Robert Millikan (top center) on the steps of Ryerson Laboratory, U. of Chicago, 1908. Other colleagues (L-R): A. A. Michelson, Carl Kinsey, Henry G. Gale

ROBERT A. MILLIKAN
Oil Drop Experiment Notebooks

NOTEBOOK ONE:
October 1911-March 1912

PART 3 OF 3
From page 80 to page 124

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Abstract

Robert A. Millikan (1868-1953) began his experiments to measure the charge on the electron, e, in 1907. The experiments were performed in Ryerson Laboratory at the University of Chicago, where Millikan was professor of physics. For this work, and for work on the photoelectric effect, Millikan was awarded the Nobel Prize in physics in 1923.

Millikan gives his own account of the electron charge determination in his published autobiography in the chapter titled "My Oil-Drop Venture (e)" (Robert A. Millikan, *The Autobiography of Robert A. Millikan*, New York, 1950). With the aid of graduate students Louis Begeman, Harvey Fletcher, and J. Y. Lee, Millikan devised the method of measuring the rate of fall of a single electrically charged oil drop under the forces of gravity and electricity. From 1909 until the spring of 1912, Millikan reports, he spent every available moment in the laboratory on his oil-drop experiment. His first comprehensive, though to some extent preliminary, results were published in September 1910 in the journal *Science* as "The Isolation of an Ion, a Precision Measurement of Its Charge, and the Correction of Stokes' Law," *Science* 32: 436-448. He soon became embroiled in a controversy with the Viennese physicist Felix Ehrenhaft, who claimed to have found much smaller electric charges. Millikan went back to work on a new

set of experiments. By the spring of 1912 he had collected the data for what he termed "the final, absolute determination of the numerical value of the electron" (*Autobiography*, p. 84). Results were published in August 1913 in "On the Elementary Electrical Charge and the Avogadro Constant," *Physical Review* 2: 109-43. This last, definitive set of experiments were recorded in the only two lab notebooks which Millikan preserved among his papers. These two notebooks are presented here in facsimile. They cover the period from October 1911 through April 1912 and contain what Millikan himself considered his conclusive, historic work on this problem.

For an analysis of Millikan's notebooks and a defense of his experimental method, see the article by David Goodstein, "In Defense of Robert Andrews Millikan," published in *American Scientist* 89/1 (Jan-Feb. 2001): 54. http://www.americanscientist.org/issues/num2/2001/1/in-defense-of-robert-andrews-millikan/1

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405) Friday - Feb. 16, 1912 $\theta = 23.0$ $P = 28.0$ 72.9 - 44.9

Volts at 4:05 PM.

848 + 12.9
842 + 13.1
824 + 14.5
855 + 12.8
827 + 14.3
841 + 13.2
5037 + 80.8 = 5117.8

y		F	
½	'	½	'
29.4	59.3	~~23.5~~	22.8
29.0	59.4		23.0
29.0	59.8		
	59.8		

Second Observation.

$\theta = 33.00$

Volts at 5.10

$P = 28.88$

848 + 12.9
839 + 13.2
821 + 14.8
854 + 12.8
826 + 14.5
840 + 13.2
5028 + 71.4 = 5099.4

G		F	
12.2	24.0		
12.3	24.0		
11.9	24.0		
	24.170		10.354
	24.014		
	24.114		
	24.280		12.464
	24.108		
			22.138
			51.3 —
	24.108		
	24.086	18.0 —	35.7 —
	24.008	62.6 — 1st div.	
		60.7 — 2nd div.	
		63.9 — 3rd div.	
		57.8 — 4th div.	
		60.0 — 5th div.	
		58.7 — 6th div.	
		58.8 — 7th div.	
		59.6 — 8th div.	
	24.210		
	24.386		~~16.8~~
			34.334
		46.00	92.30

Finished at 5.05

35)

Saturday, Feb. 17th 1912

Observation at 3:00 P.M.

$\theta = 23.0$ $\quad p = \frac{75.75}{41.65} \\ 34.10$

Volts at 2145

856 + 12.8
848 + 12.9
840 + 13.2
862 + 12.8
840 + 13.2
848 + 12.9
5094 + 77.8 = 5171.8

S		F	
16.6	32.6		
16.3	32.7		
16.0	32.3	47.6	94.4
16.6	33.2		

Lost at 3:07

Second Observation at 3:30 $\delta = 23.0$ $p = 36.17 \sim 36.04$ (37)

Volts at 3:10

856 + 12.8
848 + 12.9
839 + 13.2
862 + 12.8
839 + 13.2
847 + 12.9
5091 + 77.8 = 51688

G.		F
10.418		9.862
10.464		9.988
10.438		9.956
10.342		9.508 (?)
10.422		
10.470	23.7 —	46.8 —
10.414		
10.406	47.6	94.4
10.402		15.702
10.476		17.622
	18.9	37.8 —
	31.7	62.6 —
	31.6	62.6 —
10.430		
		23.106
10.500		23.302
	11.9	23.7 —
	32.0	63.4 —
		63.2 —
	48.4	95.8

Finished at 3:45

Third Obs. at 4:00   θ = 23.0   p = 76.95 / 40.15 / 36.80   77.05 / 40.10 / 36.95

Volt at 3.50 — 856 + 12.8
847 + 12.9
837 + 13.4
861 + 12.8
835 + 13.6
847 + 13.8
5083 + 78.5 = 5161.5

	G	F	
	20.362		13.678
	20.418		13.590
	20.380		
10.2 —	20.3 —	18.3 —	35.8 —
	20.394	25.2 —	49.8 —
	20.442	39.9 —	79.0 —
	20.340	102.2 —	202.8 —
	20.358	101.6 —	203.0 —
	20.324		
	9) 183318		
	20.369		

1/13.64 = .07331

1/35.8 = .02793

1/49.8 = .02008

1/79 = .01266

1/203.9 .004928

1/20.37 = .04909

Differences

.07331
.02793
6) .04538
.007397

2008   .01266
1266   .004928
.0742   .007732

Agreement fair. Will not work out

4909
7331
16) .12240
.00765

4909
2793
10) 7702
.007702

2008
4909
9) 69178
.007686

4909
1266
7) 6175
7719

4909
492
[5492]
7728

mean .007695

Fourth Ob. at 5:15 θ = 23.   p = 68.45 / 50.20 / 18.25

Volt at 4.23

854 + 12.8
847 + 12.9
836 + 13.6
860 + 12.8
833 + 13.4
845 + 13.0
5074 + 78.5 = 5152.5

G	F		
	64.0 —	127.0 —	$\frac{1}{127}$ = .007874
14.456		23.296	
14.464		23.300	$\frac{1}{23.28}$ = .04296
14.522		23.206	
14.522		23.310	
14.588	11.6 —	23.2 —	$\frac{1}{45.6}$ = .02193
14.540	23.4 —	45.6 —	
14.466	33.6 —	67.1 —	
14.548	33.4 —	66.6 —	$\frac{1}{66.7}$ = .01499
14.514	33.6 —	66.4 —	
~~14.564~~	17.6 —	34.4 —	$\frac{1}{34.4}$ = .02907
14.470	17.0 —	34.2 —	
11) 159.40			
14.509			

finished at 5:32

$\frac{1}{14.509}$ .068925 × 1022 = .07044

Log −2.847819

½ " = −1.4239

Pressure at 5.15 − 18.25
5.28 − 18.45
5.35 − 18.45

Differences

.04296	.04296	4296	2907
.007874	2193	1499	1499
5) .035086	3) .02103	4) 2797	2) 1408
.007017	.007010	.006993	704

.068925	68925	68925	68925	68925
7874	4296	2193	1499	2907
11) .076799	16) 111985	13) 90855	15) 83918	98256
.006981	.006999	6989	6993	7018

Mean = .006996 × 1022

$v_1 + v_2$ = .007150

Log = $\bar{3}$, ~~854~~306
1.42391
3.1983
6.476516
3.712229
10.764287

Volt 5155

e_1 = 5.8113

Apr/ 7 4th Obs. θ=23.2 P= at 5:57 68.79 / 49.73 / 19.06 at 5:55 68.85 / 49.75 / 19.10

at 5:40

Volts at 6:20
849+12.9
838+13.4
823+14.5
853+12.8
823+14.7
840+13.2
5028+81.5=5109.5

G		F
17.232	—	23.2 —
17.382		23.0 —
17.320		23.100 $\frac{1}{23.1}$=.04329
17.346	11.6 —	22.9 —
	27.4	1st div.
	—	2nd div
	—	3rd div
	28.1	4th div
	27.0	5th div
	28.0	6th div
	28.67	7th div
	—	8th div
17.324	27.6	1st div.
5/160.4	28.2	2nd div
17.321	28.2	3rd div
	28.4	4th div
	27.9	5th div
	28.1	6th div
	27.8	7th div
	27.4	8th div.
	22.3.0	

Finished at 6:15

$\frac{1}{17.321}$ =.05773 × 10²² = v_1=.05900

Log = -2.770852

$\frac{1}{2}$ .. = -1.38542

mean 22.30 $\frac{1}{22.3}$=.004484

= v_1 = .045526

Diffs

.04329
.004484
5) .038806
.007761

.05773
.004484
8) .062214
.007777

.05773
.04329
13) .10102
.007771

mean = .007774 × 10²²

= v_1+v_2 = .07945

Log = -3.900094
-1.38542
-3.1963
-6.4838
3.7084
-10.7754

5.962
4
e_1 = 5.966

Lon Premier

Beginning with Oil bath. not entirely covered with oil.

Friday - Feb. 23rd 1912.
Obs. began at 4:50 P.M.

$\theta = 23.2$ $P = 94.3 - 19.4 = 74.9$

Volts at 5:30

1 - 7:35 +18.0
2 - 857 +12.8
3 - 848 +12.9
4 - 522 +06.0
2962 + 49.7 = 3011.7

G		F		
21.4	42.6	33.8	68.4	
21.3	42.9	58.3	117.4	$\frac{1}{67.85} = .01474$
21.6	43.1	24.3	47.7	
22.0	43.3	34.0	67.3	$\frac{1}{47.325} = .02113$
21.0	42.8	23.6	47.2	
21.6	42.9	18.0	36.2	$\frac{1}{36.1} = .02770$
21.4	43.4	24.0	47.5	
21.0	42.7		36.0	$\frac{1}{117.4} = .008518$
21.6	43.2	23.6	47.0	
	1)426.9			
	42.98			

$\frac{1}{42.98} = .02327$ $\times 1022 = .02378$

$\log = -2.376212$

$\frac{1}{2}\log = -1.188111$

Finished at 5:25 P.M.

Differences

.02327	.02327	.02327
.01474	.02113	.02770
00853	00214	00443
00639	00444	00514
	6)012612	6)019182
	002102	3197
	6306	

mean = .006363

.02327	.02327	.02327	23277
.01474	.02113	.02770	8518
00853	00214	00443	14759
6)038017	6)044440	6)050970	6)31806
006335	006343	6375	6362

mean = .006354 $\times 1022$

$= v_1 + v_2 = .006494$

$\log = 3.812512$
-1.18811
3.1963
6.198922
3.47881
-10.72011

5.2495
70

$e_1 = 5.2565$ Const $= 5.310$

1.0 % low

74

Saturday Feb. 24th 1912

[1067 = middle
7 plates]

First Obs at 3:15 θ = 23.5

p = 94.45 − 19.15 = 75.30

Volts at 3:05 − 858 + 12.8
856 + 12.8
848 + 12.9
863 + 12.8
836 + 13.6
851 + 12.9
5112 + 77.8 = 5189.8

G	~F	
15.750		8750
15.712		31.4
	15.6	31.2
15.748	19.6	39.2
	19.9	39.0
15.626	12.9	25.6
	12.9	26.0
	13.0	26.0
15.680		
15.564	26.4	52.2
15.716	26.0	51.8
15.666	26.3	52.2
	26.3	52.0
15.712	26.2	51.9
15.676		39.2
10)6850		
15.685		

$\frac{1}{31.3} = .03195$

$\frac{1}{39.1} = .02558$

$\frac{1}{25.87} = .03856$

$\frac{1}{52.02} = .01922$

$\frac{1}{39.2} = .02551$

Finished at 3:45

$\frac{1}{15.685} = .06375 \times 1.022 = .06515$

Log = −2.812914

$\frac{1}{2}$ " = −1.406957

Differences

.03195	.03856	.03856	.02551
.02558	.02558	.01922	.01922
.00639	2).01298	3).01934	.00629
	.06490	.006413	

mean = .006398

.06375	6375	6375	6375
.03195	2555	3861	1922
15).09570	14)8930	16)10236	13)4297
.006380	.006379	.006394	.006382

mean = .006384 × 1.022

= $v_1 + v_2$ = .0065244

Log $v_1 + v_2$ = −3.814541
$\frac{1}{2}$ " v_1 = −1.406957
−3.1985

−6.419798
3.714414
10.705384

Mean with 5181

50743
115
5086

Amnt = 5138

1.0% low

Second Observation $\theta = 23.7$ $P = 9430 - 19.25 = 76.08$

4:05 Volt at 3:55

857 + 12.8
855 + 12.8
843 + 13.1
862 + 12.8
832 + 13.8
849 + 12.9
5098 + 78.2 = 5176.2

G		F	
11.6	1st div		
11.4	2nd div		
11.9	3rd		
11.7	4th		
11.8	5th		
11.5	6th		
11.4	7th		
11.3	8th		
92.6			
11.9	1st	—	25.2 *
11.7	2nd		
12.0	3rd		
11.0	4th		
11.4	5th		
11.6	6th		
12.0	7th		
11.6	8th		
93.2			44.018
23.6	(1+2)		
23.4	(3+4)		
23.6	(5+6)		
23.0	(7+8)		25.457
93.6			
47.0	93.5		44.094
	93.8		

mean = 93.52

Finished at 4:28

Difference
.03929
.02270
.01659

.01070 .01070
.03929 .02270
3) .04999 2) .03340
.01666 .01670

mean = .01667 × 10²²

$v_1 + v_2 = .01693$

$v_1 =$

Log $v_1 + v_2 = -2, 22866$
$\frac{1}{2}$ " $v_1 = -1, 01941$
-3 1463
-6.44637
3.71332
-10.73305

$\frac{1}{44.06} = .02270$

$\frac{1}{25.45} = .03929$

mean coll. 5166

5.408
17
5.425

Corrected to $\left(\frac{a}{10^4}\right)$ = 5.417

Corrected = 5.448

1.5 % low

Cf with Simone Feb 13th

$\frac{1}{93.52} = .01070 \times 10^{22} = .010933 = 3v_1$

Log = $-2, 03882$

$\frac{1}{2}$ " = $-1, 01941$

a
-16.9270
3.7133
-2.0388
-14.1791
-2.2287
3) -13.9504
-5.0835 .00009628 = a
1.8754
-3.6589
2.1411

$l = .00009570$
-6.9805
-5.9836
-1.9970
$.09933 = \frac{l}{a}$

13840 = $\frac{l}{2a}$

$e^{2/3}$
3) -10.7338
-4.9913
-7.8226
$66.47 = e^{2/3}$

31

Third Observation — 4:40 (No 1)

θ = 23.7 Volts at 4:30

p = 9435 − 19.15 = 75.20

856 + 12.8
854 + 12.8
838 + 13.3
861 + 12.8
830 + 14.1
849 + 17.9
5088 78.7 = 5166.7

G		F	F	
1214 — ~~250~~				
25.486	——	23.6 —	$\frac{1}{23.6}$ =	.04237
25.354	——	19.834	$\frac{1}{19.83}$ =	.05043
25.376	28.4 —	56.6 —		
25.350	28.4 —	56.5 —	$\frac{1}{56.55}$ =	.017685
25.398				
25.358	52.4 —	104.0 —	$\frac{1}{104}$ =	.009615
6)152302				
25.384				

$\frac{1}{25.384}$ = .039396 × 1.022 = .040263 = V_1

Log = −2.604907

$\frac{1}{2}$ = −1.30245

Finished at 4:55

Differences

.017685 − .009615 = .008070

.05043 − .017685 = 4)032745 = .008086

.04237 − .017685 = .024685 ÷ 3 = .008228

mean = .008128

.039396 + .05043 = 11).089826 = .008166

.039396 + .017685 = 7).057081 = .008154

.039396 + .009615 = 6).049010 = .008168

mean = .008163 × 1.022 = .0083428

Log = −3.921286
$\frac{1}{2}$ = −1.30245
−3.1983
−6.422036
71345
70888
5.1135
158
e_1 = 5.1313 Corr'd = 5.706
e_1 = 5.124 drum corr
1.46 % less

$e^{2/3}$

3)20.7102 −30
6.9034 −10
2
13.8068 −10
11.6409 −10
.6403 = $e^{2/3}$

reduced 1% for drum corr

a

16.42772
3.71315
2.60491
14.74506
−3.92128
3)12.82378
7.27459
1.67623
a = .0001882

log p a = 2.15082
log 1/pa = 1.8492
1/pa = 7.067

l = .000009518

−4.8547
1.8762
−6.9785
−4.2746
27039

l/a = .05067

pa = .01415

No 2 ✓ Fourth Observation   θ = 23.5   p = 94.4 − 19.1 = 75.3

48

Volts at 4:56

G	F	
	49.0	97.1
12.572	31.7	62.9
12.522	31.4	62.8
12.578		
	27.6 − 1st div.	
	27.4 − 2nd "	
	27.4 − 3rd "	
	27.2 − 4th "	
	26.4 − 5th "	
	27.3 − 6th "	
	26.1 − 7th "	
12.574	25.2 − 8th "	
	214.6	
12.420		36.6
		37.0
12.594		36.8
12.544	18.5	37.0
12.562		63.0
12.510		
12.514		
10) 125.400		
12.54		

$\frac{1}{97.1} = .01030$

$\frac{1}{62.85} = .01591$

$\frac{1}{214.6} = .004660$

$\frac{1}{36.65} = .027135$

$\frac{1}{63} = .01585$

Beauty

856 + 12.8
854 + 12.8
837 + 13.0
861 + 12.0
830 + 14.1
848 + 12.9
5086 + 74.0 = 5160.8

Volts at 3.30

856 + 12.0
853 + 12.0
836 + 13.0
860 + 12.0
828 + 14.3
848 + 12.9
5081 + 78.2 = 5159.0

Differences.

.01591 − .01030 = .00561
.01591 − .00466 = 2) .01125 = .00562
.027135 − .00466 = 4) .022475 = .005619
.027135 − .01585 = 2) .011285 = 5642

mean = .0056225

.07974 − .01030 = 12) .06944 ... .005627 (divisor partly legible: "16)")
.07974 − .01591 = 11) .06383 ... .005625 (partly legible)
.07974 − .00466 = 13) .07508 ... .005629 (partly legible)

.07974 − .027135 = 14) .052605 = .005625 (partly legible)
7974 − 1585 = 11) 6389 ... 5623 (partly legible)

5627
5625
5629
5625
5623
.0056244

$\frac{1}{12.54} = .07974$

Finished 5:28

$v_1 + v_2$ = mean = .005623 × 1022 = .005746

$v_1 = .07974 \times 1022 = .08149$

Log = −2.91062
$\frac{1}{2}$ = −1.45531

$\frac{a}{}$
−16.4270
3.7128
−2.9106
−13.0508
3.75940
3) −11.2915
4.4305
$\log \frac{1}{l}$ = 1.6768
3.3073

$\log \frac{1}{l}$ = 2.6927

l = 4505
4.6547
1.6768
6.4779
−4.4305
2.5479

Log = −3.75906
−1.45531
−3.1962
6.41265
3.7128
−10.9000

$\frac{l}{a}$ = .03527 ... 3.844
a = .000269 ... .000269
p = .000203 ...

5.0170
185
5.023 = e_1
5.017 = 1.57 % low

$e^{2/3}$
3) −10.7019
6.9006 − 10
13.8012 − 20
6327 × 10⁵ = $e^{2/3}$

correct = 5.113   Error 2%

$\frac{1}{l_{na}}$ = 4952

Publish this Beautiful one — good for showing method of computation and how e can be made out of p...

Tuesday - Feb. 27th 1912   θ = 22.8   p = 94.3 - 19.2 = 75.1

First Observation

Began at 3:10 P.M.

Volts at 2:50 P.M.

G		F	
28.6	58.4		293
29.4	58.8		

Finished at 3:14 P.M.

855 + 12.8
859 + 12.8
841 + 13.2
864 + 12.8
838 + 13.4
852 + 12.9
5109 + 77.9 = 5186.9
+ 16
5186.6

1/586 = .01706 × 10⁻²

1/293 = .03413

.02119 × 10⁻² = .05265 = v₁ + v₂

This curve not yet plotted on account of error P.V.O.

Log = -2.23510
½ = -1.11755
Log -2.71820
-1.11755
3.1985
5.03406
3.7120
1.32204
4) 20.992
5.248
5
5.243

e₁   5.375 ...

2.5% low

.013066

Log -2.1161

a

-16.4270
3.7120
-2.1351
-14.3741
-2.1161
3) 12.2580
-4.0860   .0001219 = a
1.8756
-3.9616   .009154 = pa
12.0384   109.2 = 1/pa

l = .00000958

-4.85474
1.8756
-6.97914
-4.0860
-2.89314

.07818 = l/a

$e^{2/3}$

3) -10.7845
6.9065 - 10
2
13.8130 - 30
81.30 ... = $e^{2/3}$
65.02 =

l = 9340

-4.8547
1.8756
6.9791
-4.4634
-2.5157
l/a = .03278

a

-16.4470
3.7118
-2.4772
-13.1160
-3.7259
3) -11.3901
-6.4634 - 10
1.8756
...

a = .0002907

-2.3390 = log pa
.02183 = pa
1.6610
45.81 = 1/pa

$e^{2/3}$

3) -10.7008
6.9003 - 10
2
-7.8006
63.19 = $e^{2/3}$

Feb. 27th 2nd [illegible]

No 3 (48)

$\theta = 22.85$ $p = 94.35 - 19.15 = 75.2$

Volts at 3:15

855 + 17.0
858 + 17.0
839 + 12.8
864 + 12.8
834 + 13.7
852 + 12.9
5102 + 78.3 = 5180.3
− 18
5162

G	F	
10.744	18.3	36.6
10.782	18.6	36.7
10.746	18.3	36.7
10.756	18.6	36.6
10.756		36.6
		10.644
		10.646
10.784	18.5	36.6
10.738	23.4	45.4
10.762	23.4	45.6
10.862	15.6	30.7
10.784	15.6	31.2
10.692	15.6	31.1
10.740		31.2
10.730	16.0	31.2
	135.8 − 1st dir	
	131.7 − 2nd	
	120.0 − 3rd	
	130.0 − 4th	
	134.8 − 5th	
	147.0 − 6th	
	147.8 − 7th	
	150.2 − 8th	
10.712	23.4	45.6
10.806	23.4	46.2
10.612	18.6	37.2
10.884	15.5	31.4
10.652	15.6	31.2
10.816	30.6	61.0
10.742		61.0

$\frac{1}{36.64} = .02729$

$\frac{1}{10.645} = .09394$

$\frac{1}{45.5} = .02198$

$\frac{1}{31.1} = .03215$

1097.3

$\frac{1}{1097} = .0009115$

$\frac{1}{45.9} = .02179$

$\frac{1}{37.2} = .02688$

$\frac{1}{31.3} = .03195$

$\frac{1}{61} = .01639$

Beauty — One of the very best

Differences

.09394 − .02729 = 13) .06665 = .005127
9394 − 2198 = .00531 (sic)
9215 − 2144 = 2) 1017 = 5085
2688 − 2179 = 509
3195 − 1639 = 3) 1556 = 5187

.03215 − .00091 = 6) 3124 = 5207
2199 − 91 = 4) 2088 = 5220

5127
5310
5085
5090
5187
5207
5220
7) 1226 = 5190

.09294 − .02729 = 23) .12023 = .005227
9294 − 9394 = 36) .18688 = .005191
9294 − 2198 = 7) 1149 = 5224

9294 − 3215 = 24) 12509 = 5212
9294 − 91 = 18) 9385 = 5214
9294 − 2179 = 22) 11473 = 5215
9294 − 2688 = 23) 11982 = 5210
9294 − 3195 = 24) 12489 = 5204
9294 − 1639 = 21) 10933 = 5206

5227
5191
5224
5212
5214
5215
5210
5204
5206
9) 1403 = 5211

ue 3 — bell shaped field

Weighted diffs.

5207 × 6
5127 × 3
5310 × 1
5220 × 4
5187 × 3

5200

Mean of last three avg. 5207, 5220, 5213

Mean = .005211 × 1021
= $v_1 + v_2$ = .005204

Log = −3.72544
−1.45861
3.1683
−6.41585
3.7129
−10.69995

.5010
3
$e_1 = 5007$
$R = 2.001$

$e^{2/3}$ 6991
3) −14.2?22
7.7994
$e^{3} = 63.00$

Fine one

mean volts 5163

Finished at 4:26

$\frac{1}{10.758} = .09294 \times 1021 = .09469 = v_1$

Log = −2.97722
−1.45861

Feb. 27 — 204 — 46

Third Check at 11:40

$\theta = 22.87$ $p = 94.2 - 19.28 = 75.0$

Volts at 4:27

851.0 + 12.9
853.0 + 12.8
837.0 + 14.3
861.0 + 12.8
837.0 + 14.3
849.0 + 12.8
5068.0 + 79.9 = 5147.9

G		F		
13.582	—	16.450	16.450 = .06079	
13.588	—	20.458		
13.504	—	20.492	20.431	.04895
13.572	—	20.366		
13.544	62.8	126.0		
13.542	63.9	127.6	126.66	.007893
13.648	63.6	126.4		
13.582	—	27.010	26.932	.03713
13.536	—	26.854		
13.500				
13.580				
13.578				
13.562				

Difference

.04895 − .00789 = 7) .04106 → .005866
.06079 − .04895 = 4) .02184 → .00546
.03713 − .00789 = 5) .02924 → .005848
~~.04895 − .03713 = 2) .01182 → .00591~~

mean = .005857

.072746 − .06079 = 21) .13836 → 5849
.073746 − .04895 = 21) .122696 → 5842
.073746 − .007893 = 11) .081639 → 5837
.073746 − .03713 = 19) .110876 → 5835

mean = .0058392 × 1.021

$v_1 + v_2$ = .0059618

Log = −3.77538
−1.43836
3.1983
6.41206
3.71095
10.70711

mean volts = 5139

5.0250
36
5.022
5.031
1.8% low

5144 = const.

Error 5%

Corrected for mean 95847 / 95839 =

e_1 = 5.016

Prob. Acme 4.5%
too low judged
from diff. but
5857 + 5839

5:00 P.M.

$\frac{1}{1356} = .073746 \times 1.021 = .075294$

Log = −2.87676
$\frac{1}{2}$ = −1.43842

$P = .0000009542$

a

−16.42790
3.7108
−2.8768
−13.0146
−3.7754
3) −11.2382
−4.4181
1.8751
−2.2882
−1.7138

.0002884 = a

51.50 = 5.173 ka

−4.9547
1.8751
−6.9798
−4.4131
−2.5665

.03686 = l/a

3702
3697 = l/a

$e^{2/3}$

3) −10.7017
6.9006 − 10
2
−7.8012
6326

7003
3) 19.0006
−7.8002
63.13 = $e^{2/3}$

Feb. 27th

$\theta = 22.86$

$p = 94.2 - 19.2 = 75.0$

Fourth Observation at — 5:15

Volts at — 5:05

No 5 (~~No 6~~)

Harwood

Dif. to correct

V. Justified

in Surface.

Perhaps. Publish

850 + 12.9
851 + 12.9
830 + 14.8
860 + 12.8
827 + 14.3
848 + 12.8
5066 + 80.6 = 51365

G		F
6.354	—	9.756
6.394	—	9.776
6.468	—	9.572
6.402	35.6	70.6
6.388	35.6	70.8
6.448	35.2	70.4
6.492	35.6	70.5
6.424	—	70.8
6.454	—	29.416
6.438	—	29.384
6.430	—	29.440
6.430		33.2
6.492		33.388
6.494		33.460
		33.366
	84.0	166.5
6.504	—	166.6
6.446		
14	7048	
	6.4405	

$\frac{1}{9.700} = .1031$

$\frac{1}{70.62} = .01416$

$\frac{1}{29.41} = .03400$

$\frac{1}{33.405} = .02994$

$\frac{1}{166.5} = .006004$

Finished at 5:45

$\frac{1}{6.44} = .1553 \times 10^{-1} = v_1 = .15828$

Log = −1.20019
½ " = −1.6001

$l = .000079542$

Log new v_1 = 1.1965
" ½ = −1.5983

Differences

.1031
.1416
23)).08894
4043

.03400
.01416
.5).01984
3968

.03400
.02994
.00406

.02994
.006004
6).23934
3989

.03400
.006004
7).27994
3999

3999
3989
3968
4043
4)15999
.004000

.1031
.1553
64)2584
4037

.1553
.1416
4).16946
4035

.1553
.03400
4).15930
4028

.1553
.02994
46)18524
4027

.1553
.006004
4)161304
4032

4037
4035
4028
4027
4032
5)20159
4032

mean of 4032 + 4000 = .004016 × 10^−1

= $v_1 + v_2$ = .004100

Log = −3.61278
½ " = −1.6001
3.1983
−6.41118
3.70995
14.70123

mean Volts = 5134

Take rather 4000 as correct

then ½ = .1540
instead of .1553
deriv. when v₂ = 1.4094

Log = −3.61117
−1.5988
3.1983
6.4077
3.7190
−10.6977
4.886
3
Correct = 5075 4.983
= e
e = 4.977

5.026
3
5.023

.5% low

Prob. by error .8% too high

Judged from dif but 4000 & 4032

a

−16.4270
3.7099
−1.1965
−13.3334
−3.6178
3)−11.7223
−4.8774
1.8751
−2.4449
1.5506

.000 3754 = a = 3743

−4.8547
1.8751
−5.9786
−4.5744
−1.4052

6.9946
−4.5748
−2.4048

.02543 = $\frac{l}{a}$
.551

4495
5505

3553 = $\frac{1}{pa}$ = final
= 3564
3544 = $\frac{1}{pa}$
pa = 3564

$e^{2/3}$

3)10.7000
−4.9003
7.8006
63.18 = $e^{2/3}$ = 6284

16.6975
3)14.3950
−7.7983

Have not yet corrected this drop. yet

#) 7 Feb. 27th
Fifth Observation

no 6

45

θ = 22.8 P 9425 − 1425 = 7750

Vaktart − 5.46

950 + 12.9
850 + 12.9
817 + 15.0
860 + 12.8
825 + 14.5
848 + 12.8
3050 + 70.9 = 5120.9

Valtart 6:15

850 + 12.9
849 + 12.9
807 + 15.7
860 + 12.8
825 + 14.5
847 + 12.9
5038 + 81.7 = 5119.7

G		F	
8.328	—	50.266	$\frac{1}{5026} = .01989$
8.554	—	50.252	
8.664	—	50.4 —	
8.414	—	16.450	$\frac{1}{16.48} = .06068$
8.644	—	15.450	$\frac{1}{15.45} = .06473$
8.612	—	21.166	$\frac{1}{21.19} = .04719$
8.460	—	21.220	
8.344	85.6	170.0 —	$\frac{1}{171.9} = .005817$
8.512	87.6	173.8 —	
8.390			
84922			
8.492			

Dif's

06068 .04719 4719 6473
01989 5817 19/54
9|.040679 6|.027330 9|4137. 448
.004532 .004550 4597

4587
4550
4532
3|11679
4560

6:15 P.M.

1178 1178 1178
1989 4719 5817
30|.13769 36|.16499 27|.1236
4590 4583 4580

mean = 4584

$\frac{1}{849} = .1178 \times 1021 = V_1 = .12027$

$\log = -1.08015$

$\frac{1}{2}\log = -1.54008$

mean of both = .04572 × 1021
$= V_1 + V_2 = .04668$

$\log = -3.669131$
-1.54008
3.1983
6.407511
3.70927
10.69824

4992
4
e, = 4.988 5061 corrected
e, 4.982
1.46% low

f = 9542

a

-16.4270
3.7043
-1.0802
-13.2165
3.6691
3|11.5474
-4.5158
1.8751
-2.3409
1.6091

-6.4796
-4.5158
-2.4638
.02419 = f/a

.0003279 = a

3270
3264

e^{γ_3}

3|-10.6479
-4.8993
-7.7986

.4066 = fa

4074
4085

62.88 = e^{γ_3} = 62.82

Wednesday - Feb. 28 - 1912 $\theta = 22.8$ $P = 6092 - 59.00 = 1.92$

First Observation. Volts at 11.55 = 853 + 12.8 = 865.8

5:00 P.M.

G		F	
31.0			
32.0			
31.2	61.6 —	—	9.9 —
30.4	63.8 —	—	10.1 —
4)46	1254		
31.15	62.7		

$\frac{1}{10} = .1000$ $.01595$

$.11595 \times 1021 = .11838 = v_1 + v_2$

$\frac{1}{62.7} = .01595 \times 1021 = .016285 = v_1$

$\log = -1.0738$
-1.1059
-3.1983
-5.3775
2.9374
-8.4401

$\log v_1 = -2.2117$

$\frac{1}{2} n = -1.1059$

$e_n = 275.5$

$e_1 = 138. = 91.8_m = 69.0_w = 55.1$

Cant compute

a

-16.4×70

$2.93 \quad 4$

Second Observation Wed - Feb. 21 — θ=22.8 P = 58.38 − 62.49 = 3.11

5:20

Volts at 5:41 = 850 + 12.0 = 862.0

G		F	
10.504		8.108	$\frac{1}{8.093}$ = .1236
10.566		8.064	
10.628		8.106	
.		15.770	
10.636		15.764	$\frac{1}{15.789}$ = .06333
10.578		15.834	
10.836			
10.588		8.018	$\frac{1}{8.02}$ .1247
10.544		15.826	$\frac{1}{15.8}$ .06329
10.586		15.770	
10.486		38.440	$\frac{1}{38.42}$ .02519
	143−	28.4—	
10.570	142−	28.418	
		28.4—	
10.458		30.662 (?)	$\frac{1}{30.66}$ = .03261
14.6980			
10.582			

Finished at 5:40

$\frac{1}{10.58}$ = .09452 × 1.021 = v_1 = .096504

Log −2.98454
½ 1.2 −1.49227

l = .0007301

no 66

700

.1236 − .06333 → 24) .06027 → .002511
.06329 − .03519 → 11) .02810 → .002554
.1247 − .06329 → 24) .06141 → .002558
.03519 − .03261 → .00258

.002541

.09452 + .1236 → 86) .21812 → .002536
.09452 + .06333 → 62) .15785 → .002545
.09452 + .03519 → 51) .12971 → .002541

mean = .002541 × 1.021 =

$v_1 + v_2$ = .0025944

Log = −3.41404
− 1.49227
3.1483
−6.10407
2.93557
~~4.16870~~
4.1685
14.76 (14.74, 14.75 Compute)

e_1 = 14.75

a
16.42705
2.9358
−2.4845
−14.3408
−3.4140
3) 12.9269
−4.3090
.4928
−4.8018
3.1982 (8018)
3.3461

−4.8547
4928
−4.3619
−4.3090
.0508 (.0529)
= .1124 = l/a

.1130 = l/a

.0002046 = a (2000 = a)

1578 = 1/pa
1973 = 1/pa

e^{2/3} = 12.94

4.1682
3) 18.3364
6.1121

3) 4.1687
−3.0562
−6.1125 × 10⁻⁸
12.955 = $e^{2/3}$

10.46136
2.9855
7.31686
3.41404
5.48282
4.3090
1.67382
0002
1.67402
.32598
2.1185
Log 1.118 = .0485
3.1982
4.8503
b = 70.85

k/1/K

.0485
.0529
.9956

A = .9900

Third Observation Wed. Feb. 28. θ = 22.8   P = 61.74 − 5809 / 3.65

No 8

Volts at 846 + 12.9 = 860.4
6:20

G		F	
17.6	35.8		21.7
	35.584		22.080
	35.912		22.036
18.0	36.2		22.196
17.6	35.2		21.940
	35.872		22.398
	35.4	29.4	57.8
18.0	35.5	29.0	57.6
17.5	35.2	29.0	57.7
18.0	35.5	19.3	37.8
17.6	35.2	19.2	38.6
~~18.6~~		18.6	37.6
17.6	35.8	18.9	37.5

1/22.13 = .04519

1/57.7 = .01733

1/37.875 = 26.41

1619 1x 1672
1774 35.60

6:20

1/35.6 = .02809 × 1.021 = .02826
02806

Log = −2.4573
1/2.11 = −1.2287

Differences

.04519 − .01733 = 3)02786 = .00929

2641 − 1733 = 908

.02806 − .04519 = 8).07328 = .00916
2806 − 1733 = 5).04542 = .009084

2806 − 2641 = 6).05450 = .009083
.009084
.009160
3).27327
mean = .009109

× 1.021 = .009287

Log = −3.9678
−1.2287
3.19776
−6.3943
−2.9306 = 861
−9.4599
e = 2.880

e = 3.2918
e₁ = 3.23

3.14.9186
.6.3062
e^{2/3} = 202.4

a
76.4209
−2.4573
+2.9350
−15.8192
−3.9678
3)−13.8454
−5.9483
.5625
−4.5100
−3.4880
4890

.0005882 = a

3088
3044
3092
3155 = 1/pa

l = .0001461
−4.8547
5625
−4.2922
−5.9483
.3439
2.2099 = l/a

e^{2/3}
3)−4.5106
−3.1702
−6.3404
−9.5303
3)1.99246
1.33082
e = 218.6

219.0 × 10⁻⁸ = e^{2/3}

al
−10.46136
2.9350
−7.39636
−3.9678
−5.42856
−5.9485
−1.48006
.0002
−1.4803
Log A/k = .51989
A/k = 3.3090
1 − A/k = 2.3090
Log = .3634
−3.4890
−4.8744
b = 7488

.3634
3437
.01987
A = 1046

No 68

Beauty for low pressure

Corrected Aug 26

(10) Thursday 7 Feb. 29th 1912 θ = 28.88 P = 61.98 − 57.80 = 4.18

First Observation 4:40.

Only one bank of battery used

Volts at 4.40 = 185 + 129 = 862.9

Volts at 5.26 = 849 + 129 = 861.9

This drop flickers as though it were unsymmetrical – in shape –

G	F	
8.680	12.834	
8.774	12.740	
8.824	12.902	→
8.652	40.402	(2) →
8.760	353 50.4—	
	50.338	
8.762	51.—	
8.704	51.—	
8.766	51.6—	
8.788	51.4—	
8.804	51.632	
8.616	26.6 52.6—	
8.856	51.434	
8.724	51.128	
8.672	51028	→
8.754	43.750	
8.778	43.758	→
	71.6—	
8.764	70.270	→
	78.390	
	78.0—	
	77.892	→
	56.466	
	56.0—	→

Finished at 5:25

(19)

2nd Observation – Feb. 24th 1912 θ= P=

Volts at 5:26 = 849+12.9 = 861.9
849+12.9 = 861.9
(2 trays used)
= 1723.8

q

15/ Friday Mar 1st 1912 θ = 23.04 P = 62.3 − 57.4 = 4.90

4:10 P.M. Volts at 3150

832 + 13.8 = 845.8
831 + 14.0 = 845.0
1690.8

G	F	
13.972	49.224	
13.830		
13.880	51.700	
13.846	51.7—	
	52.606	
13.890	52.750	
13.864	43.530	
13.972	43.738	
13.826	43.464	
13.980	90.942	
13.938	91.830	
13.916	88.480	
13.926	86.742	
13.942	85.128	
13.974	35.754	
13.930	35.980	
13.780	24.778	
	24.840	
8) 144564		
13.903		

1/52.7 = .01898
1/43.58 = .02296
1/91.3 = .01095
1/85.1 = .01175
1/35.75 = .02797
.02780
.04030
1/24.81

2296 / 1898 / 6)03983 / = 2980 | 2296 / 1095 / 3)0404 / .04003 | 2797 / 1175 / 4)1622 / 4055 | 4030 / 2750 / 3)1250 / 4167 / 4055 / 4003 / 3980 / 4)16205 / 4051

7194 / 1898 / 22)9092 / 4133 / 23 3953 | 7194 / 2296 / 23)9490 / 4126 / 24 3954

7194 / 1129 / 20)8323 / 4161 / 21 3964 | 7194 / 2789 / 24)9983 / 4160 / 3942 | 7194 / 4030 / 27)11224 / 4157 / 28 4009 | 3953 / 3954 / 3964 / 3942 / 4009 / 5)19872 / 3974

1/13.903 = .07194 × 1021 = v_1 = .07345
Log = −2.86591

Excellent

d 3974 × 1021 =
$v_1 + v_2$ = .0040574
Log = −3.60825
1/2 = −1.4330
3.1978
−6.23994
3.22737
−9.01168

V = 16880

e_1 = 10.270

4:53 P.M. 1/2 = −1.4330

a
−16.4209
3.2274
−2.6664
−14.5144
−3.6083
3)−12.4060
−4.3020 .0002005 = a
6902
−4.9922
3.0078

l = .0001460
−4.8547
6902
−4.1645
−4.3020
−1.8625

.07287 = l/a

1019. = 1/pa

No 62

$e^{2/3}$
3) −9.01168
−3.00390
−6.00782
~~1019~~ 1018 × 10^−8 = $e^{2/3}$

Cont'd Aug 26/12

−10.46136
3.22737
−7.68873
−3.60825
−4.08048 = log ...
−4.3020
−1.77847 = ...
.22152 = l/...
1.6654 = ...
Log 1.6654 = −1.82231
3.0038
−4.8153

−1.8231
−1.4601
−1.9606

A = .9123 b = .0036 .0000636

Second Observation Mar. 1st 1912 θ = 23.0

p = 62.49 − 57.20 = 5.29
62.48 − 57.20 = 5.28
5.285

5:05

Volts at 4:55 P.M.

827 + 14.4 = 841.4
830 + 14.2 = 844.2
1685.6

Volts at 5:55 P.M.

825 + 14.5 = 839.5
830 + 14.1 = 844.1
1683.6

G		F
9.264		8.862
9.144		8.792
		8.784
9.094		16.244
9.104		16.118
9.094		16.278
9.156		44.298
		44.498
9.108		58.534
9.144		58.482
9.076		40.212
		40.348
9.086		40.328
	33.0 − 1 div.	
	31.4 − 2 "	
	32.6 − 3 "	
	32.6 − 4 "	
	31.4 − 5 "	
	30.6 − 6 "	
	30.0 − 7 "	
9.060	30.4 − 8 "	
		252.00
	31.6 − 1st div.	
	31.4 − 2 "	
	30.4 − 3 "	
	30.6 − 4 "	
	30.4 − 5 "	
	31.0 − 6 "	
	29.2 − 7 "	
	31.2 − 8 "	
		243.80
9.054		227.40
10.995		
9.097		

$\frac{1}{8.813} = .1135$

$\frac{1}{16.21} = .06169$

$\frac{1}{44.40} = .02252$

$\frac{1}{58.51}$ .01709

$\frac{1}{40.30}$ .02481

→ Left speed adjusted and readings are more reliable hereafter →

$\frac{1}{252} = .003968$

Differences

.1135 − .06169 = 1) .05181 → .002590

.06169 − .02252 = 15) .03917 → .002608

.02252 − .01709 = 2) .00543 → .00271

.02481 − .01709 = 3) .00772 → .00257

.02481 − .003968 = 8) .020842 → .002605

.01709 − .003968 = 5) .01312 → .002602

2590, 2606, 2605, 2602 — 4) 10402 → .002601

.1099 − .1135 — 86) 2234 → .002602

1099 − 6169 — 66) 17159 → .002602

1099 − 2251 — 51) 13241 → .002609

1099 − 1709 — 49) .12699 → .002595

1099 − 2481 — 52) 13471 → 2598

16991 − 3968 — 4) 11868 → 2585

Mean = .002597 × 1.021 = $v_1 + v_2$ = .002652

9.106 corrected for clear.
9.106 = .1100 × 1.021 = .11231 = v_1

Log = 1.0503
$\frac{1}{2}$ = −1.52515

5:55 P.M.

a
−16.4229
3.2264
−1 0503
−14.69826
−3. 4235
3) −11 2744
−4.4247
.7230
−3.1599
+2.8492
8523

l = .0001354
−4.8547
.7230
−4.1317
−4.4248
1.7048
.5064 = $\frac{l}{a}$
.5093
.0002668 = a

7067 = $\frac{1}{pa}$
7160

Log = −3. 4235
$\frac{1}{2}$ = −1.5751
−3.1478
−6.1464 v = 1.664
3.2264
−10.9200

e_1 = 8.318

$e^{2/3}$
3) −10.9200
−4.9733
7.9466
88.42 = $e^{2/3}$

−1.6502
−.7070
−1.9432
A = .9034
A = .8774

al
−10.46136
3.2264
−7.68776
−3.4235
−4.26426
−4.4247
−7.83956
log 1/k = .16044
1/k = 1.4469
log 45645 =
−1.65820
2.0523
−4.79990
b = .6467
b = .6278

Good one worked out Aug 26

(1059)

10) Saturday – Mar. 2nd 1912

θ = 23.11 p = 63.22 – 56.32 = 6.90

Volts at 4:00 P.M.

791 + 16.5 =
787 + 16.4 =
733 + 18.1 =
2311 + 51.0 = 2362.

G		F
17.110		15.602
17.176		15.536
17.242		17.126
17.206		17.184
		40.066
17.250		40.384
		72.8—
17.534		73.090
17.496		40.808
17.512		40.928
17.540		40.6—
17.758		122.4—
17.566		122.4—
17.874	62.0	123.4—
		74.2—

This drop flickered in the unsymmetrical

5:05 P.M.

15) 709.6
1547.3

l = .00004248

-4.8547
.8887
-5.9660
-4.3792
-1.6464

.4435 = $\frac{l}{a}$

$e^{2/3}$

3)-10.8906
-4.4635
7.9266
7.9270
84.45
84.55

-16.4209
3.3657
-2.8199
-14.60685
-3.6480
3)12.9[illegible]
-4.3792
.8887
-3.2079
2.7921

.00002085 = a

.6196 = $\frac{1}{pa}$

This is on the line

-10.46136
3.36508
-7.52704
-3.6485
-4.17829
-4.3193
-1.85524
-.85904 = .444
.4096
1.3822

log .9822 = -1.6803
2.9822
-4.7981

b_{corr} = 61.07

A = 56.2

-16.5209
3.3657
-2.8199
-14.6065
3.6485
2)17.9550
-4.3193
.8885
-3.2078
7922

$\frac{1}{pa}$ = .6197

2nd Observation Mar 2, 1912 $\theta = 23.12$ $p = 63.63 - 55.89 = 7.74$ (5)

7736...

5:20

Volts at 5:07
785 + 17.0
787 + 16.8
718 + 17.9
2290 + 51.7 = 2341.7

$\frac{1}{15.473} = .06463 \times 1.021 =$
$v_1 = .065987$

Volts at 6:05
776 + 17.2
776 + 17.2
707 + 17.2
2259 + 51.6 = 2310.6

G		F	
15.634		24.660	
15.562		24.514	$\frac{1}{24.56} = .04072$
		24.512	
15.506		27.584	
		27.664	$\frac{1}{27.624} = .03619$
		27.5—	
15.488		31.868	$\frac{1}{31.85} = .03144$
15.506		31.830	
15.478		37.258	$\frac{1}{37.39}$ = .02675
15.284		37.520	
15.496		55.4—	
		55.502	$\frac{1}{55.57}$ = .01800
15.566		55.6—	
15.462		55.646	
15.498		45.2—	.02275
		45.058	$\frac{1}{44.89}$
		44.6—	
15.430		44.728	= .026615
		37.648	
		37.524	$\frac{1}{37.58}$
15.410		37.4—	
15.458		73.594	= .01361
15.472	366	73.4—	$\frac{1}{73.47}$
		73.346	
15.598 (too long)		32.0	= .03109
15.482		32.146	$\frac{1}{32.17}$
17.6330		32.090	
15.493 6.03 P.M.		32.3	

Differences

.04072	3619	3144	2675
.03619	3144	2675	1800
.00453	475	469	4875
			4375

22275	2661	26615	3109
1800	22275	1361	1361
4275	4335	3)13005	4)1748
		4335	4370

4375
4335
4370
3)13080
.004360

.06456	6456	.6456
4072	3619	3144
24)1.0528	23)1007	5=2)9600
4387	4380	4364

6456	6456	6456	6456
2675	1800	22275	26615
9)3781	4)8256	34)86835	31)9117
435	4345	4342	4341

6456	6456
1361	3109
18)7817	22)9565
4343	4348

4387
4380
4364
4350
4345
4342
4341
4343
4348
9)500
4360

$.004360 \times 1.021 =$
$v_1 + v_2 = .004451$
Log = −3.64859
1.40975
3.19726
6.25608
3.36568
10.89040

$v = 2.321.0$

Log v_1 2.81950
$\frac{1}{2}$ 1.40975

new Volts = 2321

e = 7.770
4
e = 7.774

8906
2
7)17812
-79271
8454 = $e^{\frac{2}{3}}$

Beauty corrected Aug 26

No 57

19 Monday – Mar. 4th 1912 b = 2348 P = 63.87 – 55.59 = 8.26

First Observation 4:02 P.M. Volts at 3:55 – 830 + 14.2, 833 + 13.6, 836 + 13.8 = 2499 + 40.9 = 2540.4

G		F
10.844		
11.014		13.854
10.996		15.412
10.994		14.260
11.042		16.282
10.984		31.426
10.938		31.502
		31.666
		23.540
10.956		23.704
10.900		23.720
10.932		77.0
10.954	39.2	77.4
	39.2	77.6
10.928		42.6
10.948		42.338
10.920		42.312
10.920	46.3	1+2 div.
10.880	46.6	3+4 div.
	47.5	5+6 "
10.712	45.0	7+8 div.
		185.4
10.934	46.6	1+2 div.
	46.4	3+4 div.
	46.0	5+6 div.
	46.0	7+8 div.
10.892		185.0
10.894		50.070

mean = 10.934

$\frac{1}{10.934}$ = .09154

v_1 = .09154 log = –2.96… ½ log = –1.48531

4.53 P.M.

$\frac{1}{16.28}$ = .06142

$\frac{1}{31.53}$ = .03172

$\frac{1}{23.66}$ = .04226

$\frac{1}{77.4}$ = .01292

(42.4) (42.2) $\frac{1}{42.33}$ = .02362

$\frac{1}{185}$ = .005405

$\frac{1}{50.07}$ = .01997

1107 (44) Beauty Prize

Differences

6142, 3172, 3)2970, .03712

.04226, .03172, 3)01054, 3513

.04226, .1292, 8)029 24, 3668

2362, 1292, 3)1070, 3567

2362, .5405, 5)18216 54, 3643

1997, 5405, 4)14565, 3641

mean = 3624

.09154, 3172, 34)12326, .003625

9154, 4226, 37)13380, 3617

9154, 1292, 4)10446, 3602

9154, 2362, 3)11516, 3597

9154, 5405, 27)96945, 3589

9154, 1997, 31)11151, 3597

mean = 3605

mean of means .003615 × 1021

= $v_1 + v_2$ = .003691

Log = –3.567144

½ v_1 = –1.48531

3.1983

–6.250754

3.40 634

–10.846120

v_2 = –2.554

P = .00008654

–4.8549, 9175, –5.9372, –4.4018, –1.5354, .3363 = $\frac{P}{a}$

a: –16.4270, 3.4045, –3.9706, –14.8024, –3.5671, 3)11.2353, –4.4118, 9175, –3.3293, –2.6707

.0025810a, 3365, 2289

4685 = $\frac{1}{T_a}$, 4699, 4707

7.0173, 151, e_1 = 7.0324, e_1 = 7024

Error .5%. Justly too low

$e^{2/3}$

2)–10.8468, –4.9489, –7.8978

–79.03 = $e^{2/3}$ = 79.02

8465, 3)1.6930, 7.8977

Second Obs. Mar. 4, 1912

(5:05)

θ = begin 23.45, finish 23.45 } p = 64.00 − 55.40 = 8.60

(13)

Voltage 4:55 — 829.5 + 142 = 843.7
832.5 + 13.2 = 845.7
836.0 + 13.5 = 849.5
2538.5

(no 8) (43)

S	F
11.688	39.542
11.686	39.496
11.628	39.544
11.632	30.634
	46.620
	46.966
11.640	53.302
11.704	74.176
11.640	58.396
11.632	58.302
	43.9 −1+2 div
	44.0 −3+4 div
	43.6 −5+6 div
	42.5 −7+8 div
	173.4
11.578	27.0 1+2 div
11.855	26.7 3+4
	26.3 5+6
	26.0 7+8
	106.0
11.578	105.810
	48.760
	48.386
11.680	59.462
	41.330
	41.332
	41.158
11.680	38.746
11.610	104.396
14) 9 23.1	104.6
11.659	

1/39.58 = .02526
{.00735 = 3675}
1/30.66 = .03261
{.01127/3 = 3757} — 9443
1/46.86 = .02134
1/53.38 = .01873
1/74.21 = .01348 } 3650 — 5
(58.4) 1/58.45 = .01711
{.01134/3 = 3800} — 5
1/173.4 = .005767
{3676/1 = 3676} —
1/105.9 = .009443
{.01107/3 = .3700} —
(48.9) 1/48.69 = .02056
{370 = 3700}
(59.6) 1/59.54 = .01680
{.00734 = 3695} —
1/41.33 = .02419
1/38.78 = .03536
1/104.6 = .09560

Differences

3265 / 2526 / 2) .0733 / 3675
3265 / 2137 / 3) 1128 / 3760
2137 / 1348 / 2) .0789 / 394
.0365
1713 / 5767 / 3) 11368 / 3788

2053 / 9443 / 3) 11097 / 3696
2059 / 1710 / 0349
2423 / 19599 / 4) 14651 / 3663
3540 / 2423 / 3) 1117 / 3723
3540 / 5767 / 4) 14521 / 3681

3757
3650
3800
3676
3700
3645
3677
3686
mean .003705

8577 / 2526 / 3) 11103 / 3701
8577 / 2134 / 3) 10714 / 3695
8577 / 5800 / 3) 9157 / 3663
8577 / 9443 / 4) 9521 / 3662

8577 / 2059 / 3) 10636 / 3666
8577 / 2423 / 3) 11000 / 3667
8577 / 9540 / 4) 9534 / 3667
443 / 7) 25722 / mean 3675

Moving Drops = .003705 × 1.021 = .003783

1/Log = −3.57838
−1.4712
3.1978
6.2468
3.40405
10.84285
0009
10.8434
3) 16.874
7.8958

Volts = 2535

$\frac{1}{1166}$ = .08577 + 10212 v_1 = .08757
2.94285
v_1 = −1.4712

(5.54)

−16.4270
3.4043
−15.9424 4269 4040 4424 7673
−14.7737 5712
−3.5753 1895
3) 11.1984 4.3965
−4.3965 .0025090
9345
−3.3340
2.6640
4.6634
466.9

e_1 = 6.978
e_1 6.978
$e^{2/3}$ = 78.67
$e^{2/3}$
3) 10.8935
−4.9472
−7.8944
78.42

log 0.00008322
−4.8547
9345
−5.9202
−4.3965
−1.5237
.3349 = 1/9
5 4/5

(12) Third Obs – Mar. 4 1912 $\theta = \frac{23.45}{23.48}$ (begin / end) $p = 64.20 - 55.17 = 9.03$ 9.015 av 23

(6.05) ~~No 9~~

Voltat 5.55

828.0 + 14.3
830.5 + 14.1
834.0 + 13.5
2492.5 + 41.9 = 2534.4

Voltat 6.35

827.0 + 14.3
830.0 + 14.1
833.0 + 13.7
2490.0 + 42.1 = 2532.1

G	F
19.124	
19.220	
19.346	~~46.780~~ (?)
19.348	47.382
	47.224
	27.348
	27.350
19.116	27.422
	95.564
19.162	47.0 – 1.2 div
	47.0 – 3.4 div
	47.0 – 5.6 div
	46.4 – 7.8 div
	187.4
19.276	63.016
	62.846
~~19.~~	
7) 149.2	
19.2??	

(6.34)

$\frac{1}{47.28} = .02115$

$\frac{1}{27.37} = .03654$

(48.0) (96.0) $\frac{1}{95.6} = .01046$

$\frac{1}{187.4} = .005336$

$\frac{1}{62.93} = .01590$

Differences

.03654 – .2115 = 3) .01539 = 5130
3654 – 1046 = 5) 2608 = 5216
01046 – 5336 = .005124

1590
5336
2) 10564 = 5282

5130
5216
5124
5282
4) 20752 = 5188

5188, 2115, 14) 7303, 5216
5188, 3654, 17) 8848, 5200
5188, 1046, 13) 6240, 5195

5188, 5336, 11) 57276, 5207
5188, 1590, 13) 6787, 5212

5216
5205
5200
5207
5212
5208 mean

Good.
Corrected Aug '36
No 54

$\frac{1}{19.25} = .05188 \times 1.021$

$= v_1 = .05347$

Log = –2.728

$\frac{1}{2}$ Log = –1.3640

$v_1 + v_2 = .005205 \times 1.021 = .005314$

Log = –3.72540
–1.3640
3.19776
6.28714
3.4036
10.88356
10.8843
7.658

$e_1 = $ ~~4.81~~ $7.661 \, e_1$

reduced for electron correction to 8373

a
–16.4209
3.4036
–3.7286
–14.5587
3.7758
3) –12.8274
–4.2758
9549
–3.2307
2.7693

$l = –4.8547$
9549
–5.8998
–4.2758
–1.6240

$4.142 = \frac{l}{a}$
$4.113 = \frac{l}{a}$ = .2533

1.887 cm
...

3) 1.47686
7.9229
8373 = $e^{2/3}$

5848^0 for $e^{2/3}$

10.8880
3) 14.7730
–9.9233
8380 = $e^{2/3}$

No 54

–10.46136
3.4036
–7.86496
–3.7254
–4.18956
–4.2758
–1.86326
–1.86326

–1.86326
.13674 = $Ae^{1/2}$
1.3701 = $\frac{1}{e}$
Log = –1.5683
2.7693
–4.7990
$b^{1/2}$ 62.95

–1.5683
–1.86340
–7.9443
A = 87.96

Tuesday Mar. 5, 1912 - $\theta = 23.03$

at 5:12 P.M.

27% Solution Cupric Chloride used in first Cooling tank (flat tank)

$p = 6450 - 54.80 = 9.70$

G	F
	34.9 - 142 div / 33.7 - 3+4 " / 35.4 - 5+6 " / 35.2 - 7+8 "
	139.2 -
	43.740
24.388 / 24.612 / 24.182 / 24.276 / 24.254	25.664 / 25.770 / 25.578 / 25.618
	36.6 - 2 div / 37.4 - 4 div / 37.4 - 6 " / 37.6 - 8 "
	148.0
24.274	37.4 - 2 div / 37.0 - 4 div / 37.0 - 6 div / 36.6 - 8 div
	148.0

$\frac{1}{134.2} = .007164$

$\frac{1}{43.74} = .02288$

$\frac{1}{25.66} = .03895$

$\frac{1}{148} = .006757$

834.0 + 13.5 = 847.5
836.04 + 13.5 = 849.9
842.5 + 13.7 = 853.2
829.0 + 14.1 = 844.1
838.0 + 14.3 = 852.3
(4244.6)

Volt at 5:05 P.M.
833.0 + 13.6
834.5 + 13.4
840.0 + 12.7
827.0 + 14.3
3334.5 + 54.0 = 3388.5

7010

differences

7964 / 7164 / 2) 15656 / 7828	3895 / 2288 / 2) 1617 / 8056	3895 / 6757 / 4) 32290 / 8048

4110 / 7164 / 6) 48264 / .008044	4110 / 2288 / 6) 6398 / .007998	4110 / 3895 / 8005	4110 / 6757 / 6) 47857 / 7976

8005
7991
8056
8048
5) 40076
8015

24.314
7) 2300
24.33

5:40 P.M.

$\frac{1}{24.33} = .04110 \times 1021 =$

$v_1 = .041963$

Log = $\bar{2}$.62387
$\frac{1}{2}$ = $\bar{1}$.31194

mean .008015 × 1021 =
$v_1 + v_2 = .0081880$
Log = -3.91309
$\frac{1}{2}$ log v_1 = $\bar{1}$.31194
-3.19776
6.42270
-3.53000
10.89290

$V = 3388.5$

error .5%

$e_1 = 7.8100$

$e_1 =$ 7.795 reduced for change in corr. $e_1 = 7.783$

a	l
-16.4204 / 3.5300 / -2.6239 / -14.5848 / 3.1190 / 3) 11.6618 / -4.2206 / .9888 / -3.2094 / 2.7901 / 2.7925	-4.8549 / .9868 / -5.8679 / -4.2206 / -1.6473

$4439 = \frac{l}{a}$

.001662

$6669 = \frac{1}{pa}$

6202

a/a
-10.46136
3.5300
-7.94136
-3.91300
-4.07836
4.2206
-.85776 = l/a
.14224 = $\frac{1}{a}$
13879 = $\frac{b}{a}$
b = .15885
13925
-4.7960
b = .0006251

.15885
-.16471
.9412

A = 8735

Just method and Aug 27

3) 19.7854
-7.9285
$e^{2/3}$ 8483

$e^{2/3}$
-10.5918
3) 18.7836
-7.5279
.8470 = $e^{2/3}$ reduced to 8461 = $e^{2/3}$

7058

10) March 5, 1912 – 2nd Obs.

$\theta = \begin{cases}23.00\\23.05\end{cases}$ $p = 64.69 - 54.59 = 10.10$

6:05

No 9

(H2)

G	Stop Watch	F Chronograph
15.014	44.6	44.110
15.010	44.4	44.108
14.962	44.9	44.654
15.030	45.4	45.008
14.932	30.0	30.026
14.952		
144900		

$\frac{1}{45} = .02222$

$\frac{1}{30.03} = .03330$

lost it at 6:13 P.M.

14.983

$\frac{1}{14.98} = .06675 \times 1021$

$= v_1 = .06815$

Log = −2.833466

$\frac{1}{v_1} = -1.41673$

Volts at 5:52

833.0 + 13.6
835.5 + 13.2
839.0 + 12.8
827.0 + 14.2

3334.5 + 54.0 = 3388.5

Volts at 6:15 P.M.

817.0 + 15.0
824.5 + 14.5
827.0 + 14.3
821.0 + 14.8

3289.5 + 68.6 = 3358.1

Difference =
.0330
.0222
.0108 too small because of dropping volts

.06675
.02222
8) .08897
.01112

6675
3330
9) 10005
.01112 × 1021

$= v_1 + v_2 = .011353$

Log = −2.05512
−1.41673
−3.1463
−6.67015
3.52764
9.14251

.005677
Log = −3.7541

Volts 3370
$l = .00007087$

a
−16.4270
3.5276
−2.8333
−14.7884
−3.7544
3) −11.0340
−4.3447 .0002211 = a
1.0043 2208
−3.3490
2.6510

−4.8549
1.0043
−5.8504
−4.3447
−1.5057
.3205 = $\frac{l}{a}$
3224

4469 = $\frac{1}{pa}$
4448

13.885
3
2) 13.888
$e_1 = 6.944$
$e_1 = 6.936$

Error .6% in acc. of volts

$e^{2/3}$
3) −10.8416
−4.9472
−7.8944
7.842 = $e^{2/3}$ $e^{2/3} = 7.836$

Mar. 6th 1912 -

First Observation

4:52

θ = 23.00 begin, 23.13 end

p = 69.73 (?) − 48.61 = 21.12; 69.74 (Millikan) − 48.61 = 21.13

Volt at 4:45

No 10

41

Volt at 5:55

G		F	
14.302			
14.288		43.004	
14.218	(22.2)	43.198	(43.9)
14.228		43.260	(43.8)
14.298		84.504	(84.6)
14.218		46.6 − 1st division	
		47.8 − 2nd "	
		47.2 − 3rd "	
		47.0 − 4th "	
		48.0 − 5th "	
		47.4 − 6th "	
		48.0 − 7th "	
		48.0 − 8th "	
14.222	52 / 36.8 / 630 (crossed out)	380.0 −	
14.204			
		112.0 −	$\frac{1}{112}$ = .008929
13.966		28.254	$\frac{1}{28.25}$ = .03540
14.072		23.758	
14.082		23.708	$\frac{1}{23.73}$ = .04214
14.118		65.296	$\frac{1}{65.30}$ = .01531
14.092		45.616	
		46.028 (46.0)	$\frac{1}{45.82}$ = .02182
		35.122 (35.4)	$\frac{1}{35.28}$ = .02835
14.184		35.434 (35.4)	
14.018		119.0 −	
13.944		119.4 −	$\frac{1}{119.2}$ = .008389
6) 32.196			
14.06			

Worked only below here. Weight changed on G.

Beauty

832.5 + 13.8
834.0 + 13.7
838.0 + 13.3
824.0 + 14.5
833.0 + 13.8
834.5 + 13.7
4996.0 + 82.8 = 5078.8

830.0 + 14.1
832.0 + 13.9
836.0 + 13.5
821.5 + 14.7
832.5 + 13.0
832.0 + 13.9
4983.0 + 84.0 = 5067.0

Differences

.03540 − .008929 = 4) .026471 = .006618

.04214 − .03540 = .00674

.04214 − .01531 = 4) .02683 = .006708

.02835 − .008389 = 3) .01996 = .00665

.04214 − .008929 = 5) .033211 = .006642

6708, 6618, 6650, 6642 : 4) 26618 = .006654 = mean graph

.07099 − .008929 = 12) .079899 (?) = .006658, 6672

.07099 − .04214 = 17) .11328 = .006659, 6663

7099 − 2835 = 15) 9932 = .006628, 6633

7099 − 2835 = 14) 7856 ... 6687, 6633, 6668, 6678 ; 4) 26596 = 6649

Mean = .006650 × 4.021 = v_1 + v_2 = .006762

Log = −3.8300
−1.4300
3.1963
−6.4583
−6.4583
3.7050
−10.7533

Volts = 5070

a:
−16.42700 07
3.90505 50
−3.96071 01
−14.99380
−3.8319
3) 11.1612
−4.3871 .012438 = a
1.3247
−3.7118
2.2882

l:
−4.8547
1.3247
−5.5300
−4.3871
−1.1429

.1390 = $\frac{l}{a}$ (1394)

1944 = $\frac{1}{a}$

e = 5.646, 5.642 = e

$e^{2/3}$:
3) −10.7558
−4.4886
−7.8372

6673

$\frac{1}{14.01}$ = .07112 = .07099 × 1.021 = v_1 = .07246

log = −2.8601
$\frac{1}{2}$ " = −1.4300

5.53 P.M.

8) Thursday – Mar. 7th 1912   θ = 23.70   p = 6993 / 4640 / 21.52

Volts at 3:15

841.5 + 13.2
841.5 + 13.2
845.0 + 13.0
814.0 + 15.3
843.5 + 13.1
843.0 + 13.1
5028.5 + 80.9 = 5109.4

3:35 P.M.

G	F	
~~16.322~~	(28.6)	56.696 (57.2—)
	153.0	307.4—
16.190	174.0	349.0—
16.184	51.0	102.0—
	207.6	413.8—
16.184	—	(42.0—) 42.006
	—	
15.996	—	60.314
	—	(60.6—)
16.092		

6) 130646
1.613 [? unclear]

$\frac{1}{57.2}$ = .01748
$\frac{1}{307.4}$ = .003253
$\frac{1}{349}$ = .002865
$\frac{1}{102}$ = .009804
$\frac{1}{414}$ = .002415
$\frac{1}{42.01}$ = .02381
$\frac{1}{60.31}$ = .01658

differences

.02381 − .002415 = 3) .021395 → .007132
.02381 − .01658 = .00723
.01748 + .003253 = 2) .014227 → .007114
.009804 − .002865 = .006939
9804 − 2415 = 7389
.007164

.06200 + .002865 = 9) .064865 → .007207
.06200 + .9804 = 10) .071804 → .007180
6200 + 2415 = 9) 6441 → .007157
6200 + 2381 = 12) 8631 → 7191
6200 + 1658 = 11) 7858 → 7161

$\frac{1}{16.13}$ = .06200 × 1.021 = v_1 = .06226

Log = −2.7944
$\frac{1}{2^{1/1}}$ = −1.3972

mean = .007179 × 1.021
= $v_1 + v_2$ = .0073317

Log = −3.8652
−1.3972
3.1962
−6.4607
mean volts = 5090   3.7067
10.7540

5676
18
e_1 = 5694

$e^{2/3}$

−10.75503
2
3) 19.51006
−7.8367

$e^{2/3}$ = 6870.

a

−16.4470
3.4067
−2.7944
−14.9281
−3.8652
3) 11.0629
−4.3543   .0002261 = a
1.3330
−3.6873
2.3127   2105.4 = $\frac{1}{pa}$

l

−4.8547
.3330
−5.5217
−4.3543
−1.1674   .147

This drop had been at a little distance from the bar and so had a comparatively long life.

Second Observation
Mar. 7th 1912

$\theta = 23.48$
23.54

$p = \frac{7011}{4220}$
$= 1.91$

(7)

Volts ab. H115

834.5 + 13.7
837.0 + 13.4
839.5 + 13.2
811.5 + 15.5
839.0 + 13.2
839.0 + 13.2
5000.5 + 82.2 = 5082.7

G	F	
9.132		
9.086		42,135
	(21.2)	(4214—)
	—	53,554
	(27.0)	(54.0—)
9.076	—	53,300
	(27.0)	(53.6—)
9.232	—	53.420
	(27.6)	(53.8—)
9.124		

6 Third Observation
March 7, 1912.
5:55

ϕ = ~~23.77~~ 23.41
23.63

p = ~~71631~~ 70.50
~~72200~~ 47.77
~~22.73~~ 22.73

Volts at 5:48
830.0 + 14.1
833.0 + 13.8
836.0 + 13.5
807.0 + 15.7
833.0 + 13.8
833.0 + 13.8
4972.0 + 84.7 = 5056.7

G	F	
~~Volts~~	~~Volts~~	~~Volts~~
24.312		20.728
24.326		20.540
24.256		20.728
24.128		

6:10 P.M.

Fourth Obs. 3/7/12 $\theta = \frac{29.53}{28.53}$ $p = \frac{7073}{4745}$ $\frac{}{23.25}$ (5)

6:13 P.M. Volts at 6:40

829.0 + 14.2
831.0 + 14.0
833.0 + 13.8
830.0 + 16.0
832.0 + 13.9
832.0 + 13.9

4957.0 + 85.8 = 5042.8

6	F	
17.094		
17.234		20.872
16.996		19.734
17.064		19.566
17.220		19.562
17.314		54.066
17.134		54.288
17.172		54.280
17.144		27.496
		27.506
17.094		27.658
		46.488
	72.0	142.0—
17.118	73.0	144.5—
		6:38 P.M.

4)

Monday Mch 11th 1912 $\theta = 23.07$ $p = 71.00 - 47.14 = 23.86$

3:35

No 11 ... 40

G	F		F
	24.3	48.3 —	$\frac{1}{48.2} = .02075$
18.074	24.0	48.2 —	
18.098	—	71.6 —	$\frac{1}{71.6} = .01397$
18.276	24.0	48.2 —	
18.312	—	48.5 —	$\frac{1}{48.35} = .02068$
18.230	37.0	—	
18.216	36.6	73.6 —	
18.352	37.0	73.6 —	$\frac{1}{73.6} = .01359$
18.238	25.0	49.4 —	$\frac{1}{49.4} = .02024$
18.218	37.0	73.8 —	$\frac{1}{74.2} = .01348$
18.212	37.2	74.3 —	~~$\frac{1}{74.4}$~~
18.292	37.6	74.4 —	
18.237	—	29.4	$\frac{1}{29.4} = .03401$
18.206			
13) 237.16		4:10 P.M.	
18.229			

$\frac{1}{18.22} = .05486 \times 10^{-1} = V_1 = .05601$

log = 2.7483

$\frac{1}{v_1} = \bar{1}.3742$

descent all this in small frame volts most been dropped suddenly in this period

3 P.M.

660.0 + 15.6
836.5 + 13.5
839.0 + 13.3
503.0 + 04.0
837.0 + 13.5
837.0 + 13.5
4512.5 + 83.4 = 4595.9

Differences

.02075	2068	.02029	2024
.01397	1397	.01359	1348
.00678	671	.00666	676

.03401
.01348
3) .02053
.006843

This difference must reliable bet ~~secondd diff~~

676
671
665
676
684.2
684.3
6) 4548
.006764

.05486	5486	5486	5486
.02075	,1 : 1359	1348	3401
4) .07561	10) 6845	10) 6834	13) 8887
.006874	.006845	.006834	.006836

most probable value = .006838 $\times 10^{-1}$

$= v_1 + v_2 = .069815$

Log = -3.8440
-1.3742
-3.1483
-6.4665
+3.6611
-10.7554

$e_1 = 5.694 \times 10^{-10}$ error .3%

$e_1 = 5.687$

$e^{2/3}$

3) -10.7554
-4.9185 (2)
-7.8370

6870 = $e^{2/3}$
6864

Mean volts = 4582.

$\ell = .00002444$

-4.8547
1.3777
-5.4770
-4.3308
-1.1462

$.1400 = \frac{\ell}{a}$
1403

a

-16.4270
3.6611
-2.7483
-14.8364
-3.8440
2) -18.9924
-4.3308
1.3777
-3.7085
2.2915

.0002142 = a
2133

1957 = pa
1968

Second Obs. Mar. 11, 1912 (Monday)

θ = 23.20

p = 71.23 − 46.90 = 24.33

5:28 P.M.

Volts at 4:17

659.5+15.6
835.0+13.6
837.5+13.5
503.0+04.0
835.0+13.6
835.0+13.6
4505.0+73.9 = 4578.9

No 12

39

G		F
7.874		~~x~~
7.862		23.6
7.876		24.0
7.878		23.9
7.792		23.5
7.874		23.734
7.902		23.522
7.918	40.2	79.6
7.852	40.2	79.6
7.923		79.4
7.8751		

1/23.7 = .04219

1/23.62 .04232

1/79.3 .01268

Volts at 5:15

659.0+15.0
834.0+13.8
836.5+13.5
503.0+04.0
834.0+13.8
834.0+13.8
4500.5+73.9 = 4574.4

Difference

.04232
.01268
7 | .02974
.004249

4210
1268
2942

1/7.875 = .1270 × 10^21 = .12967

.1298

5:42 P.M.

.1270
.4232
40 | .16942
.004236

.1270
.1258
33 | .13970
4233

mean = 4235 × 10^21

= v₁+v₂ = .004324

Log = −1.1134

1/2 = −.55670

Log v₁+v₂ = −3.63548
−1.55641
3.1983
−6.39019
3.6601
−10.7301

6361
5327
1677
3905
6601
7204
V = 45.72

a

−16.4209
3.6601
−1.1134
−13.1944
−3.6366
3 | 11.5583
−4.5194
1.3858
−3.9052
2.0946

−.3333 = a
7309

l

−4.8547
1.3858
−5.4689
−4.5194
−2.9490

.08853 = l/a
5692

1.237 = 1/l/a
1244

e 5395
4
e₁ = 5379
12

~~e = 5355~~

change corr.

~~e = 5.392~~

e₁ = 5.379

e^{2/3}

−10.73046
2
3 | −14.46092
−7.8203

e^{2/3} 6606

7.3299
3.04599
7.8199

e^{2/3} = 66115 − raise to 6628 for

6606

~~6607~~ .1 % ...

2)

Monday, Mar. 11, 1912

Third Obs.

θ = 23.18   p = 71.70 − 46.33 = 25.37

Volts at 545

659.0 + 15.7
833.0 + 13.9
836.5 + 13.5
502.5 + 03.8
833.0 + 13.9
833.0 + 13.9
4497.0 + 74.7 = 4571.7

(13) (78)

G		F
9.440		35.920
	(18.4)	(36.0)
9.488		36.003
	(17.6)	(35.6)
9.360		35.818
	—	(35.8)
9.398		53.472
	(27.0)	(53.4)
9.374		Balanced speed (very nearly)
5) 2040		
9.408		

1/35.91 = .02785

1/53.47   .01870

0

1/9.41 = .1063 × 1021 = .1085 = v_1

Log = −1.03543

6:10 P.M.

1/2.4 = −.5177

Differences

.02785
.01870
2) .00915
.003050
.004575

4) .01870
.004675

4675
4575
9250
4620 Difference

.1063	.1063	.1063
.1785	.1870	.000
29) .13415	27) .12500	23) .1063
.004638	.004629	.004622

mean = .004633 × 1021
= $v_1 + v_2$ = .0047303

Log = −3.6749
−1.5177
−3.1983
−6.3909
3.6599
−10.7310

v = 4570

a	l
−164270	−4.8547
3.6599	1.4043
−1.0354	−5.4504
−13.1223	−4.4825
−3.6749	−5.9679
3) 11.4474	.09788 = l/a
−4.4825	9330
1.4043	.0030375
−3.8868	3024
= .1132	3023
	1298 = 1/pa
	130.31

5.383
4
e_1 = 5.387

e_1 = 5.381

$e^{2/3}$

−7.73135
2
3) 14.46270
−7.8209

$e^{2/3}$ = 66.21
$e^{2/3}$ = 66.16

~~[illegible]~~

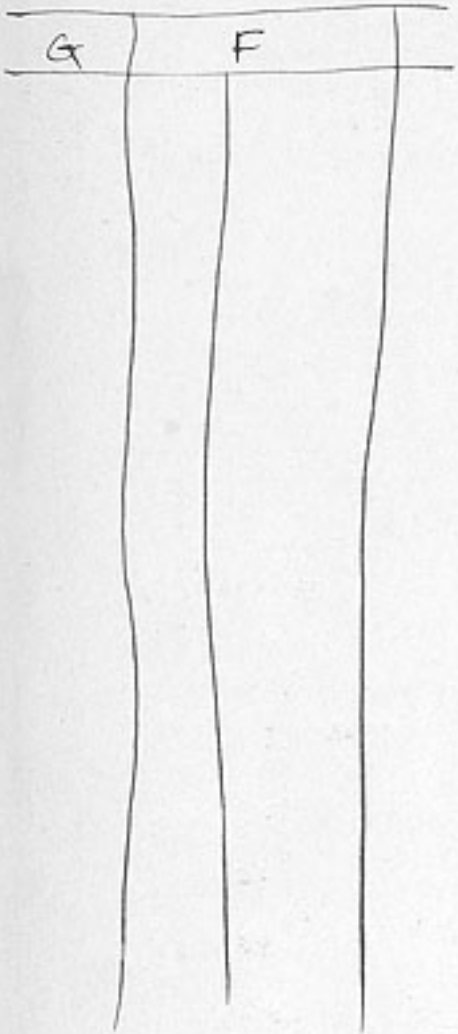
Error 7%

Period

Compare with Comp drop 49

Monday, Mar. 11, 1912 θ= p= 1.

Fourth Obs.



Volts at 6:11. P.M.

658.5 + 15.7
832.5 + 13.9
836.0 + 13.5
502.0 + 03.8
833.0 + 13.9
832.5 + 13.9

4494.5 + 74.7 = 4569.2

Calibration of Upp. Chamber Lasalle

40 second interval.

220.13 / 20.21 / 4)199.92 / 49.98

220.50 / 20.13 / 4)200.37 / 5009

220.55 / 20.50 / 4)200.05 / 5001

220.20 / 20.55 / 4)199.65 / 49.91

220 27 / 20.20 / 4)200.07 / 5002

220.27 / 20.27 / 4)200.00 / 5000

219.92 / 20.27 / 4)199.63 / 49.91

219.53 / 19.92 / 4)199.61 / 49.90

219.50 / 19.58 / 4)199.92 / 49.98

219.60 / 19.50 / 4)200.10 / 5002

mean 49.981

10 sec interval

69.98 / 20.60 / 49.38

119.14 / 69.98 / 49.26

70.71 / 19.14 / 50.65

54.55 / 4.46 / 50.09

105.31 / 54.55 / 50.46

65.34 / 5.01 / 50.38

109.93 / 55.39 / 49.54

58.82 / 8.44 / 50.38

109.40 / 58.82 / 50.58

59.33 / 9.40 / 49.93

109.91 / 9.40 / 50.51

60.03 / 9.91 / 50.12

110.27 / 60.03 / 50.24

60.25 / 10.27 / 49.98

110.58 / 60.25 / 50.33

60.81 / 10.58 / 50.23

111.03 / 60.81 / 50.22

61.33 / 11.03 / 50.30

111.54 / 61.33 / 50.21

61.49 / 11.54 / 49.95

111.69 / 61.49 / 50.20

Mean of 15 = 50.12

4 sec interval

31.80 / 11.69 / 20.11

67.62 / 31.80 / 20.02

72.11 / 51.82 / 20.29

92.11 / 72.11 / 20.00

112.28 / 92.11 / 20.17

32.77 / 12.28 / 20.49

52.80 / 32.77 / 20.03

73.87 / 52.80 / 20.07

93.05 / 73.07 / 19.98

113.25 / 93.05 / 20.20

33.50 / 13.25 / 20.25

53.94 / 33.50 / 20.44

74.30 / 53.94 / 20.40

94.52 / 74.30 / 20.22

114.77 / 94.52 / 20.25

34.94 / 14.77 / 20.22

55.14 / 34.94 / 20.20

75.40 / 55.19 / 20.21

Mean = 20.21

Key No. 1 for 10 recs

114.04
63.71
50.33

63.94
14.04
49.90

113.75
63.94
49.81

63.88
13.75
50.13

97.86
47.65
50.21

148.12
97.86
50.26

98.09
48.12
49.97

144.87
94.66
50.21

94.75
44.87
49.88

144.86
94.75
50.11

94.94
44.86
50.08

144.88
94.94
49.94

56.49
6.01
50.48

106.63
56.69
50.14

Mean of 14 readings for 10 recs = 50.104

Key No. 1 for 4 recs

26.98
6.63
20.35

47.58
26.98
20.60

67.78
47.58
20.20

87.94
67.78
20.16

108.32
87.94
20.38

28.83
8.32
20.51

58.81
28.83
29.98
2
59.96
3
19.99

79.02
58.81
20.21

99.48
79.02
20.46

20.21
99.49
20.73

ten readings

Mean = 20.357 for 4 recs.

Calibration of Hipp Chronoscope.

Wednes. Dec. 6, 1911

Key No. 1

136.15 − 86.99 = 50.06

96.09 − 46.15 = 59.94 → for 50.06 / 12 sec.

146.15 − 96.09 = 50.06

96.36 − 46.15 = 50.21

146.46 − 96.36 = 50.10

∴ 49.95 for 10 secs.

96.56 − 46.46 = 50.10

246.51 − 96.56 = 149.95 / 3 = 49.98

10 secs.

New Key

96.25 − 46.51 = 49.74

Key No. 2

145.88 − 96.25 = 49.63

245.94 − 45.88 = 200.06 / 4 = 50.00

10 secs.

258.65 − 58.93 = 199.72 / 4 = 49.93

245.96 − 45.94 = 200.02 / 4 = 50.00

245.70 − 45.96 = 199.74 / 4 = 49.94

258.59 − 58.65 = 199.94 / 4 = 49.99

258.31 − 58.65 = 199.66 / 4 = 49.92

257.66 − 58.31 = 199.35 / 4 = 49.84

Key No. 1

257.59 − 257.66 = 199.93 / 4 = 49.98

264.74 − 64.95 = 199.79 / 4 = 49.95

264.69 − 64.74 = 199.95 / 4 = 49.99

264.73 − 64.69 = 200.04 / 4 = 50.01

49.99

264.63 − 64.73 = 199.90 / 4 = 49.98

264.55 − 64.63 = 199.92 / 4 = 49.98

264.83 − 64.55 = 200.28 / 4 = 50.07

264.71 − 64.93 = 199.88 / 4 = 49.97

Mean of 10 obs. on 40 secs. at 18°C

÷ 4 = 49.975 = 10 secs

Feb 10th 1912

Calibration of Hipps chronoscope for 5 sec intervals

1st Ten readings

54.65	29.75	29.30	54.06	79.16	1.03.87
29.75	4.73	4.50	29.30	54.06	79.16
24.90	25.02	24.80	24.76	25.10	24.71

28.90	54.19	79.23	104.32
3.87	28.90	54.19	79.23
25.03	25.29	25.04	25.09

4.98
5.04
4.96
4.952
5.020
49.42
50.06
50.58
5.008
5.018
49.948
4.995

2nd Ten readings

29.10	54.22	104.45	29.63	
4.32	29.10	79.42	4.65	
24.78	25.12	~~4.70~~ 25.23	24.98	
54.58	79.86	104.72	3003	55.21 8003
29.63	54.58	79.62	74.72	30.03 5521
24.95	25.28	24.86	25.31	25.18 2482

4.452
5.024
5.046
49.96
49.90
5.056
49.72
5.062
5.036
4.964
5.0102
4.9948
2|100050
5.0025

This shows what I can rely on Hipp's chronoscope things down to 5 secs with no error longer than .2% — might call it .4% for safety then e would be in error only .6% at outside,