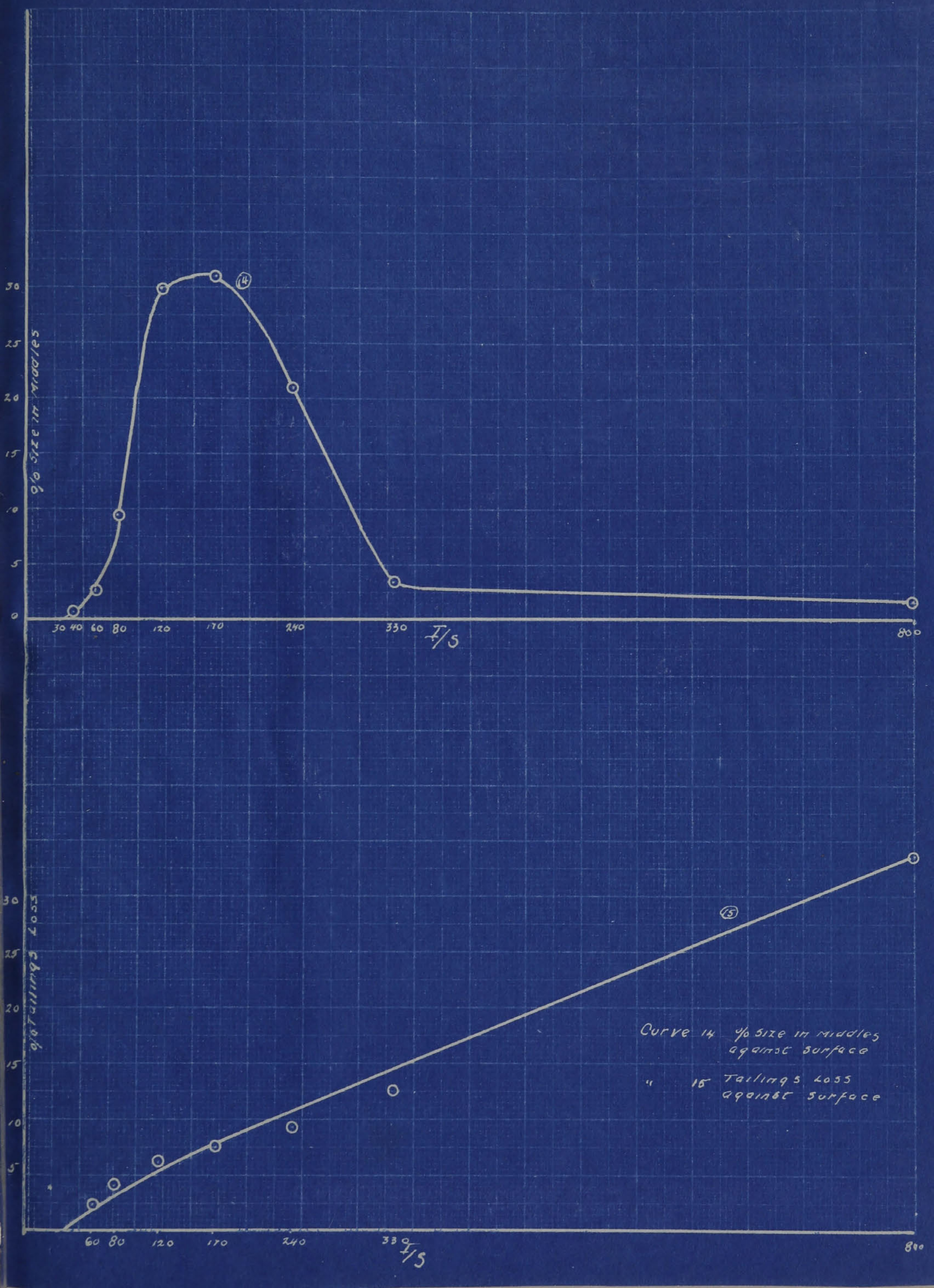
2. A decrease in the % of magnetite in the feed increases the % of total magnetite in the middles.

3. Decrease in the % of magnetite in the feed increases the tailings loss.

It may be interesting to note that throughout the different tests the majority of middles is in the intermediate sizes as shown in the curve. It appears that the rolling action comes in at about 48 and 65 mesh and suddenly you get into a size that jumps quickly. These sizes are protected by the wash water film on the table, and settle under it where they are helped to cling to the table by friction, and then are ~~moved~~ shoved along by the jerk in the table.

It is also interesting to note and is shown by the accompanying curve that the tailings losses increased with the surface exposed.


% of Mag in Feed
% Extraction
10
11
% Extraction
% Mag in Feed
13
12
Varying % of Magnetite.
Curve 10. Extract in Midd. with 30 & 50 lbs water against % Mag in Feed.
Curve 11. Extract in Midd. with 40 & 60 Lbs water, against % Mag in Feed.
Curve 12. Extract in Heads with 30 & 50 lbs water against % Mag in feed.
Curve 13. Extract in Heads with 40 & 60 lbs water against % Mag in feed.



% Size in Middles
30
25
20
15
10
5
0
30 40 60 80 120 170 240 330 800
I/S
% Tailings Loss
30
25
20
15
10
5
60 80 120 170 240 330 800
I/S
Curve 14 % size in middles against surface
" 15 Tailings Loss against surface

Conclusion

From the results of tests it seems that the table is not very sensitive to the changes in adjustment, although the extractions in some cases are effected to a small extent.

In the last series of tests on varying the percentage of magnetite in the ore, definite results were obtained that showed that with a decrease in the % of magnetite in the ore, the extraction dropped and the tailings loss increased.

It is realized that there is still a lot of room for investigation as no definite conclusions can be drawn until a great many more tests have been run. To complete this investigation tests would have to be run on the effect on minerals of different specific gravities on extraction, on a comparison of the Butchart top as it is, and without the extended riffles, and a comparison of the Butchart top with the Wilfley top.

It is suggested that if this investigation is to be continued that an ore of about 4.5% concentrate be used as the results would be more modified.

Appendix

A table showing the general summary of results is included and also two tests to show the methods of obtaining results.

Spring Pressure

Date 19 Table Test No - 1

Ore No 160X Description- 10.1% Mag. 89.9% [illegible]

Riffles- Butchart Type

	H M S	Revs.
Feed began	12 02 00	35700
Test began	12 20 00	40440
Test ended	12 30 00	
Feed ended	12 31 00	43335

Sketch with dimensions on reverse side of this form, the position of Heads, Middles and Tails bands.

Test made by-

Weight Tested- Lbs.	2444
Feed Orifice- Inch	5/16
Feed- Lbs. per minute	9
Feed- Tons per 24 Hrs.	6.4
No. 4.6 Feed Water- Lbs. per Min.	40
No. 385 Wash Water- Lbs. per Min.	40
Stroke- Inch	5/8
Strokes per Min.	263
Gradienter 212 Grade- %	7.6
Spring Pressure- Turns	1.0
Lbs Feed Water : Lbs Feed =	4.4 :1
Lbs Wash Water : Lbs Feed =	4.4 :1
Lbs Feed Water : Lbs Wash Water =	1 :1
Tons Ore : 1 Ton Concentrates =	9.2 :1

Overall Efficiency.

	Lbs.	Samp. No.	% Wt.	Analyses % Fe_3O_4	% SiO_2	lbs Fe_3O_4	lbs SiO_2	% of Total % Fe_3O_4	% SiO_2
Heads	10.18			91.5	8.5	9.33	0.85	92.9	1.0
Mid'l.	2.50			6.6	93.4	0.163	2.34	1.6	2.8
Tails	81.19			0.7	99.3	0.55	80.64	5.5	96.2
Total	93.87			10.7	89.3	10.04	83.83	100.0	100.0

Size Efficiency.

	+ 10	+ 14	+ 20	+ 28	+ 35	+ 48	+ 65	+100	+150	+200	-200
Heads			99.5	98.7	97.1	94.5	92.7	91.4	90.5	83.4	65.3
Mid'l.			0.5	0.4	0.6	1.5	2.2	2.4	2.9	3.2	5.0
Tails			0.0	0.9	2.3	4.0	5.1	6.2	6.6	13.4	29.7
Total			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	+ 10	+ 14	+ 20	+ 28	+ 35	+ 48	+ 65	+100	+150	+200	-200
Heads											
Mid'l.											
Tails											
Total											

Form No 23

	gms.	gms Fe_3O_4	gms SiO_2	% Size	wt lbs	lbs Size	% Fe_3O_4	lbs Fe_3O_4	% SiO_2	lbs SiO_2	1
+ 10											
14											
20											
28											
35											Feed
48											
65											
100					152.00						
150											
200											
-200											
Total											
+ 10											
14											
20	1.13	1.13	0.00	1.65		0.17	100.00	0.17	0.00	0.00	
28	15.59	15.59	0.00	22.75		2.32	100.00	2.32	0.00	0.00	
35	14.07	14.07	0.00	20.55		2.10	100.00	2.10	0.00	0.00	Heads
48	8.14	8.07	0.07	11.85	10.18	1.20	99.1	1.19	0.9	0.01	
65	8.07	7.46	0.61	11.75		1.19	92.5	1.10	7.5	0.09	
100	8.33	5.81	2.49	12.13		1.24	71.2	0.88	28.8	0.36	
150	7.80	5.47	2.33	11.37		1.16	70.4	0.82	29.6	0.34	
200	2.35	2.08	0.27	3.43		0.35	88.6	0.31	11.4	0.04	
-200	3.04	2.44	0.08	4.44		0.45	96.9	0.44	2.63	0.01	
Total	68.52	62.62	5.85	100.0		10.18	91.5	9.33	8.5	0.85	
+ 10											
14											Midd.
20	0.02	0.01	0.01	0.06		.0015	50.0	.0007	50.0	.0007	
28	0.18	0.113	0.05	0.57		.0142	62.9	.0089	27.6	.0053	
35	0.42	0.18	0.24	1.18		.0295	42.9	.0126	57.1	.0169	
48	1.33	0.27	1.06	3.74		.0935	20.3	.0190	79.7	.0745	
65	8.40	0.38	8.02	23.60	2.50	.5900	4.5	.0265	95.5	.4635	
100	13.56	0.33	13.23	38.20		.9550	2.4	.0229	97.6	.9321	
150	9.87	0.37	9.50	27.80		.6950	3.7	.0257	96.3	.6693	
200	1.06	0.17	0.89	2.98		.0745	16.5	.0123	83.5	.0622	
-200	0.72	0.49	0.23	2.02		.0505	68.2	.0344	31.8	.0161	
Total	35.56	2.313	33.23	100.0		2.50	6.6	16.30	93.4	23.406	

	gms.	gms Fe_3O_4	gms SiO_2	% size	wt lbs.	lbs size	% Fe_3O_4	lbs Fe_3O_4	% SiO_2	lbs SiO_2	1
+ 10											
14											
20	0.01	0.00	0.01	0.03		0.02	0.00	0.00	100.0	0.02	
28	0.63	0.01	0.62	1.54		1.25	1.40	0.02	98.6	1.23	
35	8.57	0.02	8.55	21.00		17.05	0.30	0.05	99.7	17.00	
48	8.53	0.03	8.50	20.85		17.00	0.30	0.05	99.7	16.95	tails
65	7.99	0.04	7.95	19.60		15.90	0.40	0.06	99.6	15.84	
100	5.75	0.03	5.72	14.10	81.19	11.41	0.50	0.06	99.5	11.35	
150	5.74	0.04	5.70	14.00		11.36	0.50	0.06	99.5	11.30	
200	2.09	0.02	2.06	5.12		4.15	1.40	0.05	98.6	4.10	
-200	1.53	0.10	1.43	3.75		3.05	6.50	0.70	93.5	2.85	
Total	40.84	0.29	40.54	100.0		81.19	0.7	0.55	99.8	80.64	

Fe_3O_4	+10	+ 14	+ 20	+ 28	+35	+ 48	+ 65	+100	+150	+200	-200
Heads			0.17	2.32	2.10	1.19	1.10	0.88	0.82	0.31	0.44
Midd.			0.001	0.009	0.013	0.019	0.026	0.023	0.026	0.012	0.034
tails.			0.00	0.02	0.05	0.05	0.06	0.06	0.06	0.05	0.20
Total			0.171	2.349	2.163	1.259	1.186	0.963	0.906	0.372	0.674

Date 19 Table Test No - 2

Ore No 160 R. Description- 10.7 % magnetite
89.3 % [illegible]

Riffles- [illegible] Type

	H	M	S	Revs.
Feed began	10	00	00	48677
Test began	10	15	00	52654
Test ended	10	26	20	55644
Feed ended				

Sketch with dimensions on reverse side of this form, the position of Heads, Middles and Tails bands.

Test made by-

Weight Tested- Lbs.	250
Feed Orifice- Inch	5/16
Feed- Lbs. per minute	9.5
Feed- Tons per 24 Hrs.	7.1
No. 46 Feed Water- Lbs. per Min.	40
No. 38.5 Wash Water- Lbs. per Min.	40
Stroke- Inch	5/8
Strokes per Min.	264.5
Gradienter 212 Grade- %	7.6
Spring Pressure- Turns	3
Lbs Feed Water : Lbs Feed	= 4.2 :1
Lbs Wash Water : Lbs Feed	= 4.2 :1
Lbs Feed Water : Lbs Wash Water	= 1 :1
Tons Ore : 1 Ton Concentrates	= 9.3 :1

Overall Efficiency.

	Lbs.	Samp. No.	% Wt.	Analyses % Fe_3O_4	Analyses % SiO_2	Analyses lbs Fe_3O_4	Analyses lbs SiO_2	% of Total Fe_3O_4	% of Total SiO_2
Heads	11.75			93.0	7.0	10.92	0.83	90.8	0.8
Mid'l.	2.50			14.7	85.3	0.372	2.128	3.1	2.2
Tails	95.60			0.7	99.3	0.74	94.87	6.1	97.0
Total	109.85			10.95	89.05	12.03	97.83	100.0	100.0

Size Efficiency.

	+ 10	+ 14	+ 20	+ 28	+ 35	+ 48	+ 65	+100	+150	+200	-200
Heads			80.4	95.5	96.6	95.2	90.5	92.1	82.7	78.3	64.7
Mid'l.			6.2	4.2	1.4	1.5	6.9	2.4	3.3	4.8	6.7
Tails			13.4	0.3	2.0	3.3	2.6	5.5	9.0	16.9	28.6
Total			100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

	+ 10	+ 14	+ 20	+ 28	+ 35	+ 48	+ 65	+100	+150	+200	-200
Heads											
Mid'l.											
Tails											
Total											

Form No 23

	grms.	grms Fe_3O_4	grms SiO_2	% Size	wt lbs.	lbs Size	% Fe_3O_4	lbs Fe_3O_4	% SiO_2	lbs SiO_2	Σ
+ 10											
14											
20											
28											
35											
48											Feed.
65					140.00						
100											
150											
200											
-200											
Total											
+ 10											
14											
20	0.58	0.58	0.00	1.52		0.18	100.0	0.18	0.0	0.00	
28	8.52	8.515	0.005	22.17		2.60	99.9	2.59	0.1	0.01	
35	8.10	8.09	0.01	21.16		2.48	99.9	2.47	0.1	0.01	
48	4.73	4.705	0.025	12.37		1.45	99.6	1.44	0.4	0.01	Heads.
65	4.54	4.26	0.28	11.86		1.40	93.8	1.31	6.2	0.09	
100	4.45	3.29	1.16	11.62	11.75	1.37	72.8	1.00	27.2	0.37	
150	4.13	3.16	0.97	10.81		1.27	76.5	0.97	23.5	0.30	
200	1.31	1.195	0.115	3.42		0.40	91.3	0.37	8.7	0.03	
-200	1.94	1.90	0.04	5.07		0.60	98.0	0.59	2.0	0.01	
Total	38.30	35.69	2.60	100.0		11.75	93.0	10.92	7.0	0.83	
+ 10											
14											
20	0.23	0.225	0.005	0.65		0.016	97.9	0.014	2.1	0.002	
28	1.60	1.58	0.02	4.55		0.114	98.8	0.113	1.2	0.001	
35	0.72	0.52	0.20	2.05		0.051	72.3	0.037	27.7	0.014	
48	0.98	0.32	0.66	2.80		0.070	32.6	0.023	67.4	0.047	
65	6.36	0.54	5.82	18.10	2.50	0.453	8.5	0.038	91.5	0.415	[illegible]
100	12.36	0.39	11.97	35.12		0.878	3.1	0.026	96.9	0.852	
150	10.28	0.54	9.74	29.20		0.730	5.2	0.037	94.8	0.693	
200	1.51	0.32	1.19	4.29		0.107	21.2	0.023	78.8	0.084	
-200	1.14	0.86	0.28	3.24		0.081	75.4	0.061	24.6	0.020	
Total	35.18	5.295	29.885	100.0		2.500	14.7	0.372	85.3	2.128	

	gms	gms Fe_3O_4	gms SiO_2	% size	wt lbs.	lbs size	% Fe_3O_4	lbs Fe_3O_4	% SiO_2	lbs SiO_2	2
+ 10											
14											
20	.02	.01	.01	0.06		0.06	50.0	0.03	50.0	0.03	
28	.60	.005	.595	1.83		1.75	0.7	0.01	99.3	1.74	
35	7.09	.02	7.07	21.66		20.70	0.2	0.05	99.8	20.65	
48	6.86	.02	6.84	20.97	95.51	20.05	0.2	0.05	99.8	20.00	
65	6.31	.04	6.27	19.30		18.45	0.6	0.10	99.4	18.35	
100	4.41	.03	6.38	13.50		12.91	0.6	0.06	99.4	12.85	Tails.
150	4.45	.04	4.41	13.60		13.00	0.9	0.10	99.1	12.90	
200	1.69	.03	1.66	5.17		4.95	1.7	0.08	98.3	4.87	
-200	1.28	.09	1.19	3.91		3.74	7.0	0.26	93.0	3.48	
Total	32.71	0.285	32.425	100.0		95.6	0.7	0.74	99.3	94.87	

Total

Fe_3O_4	+10	+ 14	+ 20	+ 28	+35	+ 48	+ 65	+100	+150	+200	-200
Heads			0.18	2.59	2.47	1.44	1.31	1.00	0.97	0.37	0.59
Midd.			0.014	0.113	0.037	0.023	0.038	0.026	0.037	0.023	0.061
Tails			0.03	0.01	0.05	0.05	0.10	0.06	0.10	0.08	0.26
Total			0.224	2.713	2.557	1.513	1.448	1.086	1.107	0.473	0.911

Total

Total

Total

No of Test	% Mag	% Ting	Width of Middle Band in inches	Width of Head Band in inches	Tail on Band at Ends in inches	Feed Orifice in inches	Feed lbs per Minute	Feed Tons per 24 hours	Feed Water lbs per Minute	Wash Water lbs per Minute	Stroke in inches	Strokes per Minute	% Grade	Spring Pressure Turns	Feed Water to Feed (lb)	Wash water to Feed (lb)	Feed water to Wash water	Tons Ore to Tons Conc.
1	10.1	89.9	2 1/4	9	54	5/16	9.0	6.4	40	40	5/8	263	7.6	1	4.4	4.4	1.0	9.2
2	10.7	89.3	3	9	53	"	9.5	7.1	40	40	"	264.5	7.6	3	4.2	4.2	1.0	9.3
3	10.8	89.2	3	10	66	"	9.1	6.5	40	40	"	265	7.6	-1	4.4	4.4	1.0	9.4
4	10.5	89.5	3	9	60	"	9.0	6.4	55	40	"	266.5	7.6	2	6.0	4.4	1.3	9.4
5	10.5	89.5	4	11	50	"	9.1	6.5	30	40	"	265	6.8	1	3.3	4.4	0.75	9.25
6	10.5	89.5	4	10	46	"	9.4	6.8	20	40	"	260	6.8	"	2.1	4.2	0.5	9.1
7	10.0	90.0	4	10	61	"	9.6	6.9	60	40	"	266	7.4	"	6.2	4.2	1.5	10.0
8	10.2	89.8	4	9	60	"	9.4	6.8	50	40	"	265	7.4	"	5.3	4.2	1.25	9.6
9	10.5	89.5	6	9	54	"	9.3	6.7	30	20	"	267.5	8.3	"	3.2	2.1	1.5	9.3
10	10.0	90.0	"	9	63	"	9.0	6.4	30	30	"	268	8.3	"	3.3	3.3	1.0	10.0
11	10.5	89.5	"	11	54	"	9.6	6.9	30	50	"	262	6.7	"	3.1	5.2	0.6	9.0
12	10.6	89.4	"	11	54	"	9.6	6.9	30	60	"	263.5	6.4	"	3.1	6.2	0.5	9.7
-13	10.0	90.0	"	10	51	"	10.0	7.2	30	70	"	265.5	5.9	"	3.0	7.0	0.43	10.4
14	10.5	89.5	"	10	48	"	9.1	6.5	20	50	"	266.5	7.1	"	2.2	5.5	0.4	9.15
15	10.0	90.0	"	9	45	"	8.3	6.0	20	60	"	261.5	6.7	"	2.4	7.2	0.33	10.1
16	10.6	89.4	"	14	61	7/16	17.8	12.8	30	40	"	266	7.3	"	1.7	2.3	0.75	9.8
17	10.5	89.5	"	13	64	"	17.7	12.7	40	60	"	264	6.6	"	2.3	3.4	0.66	9.8
18	10.5	89.5	"	14	61	"	18.4	13.2	40	70	"	266	5.9	"	2.2	3.8	0.43	9.6
19																		
20	9.6	90.4	"	15	70	1/2	24.8	17.9	40	70	"	266	5.9	"	1.6	2.8	0.57	12.4
21	10.2	89.8	"	12	65	3/8	14.8	10.7	40	50	"	266	7.6	"	2.7	3.4	0.8	9.6
22	9.9	90.1	"	11	68	"	15.1	10.9	30	40	"	267	8.2	"	2.0	2.6	0.75	10.8
23	9.8	90.2	"	11	66	"	14.6	10.5	30	60	"	268	6.3	"	2.1	4.1	0.5	10.5
24	10.5	89.5	"	14	69	7/16	18.7	13.5	55	70	"	265	5.7	"	2.9	3.7	0.8	9.6
25	9.7	90.3	"	12	69	"	19.0	13.7	45	50	"	266	6.5	"	2.4	2.6	0.9	10.8
26	10.6	89.4	"	16	72	1/2	24.7	17.7	60	70	"	266	5.5	"	2.4	2.8	0.85	9.8
27	10.3	89.7	"	15	72	"	24.5	17.6	50	60	"	268.5	5.6	"	2.0	2.4	0.83	9.3
28	10.4	89.6	"	15	71	"	24.4	17.5	40	60	"	264	6.7	"	1.6	2.5	0.66	10.7
29	10.4	89.6	"	14	66	3/8	14.5	10.4	30	50	"	241.5	7.2	"	2.1	3.4	0.6	9.4
30	10.1	89.9	"	13	64	"	14.4	10.4	30	50	"	251.5	7.7	"	2.1	3.5	0.6	10.4
31	10.1	89.9	"	11	61	"	15.0	10.9	30	40	3/4	244	7.9	"	2.0	2.7	0.75	9.6
32	10.2	89.8	"	10	62	7/16	18.9	13.6	40	60	"	260.5	6.7	"	2.1	3.2	0.66	10.7
33	10.1	89.9	"	9	54	3/8	15.3	11.0	30	40	7/8	265	8.0	"	2.0	2.6	0.75	10.4
34	10.3	89.7	"	11	50	7/16	18.4	13.3	40	60	"	262.5	6.6	"	2.2	3.3	0.66	9.5
35	8.2	91.8	"	10	58	3/8	14.9	10.7	30	50	5/8	262	7.3	"	2.1	3.4	0.6	12.7
36	8.6	91.4	"	12	60	"	15.1	10.9	40	60	"	260	6.7	"	2.6	4.0	0.66	11.5
37	6.7	93.3	"	8	60	"	14.8	10.7	30	50	"	263	7.3	"	2.0	3.4	0.6	16.8
38	6.7	93.3	"	7.5	62	"	14.4	10.4	40	60	"	265.5	6.7	"	2.8	4.2	0.66	15.8
39	4.6	95.4	"	6	61	"	14.4	10.4	30	50	"	264	7.5	"	2.1	3.5	0.6	22.7
40	4.5	95.5	"	8	60	"	15.1	10.9	40	60	"	257	6.0	"	2.6	4.0	0.66	20.9
41	2.2	97.8	"	5	65	"	14.6	10.5	30	50	"	258.5	7.6	"	2.0	3.4	0.6	42.4
42	2.7	97.3	"	5.5	64	"	14.7	10.6	40	60	"	264	6.2	"	2.7	4.1	0.66	35.6

No of Test	ANALYSES % Fe_3O_4 Heads	Midd.	Tails	% SiO_2 Heads	Midd	Tails	% EXTRACTION Fe_3O_4 Heads	Midd	Tails	SiO_2 Heads	Midd	Tails	WTS OF PRODUCTS Heads	Midd	Tails	Total
1	91.5	6.6	0.7	8.5	93.4	99.3	92.8	1.6	5.5	1.0	2.8	96.2	10.18	2.50	81.19	93.87
2	93.0	14.7	0.7	7.0	85.3	99.3	90.8	3.1	6.1	0.8	2.2	97.0	11.75	2.50	95.60	109.86
3	94.7	6.7	0.9	5.3	93.3	99.1	91.0	1.4	7.6	0.6	2.2	97.2	7.75	1.56	63.50	72.81
4	92.4	11.0	1.0	7.6	89.0	99.0	90.4	2.3	7.3	0.9	2.3	96.8	15.00	3.29	123.18	141.47
5	89.7	5.0	0.8	10.3	95.0	99.2	90.0	3.7	6.3	1.2	4.1	94.7	9.81	3.63	77.25	90.69
6	87.2	4.2	0.8	12.8	95.8	99.2	91.8	1.9	6.3	1.6	4.8	93.6	10.50	4.37	81.25	96.12
7	91.6	5.6	0.7	8.4	94.4	99.3	91.1	1.8	7.1	1.0	3.2	95.8	10.06	3.06	86.31	99.43
8	91.5	6.6	0.7	8.5	93.4	99.3	91.5	1.9	6.6	1.0	3.0	96.0	10.62	3.00	89.12	102.74
9	89.0	5.4	0.8	11.0	94.6	99.2	90.2	3.1	6.7	1.3	6.5	92.2	10.37	5.94	79.94	96.25
10	91.8	6.4	0.5	8.2	93.6	99.5	91.3	3.0	5.7	0.9	4.9	94.2	9.00	4.25	77.38	90.63
11	87.6	4.5	0.9	12.4	95.5	99.1	91.1	2.1	6.8	1.5	5.2	93.3	10.38	4.63	79.44	94.45
12	92.0	6.8	1.0	8.0	93.2	99.0	88.9	2.3	8.8	0.9	3.9	95.2	10.13	3.63	83.87	97.63
-13	93.0	8.3	0.6	7.0	91.7	99.4	91.3	3.4	5.3	0.7	4.0	95.3	9.88	4.00	88.50	102.38
14	88.0	4.3	0.7	12.0	95.7	99.3	92.2	2.6	5.2	1.4	6.7	91.9	8.19	4.69	62.07	74.95
15	92.5	8.3	0.6	7.5	91.7	99.4	91.5	3.1	5.4	0.8	3.9	95.3	8.31	3.25	72.25	83.81
16	91.0	8.8	1.2	9.0	91.2	98.8	88.1	3.2	8.7	1.0	4.0	95.0	5.62	2.12	46.98	54.67
17	93.0	10.9	1.1	7.0	89.1	98.9	88.7	2.4	8.9	0.8	2.4	96.8	9.06	2.13	77.81	89.00
18	91.2	8.7	1.0	8.8	91.3	99.0	89.8	2.3	7.9	1.0	2.8	96.2	9.44	2.50	78.62	90.56
19																
20	91.5	15.3	1.7	8.5	84.7	98.3	79.8	3.3	16.9	0.7	1.9	97.4	10.13	2.50	112.80	125.43
21	91.0	8.8	0.9	9.0	91.2	99.1	90.1	2.6	7.3	1.0	3.1	95.9	10.88	3.19	90.06	104.13
22	92.3	9.6	0.9	7.7	90.4	99.1	88.8	2.5	8.7	0.8	2.6	90.6	9.19	2.56	87.82	99.57
23	90.0	6.9	0.8	10.0	93.1	99.2	90.8	1.8	7.4	1.0	2.6	96.4	9.01	2.37	83.63	95.01
24	89.0	8.7	1.1	11.0	91.3	98.9	89.0	1.8	9.2	1.3	2.2	96.5	9.75	2.00	82.63	94.38
25	88.9	7.0	1.3	11.1	93.0	98.7	85.9	2.1	12.0	1.1	2.9	96.0	7.94	2.38	75.37	85.69
26	87.3	13.4	1.5	12.7	86.6	98.5	85.3	2.5	12.2	1.5	1.9	96.6	7.75	1.50	66.38	75.63
27	87.6	10.2	1.0	12.4	89.8	99.0	89.8	2.0	8.2	1.5	2.1	96.4	8.06	1.57	65.31	74.93
28	90.5	15.3	1.7	9.5	84.7	98.3	80.6	3.7	15.7	1.2	1.7	97.1	7.13	1.50	68.06	76.69
29	91.5	8.5	0.8	8.5	91.5	99.2	90.7	2.2	7.1	1.3	3.0	95.7	9.75	2.69	79.14	91.58
30	92.2	9.0	0.7	7.8	91.0	99.3	91.0	2.5	6.5	0.7	2.7	96.6	8.25	2.31	75.37	85.93
31	91.1	7.4	0.7	8.9	92.6	99.3	91.1	2.9	6.0	1.0	4.1	94.9	7.94	3.06	65.61	76.61
32	92.1	6.5	1.1	7.9	93.5	98.9	89.2	1.7	9.1	0.8	2.6	96.6	8.56	2.25	78.50	89.31
33	90.3	6.7	0.8	9.7	93.3	99.2	90.3	2.6	7.1	1.0	3.9	95.1	8.94	3.50	80.88	93.32
34	89.4	6.7	1.0	10.6	93.3	99.0	89.4	2.2	8.4	1.2	3.7	95.1	8.13	2.75	66.25	77.13
35	92.7	7.5	0.8	7.3	92.5	99.2	89.0	3.0	8.0	0.6	3.3	96.1	8.13	3.32	91.38	102.83
36	92.4	5.8	0.5	7.6	94.2	99.5	92.6	2.7	4.7	0.7	4.1	95.2	6.88	3.19	69.06	79.13
37	93.2	8.6	0.6	6.8	91.4	99.4	82.5	8.8	8.7	0.4	2.1	97.5	5.25	2.31	81.13	88.69
38	92.0	7.8	0.8	8.0	92.2	99.2	85.4	3.6	11.0	0.5	3.1	96.4	3.56	1.75	51.13	56.44
39	89.8	6.8	0.6	10.2	93.2	99.4	84.7	3.6	11.7	0.4	2.4	97.2	3.62	2.07	76.43	82.12
40	88.0	4.3	0.6	12.0	95.7	99.4	84.3	3.4	12.3	0.6	3.5	95.9	4.25	3.13	82.00	89.38
41	75.7	4.6	0.4	24.3	95.4	99.6	79.9	4.9	15.2	0.6	2.3	97.1	1.94	1.94	78.50	82.38
42	78.8	4.3	0.5	21.2	95.7	99.5	78.5	4.7	16.8	0.7	3.0	96.3	2.44	2.69	81.81	86.94