Bachelors Theses   Student Theses and Dissertations

1900

Bromination of gold ore

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THESIS

FOR

Degree of Bachelor of Science

IN

MINING ENGINEERING.

SUBJECT: "Bromination of Gold Ore."

FRANCIS JOSEPH TAYMAN and **SANTIAGO CHAMBERLAIN.**

1900.

THE BROMINATION OF GOLD ORE,

in which the gold is extracted by means of Bromine in water, under local conditions.

Object.

Derivation of some empirical formulae, showing the relation between extraction and various functions which may **enter this work.**

We find but few results of experimental work along this line, and but few curves plotted. There seems to be but little attempt towards fitting equations to these curves. This then leaves a large opening for **original investigation.**

During our experiments quite a variety of interesting point have been made manifest. Most of them are of **no practical benefit,** but merely of **interest in themselves.**

My work has been on a few of the most important experiments which will be given subsequently. Upon these and a few others lies the foundation of extraction, as given by all writers upon the subject.

The extraction of Gold seems to be of primary importance, so my work has been to derive with experimental data, the relation between the Extraction of Gold in ounces per ton, and other functions which vary according to conditions given in each experiment.

Ore.

Our work was on a Cripple Creek Gold Ore from Cripple Creek, Colorado.

Contents of Ore.

1st. Qualitatively.

Silicon as Silica.

Iron

Manganese

Aluminium

Calcium,Barium

Gold.

2nd. Quantitatively

Silica (SiO_2)	58.866%
Aluminium (Al)	11.508%
Calcium (Ca)	10.324%
Iron (Fe)	7.905%
Manganese (Mn)	7.234%
$BaSO_4$	3.9%
Gold	.000082%

3rd. Mineralogically.

It is a mixture of Augite,Anorthite,Rhodomite and mixed with Barytes, carrying free gold.

Sampling.

The ore was crushed in a Dodge Crusher at the Missouri School of Mines and afterwards by a Gates Crusher. From here it passed through rolls and was then sampled.

The method of sampling is as follows: The ore was shoveled(after rolling) into a pile upon the floor, it was then divided into four parts by a line drawn through the pile at right angles to each other.

Then sections one(1) and three (3) were shoveled away and sections two and four mixed and put into another pile and again divided into sections. This time sections two and four were shoveled

away.

This method was continued until the deeired sample and amount of ore was obtained.

Now in all of our subsequent experiments after the ore had been bucked and sieved to the proper size this method of sampling the ore for the different experiments was resorted to.

Apparatus.

Following is a list of apparatus used and a brief descripXtion of the most important ones.

1   Funnels.

2   Beakers.

3   Flasks.   { Litre(1000cc) / Different Volumnes

4   Wash Bottles.

5   Lixiviation Jars.   { New / Old.

6   Filter Stands.

7   Evaporating Dishes.

8   Cassaroles and Burrets.

9   Crucibles   { Glazed Porcelain / Unglazed for Assaying(30gr).

10 Roasting Dishes.

11   Scorifying Dishes for Assaying.

12   Parting cups.

13   Burners(Bunsen)

14   Morters.

15   Sand Baths.

16   Triangles(wire covered with porcelain)

17   Tripods.

18   Cupells for Assaying.

19   Tongs for Assaying.

20   Hammer and Anvil

21   Balances Analytic

                    Gravity.

22   Moulds.

23   Matches, Filter paper, Sieves,etc.

24   Furnaces Wind

                    Muffle.

Lixiviation Jars: Were glass jars. The new ones were of one-half gallon size and the old ones were of quart size. The old ones were colored glass, and on account of their small size were only used in experiments No. I and II . The new ones were used for the rest.

Cassaroles:-- They were of best quality of white glazed porcelain with a cover, and were used in the qualitative analysis of theOre.

Roasting Dishes:-- They were of best quality of unglazed porcelain, and could hold about 60 grams of ore at one time.

Mortars: Were of Agate and Procelain. They were used to pulverize our ore to a finer degree than that of the bucking board. They were mostly used in the analysis of ore.

Hammer and Anvil:were used to make the buttons from our Crucible work of the right shape and size for cupelling. This was also a means of cleaning the buttons.

Filter Papers:- They were of the best quality that could economically be used in this work. That is, a good qualitative analysis filter.

Sieves:- They were of "Standard Mesh",ranging from ten mesh,i,e. (100) meshes to the square inch to one hundred and twenty meshes(12000) meshes to the square inch. Used to get the various sizes of ore required.

Sizing.

This was our means of obtaining (by seiving) the required size for the different experiments.

The method we used is as follows: Suppose we wished to obtain a size of twenty mesh. After bucking our ore, we would seive it through a twenty mesh sieve and catch it on a thirty mesh and what remained upon the thirty mesh sieve was of all meshes between twenty and thirty. This was taken as our twenty mesh ore. This was our method of sizing for this work.

Material.

The material for our work was Ore, water and bromine. The ore has already been described. The water was taken from the cistern of the Missouri School of Mines, containing iron. The Bromine was chemically pure liquid bromine in one pound bottles, with tightly fitting stoppers to prevent the escape of bromine.

Mixing.

Our method of mixing the material together was as follows: We first added the right weight of ore to be treated, then added the desired quantity of water and after mixing these (and noting time, etc according to conditions of the experiment) we added the amount of Bromine necessary to make the right percent solution desired; by means of a graduated burrette and afterwards by shaking the whole was mixed, and the action began. The jars were shaken at short intervals all during the time limited for the experiment.

Experiments.

The experiments carried out will first be taken up in a general way.

The object of each experiment was to find, if possible, a relation between extraction and some other one of the varying functions, keeping all other conditions constant.

They are as follows:

   I   Extraction with different strength of solution.

  II   Extraction with different size of ore.

 III   Extraction with different length of time.

Roasted ore.

  IV   Extraction with different strength of solution.

   V   Extraction with different size of ore.

  VI   Extraction with different length of time.

 VII   Extraction and varying length of roasting.

We made different samples for the different experiments and this is what gives us different amounts of gold in different experiments . We deal with different percent extraction in Experiments II,V, and directly in extraction in other experiments.

Experiment Number One.

The object of this experiment was to find a relation between extraction of gold from ore with different strength of solution.

The method followed in this case was to mix the ore, water, and bromine as previously described.

The amount of ore used in this experiment was two assay tons(2 A.T.)

In this experiment the time and other functions were constant. The time allowed for action of bromine upon gold or ore was twelve hours with repeated shaking.

Size of ore was ninety mesh.

We made four assays of the samples of this experiment and found it to be:

Assay No. 1,2,and 4 gave us   2.475 ounces to a ton

  " No 3.   " "   2.47 ounces per ton.

Z   On an average of 2.4737 ounces per ton.

In order to get a good average for the extraction of gold from
ore we checked ourselves by making two to three assays of the
different tails and if we failed to check we repeated it until it
was satisfactory to ourselves.

The results will be recorded in the data for the discuss-
ion of the curve.

Experiment Number Two.

The object of this experiment was to find a relation
between extraction of gold from the ore and different size of ore.
All other conditions being constant.

The method of mixing is as previously described. Although
every possible size of ore was not taken, it seems rational to suppose
that the conditions for any other size ought to follow the same law,
the only difference being perhaps the constants involved in the
equation.

The amount of ore used in this experiment was two assay
tons (2 A.T.) Amount of water, 100 cc.

The time of action was twelve hours, with frequent shaking. We
used a two percent solution. In this experiment the ore was of
different size and consequently the head of each size was a different
sample from the other sizes. Therefore the heads and tails of
each size after the action of bromine upon them, were pulverized and
each assayed separately.

The result of our checks, will be given in data for
discussion of curve No. 2.

Experiment Number Three.

In this experiment the object was to find a relation between extraction of gold from the ore and different time, when all other conditions are constant.

In this experiment the method followed was to mix the ore, water and bromine as previously described and after the different time as stated in data to curve Number 3. the solution was filtered from tailing. Large errors are liable to occur in those points which represent the short limit of time.

1st. As it need speed, and accuracy to finish in time.

2nd The ore, and solution may not be mixed as desired.

3rd The Bromine may not be entirely dissolved by water.

4th. The length of time it takes to filter solution from ore.

In this experiment a two percent solution was used.

Experiment Number Four.

This experiment is somewhat different from Experiment No. 1 The only difference lies in the fact that it is a roasted ore.

The object is to find the relation between extraction of gold from the Roasted ore with different strength of solution, the other functions remaining constant.

In this experiment we expected to obtain a curve similar to that of Number one, and which was obtained. The constants were somewhat different and the curve was lower, which is natural to suppose as gold volatilized in roasting or perhaps very fine particle of gold in the dust were carried off by draft, during stirring, etc.

The time of roasting the ore was one and one-half hours. The conditions of mixing and quantity of material used were the same as in experiment number one.

Ore used was(2) two assay tons. Water used was loo cc. Percent of solttion varried. Mesh of ore was ninety mesh. Time of action of solution was twelve hours. Results are given in discussion of Curve Number four.

Experiment Number Five.

This experiment is to find the relation existing between extraction of gold from roasted ore and different size of ore.

The discussion and shape of curve is similar to that of Curve Number two. The cause of the difference is on account of ore being roasted.

Ore used was two assay tons. Roasted for three hours. Water used 100 cc. Percent of solution was two percent. Time for extraction, twelve hours.

Size of ore varried from 10 mesh to 100 mesh.

This experiment was accompanied by the same difficulties in regard to different samples, for each different size of heading. Hence each head and tails of the different sizes had to be assayed separately.

For discussion of results see data and curve Number 5.

Experiment Number Six.

The varying functions of this experiment were extraction of gold from roasted ore and different length of time.

The curve and discussion is similar to that of experiment number three. The difference is that in this case the ore is roasted.

Time = variable.

Ore used = Two assay tons.

Water used. = 100 cubic centimeters.

Time roasted = Three hours.

Strength of Solution. = Two percent.

Size of ore = 80 mesh.

This experiment is liable to same errors as in experiment Number three for those points which represent short time.

Experiment Number Seven.

Among other functions which enter the extraction of gold from ore,is the varying length of roasting. Hence we get a relation between the extraction of gold from ore and different length of roasting.

In this experiment there are varying errors,liable to occur and experiment is not reliable.

1st. The error of roasting those ores subject to short time

2nd. Difficulty of keeping furnace at constant heat,as result of frequent firing,opening and closing muffle when stirring ore.

3rd. The longer the ore is roasted the more it is stirred and hence more dust escapes with draft.

4th. The varying quality of combustable material.

It is seen from Plot that tendency of gold is to decrease with length of roast as a result of volatilization and third condition above named.

The results can be seen cfrom data and plot of points No.%.

Time of roasting varried.

Amount of ore used for each roast was 4 A.T. and for each extraction 2A.T.

Amount of water used was 100 cc.

Time of Extraction was twelve hours.

Strength of solution was two percent.

Size of ore was 80 mesh.

The following is the data, curve and discussion of
~~Experiment~~ Number One.

Data No. 1.

| No.	Strength Sol.	Ore oz to ton	Tails	Extraction	$\dfrac{1}{e-e'}$	$\dfrac{1}{s-s}$
1	5%	2.473	.2057	2.2673	.472	.204
2	4%	"	.3387	2.1443	.501	.256
3	3%	"	.6877	1.7853	.611	.344
4	2%	"	.9186	1.5544	.711	.526
5	1%	"	1.3732	1.0998	1.176	1.111
6	0.8%	"	1.7133	0.7597	1.639	1.428
7	0.4%	"	1.8745	0.5985	2.227	3.333
8	0.2%	"	2.1577	.3133	6.108	10.
9	0.1%	"	2.3234	.1496	∞	∞
10	0%	"	2.4737	0		

Extraction in ounces per ton being plotted as ordinates
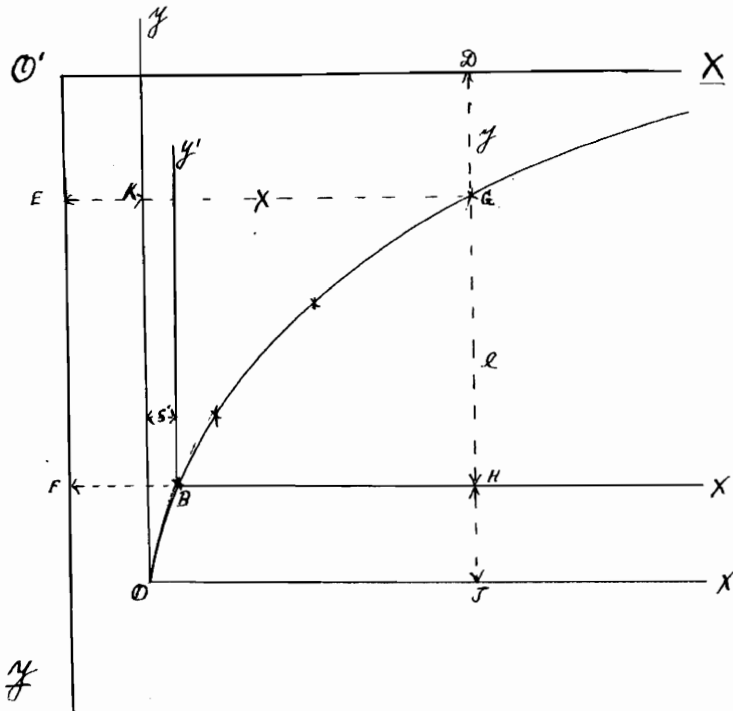and strength of solution as abscessae.

A curve drawn through these points resembles that of an
~~equalateral~~ hyperbola, referred to X Y as axis as shown on Plate I.

The discussion is as follows:

The curve is shown on Figure one and all reference will
be made to it during derivation of the equation.

Plate I

E = extraction in % per ton.

$\dfrac{1}{e-e'}$
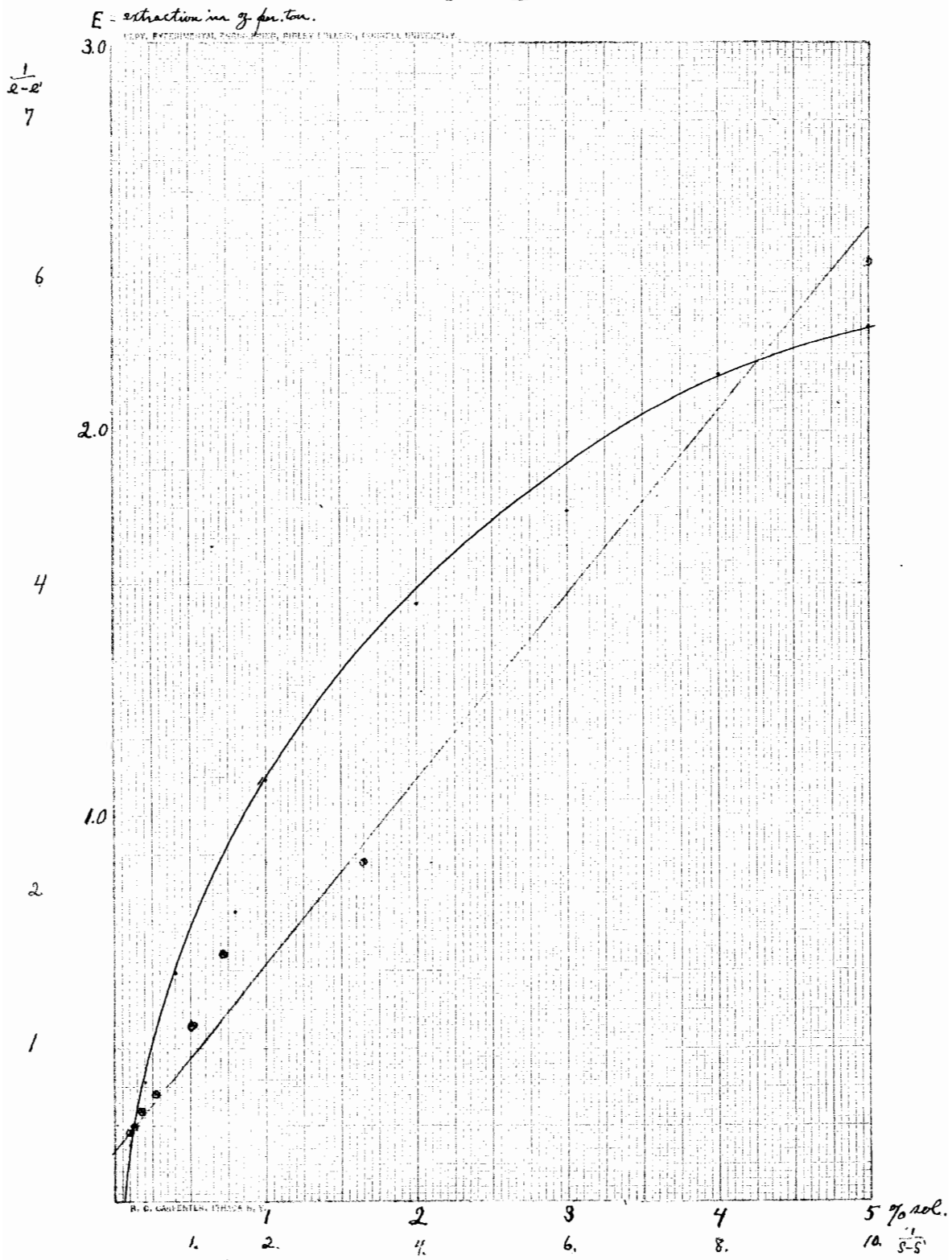
We assume that equation referred to $\underline{x}\ \underline{Y}$ axis is

$$xy = c \quad - - - - - - - - - - - - - - -(1)$$

c being a constant.

Let $e = G\ J =$ average extraction in ounces per ton after action of solution.

$S = G\ K =$ strength of solution in percent for average extraction.

$A = B\ H =$ distance x' axis from $\underline{X}$ axis.

$b = F\ B =$ distance of y' axis form $\underline{Y}$ axis.

$e' =$ extraction with a 0.1 percent solution.

$s' =$ strength of solution from first extraction.

As it is not know for certain whether extraction takes place the resistance instant the solution and ore are mixed, let us take some known point as B. for reference. The coordinates of this point being e' and s'. Let us pass x' and y' axis through B and use it as origin, transferring to these new axis.

The values of x and y for any variable point on the curve such as G are:

$$x = (b + s - s')$$

$$y = (a - e + e')$$

Substituting these in equation(1) we have.

$$(b+s-s')(a-e-e') = c \text{ -- -- -- -- -- -- -- -- -- -- -- -- -- } (2)$$

The value of $x\,y = c$ is (ab) for point B.

Therefore equation (2) becomes:-

$$\left[b+(s-s')\right]\left[a - (e-e') = ab \text{ -- -- -- -- -- -- -- } (3)\right.$$

Multiplying out

$$ab - b\,(e-e') + a\,(s- s') - (s- s')(e - e') = ab$$

Cancelling out ab's and collecting.

$$(s-s')\,(a - (e - e') - b\,(e - e')$$

Dividing by $s - s'$

$$a - (e-e') = \frac{b\,(e - e)}{a\,(s - s')}$$

Divinding out by $(e - e')$

$$\frac{a}{b\,(e-e')} \quad - \quad \frac{e - e'}{b\,(e - e')} = \frac{1}{s - s'} \qquad \text{or}$$

$$\frac{a}{b} \quad \frac{1}{e - e'} - \frac{1}{b} = \frac{1}{s - s'} \quad \text{-- -- -- -- -- -- -- } (4)$$

Dividing (4) by a/b we have.

$$\left(\frac{1}{e - e'}\right) = \frac{b}{a}\left(\frac{1}{s - s'}\right) + \frac{1}{a} \quad \text{-- -- -- -- -- -- } (5)$$

Equation (5) is a general equation for a straight line $\underline{b}$ being
                                                          a

slope and $\frac{1}{a}$ the intercept on $\frac{1}{e - e'}$ axis.

If we plot $\frac{1}{e - e'}$ as cordinates and $\frac{1}{s - s'}$ as abscessae we
will get a straight line if our assumption is true.

The points plotted from values of $\frac{1}{e - e'}$ and $\frac{1}{s - s'}$

(given in data)for this curve are shown on Plate I

Now let us next investigate the meaning of the constants involved in this equation.

From intercept on the $\frac{1}{e - e^!}$ axis the value of $\frac{1}{a}$ taken from the plot is .35 from which $a = 2.085$.

Likewise $\frac{b}{a} = \tan\alpha = \frac{4}{5} = .8$

Therefore $b = a \tan\alpha = 2.085 \times .8 = 1.668$

$e^!$ and $s^!$ are other constants of equation that enter but they are given in table.

Having these constants determined we may simplify equation (5) by putting in these values:

$$e^! = .1496$$

$$s^! = .1$$

$$a = 2.585$$

$$b = 1.668$$

Then (5) becomes $\frac{1}{e - .1496} = \frac{1.668}{2.085} \left(\frac{1}{s - .1}\right) + \frac{1}{2.085}$ - - - (6)

or $s = \frac{1.668}{2.085} \left[(e - 1496) - (2.085)\right] + 1$

$= $ average (best value) solution to use.

Similarly $e = $ best extraction for best solution.

By making $e = 0$ we get $s = \frac{1.668}{2.085} \left[-2.085\right] + 1$

Which shows by calculation and plot that extraction commences as soon as any solution of Bromine water is mixed with ore.

Equation (5) is a general one for experiment number one and probably can be applied to any ore. The constants however, varying for each case in hand.

We should like to have had more data in order that the results of our experiment might be fully varified. It is to be hoped and seems most likely that equation (6) is a law rather than a mere relation existing between extraction and strength of solution.

One of the most favorable features of equation(6) is that the extraction approaches its maximum limit with a comparatively dilute solution. In this discussion the maximum value of extraction is

$a = e'$

2.085 $+$ .1496 = 2.2346 = 90%. Best solution is $=$ .6%

Discussion of Curve Number Two.

Data for Curve No. 2.

No.	Heads oz.per ton	Tails	Extraction	$e = \%$ ex.	$s = $ size mesh	$\dfrac{1}{e-e'}$	$\dfrac{1}{s-s'}$
1	1.1	.988	.112	10.2	10	∞	∞
2	1.41	1.228	.182	12.9	20	.3703	.1
3	1.8	1.454	.346	19.2	30	.1111	.05
4	1.41	1.197	.213	15.1	40	,2040	.0333
5	2.225	1.121	1.104	49.6	50	.0253	.025
6	2.26	.35	1.81	80	60	.0144	.02
7	1.86	.358	1.502	81.3	70	.014	.0166
8	—	1.93	—	—	80	—	.
9	3.725	.842	2.883	77.4	90	.0148	.0125
10	3.655	.651	3.004	82.2	100	,0138	.0111

This curve is shown on plate II and when plotted it has the same appearance of being of the type as Curve I.

This justifies the assumption of a similar equation, the derivation of which need not be repeated.

If we use equation (5) of experiment No. 1 we get an other straight line on plotting $\dfrac{1}{e-e'}$ and $\dfrac{1}{s-s'}$, as before, if our second assumption is correct. The values of these quantities being given in Table or Data II

The result of this plot is shown on Plate II/ A straight line apparently satisfies all the points, corresponding to those points that satisfy the curve. This being true our assumption in experiment No. I holds good in experiment No. 2.

The symbols e, s and e, involved in the following discussion, are extraction, size mesh, etc. as before.

Plate II
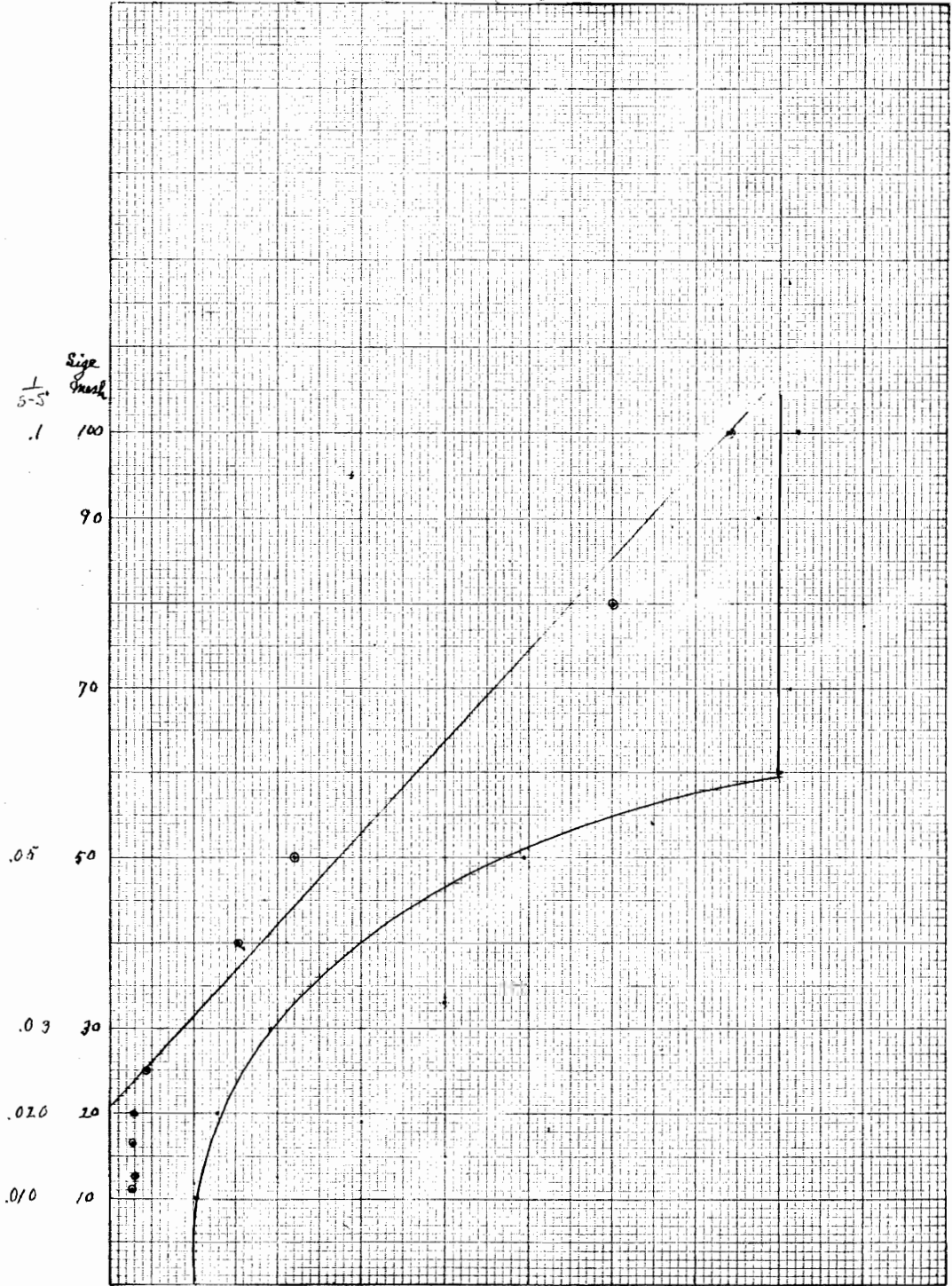
The equation is

$$\frac{1}{e - e'} = \frac{b}{a}\left(\frac{1}{s - s'}\right) + \frac{1}{a} \quad - - - - - - - - - - - - - (1)$$

The constants of this equation are determined by same method as used in previous discussion. $\frac{1}{a}$ the intercept on $\frac{1}{e - e'}$ axis is $= .0205$ from this

$a = 48.7$

$\frac{b}{a} = \tan \beta$ then $b = a \tan \beta$

$$= 48.7 \text{X } 1 = 48.7$$

$a + e'$ gives extraction that the ore would give under an average size of mesh.

This is shown directly from equation by making

$s = \infty$ thus $\frac{1}{e - e'} = \frac{b}{a}\left(\frac{1}{s - s'}\right) + \frac{1}{a}$ becomes

$$\frac{1}{e - e'} = 0 + \frac{1}{a}$$

or $a = e - e'$ or $e = a + e' = 48.7 + 10.22 = 58.9$

This shows that it is possible to get the best extraction from a 58.9 or 60 mesh sieve just as well as a 100 mesh.

This helps to explain the reason why points at end of curve use line up into a straight line, and it also explains why the points at lower part of straight line are off of it, as they are the corresponding points that are off of sieve curve.

The fact that curve does not pass through the origin tends to prove that we can get some extraction from the ore no matter how large a lump it is in, which is reasonable to suppose as some of the fine particles of gold are on outside as well as on the inside.

As the size of ore decreases the extraction increases.

The maximum extraction reaches 82.2%

Discussion of Curve No.III

Data.

No.	Assay of Ore	Tails	E = Extract.	T = time in hours	$\dfrac{1}{e-e'}$	$\dfrac{1}{t-t'}$
1	3.185	1.865	1.32	.25	∞	∞
2	"	1.864	1.321	.50	100	4.00
3	"	1.845	1.34	1.0	50.	1.333
4	"	1.803	1.382	2.0	16.129	?571
5	"	1.760	1.425	4.0	9.523	.266
6	"	1.575	1.61	8.0	3.447	.129
7	"	1.325	1.86	12.0	1.851	.085
8	"	.785	2.4	16.0	.927	.064
9	"	.620	2.565	24.0	.803	.042
10	"	.695	2.49	36.0	.854	.027
11	"	.685	2.5	48.0	.847	.021

This curve is shown on Plate III and it resembles Curve No. I.
Hence we assume a similar equation and do not need to discuss itw
derivation as it is similar to that of experiment No. I.

We use equation(5) of experiment No. 1 and we get another
straight line, on plotting $\dfrac{1}{e-e'}$ and $\dfrac{1}{t-t'}$ as before. This
shows that our assumption in this experiment is correct.

e =extraction of gold in ounces per ton.

t =time in hours for extraction of gold by solution.
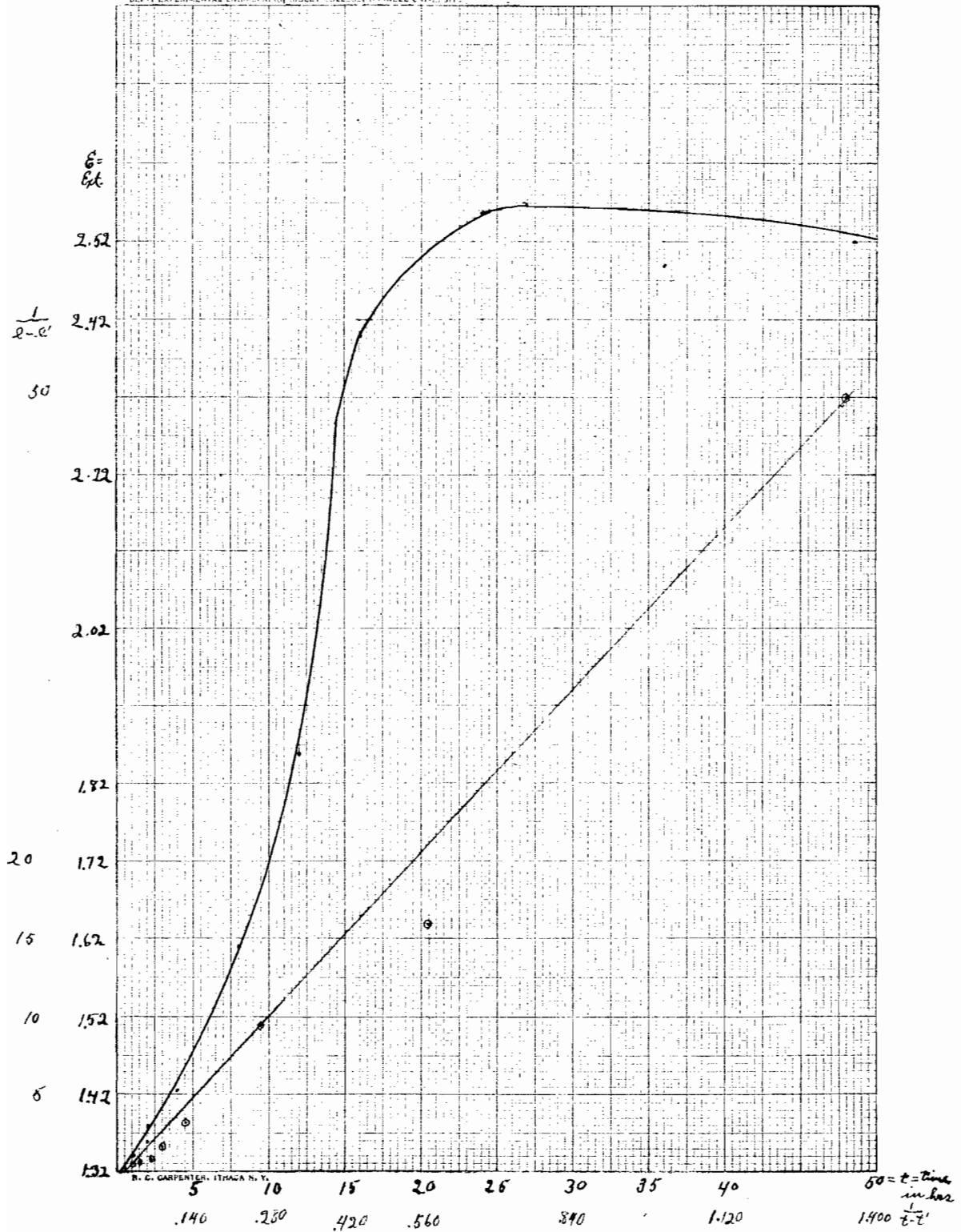
e' = extraction after action of solution for first period.

t' = time of action of solution.

These values are given in data III.

The results are shown on PlateIII and a straight line satisfies
the points.

Plate III

$\frac{\mathcal{E}=}{\mathcal{E}_t}$

$\frac{1}{\mathcal{C}-\mathcal{C}'}$

2.52

2.42

50

2.22

2.02

20   1.72

15   1.62

10   1.52

5   1.42

1.32

20

15

10

5

5   10   15   20   25   30   35   40   50 = t = time in hrs

.140   .230   .420   .560   .840   1.120   1.400 $\frac{1}{t-t'}$

The equation as

$$\frac{1}{e - e^{t}} = \frac{b}{a} \left(-\frac{1}{t - t^{t}} \right) + \frac{1}{a} \} \} \ -- \ -- \ -- \ -- \ -- \ -- \ -- \ -- \quad (1)$$

The constants are determined the same as before.

$\frac{1}{a} =$ intercept on $\frac{1}{e - e^{t}}$ axis and is $= 1.303$ and

$a = .767$

$\frac{b}{a} = \tan \alpha \quad b = a \tan \gamma$

$$= .75 \times 1.125 = .862$$

$a + e^{t}$ gives extraction that ore would give under the best average time $= 1.303 + 1.32 = 2.623$ of gold per ton of ore when ore runs 3.185 ounces per ton, this gives extraction of $=$ about 82%

This is shown from equation. make $t = \infty$

$$\frac{1}{e - e^{t}} = \frac{b}{a} \left(-\frac{1}{s - s} \right) + \frac{1}{a} \quad \text{becomes}$$

$$\frac{1}{e - e^{t}} = 0 + \frac{1}{a} \quad \text{or} \quad a = e + e^{t} \quad \text{or} \quad e = a + e^{t} = 82\%$$

This extraction is just as goos as though you waited an infinite time for same strength of solution to act upon the ore.

This is the reason the curve approaches a horizontal line for large values of time.

The best time is $a + t^{t} = 1.367 + .25 = 1.617$ days. which is $24 \times 1.017 = 24.4$ hours.

The fact that curve does not pass through the origin proves that solution begins extracting the precious metal the instant they are mixed together.

As time increases the extraction increases until maximum is reached 24.4 hours and then we get 82% extraction.

Discussion of Curve No. IV.

Data No. IV.

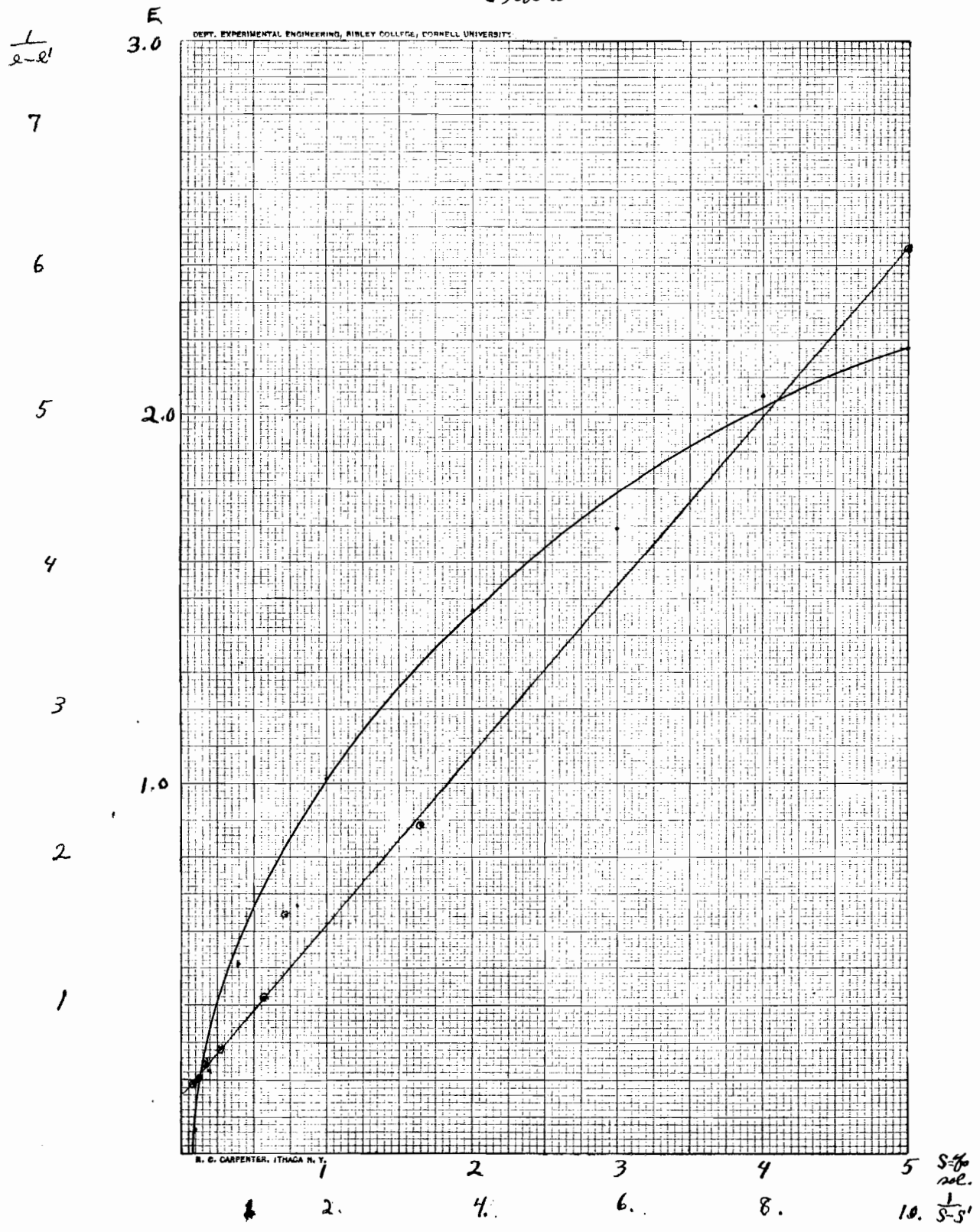| No.	S=strength Solution	Ore in oz per ton	Tails oz. per ton	E = Extract.	$\dfrac{1}{e-e'}$	$\dfrac{1}{s-s'}$
1	5. %	2.36	.1798	2.1802	.472	.204
2	4. %	"	.3028	2.0572	.501	.256
3	3. %	"	.6618	1.6982	.611	.344
4	2. %	"	1.0997	1.4673	.711	.526
5	1. %	"	1.3473	1.0127	1.052	1.111
6	0.8%	"	1.6874	.6726	1.639	1.428
7	0.4%	"	1.8486	.5114	2.227	3.333
8	0.2%	"	2.1338	.2262	6.108	10.
9	0.1%	"	2.3075	.0625	∞	∞
10	0%	"	2.361	0		

The plot of curve is shown on Plate IV and resembles No. I . Now as experiment is the same as No. I. the proof and equations are the same. We make every condition as regards to time, amount of solution ore, etc. exactly the same so that there is no need of getting the constants, because the only possible difference between this experiment and that of No. I is that the ore is roasted.

It can be seen from the plot that in every case the extraction is lower for the corresponding solution which is caused by the loss of Gold, during roasting (the gold volatilized). *or escaping dust.*

Hence the constants are the only things that vary.

The best strength solution of Experiment No. I is also the best strength (for best extraction) in this experiment.

Plate IV

$\frac{1}{e-e'}$

E
3.0

7

6

5   2.0

4

3

2   1.0

1

DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY.

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1   2   3   4   5 $S=\frac{S_0}{sol.}$

2.   4.   6.   8.   10. $\frac{1}{S-S'}$

Discussion of Curve No.V.

Data.

No.	Heads	Tails	Extract.	$N = \frac{\%}{Ex}$	S—size Mesh	$\frac{1}{e - e^2}$	$\frac{1}{s - s^2}$
1	2.41	2.3281	.0829	3.4%	10	∞	∞
2	1.65	1.551	.099	6.0	20	.3846	.1
3	3.84	3.349	.491	12.8	30	.1063	.05
4	2.67	2.157	.513	19.2	40	.0632	.0333
5	2.61	1.668	.942	36.1	50	.0305	.025
6	1.92	.653	1.267	66.	60	.0159	.02
7	1.76	.601	1.159	65.9	70	.016	.0166
8	1.1	.394	.706	64.2	80	.0144	.0142
9	3.2	1.056	2.144	67.	90	.0157	.0125
10	2.23	.711	1.519	68.1	100	.0154	.0111

The plot of this purve is shown on Plate V.

This experiment is exactly like experiment No. II just as experiment No. IV is like No. I with the difference ,that ks, the ore is roasted instead of treating it raw.

The constants are the only thing that varies.

Hence will say that from the plot you can see that extraction is less in each case cuased by roasting.

Plate V

DEPT. EXPERIMENTAL ENGINEERING, SIBLEY COLLEGE, CORNELL UNIVERSITY
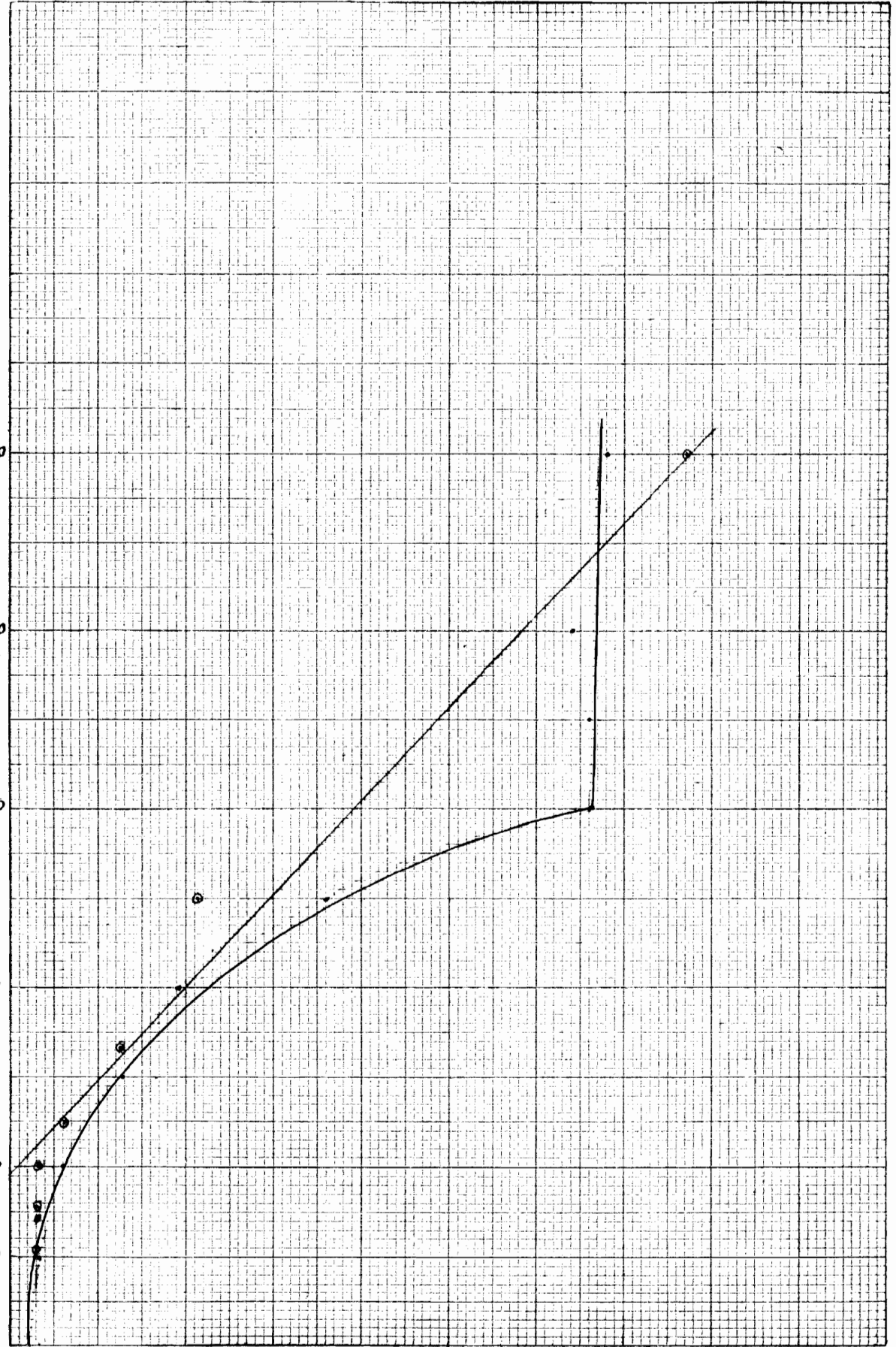
Discussion of Curve No. VI.

Data.

No.	Assay of ore in oz per ton	Tails in oz per ton	E = Extract.	T = time in hours	$\dfrac{1}{e-e'}$	$\dfrac{1}{t-t'}$
1	2.98	1.51	1.47	.25	∞	∞
2	"	1.509	1.471	.50	1000	4.00
3	"	1.49	1.48	1.00	48.	1.333
4	"	1.41	1.57	2.00	19.7	.571
5	"	1.40	1.58	4.00	8.5	.266
6	"	1.22	1.76	8.00	3.4	.129
7	"	1.01	1.97	12.00	2.	.085
8	"	.80	2.18	16.00	1.4	.064
9	"	.51	2.47	24.00	.92	.042
10	"	.47	2.51	36.00	.96	.27
11	"	.44	2.54	48.00	.93	021.

This curve is shown on plate No. VI and like No. Iv and V
The only difference in discussion, constants and etc. from that of
experiment No. III lies in the fact that it is a roasted ore,
and like the two previous experiments the results are lower than
those of experiment No. III due to roasting the ore.

Plate VI

$\mathcal{E}$

$\dfrac{1}{\alpha - \alpha'}$

$50 = time$

$\dfrac{1}{t - t}$

A. C. CARPENTER, ITHACA N. Y.
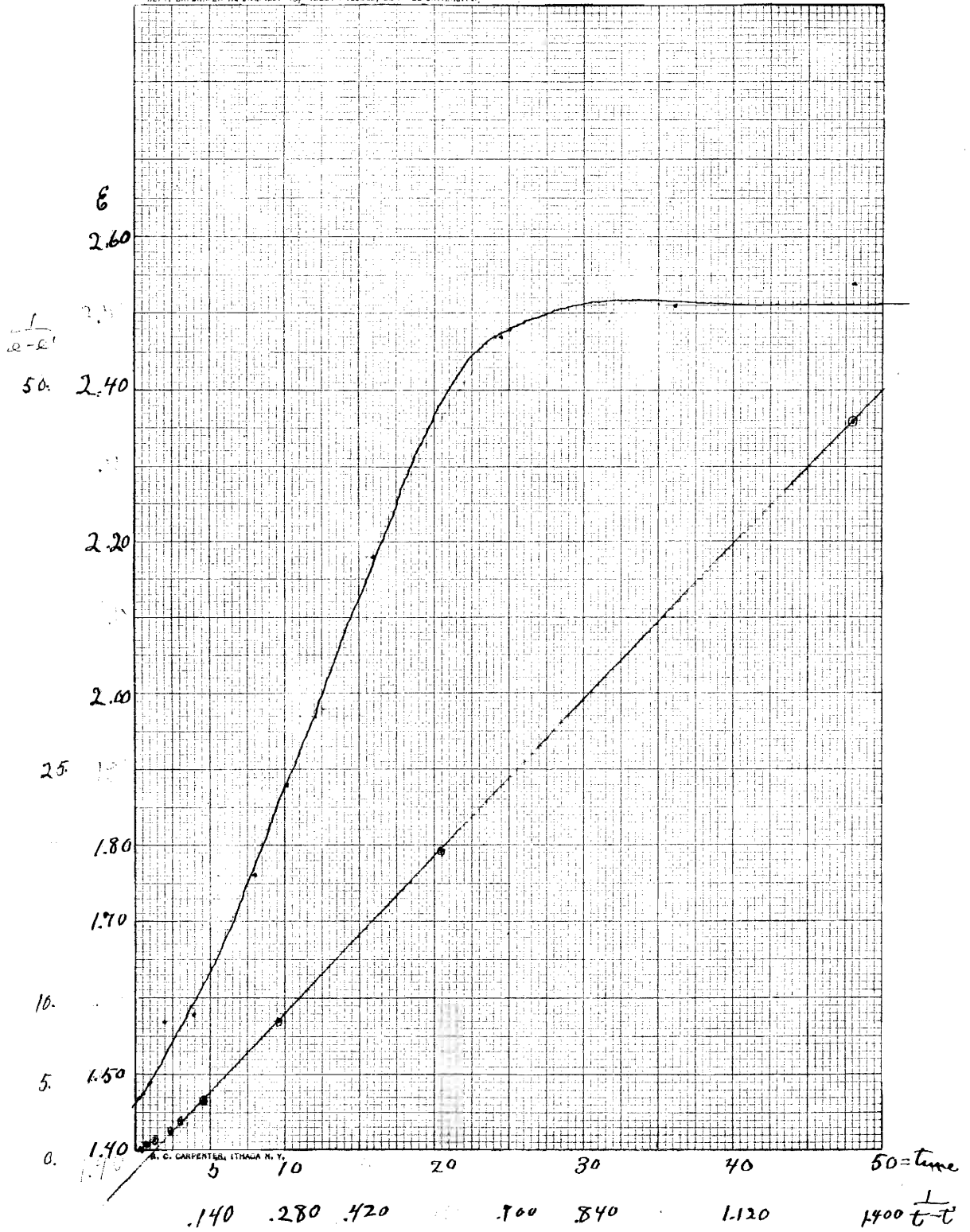
Discussion of Curve No. VII.

Data.

No.	Assay of ore in ounces per ton.	Assay of tails ounces per ton.	E extract.	T time. Roast.
1	2.75	2.578	.172	.25
2	"	2.65	.1	.50
3	"	2.419	.331	1.
4	"	2.12	.63	2.
5	"	2.435	.315	4.
6	"	2.05	.7	6.
7	"	{0.85 / 313}	{1.9 / 1.437}	8
8	"	1.115	1.635	10
9	"	{1.315 / 0.849}	{1.435 / 1.901}	12
10	"	0.70	2.05	18

The plot of points for this data is shown on plate VII.
Here we use best solution ,time and best size of ore(so as not to
waste more than is possible by dust,etc.). These quantities
determine by previous experiments. On account of many changes in
conditions as previously mentioned the curve does not show as
much information as was hoped. From the location of points by
plotting extraction in ounces per ton has ordinates and time of
roasting as abscessae we can get enough information to draw the
following conclusions. As the time of roasting increases the amount
of extraction will be less,because the assay before and after roast-
ing showed a loss which increased with length of roasting. due to
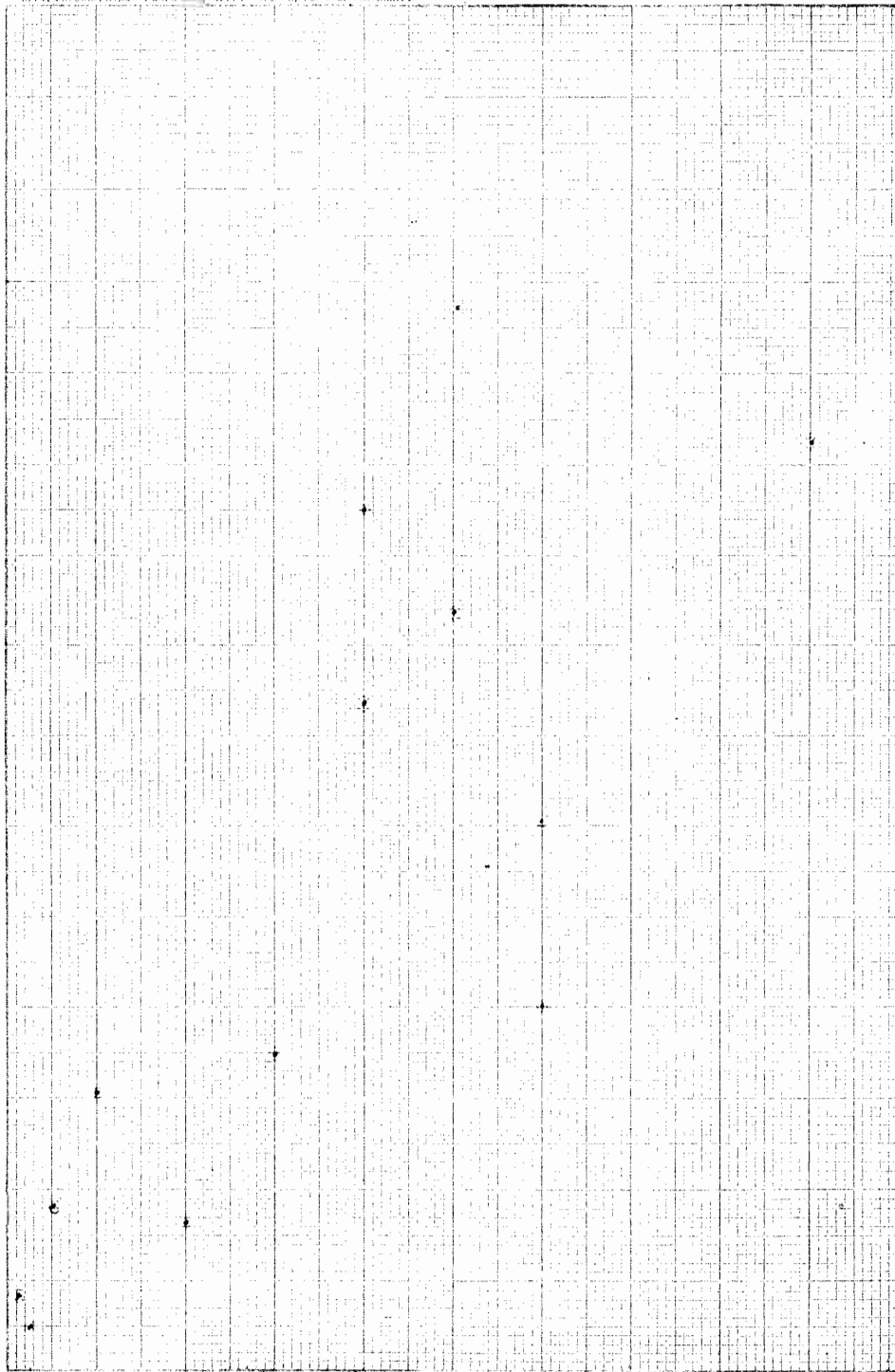volitilization of gold. *of escape & dust.*

Plate № 7

Ex

2.

1.

1 2   4   6   8   12   16   18 t = time of
                                                        roasting.

Conclusions.

From the experiments carried out many of other relations might be obtained. As the above experiments were being performed new points of interest arose some of which have been mentioned. If the new points are developed there will in all probability be some remarkable results accomplished, but the short limit of time prevented us from proceeding further with this work. The following are some important conclusive notes on all the experiments

Charge.

Charge used in assaying(we always ran checks)

Ore	1 A.T.
$NaHCO_3$ (soda)	1 a.T.
Litharge(PBO)	0.4 A.T. .7 A.T.
Charcoal (C)	2 grams
Borax ($Na_2B_4O_7$)	10 grams
Salt cover.	

This charge was used as it contained no sulphur.

Errors.

Errors are liable to happen in all the early points of the different experiments on account of small time and strength of solution, large size of ore, etc.

Now in case of small time, say that only let solution act on ore 15 minutes then it will actually take more than fifteen minutes to filter solution from tails and wash them, this gives a large error.

As for small strength of solution, if we get one drop of Bromine in excess, or less, it makes a great difference in value of percent especially with the small percent of solution used in experiments.

Tails.

In treatment of tails we air dried the tails of experiment No. 1, and put the tails of all the rest in evaporating dishes and dried them in an air bath heated by bunsen burner.

Buttons.

The buttons were detached from any slag by hammering into the form of cube and then brushed clean with a stiff brush before cupelling.

Notes on Experiment No. 1.

The cause of flat appearance in end of curve is because when a 5% solution of Bromine is added this is over saturated and the free bromine causes the over extraction.

Point No.8 represents extraction of .25 % solution instead of .2% solution caused by accidental addition of more Bormine than we intended.

Notes on Experiment No. 2.

In this experiment owing to loss of assay, etc. of some of heads we had to use 1/2 A.T. to represent assay insead of 1 A.T. The same is also true for some of the tails, they are as follows:

Heads representing points 6,7, and 10, we lost heads to 8 entirely.

Tails representing points 1,2,3,4, and 5.

There are also errors liable to be represented by tails corresponding to points 3,8,10 for instead of a 2% solution which we intended using in the experiment the following strengths 3,5% 2.1% 2.1% acted upon ore instead ,giving a chance for error.

Notes on Experiment III

Here the only mistake was in first point. Here a 1% solution acted upon ore instead of the intended 2% solution.