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The cyaniding of a Mexican silver ore

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THE CYANIDING OF A MEXICAN SILVER ORE

- by-

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and
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A
THESIS

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PURPOSE

The purpose of this thesis is to determine whether or not a certain Mexican silver ore is amenable to cyanidation.

DESCRIPTION AND COMPOSITION OF ORE

The ore consists, chiefly of quartz, calcite and alteration products, derived from eruptive igneous rocks (quartz porphyry). Chalcopyrite, tetrahedrite, galena, sphalerite and pyrite are present in small quantities, finely disseminated throughout the poryphyry. It is probable that argentite (Ag_2S), intimately mixed with the sulphides, is the source of the silver.

Assay of Original Ore.

Silver-----------11.14

Gold------------ trace.

The gold was not taken into consideration.

Acidity.

The total acid in the ore required 10.8# of CaO per ton to neutralize it. A protective alkalinity of 3# of CaO per ton was maintained throughout our experiments, making a total of 13.8# of CaO consumed per ton of ore.

Petrographical Analysis.

Some of the ore was examined microscopically to discern its mineral composition. Pyrite, sphalerite, tetrahedrite, galena, etc. were plainly visible. Other minerals were determined by quantative analysis of the ore.

SCREEN ANALYSIS.

Object.

The object of this analysis is to determine the minimum size to which the ore should be crushed to liberate the values. In the mechanical preparation of the ore for any solution process, this knowledge would be almost essential.

Method.

A sample of 1000 grams of ore was crushed to pass a 28 mesh (0.417)mm. screen. The sample was screened through a nest of screens consisting of 28, 35, 48, 65, 100, 150, 200, 240 and 260 mesh. The material remaining on each screen and also that which passed through 260 mesh was then weighed and assayed. The results of the experiment are given in Table I.

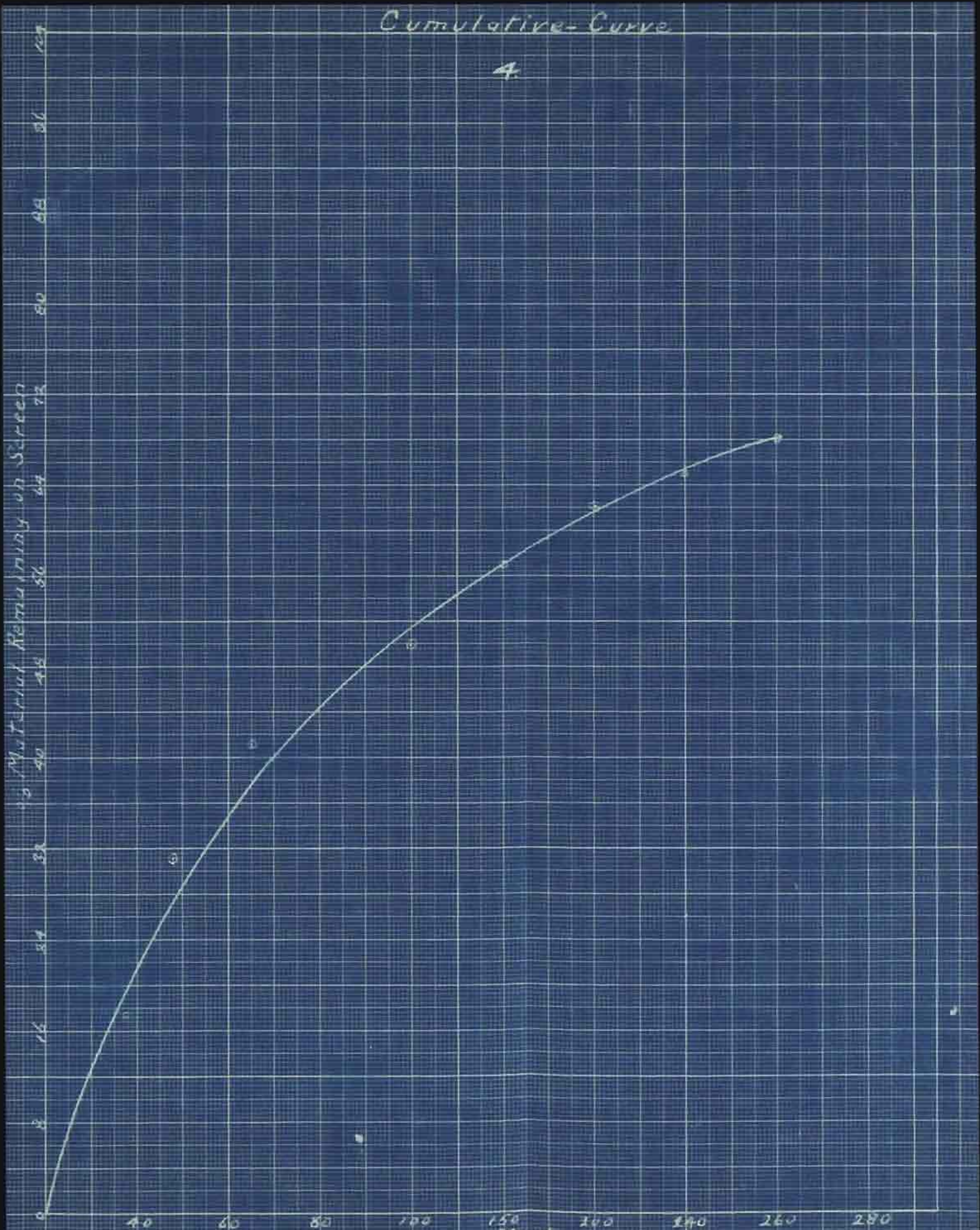
Table I.

Mesh Thro.	Mesh On.	Size of Opening	Avge. Diam. of Grain	Wt.	%	Oz.Ag per Ton.
28	35	0.417	0.503	173.47	17.347	6.28
35	48	0.295	0.356	136.97	13.697	8.18
48	65	0.208	0.251	104.00	10.400	9.58
65	100	0.147	0.177	89.71	8.971	11.14
100	150	0.104	0.125	66.47	6.647	11.74
150	200	0.074	0.089	51.97	5.197	13.52
200	240	0.066	0.070	28.47	2.847	16.35
240	260	0.056	0.061	32.47	3.247	16.20
260				316.47	31.647	13.10
				1000.00	100.00	

Conclusion.

This analysis showsthat the silver values increase with the mesh up to -200. Beyond this they decrease slightly. It also shows that a large per cent of fine material is present in the relatively coarse ground material. The accompanying cumulative curve gives a graphical representation of the analysis.

The sereen sized material was also examined microscopically to determine the mesh at which the sulphides were broken free. Practically all of the sulpides, except a small amount of pyrite, were broken free at 150 mesh. This indicated that the ore would have to be ground very fine, at least -150 mesh, to free the silver bearing sulphides.


Cumulative-Curve
4
% Material Remaining on Screen
Mesh

CYANIDE TESTS.

Introduction.

Leaching schemes were not tried on this ore on account of the excessive amount of fines resulting from the fine grinding which was necessary to free the sulphides.

Object.

This series of experiments was performed to determine the effect of certain variables on the extraction of values. The variables were the mesh of the ore, the time of agitation and the degree of concentration of the KCN solution.

Method.

Samples of the ore were crushed to pass 100, 150, 200, and 240 mesh, placed in the agitator with different strengths of solutions and agitated. The solutions were varied in strength from 0.05% to 0.5%. The time was varied from 3 to 24 hours. The agitation was done in a battery of six agitators. The agitator was made of an iron frame holding bushings, through which glass rod propellors were run by a 1/8 H. P. motor. The ore and the solutions were placed in anatomical jars and agitated.

There are some irregularities in these experiments which may be due to the following causes:-

1. Irregular agitation due to the breaking of the machine belt.

2. Loss of pulp by spattering.

3. Evaporation.

4. Cyanicides.

In the following experiments 2 A. T. of ore with 4 A.T of solution were used. A curve showing a graphical representation of our results, accompanies all of the tables.

SERIES ONE.

In the first series of experiments we used a .05% KCN sokution and varied the time from 3 to 24 hours. The best extraction was obtained on 240 mesh material. The time of agitation was 6 hours.

Extraction-----------19.20%

KCN consumed----------0.55# per ton.

There was a marked decrease in the extraction of the 24 hour material which was probably due to the depletion of KCN as there remained only 0.15# per ton.

Fron the results it is evident that a solution so weak as 0.05% could not be used to any advantage on this ore.

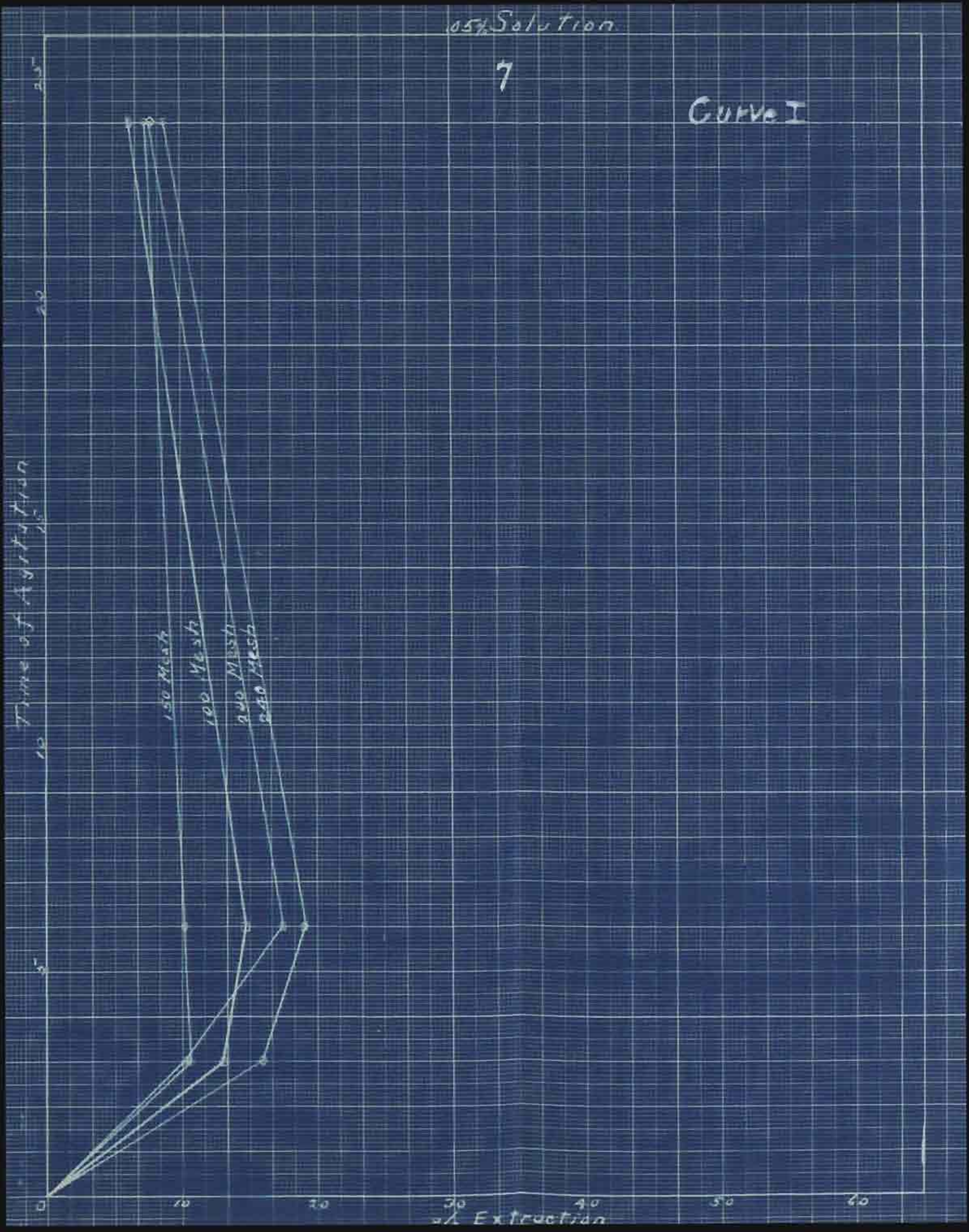

.05% Solution
7
Curve I
Time of Agitation
% Extraction
0
10
20
30
40
50
60
5
10
15
20
25
150 Mesh
100 Mesh
200 Mesh

Table I.

Mesh	Hrs. Time	% KCN	cc AgNO	KCN Added	KCN Present.	KCN Consumed.	Assay	% Ext.
100	3	.05	.40	.9	.40	.50	9.70	12.93
150	3	.05	.40	.9	.40	.50	9.96	10.59
200	3	.05	.45	.9	.45	.45	10.00	10.23
240	3	.05	.45	.9	.45	.45	9.36	15.98
100	6	.05	.40	.9	.40	.50	9.52	14.52
150	6	.05	.40	.9	.40	.50	9.92	10.12
200	6	.05	.35	.9	.35	.55	9.20	17.39
240	6	.05	.35	.9	.35	.55	9.00	19.20
100	24	.05	.20	.9	.20	.70	10.45	6.15
150	24	.05	.15	.9	.15	.75	9.92	7.20
200	24	.05	.15	.9	.15	.75	10.32	7.35
240	24	.05	.20	.9	.20	.70	10.17	8.70

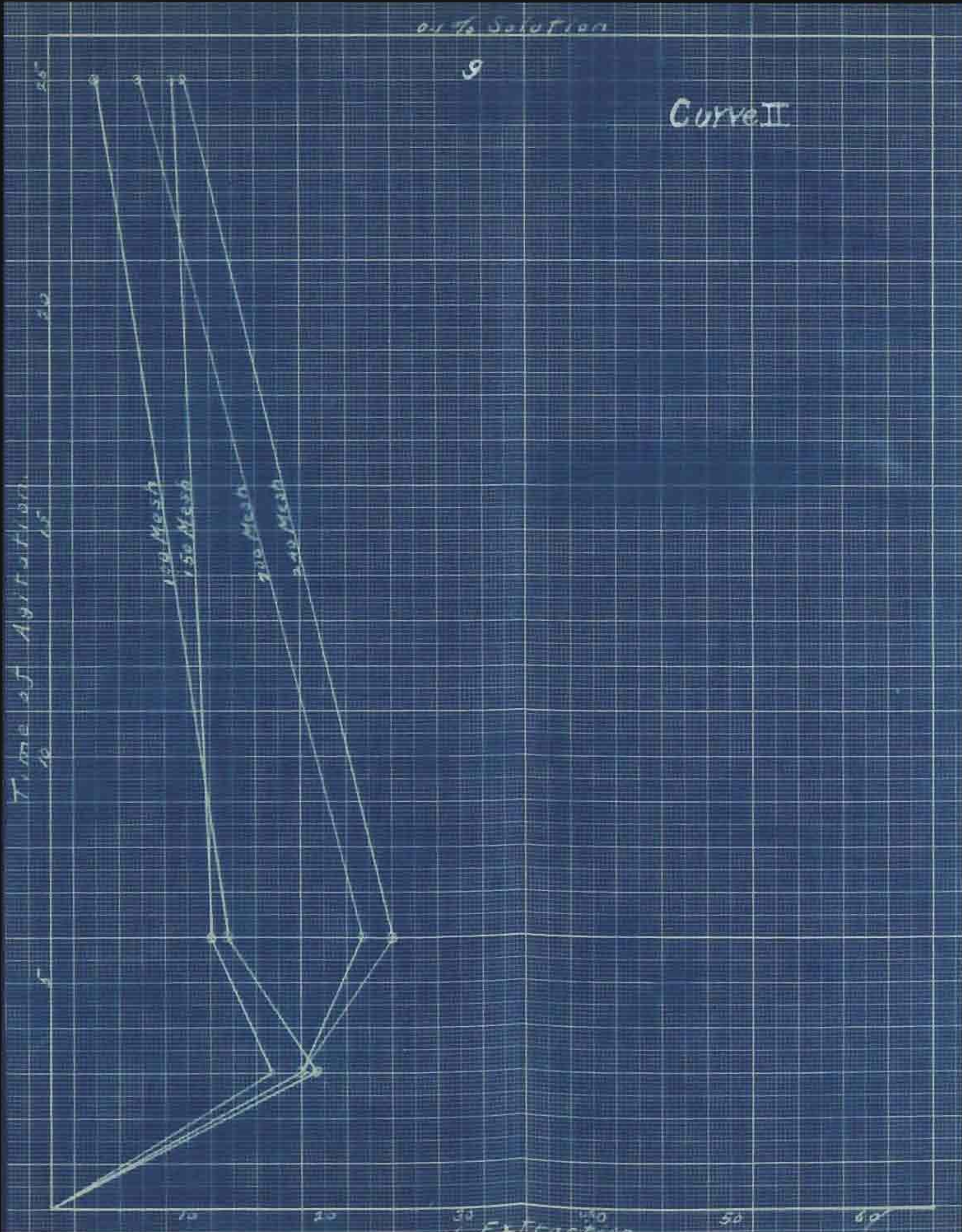
SERIES TWO

With this series of experiments we used a 0.1% solution of KCN. The results show no marked improvement in extraction. There was a very noticable decrease in extraction with an increase of time beyond 6 hours.

The maximum extraction was obtained with 240 mesh material. The time of agitation was 6 hours.

Extraction---------------25.13%

KCN consumed ------------0.9# per ton.



.01 % Solution
9
Curve II
Time of Agitation
25
20
15
10
5
100 Mesh
150 Mesh
200 Mesh
10
20
30
40
50
60

Table II

Mesh	Hrs. Time	% KCN	cc AgNO	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
100	3	.1	1.30	1.8	1.30	0.50	8.96	19.56
150	3	.1	1.40	1.8	1.40	0.40	9.36	15.98
200	3	.1	1.30	1.8	1.30	0.50	9.10	18.31
240	3	.1	1.30	1.8	1.30	0.50	8.94	19.73
100	6	.1	0.90	1.8	0.90	0.90	9.72	12.75
150	6	.1	0.85	1.8	0.85	0.95	9.84	11.68
200	6	.1	1.00	1.8	1.00	0.80	8.60	22.79
240	6	.1	0.90	1.8	0.90	0.90	8.34	25.13
100	24	.1	0.10	1.8	0.10	1.70	10.78	3.23
150	24	.1	0.10	1.8	0.10	1.70	10.14	8.97
200	24	.1	0.10	1.8	0.10	1.70	10.42	6.50
240	24	.1	0.15	1.8	0.15	1.65	10.04	9.88

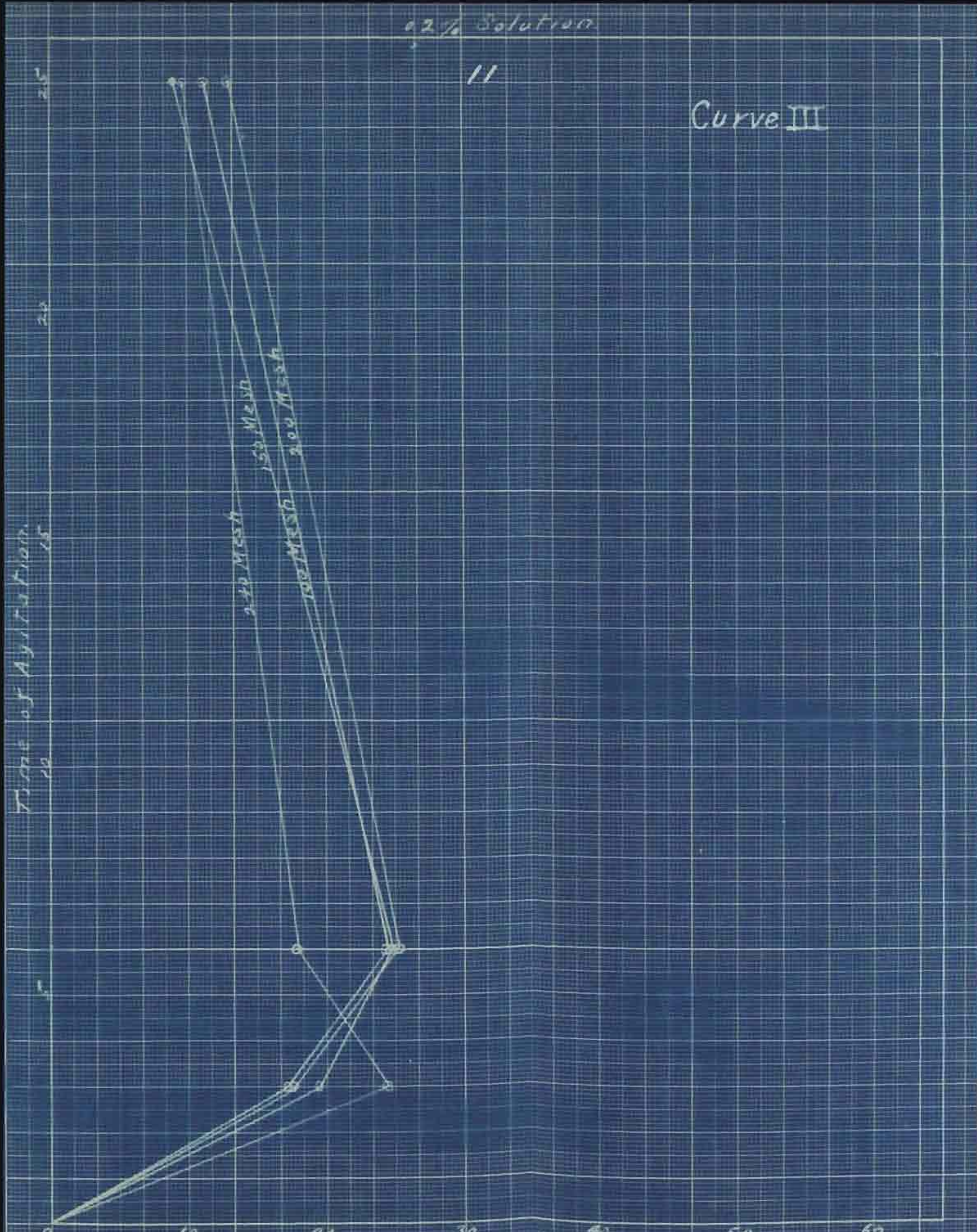
SERIES THREE

A 0.2% solution was used in performing these experiments. The results are not far different from those of series two. Since the extraction was not increased when agitation was maintained for more than 6 hours, we did not agitate longer than this time in any of the following experiments.

The maximum extraction was obtained on 200 mesh material. Time of agitation was 6 hours.

Extraction-----------24.89%

KCN consumed----------1.4# per ton.



0.2 % Solution
11
Curve III
Time of Agitation
240 Mesh
150 Mesh
200 Mesh
100 Mesh
0
10
20
30
40
50
60

Table III

Mesh	Hrs. Time	% KCN	cc $AgNo_3$	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
100	3	.2	2.4	3.2	2.4	.8	9.22	17.20
150	3	.2	2.5	3.2	2.5	.7	8.96	19.55
200	3	.2	2.5	3.2	2.5	.7	9.20	17.39
240	3	.2	2.4	3.2	2.4	.8	8.44	24.21
100	6	.2	2.8	3.2	1.8	1.4	8.44	24.21
150	6	.2	1.9	3.2	1.9	1.3	8.38	24.69
200	6	.2	1.8	3.2	1.8	1.4	8.36	24.89
240	6	.2	1.9	3.2	1.9	1.3	8.92	19.92
100	24	.2	.1	3.2	.1	3.1	9.88	11.13
150	24	.2	.1	3.2	.1	3.1	10.16	8.78
200	24	.2	.1	3.2	.1	3.1	9.80	12.93
240	24	.2	.1	3.2	.1	3.1	10.04	9.88

SERIES FOUR

A 0.3% solution of KCN was used in the following experiments. The extraction did not increase, but remained nearly constant with that of series three.

The maximum extraction was obtained on 240 mesh material. Time of agitation was 6 hours.

Extraction----------24.49%

KCN consumed --------2.5# per ton.

Table IV

Mesh	Hrs. Time	% KCN	cc $AgNo_3$	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
100	3	.3	4.5	5.7	4.2	1.2	8.60	22.80
150	3	.3	4.6	5.7	4.3	1.4	8.44	24.21
200	3	.3	4.5	5.7	4.5	1.2	8.40	24.49
240	3	.3	4.6	5.7	4.4	1.1	8.40	24.49
100	6	.3	1.9	5.7	3.4	2.3	8.96	19.56
150	6	.3	1.9	5.7	2.9	2.8	8.80	20.98
200	6	.3	1.8	5.7	3.3	2.4	8.40	24.49
240	6	.3	2.	5.7	3.2	2.5	8.40	24.49

SERIES FIVE

Here we used a 0.4% KCN solution. The material that was agitated for 6 hours showed a slight increase in extraction over the material agitated for 3 hours. The KCN consumption was increased by 2.4# per ton, however.

The best extraction was obtained on 200 mesh material. Time of agitation was 6 hours.

Extraction ---------------36.22%

KCN consumed ------------- 3.8$ per ton.

Table V

Mesh	Hrs. Time	% KCN	cc $AgNo_3$	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
100	3	.4	6.3	7.6	5.3	2.3	8.40	24.59
150	3	.4	6.2	7.6	5.2	2.4	8.60	22.79
200	3	.4	6.3	7.6	5.3	2.3	8.36	24.85
240	3	.4	6.2	7.6	5.2	2.4	8.20	26.39
100	6	.4	4.8	7.6	4.0	3.6	8.00	28.80
150	6	.4	3.9	7.6	3.9	3.7	7.50	32.70
200	6	.4	3.9	7.6	3.9	3.7	7.10	36.22
240	6	.4	3.8	7.6	3.8	3.8	7.16	35.65

SERIES SIX

To perform this series of experiments a 0.5% solution of KCN was used. The extraction was about the same for the different periods. It was slightly the greatest for the 6 hour material. The finest mesh of each period showed the best extraction.

Maximum extraction was obtained on the 200 mesh material, that was agitated for 6 hours.

Extraction---------56.50%

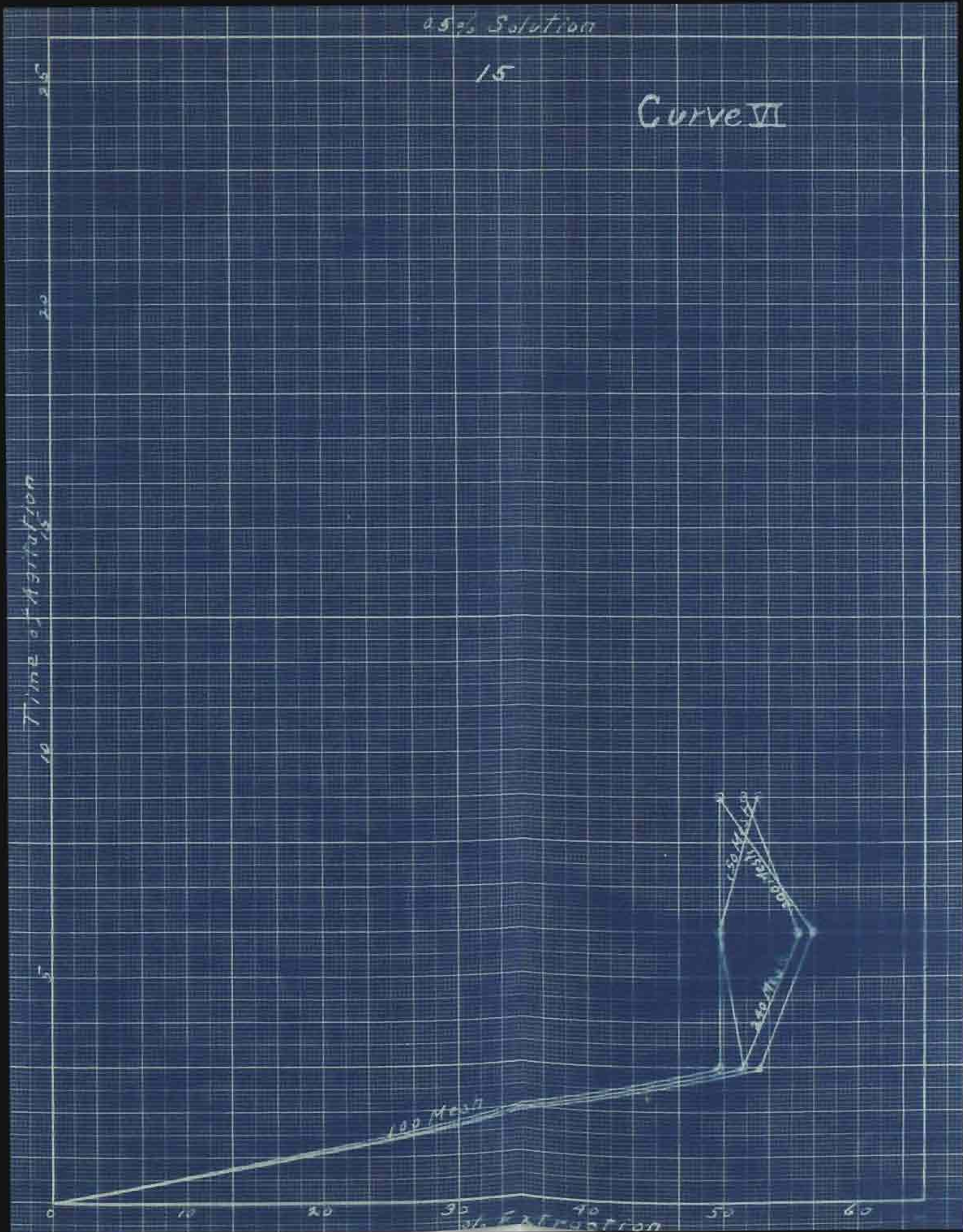
KCN consumed--------5.0 per ton.

Table VI

Mesh	Hrs. Time	% KCN	cc $AgNO_3$	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
100	3	.5	5.4	9.4	5.4	4.0	5.6	49.74
150	3	.5	5.1	9.4	5.1	4.3	5.4	51.52
200	3	.5	4.9	9.4	4.9	4.5	5.3	52.42
240	3	.5	5.2	9.4	5.2	4.2	5.4	51.52
100	6	.5	3.9	9.4	3.9	5.5	5.60	49.74
150	6	.5	3.0	9.4	3.0	6.4	5.6	49.74
200	6	.5	4.4	9.4	4.4	5.0	4.84	56.50
240	6	.5	4.	9.4	4.	5.4	5.0	55.11
100	9	.5	2.6	9.4	2.6	6.8	5.6	49.74
150	9	.5	1.9	9.4	1.9	7.5	5.3	52.42
200	9	.5	2.6	9.4	2.6	6.8	5.6	49.74
240	9	.5	1.9	9.4	1.9	7.5	5.4	51.50

CONCLUSIONS FROM ALL PREVIOUS EXPERIMENTS

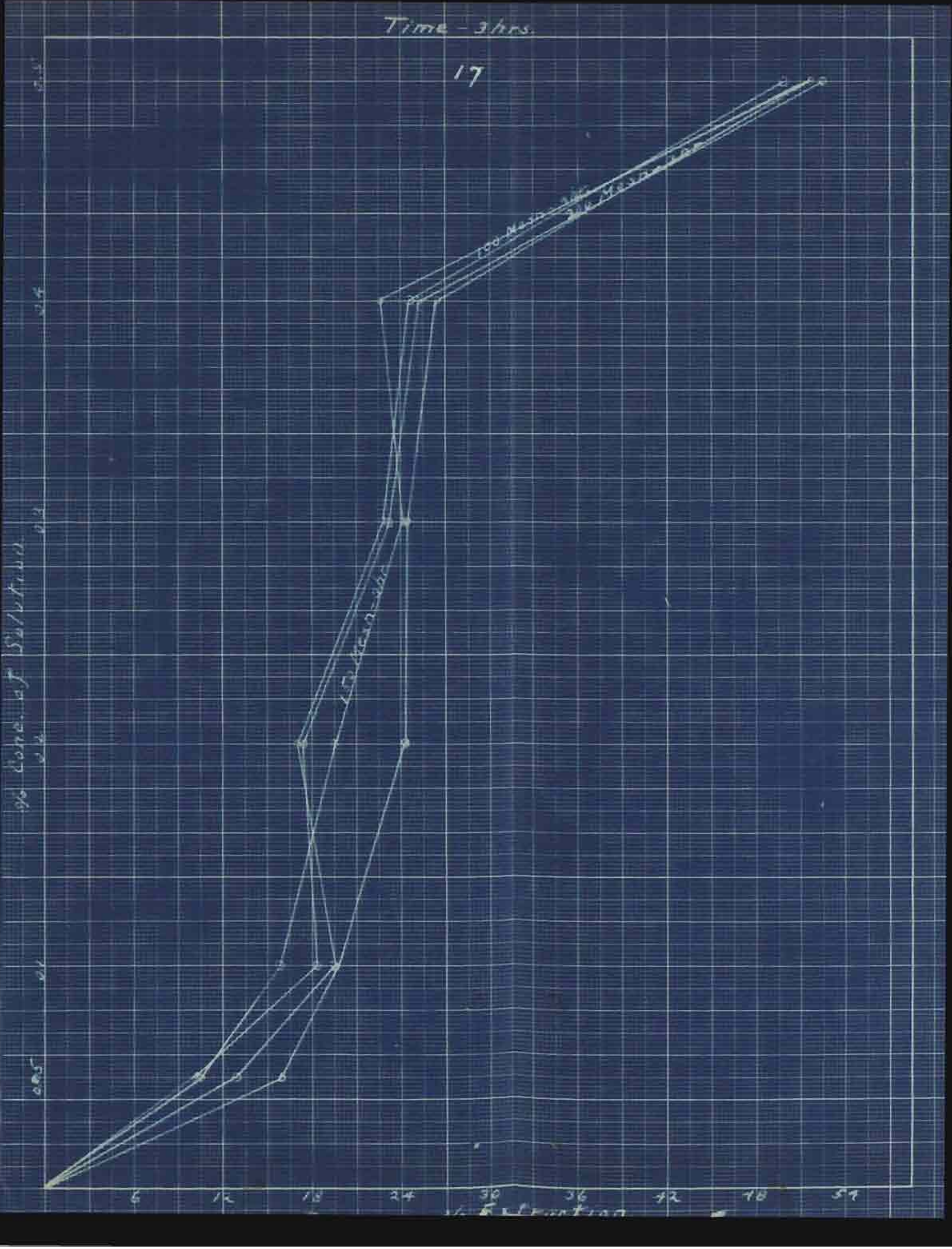
The previous experiments show that a rather strong solution of KCN will have to be maintained at all times. The extractions with the 0.1%, 0.2%, 0.4% and 0.5% solutions show a gradual increase. Beyond a 0.5% solution there is no increase, and therefore a 0.5% solution was used in subsequent experiments.


0.5% Solution
15
Curve VI
Time of Agitation
% Extraction
100 Mesh
150 Mesh
200 Mesh
240 Mesh
0
10
20
30
40
50
60
5
10
15
20
25

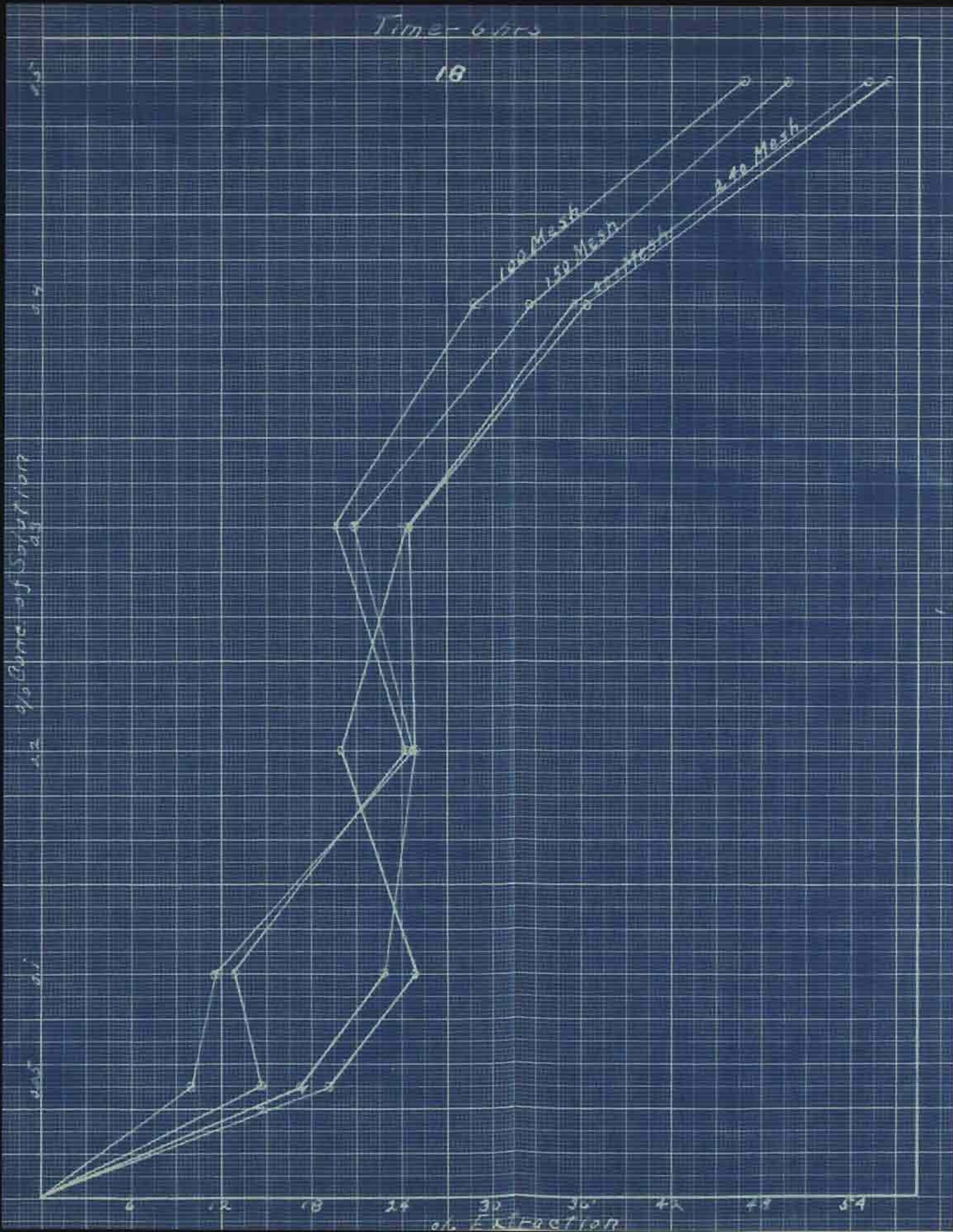
The KCN consumption (6.5#s per ton) is high. A test was made on some of the solution to determine what substances were acting as cyanicides. The test showed that copper was the large consumer. A small amount of antimony was also found to be present.

The material that passed through the 200 mesh gave the highest extraction(56.50%). This is not much higher than the 100 and 150 mesh material, probably not enough to warrant such fine grinding. But, when we considered the complexity of the ore, the low extraction obtained, and the slight increase over coarser mesh extractions, we decided to grind the ore to-200 mesh for further treatment.

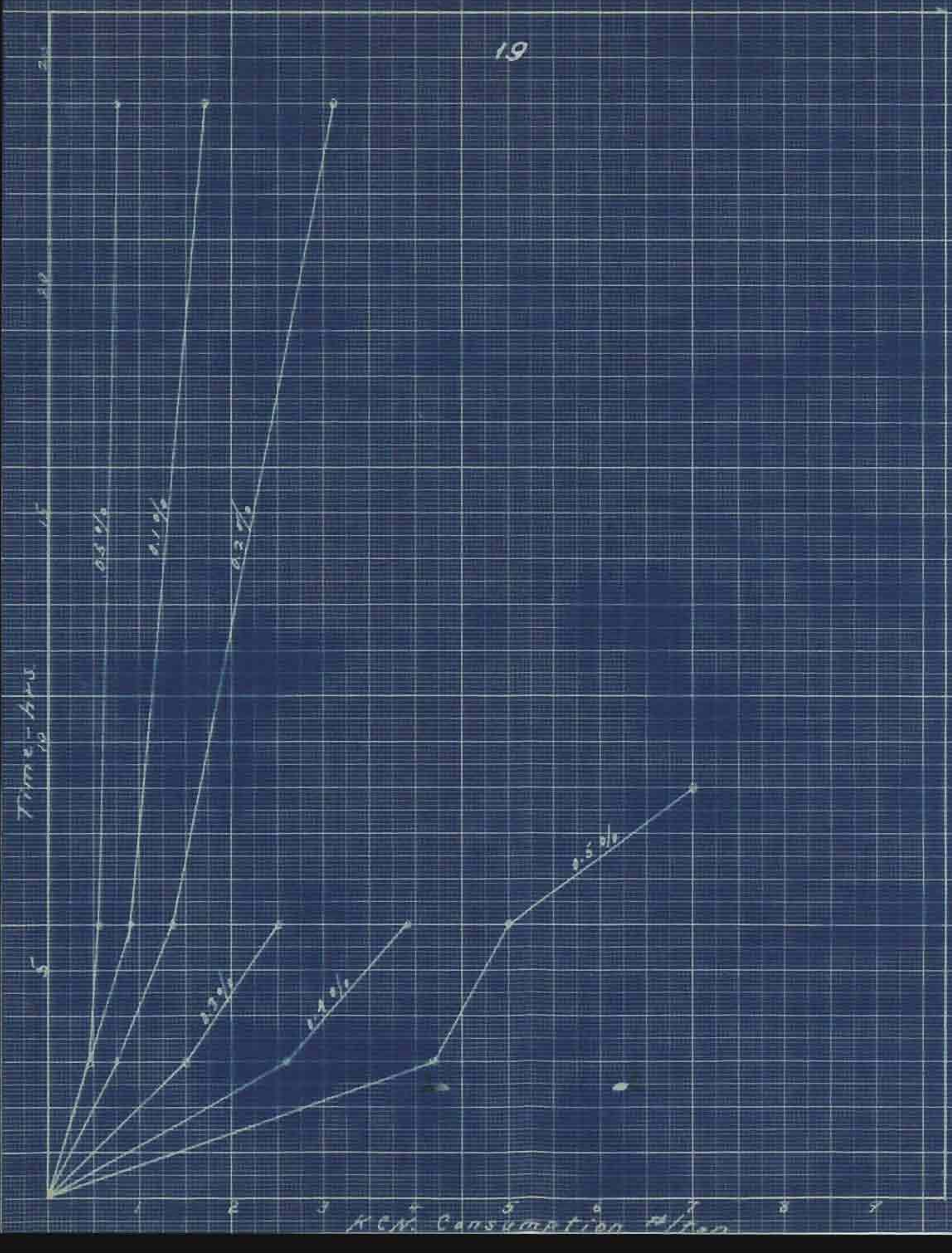
The following curves were plotted from the previous tests. The first two show the per cent extraction of a given mesh with a change in the strength of the solution. The third shows the KCN consumption for the different strengths of solution.



Time - 3hrs.
17
% Conc. of Solution
.005
6
12
18
24
30
36
42
48
54



Time - 6 hrs
18
100 Mesh
150 Mesh
240 Mesh
6
12
18
24
30
36
42
48
54
% Extraction


Time - hrs
KCN Consumption #/ton
5
10
15
20
1
2
3
4
5
6
7
8
9
0.05 %
0.1 %
0.2 %
0.3 %
0.4 %
0.5 %

SERIES SEVEN

Object.

These experiments were performed to determine what the effect would be if we varied the strengths and the amounts of solution.

With some ores, if a weak solution of KCN (say .05%) is applied, a hard, insoluble coating of sulphide seems to be formed on the surface of the metallic silver particles. This coating prevents stronger solutions from attacking the silver. But when a strong solution is used at first, the sulphide seems to adhere as a loose slimy deposit, which does not prevent the weaker solutions, afterwards attacking the silver.

In the case of our ore the extraction was not increased by increasing the strength of solution to 0.5% and then later applying a weak solution.

We also varied the amount of solution to 5 A.T. and the extraction was not improved.

Table VII

Mesh	Hrs. Time	KCM Sol.	Assay	% Ext.
200	3	5 A.T..5%	5.6	49.74
200	3 3	4 A.T..5% then .05%	5.4	51.50
200	3.5 3.5	4 A.T..05% then .5%	5.7	48.83

SERIES EIGHT

Additional Agents.

Lead salts are sometimes added to cyanide solutions for the purpose of removing dissolved sulphides. This is accomplished by precipitating insoluble lead sulphides.

$Na_2S \quad Pb\,(C_2H_3O_2) \qquad PbS \quad Na_2(C_2H_3O_2)$

When alkaline soluble sulphides occur, the action would be to to immediately re-precipitate the silver as sulphides, thus defeating the object of the operation. The addition of lead salts did not increase the extraction with this ore.

Table VIII

Mesh	Hrs. Time	% KCN	cc $AgNo_3$	KCN Added	KCN Present	KCN Consumed	Assay	% Ext.
200	3	.5 .1 grm.Pb	4.3	9.4	4.3	5.1	5.54	50.26
200	3	.5 .5 grm.Pb	4.6	9.4	4.6	4.8	5.60	49.73

SERIES NINE

Experiments to Lower KCN Consumption.

Some ammonium hydroxide was added with the KCN solution to several samples. This did not affect the KCN consumption however. Preliminary washes with H_2SO_4, $NH_4(OH)$ and H_2SO_4 plus $NH_4(OH)$ were also tried, but the KCN consumption was not lowered.

CONCLUSION

Although these experiments were performed on a small scale, and the results were rather irregular, we believe that they are sufficiently conclusive and accurate to show that this ore cannot be treated economically by cyanidation. The fine grinding necessary (-200 mesh) and the high KCN consumption, together with the low extraction, lead us to the above conclusions.