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THESIS

for the Degree of

Bachelor of Science.

1910.

T21?

A STUDY OF SOME PROBLEMS IN CYANIDING.

by

Sidney S. Schmidt. Russell B. Caples, Jr.

10915

PART 1.

THE DETERMINATION OF THE LOSS OF POTASSIUM CYANIDE AND OF SODIUM CYANIDE IN DILUTE SOLUTION, BY AGITATION WITH COMPRESSED AIR, AND BY AGITATION WITH COMPRESSED AIR IN THE PRESENCE OF IRON PYRITE AND OF IRON FILINGS.

PART 2.

THE DETERMINATION OF RATES OF PERCOLATION OF WATER THROUGH PURE QUARTZ OF VARIOUS SIZES AND VARIOUS MIXTURES OF SIZES.

BY

SIDNEY S. SCHMIDT AND RUSSELL B. CAPLES. JR.

Approved
Durward Copeland.

TABLE OF CONTENTS.

TABLE OF CONTENTS. (cont'd)

PART ONE.

The object of the following tests was rather to determine quanitatively the consumption of Potassium Cyanide and of Sodium Cyanide when agitated by compressed air, and when agitated by compressed air in the presence of iron pyrite and in the presence of iron filings, than to explain chemically the causes for this consumption.

We have attempted to determine the amounts of cyanide consumed by the various substances, compressed air,iron pyrite and iron filings, and also to find out under what conditions the consumption was greatest. The literature, containing such information on cyaniding, is exceedingly meagre.

BIBLIOGRAPHY.

The following references constitute practically the whole bibliography:

<u>Julian</u> and <u>Smart.</u>

Cyanidation of Concentrates.(Very little is given on this subject by these authors, and no definite conclusions are drawn, neither is any reliable data given).

<u>Julian</u> and <u>Smart</u>.

Solubility of Pyrite and Cast iron in KCN. Both pyrite and cast iron are slightly soluble in KCN solution, the degree of solubility increasing with the strength of KCN solution used.

In our tests we did not find this to be the case. The solutions were tested with $K_4 Fe CN_6$ and KCNS, but no trace of iron was indicated.

METHOD OF PROCEDURE.

We attempted to conduct all of the tests under as nearly similar conditions as possible. In order that no outside chemical agents should be present to affect the results all of the apparatus used in the tests was of glass. The tanks were conical in shape and had a capacity of about ten litres each. In order to insure a perfect agitation and a thorough aeriation of the solution various schemes were tried. The one finally adopted was that of installing a miniature air pump as shown in the accompanying illustration. The central glass tube is one half inch in diameter, and held in position by being passed through a glass ring which holds it in a vertical position. Compressed air is supplied by a one eighth inch glass tube, which conducts the air to the bottom of the central tube. The agitating apparatus is really a small Brown or Pachuca tank. This method furnishes good agitation and aeriation. In order that the amount of air supplied to each tank should be the same a T joint was inserted in the hose carrying the air, and the tanks connected to this T joint and the air was admitted under the same head of water. The air supply in the hose was controlled by a needle valve which enabled us to easily regulate the air supply.

All of the tests were run at a constant temperature. Each test was run for ten hours.

The cyanide salts used were; chemically pure potassium cyanide and chemically pure sodium cyanide.

During the course of the tests, samples were taken at the end of each hour, by means of a graduated pipette. Each of the samples from all of the tests was titrated against the same solution of silver nitrate which contained 6.538 grams of chemically pure silver nitrate per litre. One c.c. of the silver nitrate solution equals 0.00500 grams KCN and 0.00377 grams NaCN according to the reactions:

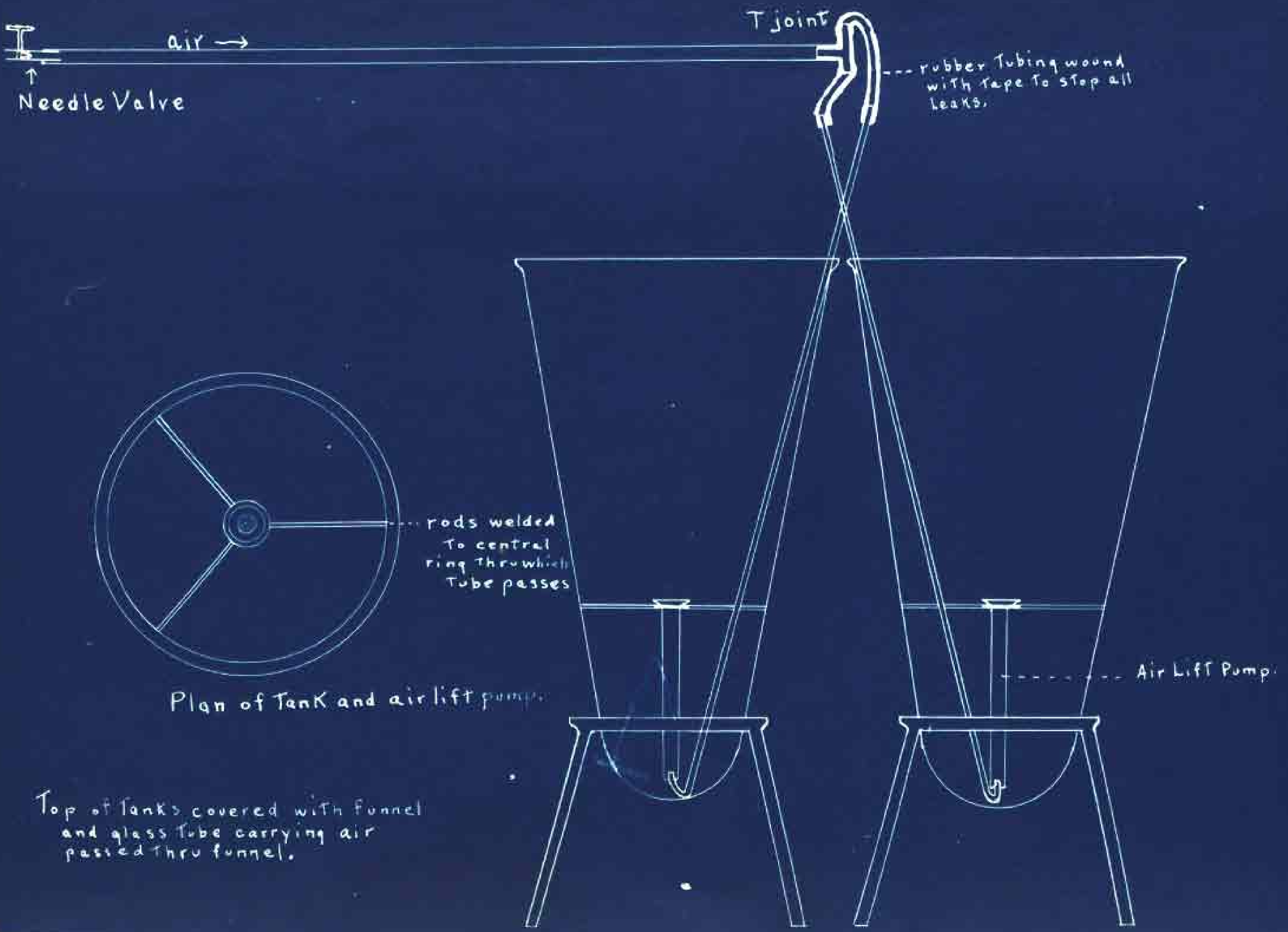
$$AgNO_3+2KCN=KAgCN_2+KNO_3$$

$$AgNO_3+2NaCN=NaAgCN_2+NaNO_3$$

But as all of the samples were titrated against the same solutions the results are comparative anyway, so the above precautions are somewhat unnecessary. Adsorption looses by filter paper in filtering, were undetectable, experiments with solutions of KCN and NaCN of known strength, after passing one,two and three filters, showing no discernable loss.

Evaporation losses were corrected for by adding distilled water before taking the hourly sample; the amount to be added being shown by a scale pasted on the outside of the glass, the height of the solution being marked at the beginning of each hour and the tank filled to this mark before taking the samples at the end of the hour.

Agitation Tanks of Glass used in Experiments



TEST NUMBER ONE.

This test was run to determine the losses of potassium cyanide and sodium cyanide, when agitated by compressed air. No solids were present. In one tank was placed five thousand c.c. of potassium cyanide solution, which contained 22.75 grams KCN or 0.455%, and into the other, five thousand c.c. of sodium cyanide, which contained 22.05 grams of NaCN or 0.441%. The amounts of KCN and NaCN were determined by analysis of the solutions, and not by considering the cyanide salts used pure KCN and pure NaCN. Agitation was started at 1:10 P.M. and continued for ten hours. Fifty c.c. samples were removed at the end of each hour and titrated to determine the loss of cyanide.

The full results of this test are contained in tables 1 and 2. From these tables and the curves, it will be seen that the greatest loss took place during the first hour of the test. Also that the percentage consumption of KCN was nearly twice that of the NaCN. Although a variation of the losses during the last nine hours is shown, they are not enough to materially affect the value of the experiments and can probalby best be accounted for by the variable evaporation losses, for which we corrected by adding distilled water and then agitating for a minute to insure a good mixture.

The average loss per hour of KCN during the last nine hours is 0.191 grams. The loss during the ninth hour at a variance with the general trend of losses.

In conclusion; the results show that the maximum loss occurs during the first hour, and that from then on the hourly loss diminishes. From this test it would seem that losses due to agitation by compressed air, are greater for KCN than for NaCN.

Table No. 1 — KCN Blank.

Time	% KCN	Calculation of Loss in Grams per Hour.	Total Loss in Grams	% Loss.
Start-1:10	0.455	5000 x 0.455% = 22.75 grams KCN at Start.		
2:10	0.446	5000 x (0.00455 - 0.00446) = 0.450 grams	0.450 grams	2.00 %
3:10	0.440	4975 x (0.00446 - 0.00440) = 0.298 "	0.748 "	3.30 "
4:10	0.435	4950 x (0.00440 - 0.00435) = 0.247 "	0.996 "	4.30 "
5:10	0.430	4925 x (0.00435 - 0.00430) = 0.246 "	1.242 "	5.40 "
6:10	0.427	4900 x (0.00430 - 0.00427) = 0.147 "	1.389 "	6.10 "
7:10	0.424	4875 x (0.00427 - 0.00424) = 0.146 "	1.535 "	6.70 "
8:10	0.421	4850 x (0.00424 - 0.00421) = 0.145 "	1.681 "	7.40 "
9:10	0.418	4825 x (0.00421 - 0.00418) = 0.144 "	1.825 "	8.00 "
10:10	0.414	4800 x (0.00418 - 0.00414) = 0.192 "	2.017 "	9.00 "
11:10	0.411	4775 x (0.00414 - 0.00411) = 0.143 "	2.161 "	9.50 "

Samples = 25 c.c. Each. 5000 c.c. of Solution at Start. No Iron or Free Acid.

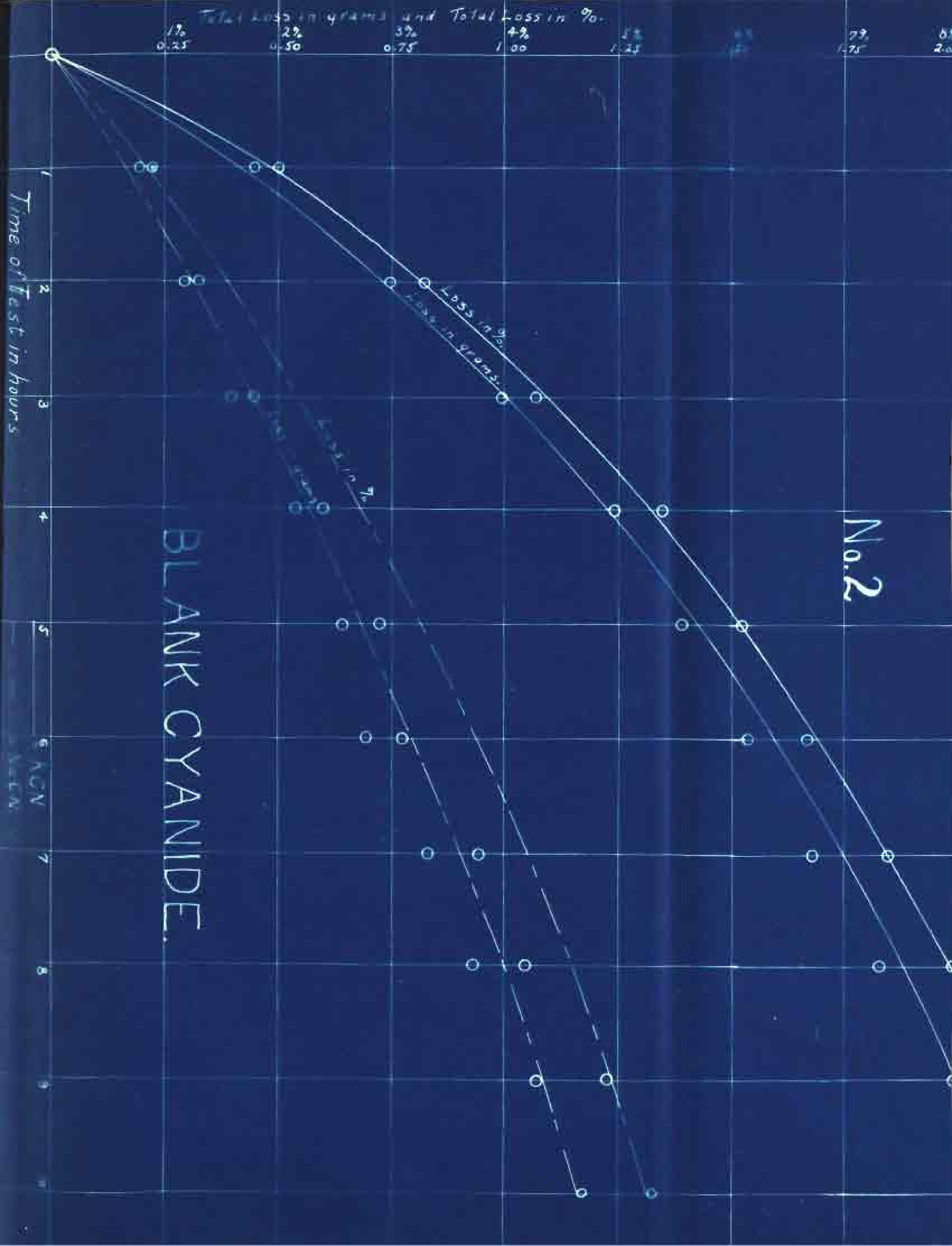
Table No. 2 — NaCN Blank.

Time	% NaCN	Calculation of Loss in Grams per Hour.	Total Loss in Grams	% Loss.
Start-1:10	0.441	5000 x 0.00441 = 22.05 grams NaCN at Start		
2:10	0.437	5000 x (0.00441 - 0.00437) = 0.200 grams.	0.200 grams	0.90 %
3:10	0.435	4975 x (0.00437 - 0.00435) = 0.099 "	0.299 "	1.30 "
4:10	0.433	4950 x (0.00435 - 0.00433) = 0.099 "	0.399 "	1.80 "
5:10	0.430	4925 x (0.00433 - 0.00430) = 0.147 "	0.546 "	2.40 "
6:10	0.428	4900 x (0.00430 - 0.00428) = 0.098 "	0.644 "	2.90 "
7:10	0.427	4875 x (0.00428 - 0.00427) = 0.048 "	0.693 "	3:10 "
8:10	0.424	4850 x (0.00427 - 0.00424) = 0.145 "	0.839 "	3:80 "
9:10	0.422	4825 x (0.00424 - 0.00422) = 0.096 "	0.935 "	4.20 "
10:10	0.419	4800 x (0.00422 - 0.00419) = 0.144 "	1.079 "	4.90 "
11:10	0.417	4775 x (0.00419 - 0.00417) = 0.095 "	1.175 "	5.30 "

Samples = 25 c.c. Each. 5000 c.c. of Solution at Start. No Iron or Free Acid.

CN determined by titration with $AgNO_3$ solution.


No. 1
BLANK CYANIDE.
Loss of weight in grams per hour.
0.10
0.20
0.30
0.40
0.50
1
2
3
4
5
6
7
8
9
10
Time of Test in hours.
= KCN.
= NaCN.



Total Loss in grams and Total Loss in %.
1%
0.25
2%
0.50
3%
0.75
4%
1.00
5%
1.25
7%
1.75
Time of Test in hours
1
2
3
4
5
6
7
8
9
Loss in %.
Loss in grams.
Loss in %
BLANK CYANIDE.
No. 2

TEST NUMBER TWO.

In this test, the conditions as to the amount of air supplied, temperature, and strength of solutions, were practically the same as for test number one.

Five thousand c.c. of solution, assaying 0.500% KCN, were placed in one tank, and five thousand c.c. of solution, assaying 0.509% NaCN, in the other. Agitation was started and then 500 grams of clean iron filings, that had been passed through an 80 mesh, were added to each tank. Fifty c.c. samples were taken at the end of each hour and assayed. The results of these tests are given in tables 3,4,9and 10, and in the accompanying curves. The greatest loss of cyanide occurred during the first hour, and from then on diminishes.

No soluble iron was found to be present. Tests for acidity were made but no acid was found. The total losses for these tests were not much greater than in test number 1. In this test, as in the preceding one, the loss of KCN exceeded the loss of NaCN. The net losses by iron filings are shown in tables 9 and 10.

The losses by aeriation in test 1, are subtracted from the losses in test 2. The presence of 500 grams of filings, caused a total loss in ten hours, of 1.098 grams or 4.4%, of the total potassium cyanide, and of 1.754 grams or 6.8%, of the total sodium cyanide.

The loss of sodium cyanide, although less both in the presence and absence of iron filings, than the loss of potassium cyanide, is greater due to the action of iron filings alone.

Table No. 3 — IRON FILINGS. — 500 grams KCN.

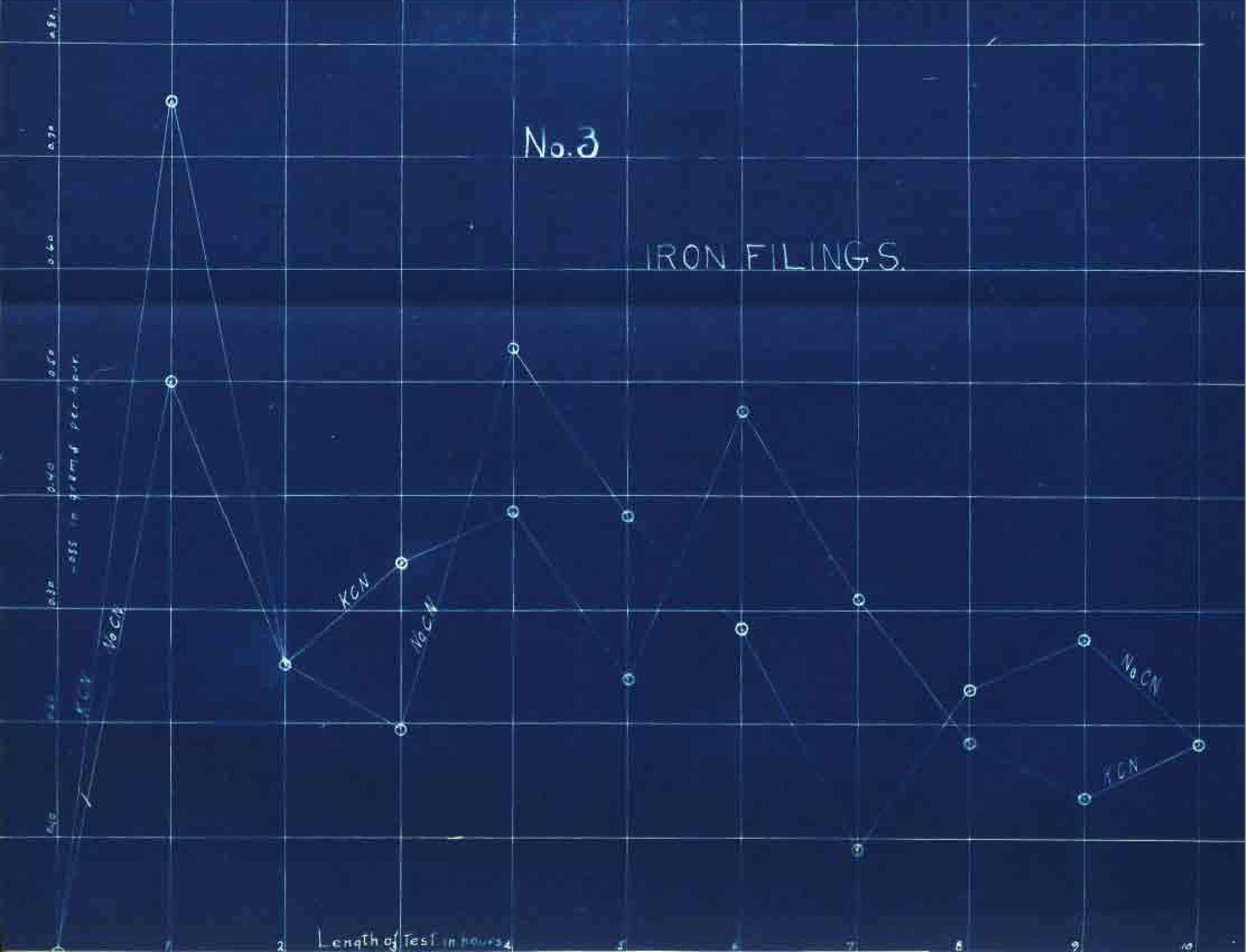
Time.	% KCN.	Calculation of Loss in grams per hour.		Total Loss in grams	% Loss.
9.10 A.M.	0.500	5000 x 0.500 = Start	0.000	0.000	0.00
10.10 "	0.485	5000 x 0.015 =	0.750	0.750	3.00
11.10 "	0.480	4950 x 0.005 =	0.247	0.997	3.90
12.10 P.M.	0.473	4900 x 0.007 =	0.343	1.340	5.30
1.10 "	0.465	4850 x 0.008 =	0.388	1.728	6.90
2.10 "	0.460	4800 x 0.005 =	0.240	1.968	7.80
3.10 "	0.450	4750 x 0.010 =	0.475	2.443	9.80
4.10 "	0.443	4700 x 0.007 =	0.310	2.753	11.00
5.10 "	0.439	4650 x 0.004 =	0.186	2.939	11.70
6.10 "	0.436	4600 x 0.003 =	0.138	3.077	12.30
7.10 "	0.432	4550 x 0.004 =	0.182	3.259	13.00

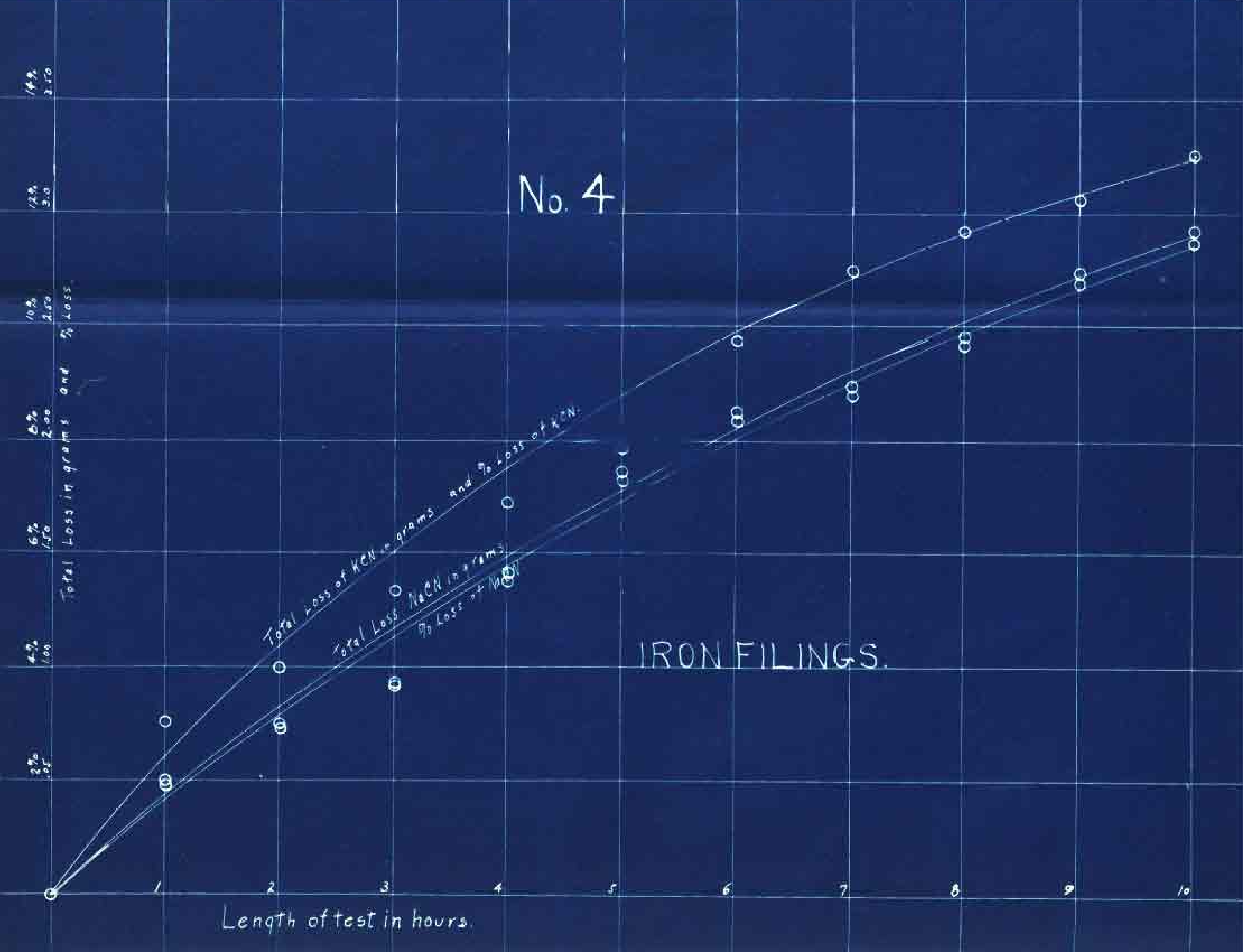
[illegible]. No Acid. Samples = 50cc. Column Two obtained by Titration against $AgNO_3$.

Table No. 4 — IRON FILINGS. — 500 grams NaCN.

Time.	% NaCN	Calculation of Loss in grams per hour.		Total Loss in grams.	% Loss.
9.10 A.M.	0.509	5000 x 0.509 = Start	0.000	0.000	0.00
10.10 "	0.499	5000 x 0.010 =	0.500	0.500	1.90
11.10 "	0.494	4950 x 0.005 =	0.247	0.747	2.90
12.10 P.M.	0.490	4900 x 0.004 =	0.196	0.943	3.70
1.10 "	0.479	4850 x 0.011 =	0.533	1.476	5.70
2.10 "	0.471	4800 x 0.008 =	0.384	1.866	7.30
3.10 "	0.465	4750 x 0.006 =	0.285	2.145	8.40
4.10 "	0.463	4700 x 0.002 =	0.094	2.231	8.80
5.10 "	0.458	4650 x 0.005 =	0.232	2.471	9.7
6.10 "	0.452	4600 x 0.006 =	0.276	2.747	10.8
7.10 "	0.448	4550 x 0.004 =	0.182	2.929	11.5

[illegible]. No Free Acid. Samples = 50 cc each. Column Two obtained by Titration.


No.3
IRON FILINGS.
Loss in grams per hour.
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
KCN
NaCN
Length of Test in hours
1
2
3
4
5
6
7
8
9
10


No. 4
IRON FILINGS.
Total Loss in grams and % Loss.
2% .05
4% 1.00
6% 1.50
8% 2.00
10% 2.50
12% 3.0
14% 3.50
Total Loss of KCN in grams and % Loss of KCN.
Total Loss NaCN in grams
1
2
3
4
5
6
7
8
9
10
Length of test in hours.

TEST NUMBER THREE.

The conditions as to amount of air supplied, temperature and strength of solutions, were practically the same for this test as for the preceding ones. Five thousand c.c. of solution, assaying 0.485% potassium cyanide, and five thousand c.c. of solution, assaying 0.462% sodium cyanide, were used. Samples were taken as before.

Agitation was started, and to each tank was added 1500 grams of iron pyrite, which had been passed through a 100 mesh screen. The purite was unsized but all was through 100 mesh, and contained about one half of one percent metallic iron, derived from the mill used in grinding. Some trouble was encountered in filtering, as the finely divided pyrite persisted in coming thru the filters, although "White Ribbon" filters were used. The cloudiness of the filtrate was removed by diluting the sample to be titrated, to one hundred and fifty c.c. before titration, thus allowing the end point to be easily detected.

The results of this test are given in tables 5,6,9,10 and in the accompanying curves.

Tests for acidity were made, and showed no free acid at any time during the test, or at its conclusion.

The consumption of potassium cyanide was greater than for the sodium cyanide, as in the previous tests.

1500 grams

Table No. 5. Pyrite with particles of iron abraded from Coffee mill grinder. KCN.

Time	% KCN	Calculation of Loss in grams per hour.		Total Loss in grams	% Loss.
9.20 AM	0.485	5000 x 0.485 = 24.25 gms KCN at Start	0.000	0.000	0.000
10.20 "	0.160	5000(0.485 − 0.160) =	16.250	16.250	67.01
11.20 "	0.156	4950(0.160 − 0.156) =	0.198	16.448	67.82
12.20 PM	0.140	4900(0.156 − 0.140) =	0.784	17.232	71.06
1.20 "	0.130	4850(0.140 − 0.130) =	0.485	17.717	73.06
2.20 "	0.120	4800(0.130 − 0.120) =	0.480	18.197	75.04
3.20 "	0.110	4750(0.120 − 0.110) =	0.475	18.672	77.00
4.20 "	0.097	4700(0.110 − 0.097) =	0.611	19.283	79.52
5.20 "	0.091	4650(0.097 − 0.091) =	0.279	19.562	80.66
6.20 "	0.085	4600(0.091 − 0.085) =	0.276	19.838	81.80
7.20 "	0.082	4550(0.085 − 0.082) =	0.136	19.974	82.37

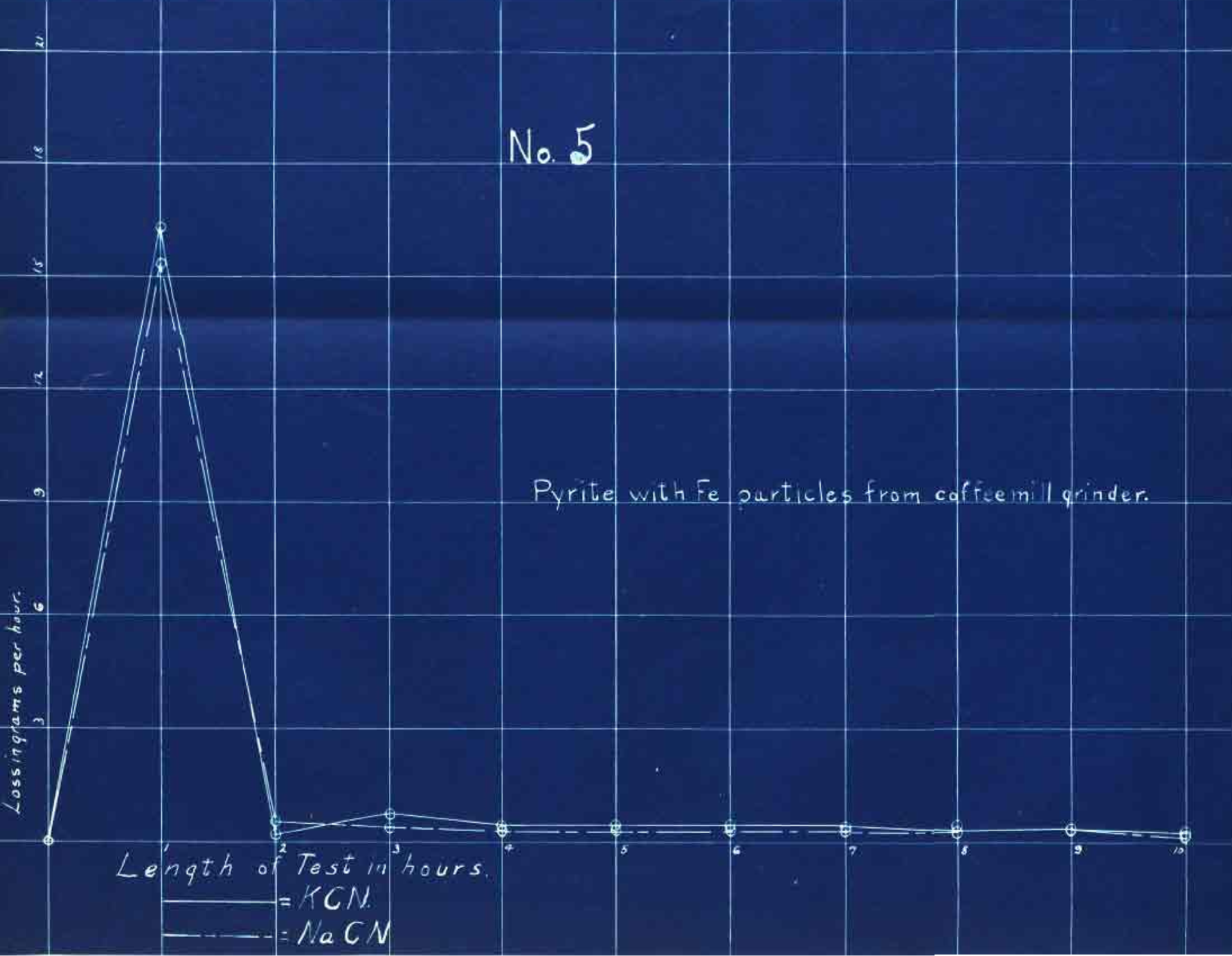
No acid. Samples = 50 c.c. Column Two obtained by Titrating against $AgNO_3$

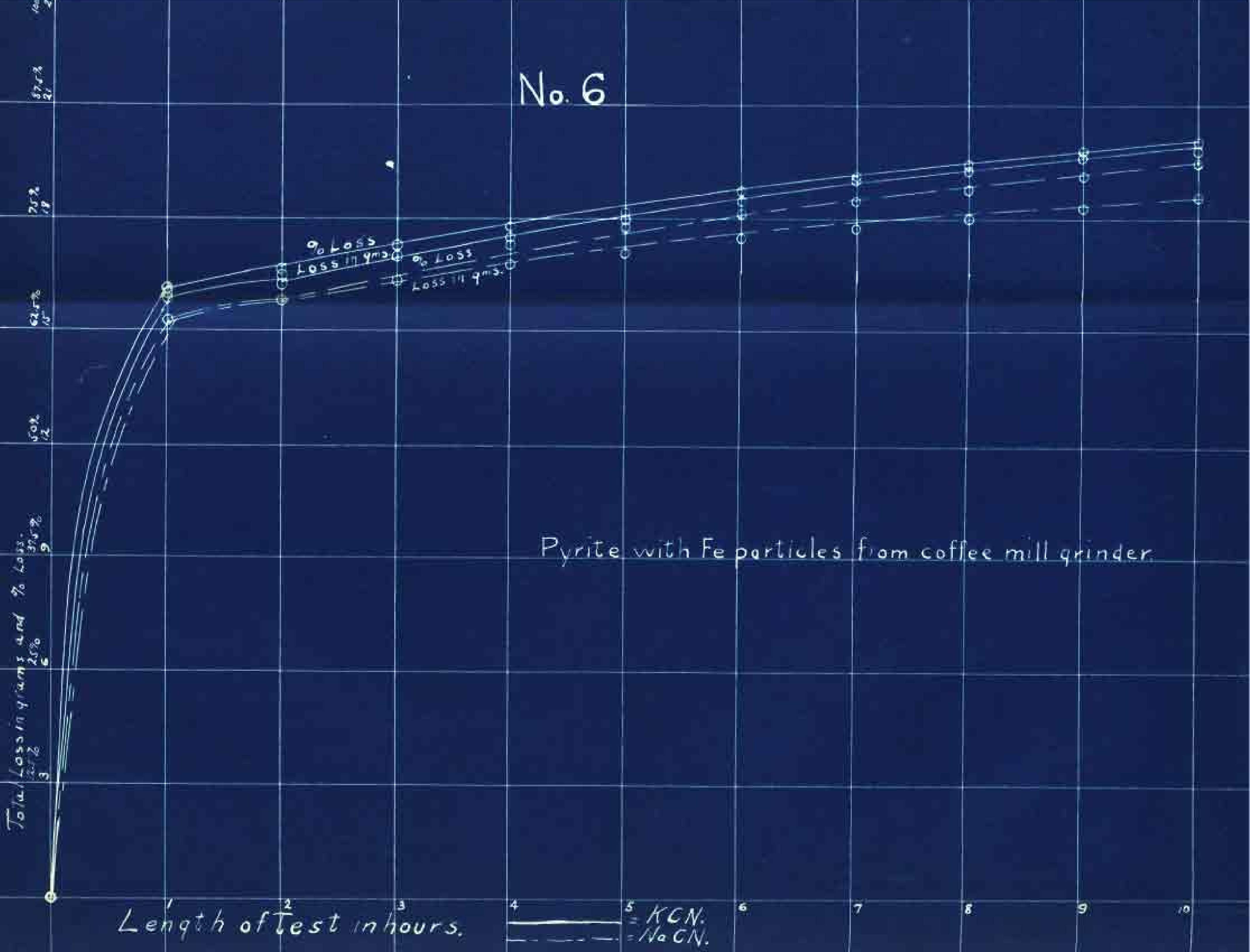
1500 grams.

Table No. 6 Pyrite with particles of iron abraded from Coffee mill grinder. Na CN.

Time	% Na CN	Calculation of Loss in grams per hour.		Total Loss in grams.	% Loss.
9.20 AM	0.462	5000 x 0.462 = 23.10 gms Na CN at Start.	0.000	0.000	0.000
10.20 "	0.154	5000(0.462 − 0.154) =	15.400	15.400	66.66
11.20 "	0.142	4950(0.154 − 0.142) =	0.594	15.994	69.23
12.20 PM	0.134	4900(0.142 − 0.134) =	0.392	16.386	70.93
1.20 "	0.127	4850(0.134 − 0.127) =	0.340	16.726	72.40
2.20 "	0.120	4800(0.127 − 0.120) =	0.336	17.062	73.86
3.20 "	0.111	4750(0.120 − 0.111) =	0.427	17.489	75.71
4.20 "	0.105	4700(0.111 − 0.105) =	0.282	17.771	76.93
5.20 "	0.097	4650(0.105 − 0.097) =	0.279	18.050	78.14
6.20 "	0.092	4600(0.097 − 0.092) =	0.282	18.332	79.36
7.20 "	0.087	4550(0.092 − 0.087) =	0.227	18.559	80.34

No acid Samples = 50 cc. Column Two obtained by Titrating against $AgNO_3$


No. 5
Pyrite with Fe particles from coffeemill grinder.
Loss in grams per hour.
3
6
9
12
15
18
21
1
2
3
4
5
6
7
8
9
10
Length of Test in hours.
= KCN.
= NaCN


No. 6
Pyrite with Fe particles from coffee mill grinder.
Total Loss in grams and % Loss.
% Loss
Loss in gms.
% Loss
Loss in gms.
Length of Test in hours.
= KCN.
= NaCN.

TEST NUMBER FOUR.

In this test, the conditions as to amount of air supplied, temperature, and strength of solutions were practically the same as in the previous tests. Five thousand c.c. of solution, assaying 0.468 % potassium cyanide, was placed in one tank, and five thousand c.c. of solution, assaying 0.435% sodium cyanide in the other. Agitation was started and then one thousand grams of iron pyrite added, from which the iron filings, derived in grinding, had been removed by means of a strong magnet. The pyrite was unsized, but all passed a one-hundred-mesh screen.

The greatest loss occurred during the first hour. The potassium cyanide again suffered the greater loss. In the potassium cyanide solution the total loss due to pyrite when using fifteen hundred grams of pyrite, under our conditions, is 12.724 grams of KCN, which is nearly a gram more than two-thirds of 17.802, see last column of Table 9. The loss is, then, somewhat proportional to the amount of pyrite used.

In conclusion: Agitation by compressed air, results in a consumption of cyanide, the loss being greatest during the first hour, and then gradually (hourly) diminishing to a nearly constant loss. Potassium cyanide suffers a greater loss than does sodium cyanide. Losses due to the presence of finely divided particles of metallic iron, are very small, and practically negligable. Losses due to the presence of iron pyrite, are large, the greatest loss occurring in the first hour.

More experiments along this line are greatly needed, but lack of time has prevented our taking them up.

Table No. 7. PURE CLEAN PYRITE 1000 grams KCN

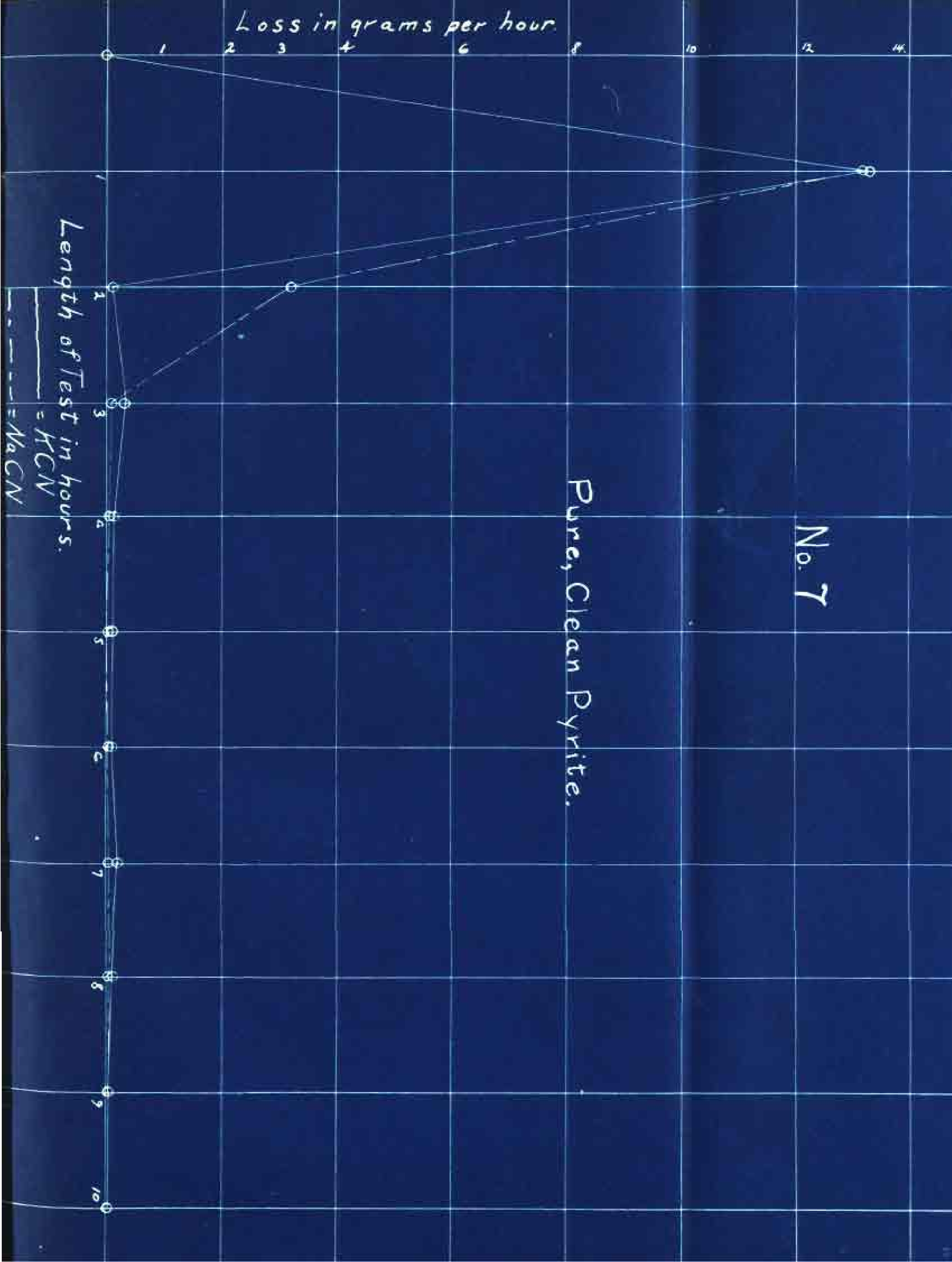
Time	% KCN	Calculation of Loss in grams per hour.		Total Loss in grams	% Loss.
9.20 AM	0.465	5000 × 0.465 = 23.25 gms at Start.	0.000	0.000	0.000
10.20 "	0.200	5000(0.465 − 0.200) =	13.250	13.250	57.000
11.20 "	0.197	4950(0.200 − 0.197) =	0.148	13.398	57.62
12.20 PM	0.188	4900(0.197 − 0.188) =	0.401	13.799	59.35
1.20 "	0.184	4850(0.188 − 0.184) =	0.194	13.993	60.18
2.20 "	0.180	4800(0.184 − 0.180) =	0.192	14.185	61.01
3.20 "	0.177	4750(0.180 − 0.177) =	0.142	14.327	61.62
4.20 "	0.172	4700(0.177 − 0.172) =	0.235	14.562	62.63
5.20 "	0.168	4650(0.172 − 0.168) =	0.186	14.748	63.43
6.20 "	0.166	4600(0.168 − 0.166) =	0.092	14.840	63.83
7.20 "	0.165	4550(0.166 − 0.165	0.045	14.885	64.02

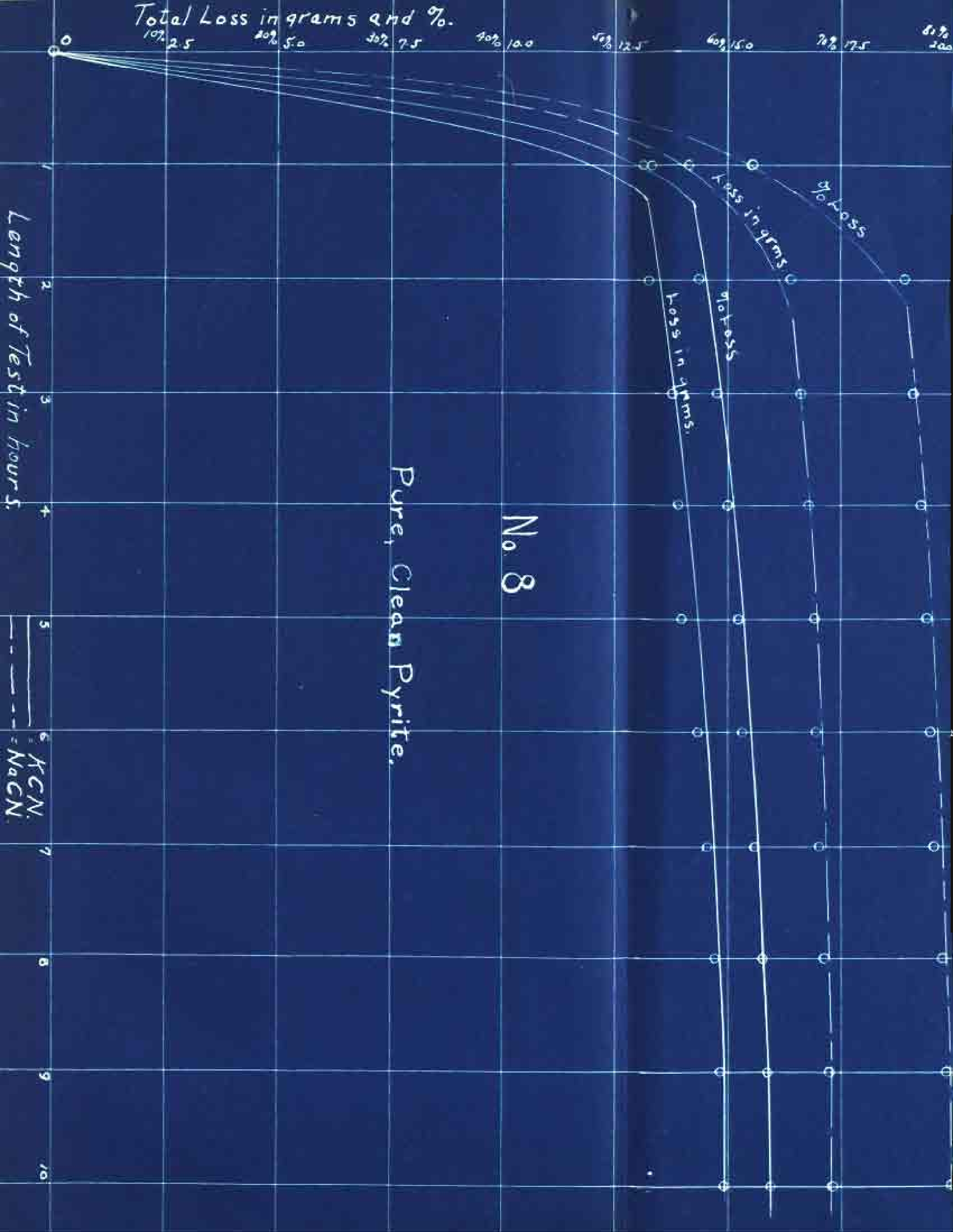
No Acid. Samples = 50 c.c. Column Two obtained by Titration against $AgNO_3$

Table No. 8 PURE CLEAN PYRITE 1000 grams NaCN

Time	% NaCN	Calculation of Loss in grams per hour.		Total Loss in grams.	% Loss
9.20 AM	0.435	5000 × 0.435 = 21.75 gms at Start.	0.000	0.000	0.000
10.20 "	0.169	5000(0.435 − 0.169) =	13.300	13.300	62.59
11.20 "	0.103	4950(0.169 − 0.103) =	3.270	16.57	76.18
12.20 PM	0.100	4900(0.103 − 0.100) =	0.150	16.72	76.87
1.20 "	0.097	4850(0.100 − 0.097) =	0.140	16.86	77.51
2.20 "	0.095	4800(0.097 − 0.095) =	0.100	16.96	77.97
3.20 "	0.094	4750(0.095 − 0.094) =	0.050	17.01	78.20
4.20 "	0.091	4700(0.094 − 0.091) =	0.140	17.15	78.85
5.20 "	0.089	4650(0.091 − 0.089) =	0.090	17.24	79.26
6.20 "	0.088	4600(0.089 − 0.088) =	0.050	17.29	79.50
7.20 "	0.086	4550(0.088 − 0.086) =	0.090	17.38	80.00

No Acid. Samples = 50 c.c. Column Two obtained by titration against $AgNO_3$


Loss in grams per hour.
1 2 3 4 6 8 10 12 14.
Length of Test in hours.
= KCN
= NaCN
1 2 3 4 5 6 7 8 9 10
Pure, Clean Pyrite.
No. 7



Total Loss in grams and %.
0
10% 2.5
20% 5.0
30% 7.5
40% 10.0
50% 12.5
60% 15.0
70% 17.5
80% 20.0
Length of Test in hours.
1
2
3
4
5
6
7
8
9
10
% Loss
Loss in grms.
% Loss
Loss in grms.
No. 8
Pure, Clean Pyrite.
—— : KCN.
- - - : NaCN.

Table No. 9 KCN.

Time	500 grams. Total Net Loss due to Fe Filings.	1000 grams Pyrite. Total Net Loss due To pure Pyrite.	1500 grams Pyrite. Total Net Loss due to pure Pyrite.
1st hour.	0.450 from 0.750 = 0.300	0.450 from 13.250 = 12.800	0.450 from 16.250 = 15.800
2nd "	0.748 " 0.997 = 0.249	0.748 " 13.398 = 12.650	0.748 " 16.448 = 15.700
3rd "	0.996 " 1.340 = 0.344	0.996 " 13.799 = 12.803	0.996 " 17.232 = 16.236
4th "	1.242 " 1.728 = 0.486	1.242 " 13.993 = 12.751	1.242 " 17.717 = 16.473
5th "	1.389 " 1.968 = 0.579	1.389 " 14.185 = 12.796	1.389 " 18.197 = 16.808
6th "	1.535 " 2.443 = 0.908	1.535 " 14.327 = 12.792	1.545 " 18.672 = 17.127
7th "	1.681 " 2.753 = 1.072	1.681 " 14.562 = 12.881	1.692 " 19.283 = 17.591
8th "	1.825 " 2.939 = 1.114	1.825 " 14.748 = 12.923	1.846 " 19.562 = 17.762
9th "	2.017 " 3.077 = 1.060	2.017 " 14.840 = 12.823	2.020 " 19.831 = 17.811
10th "	2.161 " 3.259 = 1.098	2.161 " 14.885 = 12.724	2.172 " 19.974 = 17.802
	Aeriation " Aeriation + Filings	Aeriation " Aeriation + pyrite	Aeriation " Aeriation + Pyrite + 0.5% Fe Filings

Table No. 10 NaCN.

Time	500 grams. Total Net Loss Due to Fe Filings.	1000 grams. Total Net Loss due to pure pyrite.	1500 grams. Total net Loss due To pure pyrite.
1st hour.	0.200 from 0.500 = 0.300	0.200 from 13.300 = 13.10	0.200 from 15.400 = 15.200
2nd "	0.298 " 0.747 = 0.449	0.299 " 16.57 = 16.271	0.299 " 15.994 = 15.695
3rd "	0.399 " 0.943 = 0.544	0.399 " 16.72 = 16.321	0.399 " 16.386 = 15.987
4th "	0.546 " 1.476 = 0.930	0.546 " 16.86 = 16.334	0.546 " 16.736 = 16.184
5th "	0.644 " 1.866 = 1.222	0.644 " 16.96 = 16.316	0.644 " 17.062 = 16.418
6th "	0.693 " 2.145 = 1.452	0.693 " 17.01 = 16.317	0.693 " 17.489 = 16.796
7th "	0.839 " 2.231 = 1.396	0.839 " 17.15 = 16.311	0.840 " 17.771 = 16.931
8th "	0.935 " 2.471 = 1.536	0.935 " 17.24 = 16.305	0.945 " 18.050 = 17.105
9th "	1.079 " 2.747 = 1.668	1.079 " 17.29 = 16.211	1.089 " 18.332 = 17.243
10th "	1.175 " 2.929 = 1.754	1.175 " 17.38 = 16.245	1.185 " 18.559 = 17.374
	Aeriation " Aeriation + Filings	Aeriation " Aeriation + Pyrite.	Aeriation + 0.5% Filings from Pyrite.

PART TWO.

The following tests were made to study the rate of percolation of water, under certain conditions, through pure quartz.The information sought is of importance in the cyanide process. By "rate of percolation" we mean the distance travelled in a unit time, by water through a bed of quartz or other ore. In all of our experiments no suction was used.

The data obtained is given in the accompanying tables. The curves are plotted from these tables. All time was taken with a stop watch. The glass tubing was three inches inside diameter, and in seven feet lengths. All the quartz was carefully sized and quite free from dust. In order to better follow the liquid through the quartz, the water was colored with potassium permanganate or with ordinary washing bluing. Neither coloring agent was at all satisfactory, as the solution lost its color rapidly, in passing through the column of quartz. The quartz particles seemed to extract the coloring salt from the liquid. In the case of the permanganate, the first coloring agent used,we decided that the loss of color was due to ferrous iron dissolved from the quartz, but when the bluing solution also lost its color, we decided that probably adsorption played an important part.

Drainage was never complete, the last six inches of ore never draining dry. The head was kept constant at six inches above the top of the ore until the water came through the screen at the bottom, when this head was allowed to subside. The time of drainage includes time of subsidence of the head. The water came down very evenly, the center travelling equally as fast as the outside, as was ascertained by glass tubes at the bottom.

It will be noticed that the percolation through the dry quartz was uniformly faster than through the wet quartz, and that the percolation uniformly became slower with the number of times the test was run on the wet quartz. All of the tests numbered 2 on the wet quartz, show a slower rate than the first test, and all tests numbered three, show a slower rate than those numbered 2. A curve of the average of the three wet tests was plotted, but we believe that the results of number three are more valuable, as they would more nearly represent the conditions in actual practice, where the ore had been crushed wet.

It was noticed that, in the tests on the wet ore, air was forced out of the bottom under considerable pressure, as the water percolated downward.

BIBLIOGRAPHY.

The following references constitute practically the whole bibliography:

Julian and Smart.

Percolation is affected by;

1. Volume and uniformity of interstices.
   The greater the size and percentage of interstices and the more uniform the interstices, the faster the percolation.
2. Depth of ore.
   The shorter the column, the faster will be the average rate of percolation.
3. Pressure.
   An increase in head gives an increase in the rate of percolation, but this increase in rate of percolation is small in comparison to the increase in head required to produce it.
4. Temperature.
   The rate of percolation increases with the temperature of the solution.
5. Direction.

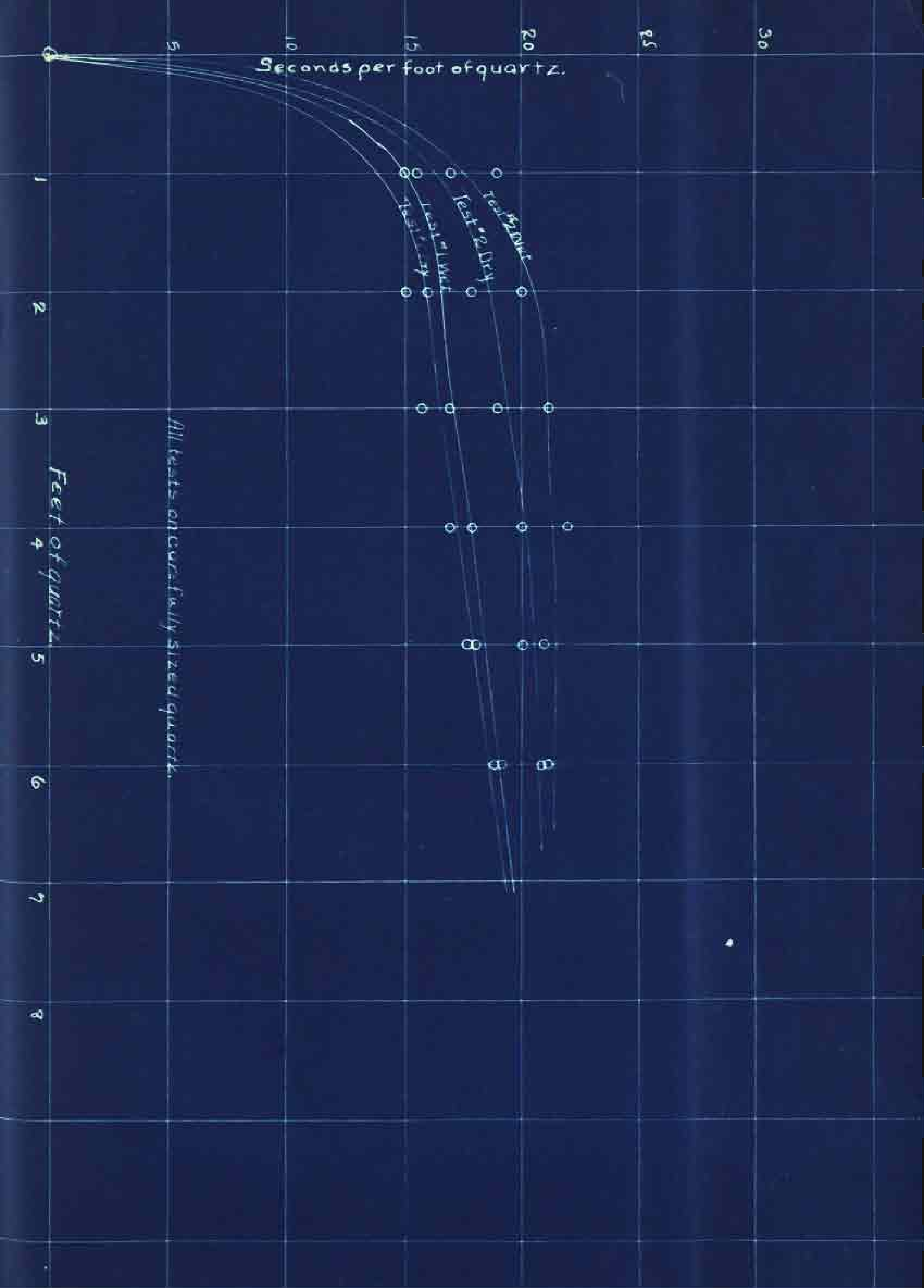
Upward percolation is faster than downward percolation. This applies especially for a short column of ore.

No definite reasons were given for these conclusions, they being largely taken from data obtained from experiments.

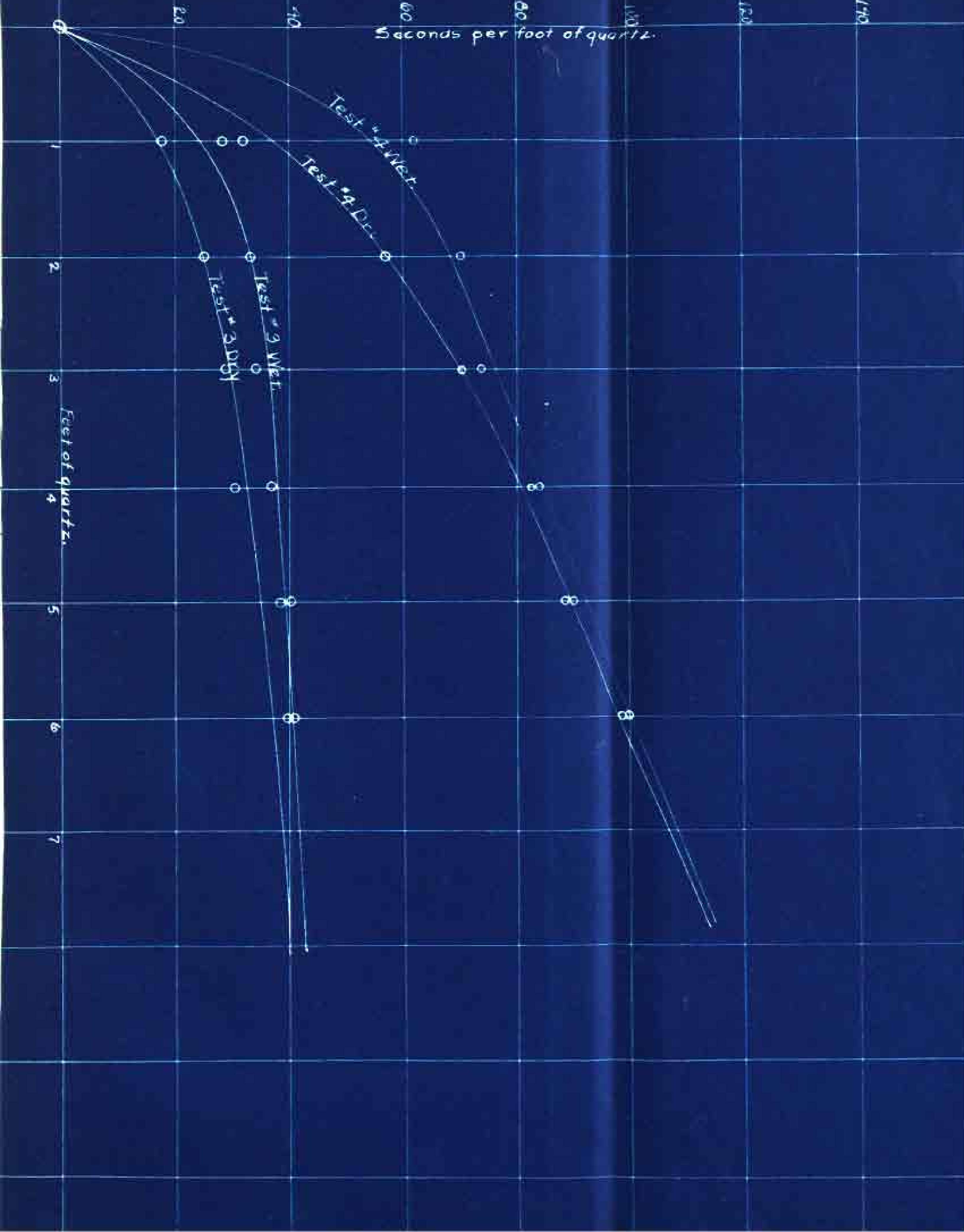
No.	Size: Thru	Size: On	Conditions	Head of Water	Rate of Percolation - seconds per foot of quartz: 1st foot	2nd foot	3rd foot	4th foot	5th foot	6th foot	Rate of subsidence of Head	Rate of Drainage
I												
100%	10	14	Dry - 15°C	6 inches	15	15	16	17	18	19	17 secs.	350 seconds
			Wet " "	" "	15	16	16	17	17	19	17 "	355 "
			" - " "	" "	15	16	17	18	18	19	19 "	365 "
			" - " "	" "	16	16	18	18	19	20	20 "	378 "
II												
100%	14	20	Dry - 15°C	6 inches	17	18	19	20	20	21	25 secs.	380 secs.
			Wet " "	" "	18	19	19	20	21	21	32 "	390 "
			" - " "	" "	20	20	21	22	21	21	37 "	395 "
			" - " "	" "	19	20	22	22	21	21	38 "	400 "
III	20	30	Dry - 15°C	6 inches	18	25	29	30	39	39	48 secs	440 secs.
			Wet - " "	" "	28	33	36	36	39	39	72 "	455 "
			" - " "	" "	28	34	34	36	40	40	77 "	470 "
			" - " "	" "	30	33	34	38	46	46	79 "	475 "
IV												
100%	30	40	Dry - 15°C	6 inches	32	57	70	82	88	99	128 Secs.	745 secs.
			Wet - " "	" "	56	67	69	83	85	101	165 "	899 "
			" - " "	" "	65	71	69	84	85	96	168 "	960 "
			" - " "	" "	66	72	80	83	87	100	170 "	1050 "
V												
100%	40	60	Dry - 15°C	6 inches	63	92	112	130	141	162	[illegible] secs.	1650 secs.
			Wet " "	" "	132	138	146	18[illegible]	195	206	387 "	1800 "
			" - " "	" "	188	1[illegible]3	150	200	204	213	392 "	2070 "
			" - " "	" "	193	161	160	212	218	226	411 "	2195 "
VI												
100%	60	80	Dry 15°C	6 inches	300	720	880	1010	1170	1280	1380 secs.	—
			Wet - " "	" "	—							—
			" - " "	" "	—							
			" - " "	" "								

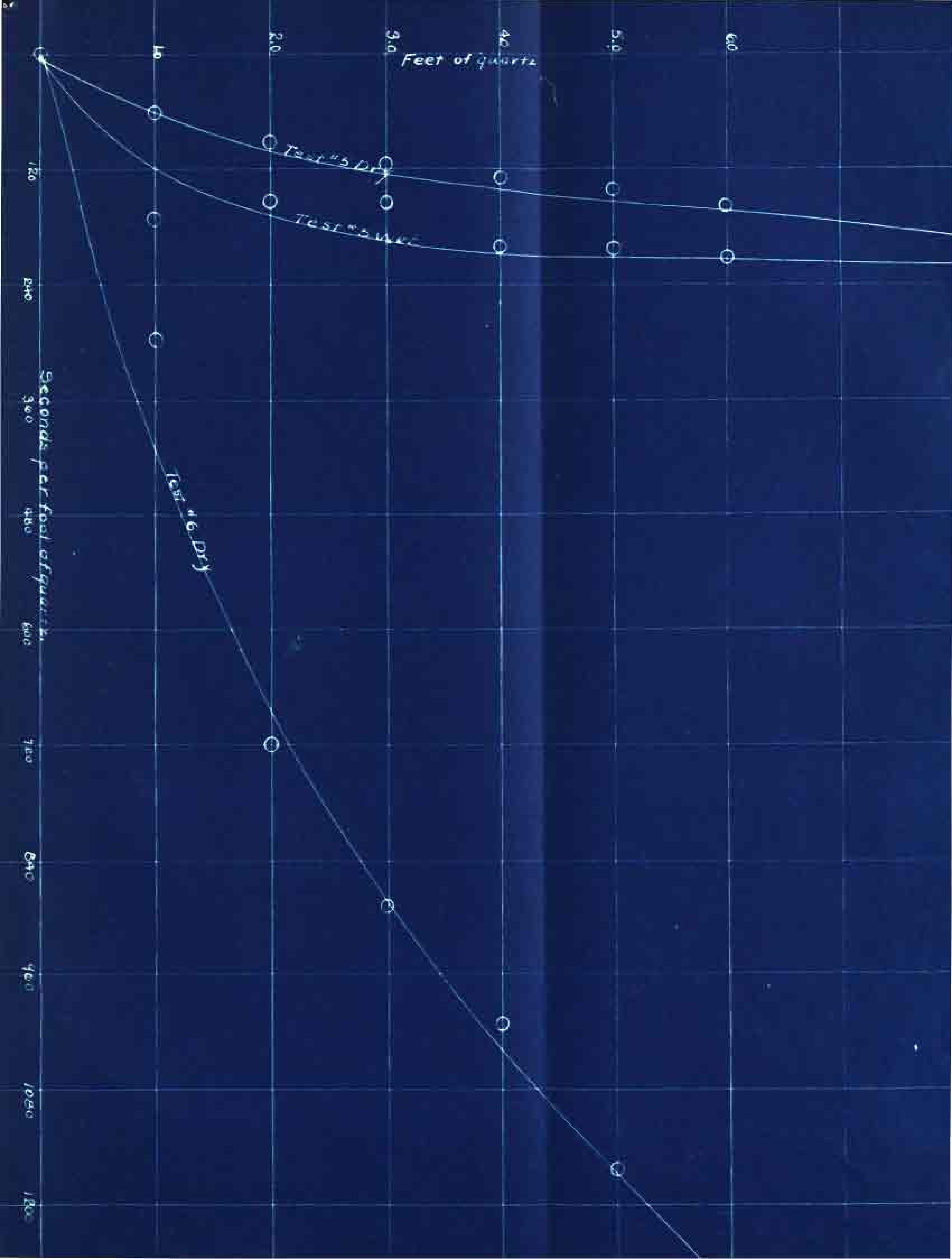
Owing to rapid loss of color of indicators used and very slow rate of percolation no further data could be obtained.

All results are for carefully sized quartz - downward percolation.



Seconds per foot of quartz.
5
10
15
20
25
30
Feet of quartz
1
2
3
4
5
6
7
8
All tests on carefully sized quartz.
Test #2 Wet
Test #2 Dry
Test #1 Wet

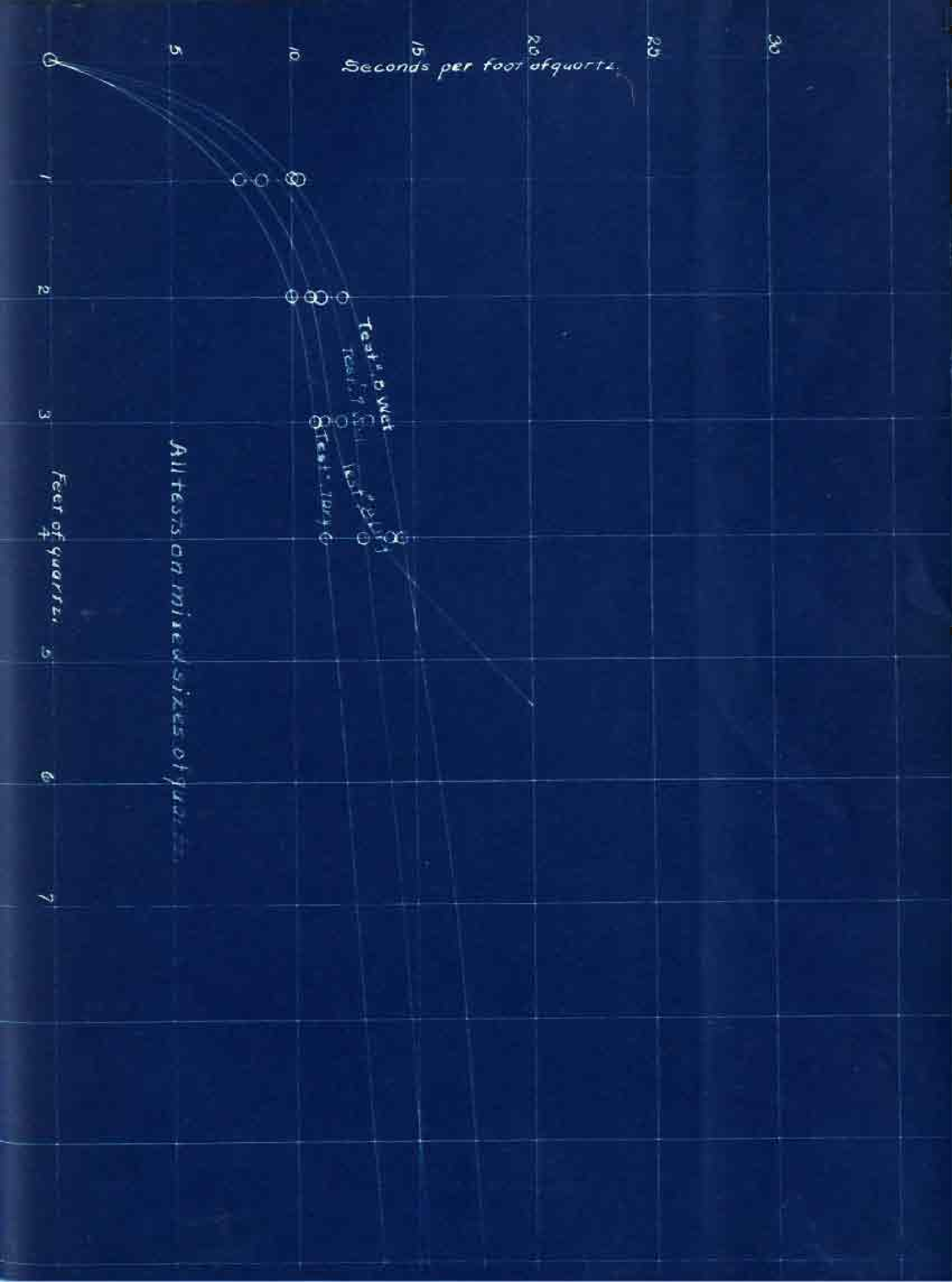

Seconds per foot of quartz.
20
40
60
80
100
120
140
Feet of quartz.
1
2
3
4
5
6
7
Test #4 Wet.
Test #4 Dry
Test #3 Wet.
Test #3 Dry.



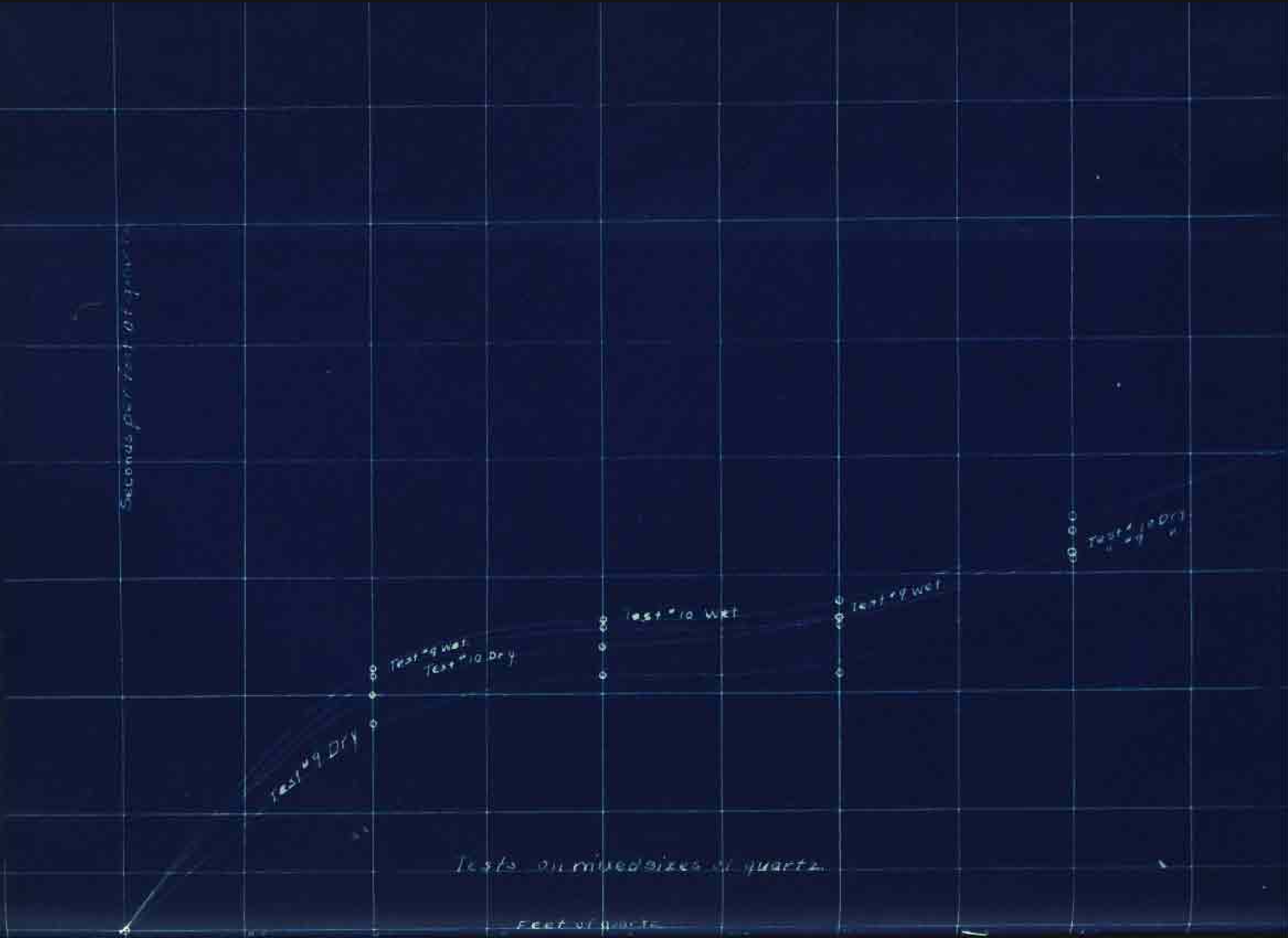
Feet of quartz
2.0
3.0
4.0
5.0
6.0
Test #5 Dry
Test #5 Wet
Test #6 Dry
Seconds per foot of quartz
120
240
360
480
600
720
840
960
1080
1200

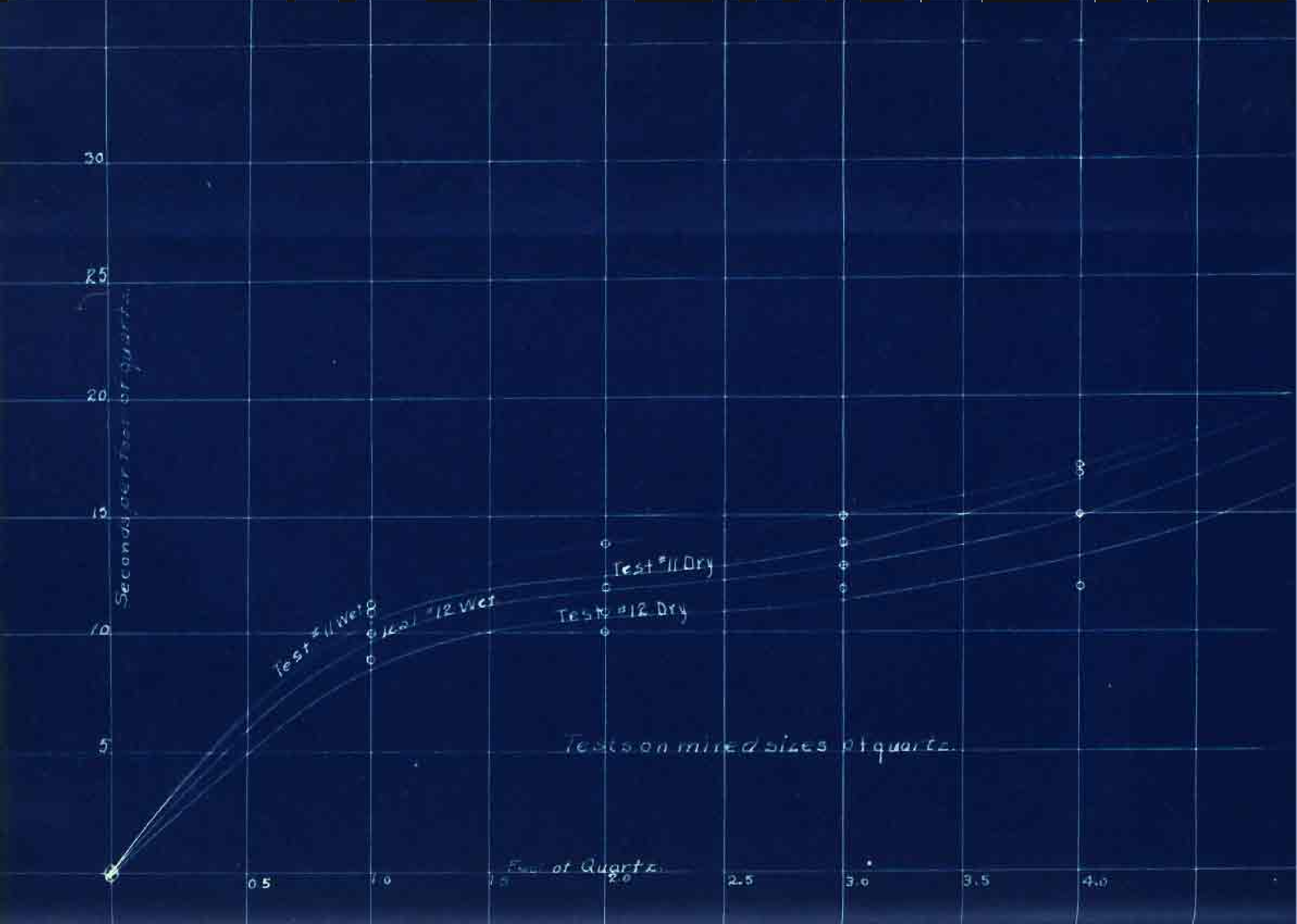
No. Size				Head of	Rate of Percolation-seconds per foot of quartz				Rate of subsidence of Head	Rate of Drainage.
7	Thru	On	Conditions	Water	1st foot	2nd foot	3d foot	4th foot		
90%	10	14	Dry-20°C	6 inches	8	9	11	11	21 seconds	120 seconds
10%	14	20	Wet- " "	" "	9	11	12	12	24 "	132 "
			" - " "	" "	10	12	12	13	26 "	140 "
			" - " "	" "	10	12	12	13	29 "	145 "
8										
80%	10	14	Dry-20°C	6 inches	9	10	11	14	23 seconds	125 seconds
20%	14	20	Wet- " "	" "	10	11	13	14	33 "	145 "
			" - " "	" "	10	11	13	14	36 "	150 "
			" - " "	" "	10	12	13	15	40 "	157 "
9										
70%	10	14	Dry-20°C	6 inches	9	11	11	16	24 seconds.	140 seconds.
30%	14	20	Wet- " "	" "	10	12	13	16	29 "	155 "
			" - " "	" "	11	12	13	16	37 "	162 "
			" - " "	" "	11	13	14	16	40 "	169 "
10										
60%	10	14	Dry-20°C	6 inches	10	12	13	16	26 seconds	153 seconds
40%	14	20	Wet- " "	" "	10	13	13	17	32 "	167 "
			" - " "	" "	11	13	14	17	43 "	180 "
			" - " "	" "	12	14	14	18	50 "	188 "
11										
50%	10	14	Dry-20°C	6 inches	11	12	14	17	28 seconds	168 seconds
50%	14	20	Wet-20°C	" "	11	13	15	17	35 "	185 "
			" - " "	" "	11	14	15	18	48 "	197 "
			" - " "	" "	12	14	15	18	57 "	206 "
12										
80%	10	14	Dry-20°C	6 inches	9	10	12	12	24 seconds.	127 seconds
10%	14	20	Wet- " "	" "	9	11	13	13	29 "	143 "
10%	20	30	" - " "	" "	10	11	13	15	38 "	150 "
			" " "	" "	11	12	14	15	45 "	156 "

All results are for downward percolation thru mixed sizes of quartz. The percentage of each size used is given in first column.



Seconds per foot of quartz
5
10
15
20
25
30
1
2
3
4
5
6
7
Feet of quartz
All tests on mixed sizes of

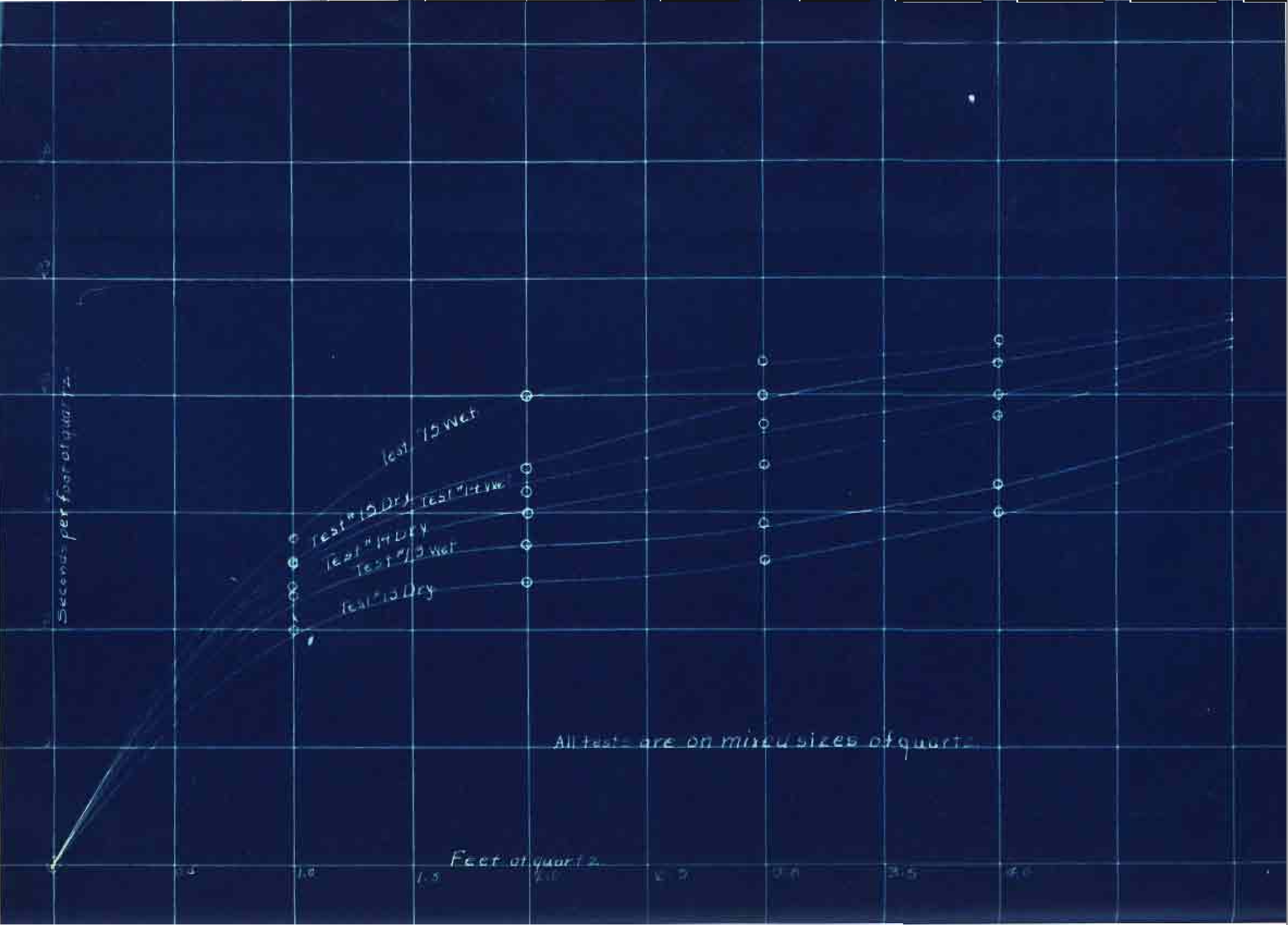

Seconds per foot of gravel
Test #9 Dry
Test #9 Wet
Test #10 Dry
Test #10 Wet
Test #9 Wet
Test #10 Dry
Test #9 "
Tests on mixed sizes of quartz
Feet of quartz



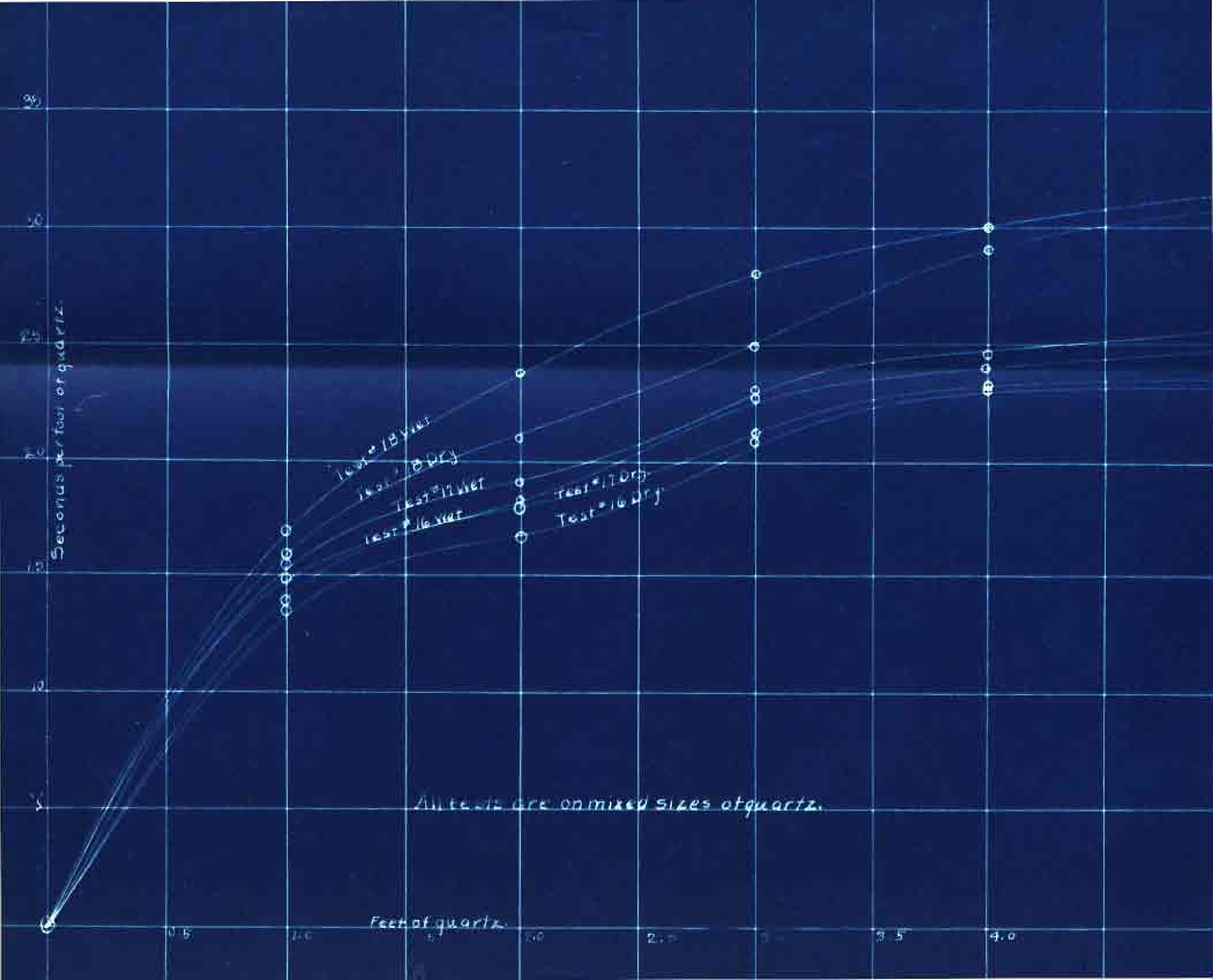
Seconds per Foot of quartz.
30
25
20
15
10
5
Test #11 Wet
Test #12 Wet
Test #11 Dry
Test #12 Dry
Tests on mixed sizes of quartz.
Feet of Quartz.
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

No 13	Size Thru	On	Conditions	Head of water	Rate of Percolation - seconds per foot of quartz 1st foot	2nd foot	3d foot	4th foot	Rate of subsidence of Head	Rate of Drainage
70%	10	14	Dry - 20°C	6 inches	10	12	13	15	31 seconds	155 Seconds
20%	14	20	Wet - 20°C	" "	11	13	14	16	36 "	162 "
10%	20	30	" " "	" "	12	14	14	16	39 "	171 "
			" - " "	" "	12	14	15	16	40 "	175 "
14										
40%	10	14	Dry - 20°C	6 inches	12	15	17	19	34 "	160 "
30%	14	20	Wet - 20°C	" "	13	15	18	20	43 "	180 "
30%	20	30	" - " "	" "	13	16	19	20	50 "	196 "
			" - " "	" "	14	17	19	21	53 "	203 "
15										
30%	10	14	Dry - 20°C	6 inches	13	17	20	21	39 "	171 "
40%	14	20	Wet " "	6 "	14	19	20	22	49 "	186 "
30%	20	30	" " "	" "	14	20	21	22	57 "	204 "
			" " "	" "	15	20	22	24	63 "	216 "
16										
20%	10	14	Dry - 20°C	6 inches	14	17	21	23	42 "	180 "
40%	14	20	Wet " "	" "	14	18	22	23	53 "	198 "
40%	20	30	" - " "	" "	15	18	23	24	64 "	221 "
			" - " "	" "	15	19	23	25	72 "	239 "
17										
40%	10	14	Dry - 20°C	6 inches	14	18	21	23	44 "	184 "
25%	14	20	Wet " "	" "	15	18	23	24	54 "	212 "
25%	20	30	" - " "	" "	16	19	23	24	65 "	240 "
10%	30	40	" - " "	" "	16	20	24	26	74 "	270 "
18										
20%	10	14	Dry - 20°C	6 inches	16	21	25	29	49 "	192 "
20%	14	20	Wet - " "	" "	16	23	26	29	63 "	225 "
30%	20	30	" - " "	" "	17	24	28	30	75 "	257 "
30%	30	40	" - " "	" "	18	25	30	31	86 "	280 "

All the tests are for downward percolation thru mixed sizes of quartz. The percentage of each size used is given in the first column.



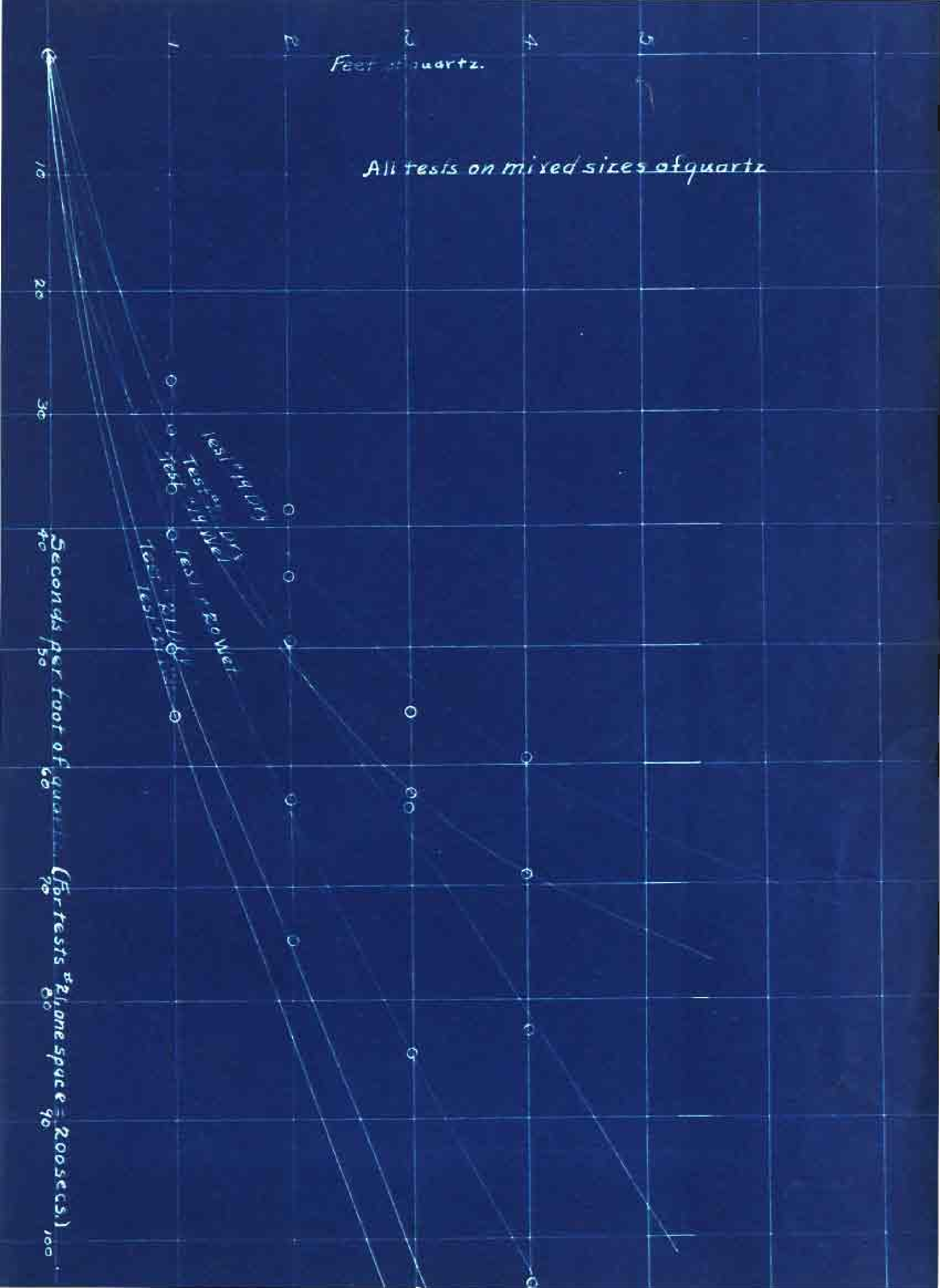
Seconds per foot of quartz
Test #15 Wet
Test #15 Dry
Test #14 Wet
Test #14 Dry
Test #13 Wet
Test #13 Dry
All tests are on mixed sizes of quartz
Feet of quartz
1.0
1.5
2.0
2.5
3.0
3.5
4.0


Seconds per foot of quartz.
Feet of quartz.
0.5
1.0
2.5
3.5
4.0
5
10
15
20
25
30
35
Test #18 Wet
Test #18 Dry
Test #17 Wet
Test #16 Wet
Test #17 Dry
Test #16 Dry
All tests are on mixed sizes of quartz.

No.	Size Thru	Size On	Conditions	Head of Water	Rate of Percolation—seconds per foot of quartz: 1st foot	2nd foot	3rd foot	4th foot	Rate of subsidence of Head	Drainage Rate
19										
26%	10	14	Dry - 20°C	6 inches	28	39	56	60	85 seconds	460 seconds
24%	14	20	Wet " "	" "	32	42	59	64	120 "	555 "
18%	20	30	" — " "	" "	37	44	64	71	140 "	695 "
18%	30	40	" — " "	" "	41	45	66	75	146 "	730 "
14%	40	60								
20										
25%	10	14	Dry - 20°C	6 inches	32	50	64	83	140 seconds	550 seconds
25%	14	20	Wet - " "	" "	36	54	73	97	192 "	685 "
20%	20	30	" — " "	" "	42	67	89	112	209 "	795 "
10%	30	40	" — " "	" "	46	[illegible]	97	128	231 "	890 "
10%	40	60								
10%	60	80								
21										
12%	10	14	Dry - 15°C	6 inches	1020	1570	2290	2790	3840 seconds	
14%	14	20	Wet - " "	" "	1155	—	—	—	—	—
13%	20	30	" — " "	" "	—	—	—	—	—	—
9%	30	40	" — " "	" "	—	—	—	—	—	—
13%	40	60								
13%	60	80								
10%	80	100								
7%	100	150								
4%	150	200								
[illegible]	200	—								

Owing to the extremely slow rate of percolation and difficulties arising from the loss of color of indicators used, further data on this test was impossible.

All results are for downward percolation thru mixed sizes of quartz. Percentage of each size used is given in first column.


Feet of quartz.
1
2
3
4
5
All tests on mixed sizes of quartz
Seconds per foot of quartz (For tests #21, one space = 200 secs.)
10
20
30
40
50
60
70
80
90
100

CONCLUSIONS.

The conclusions we arrived at from the study of percolation, under the various conditions stated, are as follows.

The rate of percolation of water through quartz is dependent upon the space in the quartz column that is occupied by air, therefore the rate of percolation is dependent upon the fineness of grinding, for the percentage of interstices decreases with the fineness of grinding. In the tests on coarse grinding, or coarser sizes of quartz, the time of subsidence of the six inch head of water, was nearly the same for the time of passage of the solution through a foot of quartz, showing the space occupied by air to be approximately equal to the space occupied by quartz. In the tests on finer sizes of quartz the time of subsidence of the six inch head increased with the fineness of the quartz particles, showing that the percentage of the interstices decreased with the fineness of the quartz particles. By refering to the tabulated data, the percentage of interstices for any test can be obtained by dividing the average time of percolation, of the solution through a foot of quartz by twice the time required for the subsidence of the six inch head.

It is our opinion that a considerable percentage of the loss of KCN in cyanidation of siliceous ores, is due to adsorption. Potassium permanganate solution and washing bluing solution lose their color, due to adsorption, in passing through pure quartz, so it seems reasonable to believe that KCN solution, would loose a part, at least, of its solid material in passing through a similar column of quartz. We believe that a series of experiments along this line would account for a large part of the losses of KCN, in cyanidation by percolation.