

Mass I -
SAM 1965

21



COMPUTATION NOTE BOOK

43-648

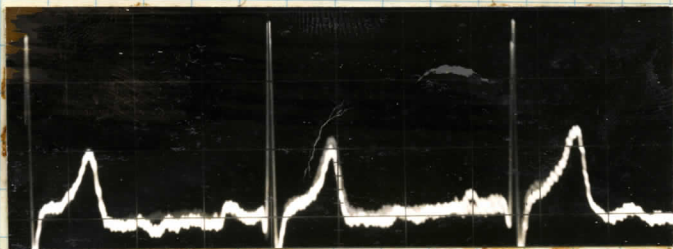
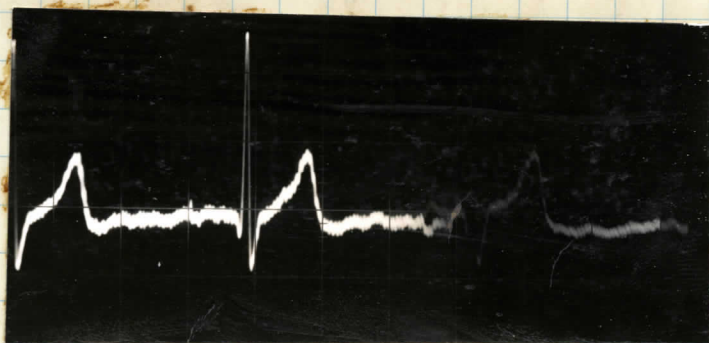
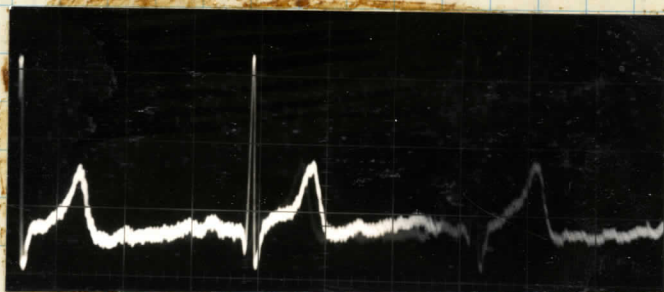
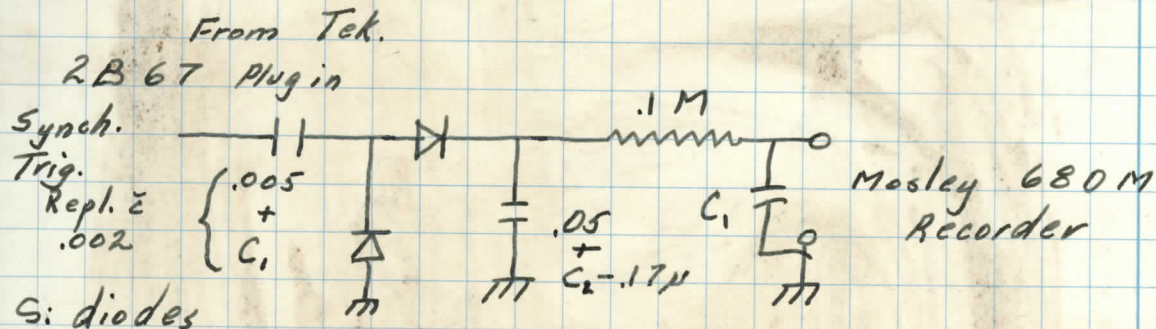
Course E K G - Mass

Name W^{III} Thornton, Capt. M.C. USAF
Brooks AFB

5131 Lancelot Dr. *Mar 65 - Mar 66*

Walter apparatus.

Rate meter:



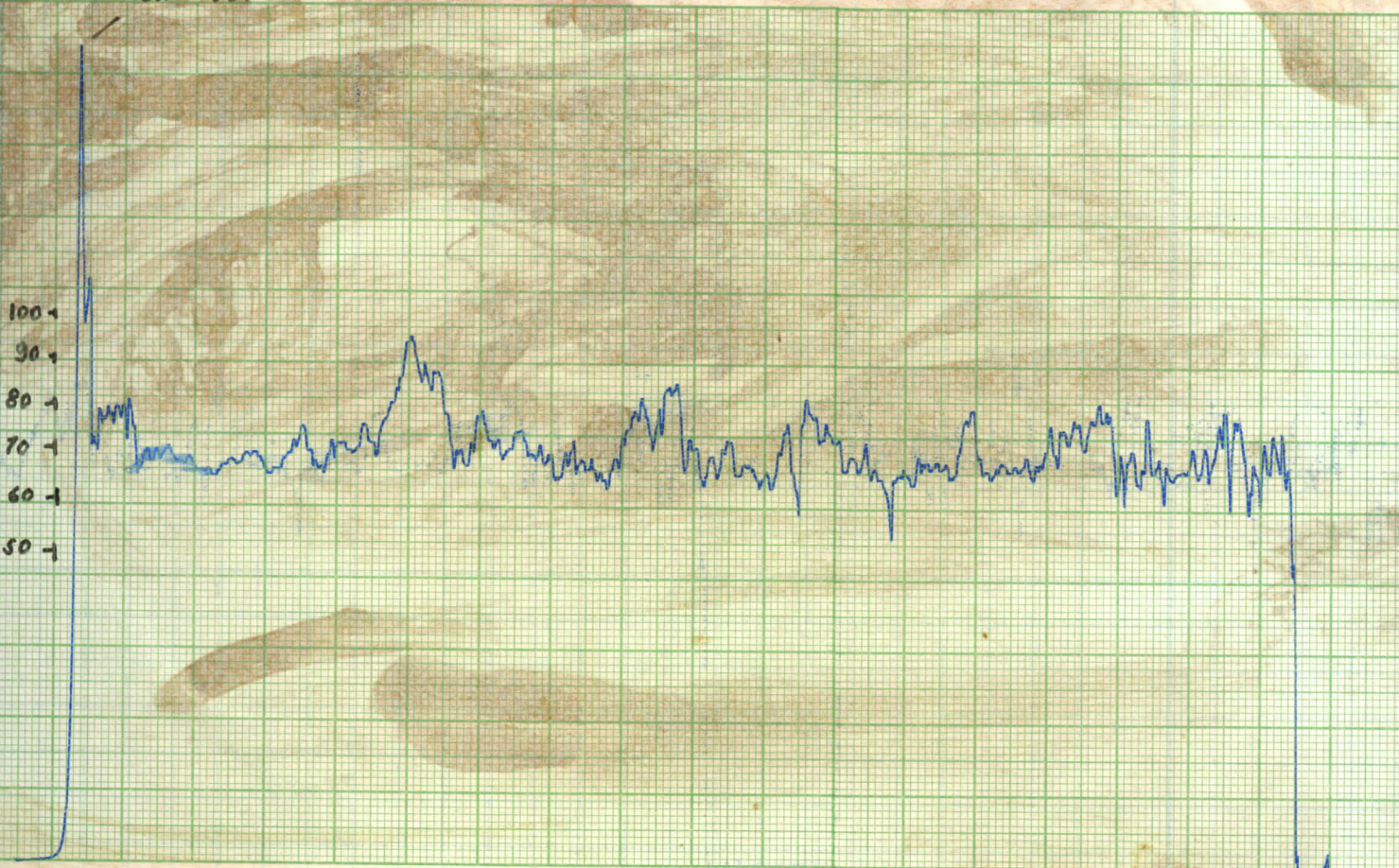
Excerpts From Record on

Following Pg. 5 m 5./cm.

Tek 564 scope

F.L. MOSELEY CO. 228-0025

Cal. Error

100
90
80
70
60
50

10 cm/Min Paper Speed (1 min = 1 hr.)

Rate Record of W.T. 10 Aug. '65 - Calib. on rear.

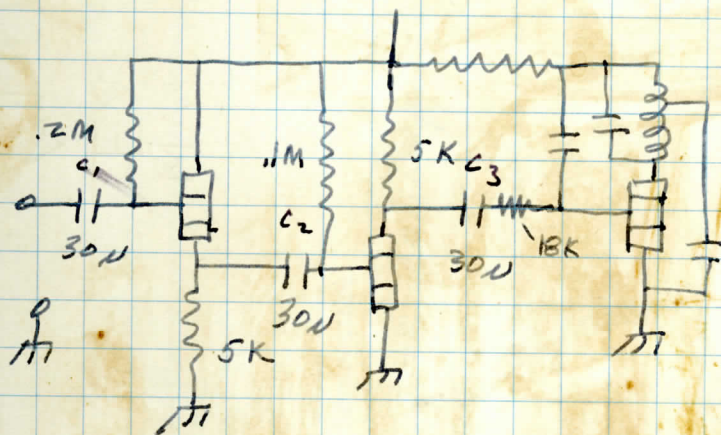
Exam. of BME EKG Xmtr.

	C	low D	
Input	3.2 X10	.15	C ₁
Mid-	3.5 "	.18	C ₂
Out-	3.3 "	.14	C ₃

GR Bridge 1650A

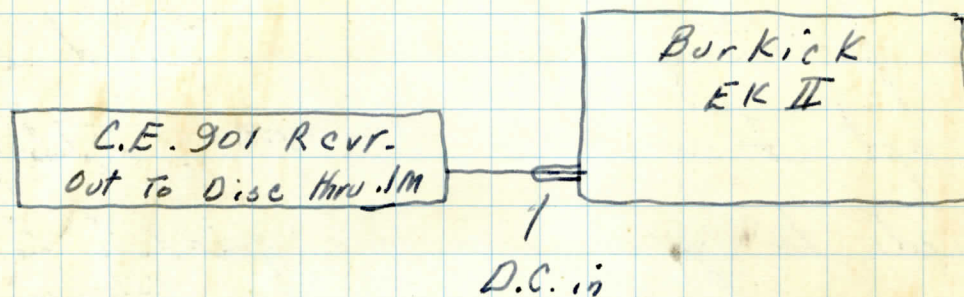
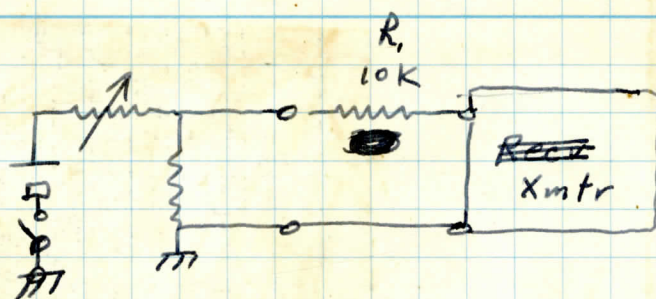
The following ckt^{*} was published in NEJM by Capt. Fascinelli of SAM, 5th. Med. Sect. Claimed to yield "clinical quality" EKG's.

The side by side wire + telemetered records were not, could not be made in ckt shown. Still build ckt. to verify using values measured caps above.



Poor design in general + estimate T.C. at 300 msec or less -

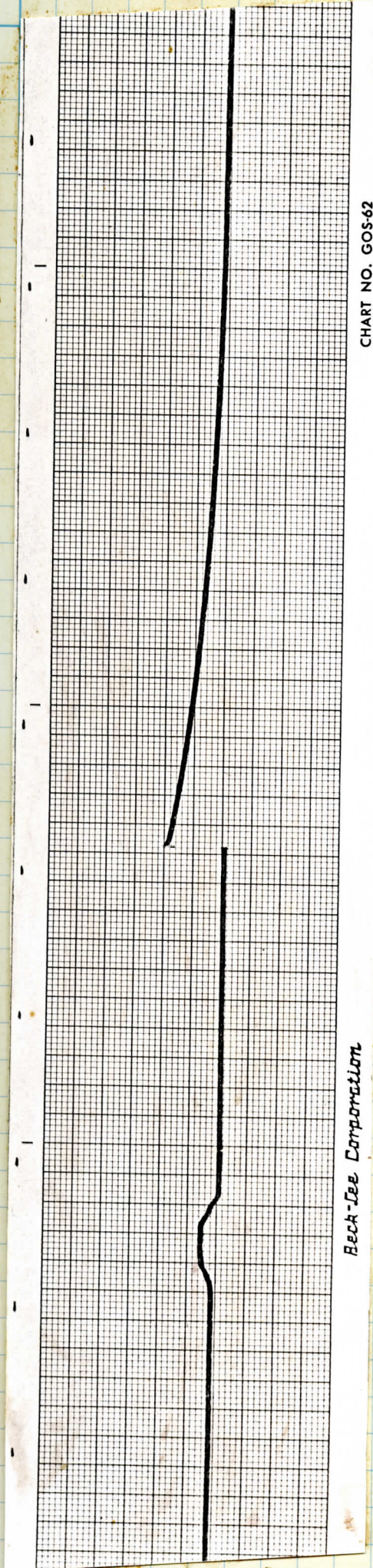
* have corrected one obvious error -



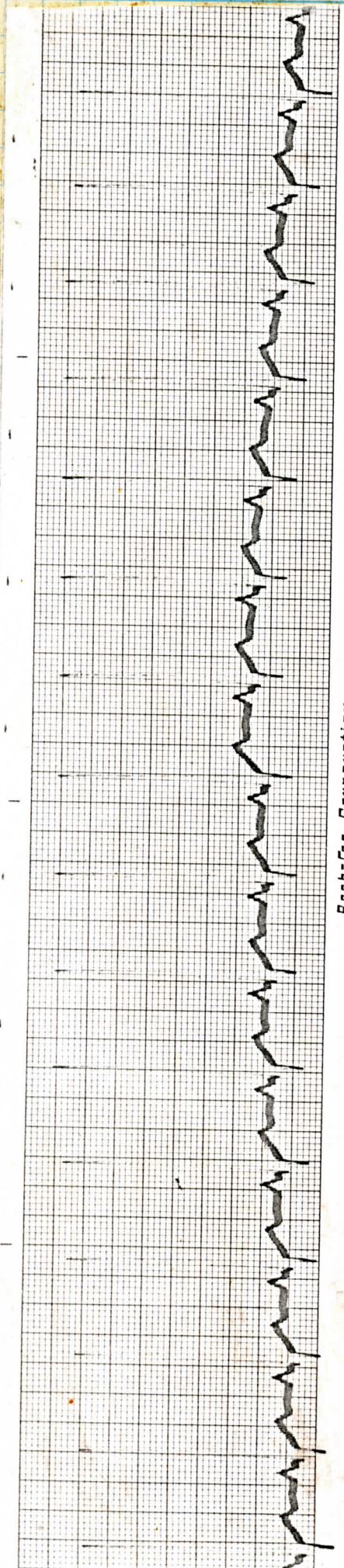
Input Z meas. as $18K - \bar{c}$ above ckt.
 + R_1 to sim. skin Z , response below obtained
 Response is probably not greater than 100 msec.

D.C. response of ^{Rcvr.} tuned ckt. tuned to
 F.M. station $\bar{c}$ detuning -

Burdick EK-III Recorder



1mV. calib. pulse - T.C. ~ 2 sec.



Precord lead ($\sim V_5$) recorded from
normal young male

CHART NO. GOS-62

Beck-Dee Corporation

D.C. Response of Revr. Recorder - Revr. Tuned to station & detuning about center f.

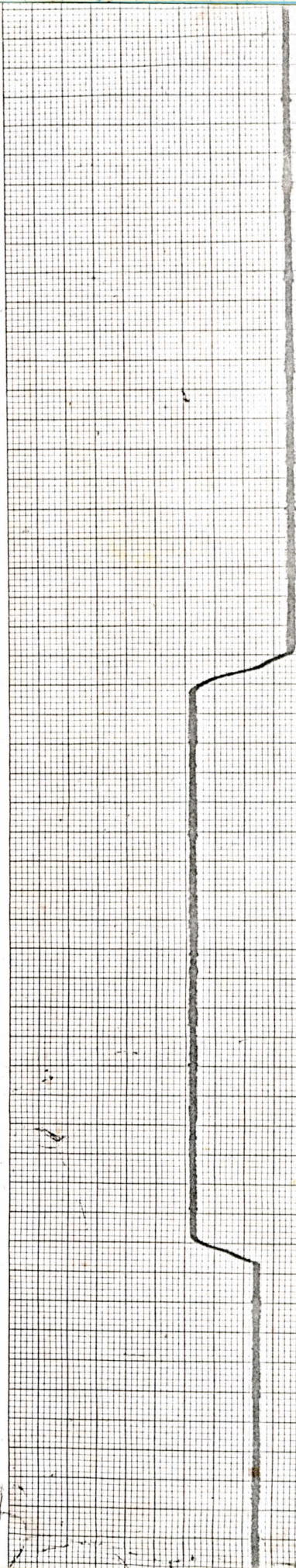
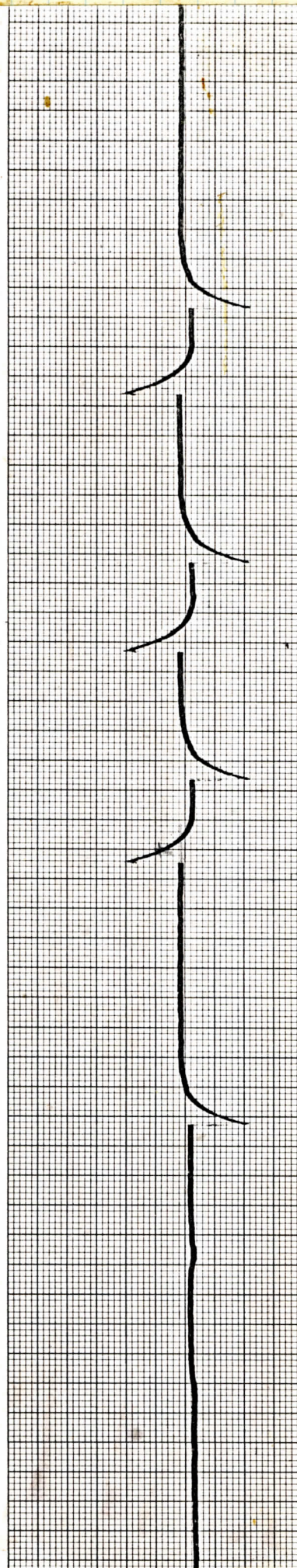


CHART NO. GOS-62

Beck-Dee Corporation

Response of Xmr. to 1mv. step function thru 18K sim. skin Z.
RC ~ 200 msec.



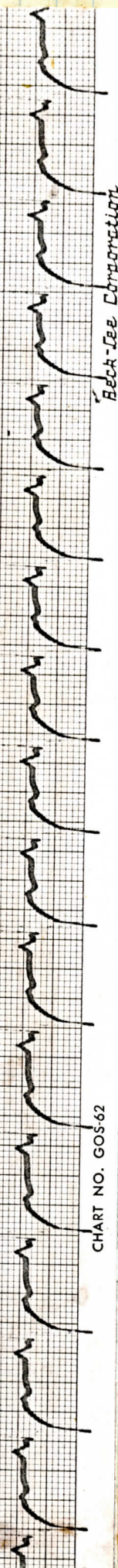
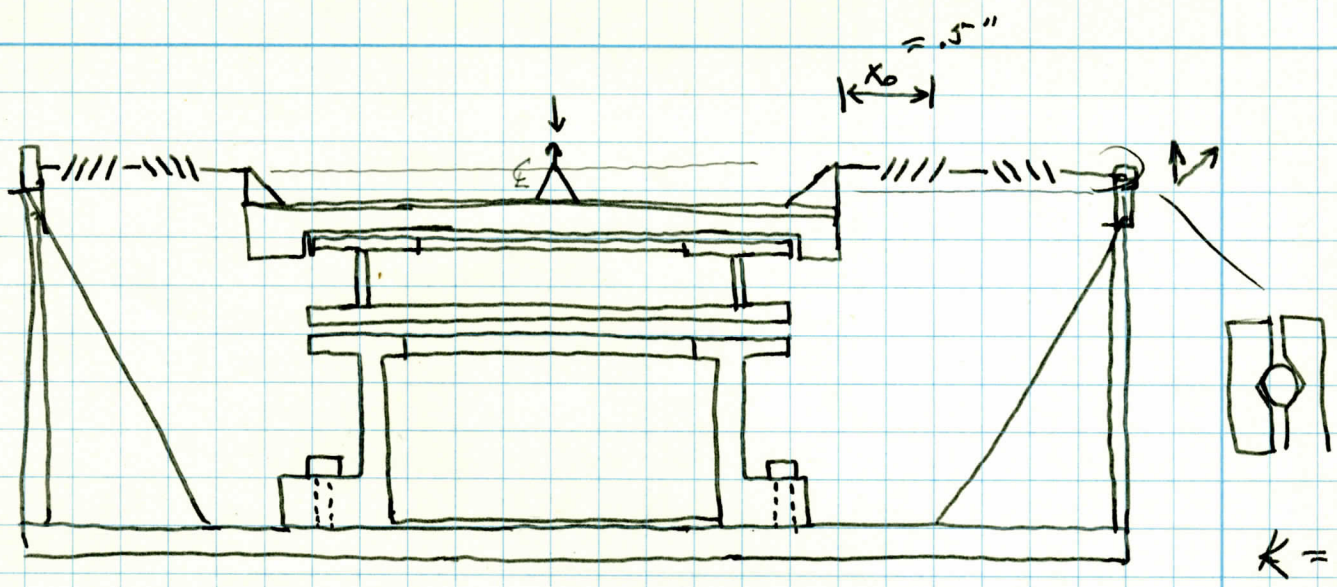


CHART NO. GOS-62

Same lead as on P-7 recorded thru Xmr-Recorder
 Note: gross distortion of QRS producing markedly abnormal
 Q X-Q T ratios, biphasic T of $\downarrow$ ampl. & reduced P
 wave amplitude

Saw Dr. F. who had
 apparently constructed the device
 from Bioengineering ckt., ran
 the two tracings shown in
 the article & put it into print,
stat. Pointed out the wiring error
 & some difficulty and demonstrated
 the error introduced by the ckt.
 & his instr. which had an even
 shorter TC. He agreed that it
 was possible "some wires were
 crossed" when the side by side
 recordings were made & ~~would~~
 will correct the article - Another
 expert -



$K = 10^6 \text{ lb/in}$

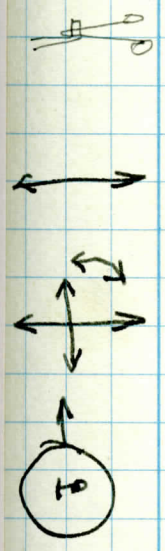
$3/4 \times 10^6 = 7.5 \times 10^5$

$$T = 2\pi \sqrt{\frac{W}{KG}}$$

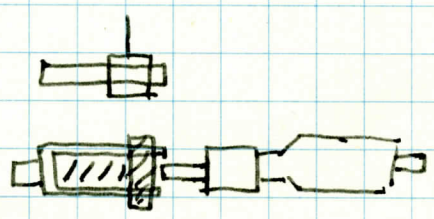
$$\Delta T = 0.5 \times 10^{-3} \text{ sec}$$

$$V \approx 5 \text{ in/sec}$$

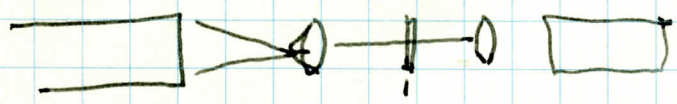
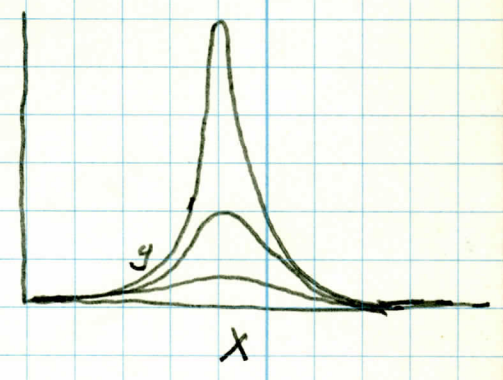
$$0.5 \times 10^{-3} \times 5 = 2.5 \times 10^{-3}$$



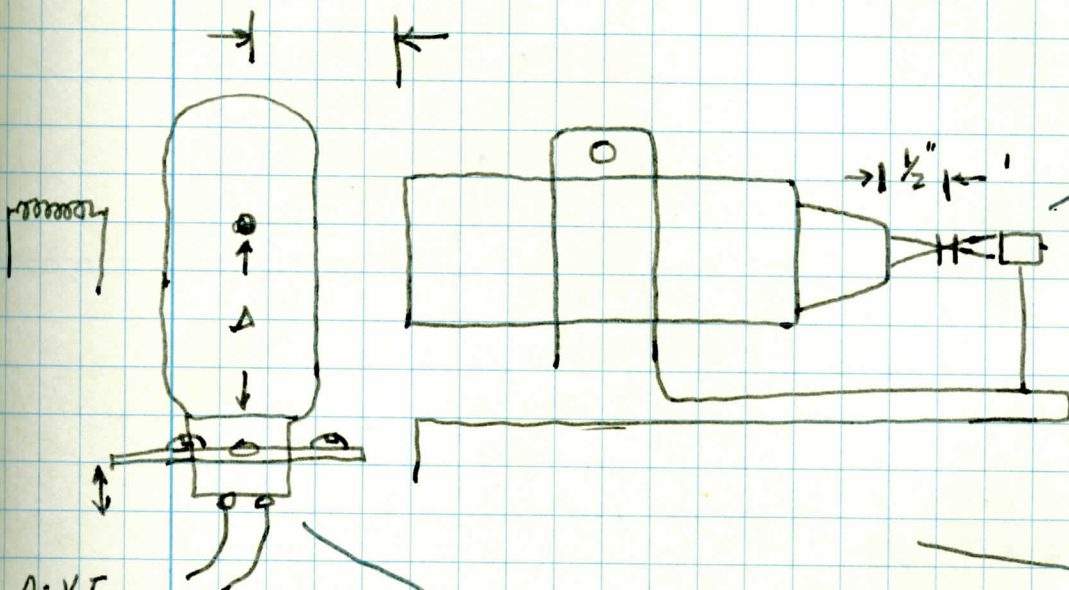
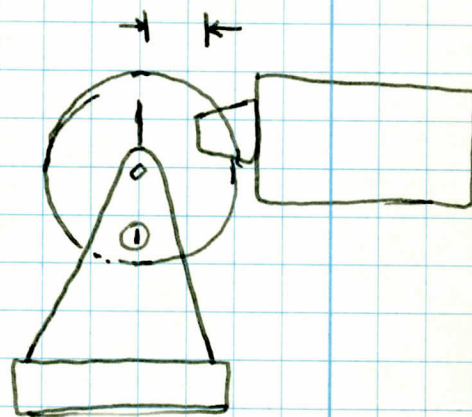
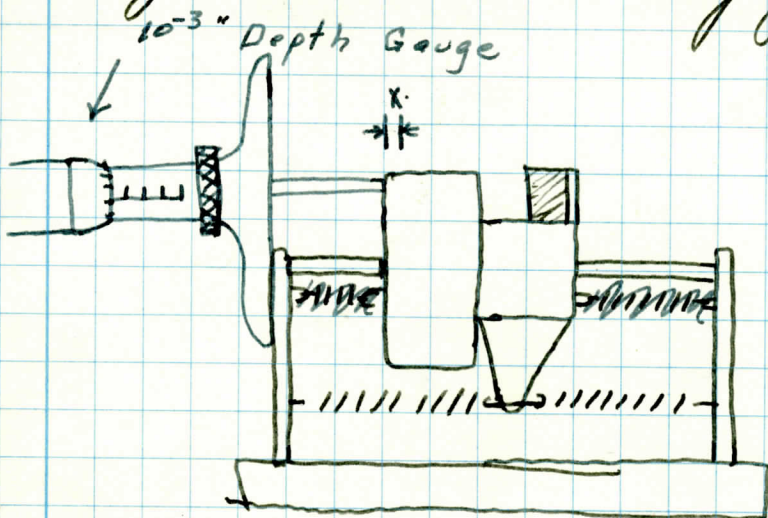
$$X_0 \cos \omega^2$$



$$\frac{1}{\Delta K} \text{ Cap}$$



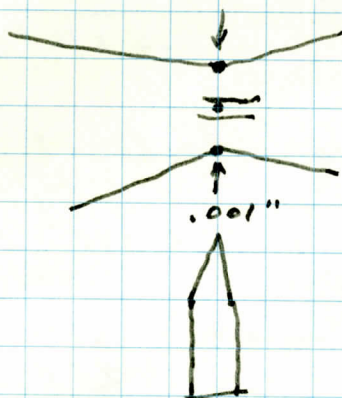
Zero detector test jig

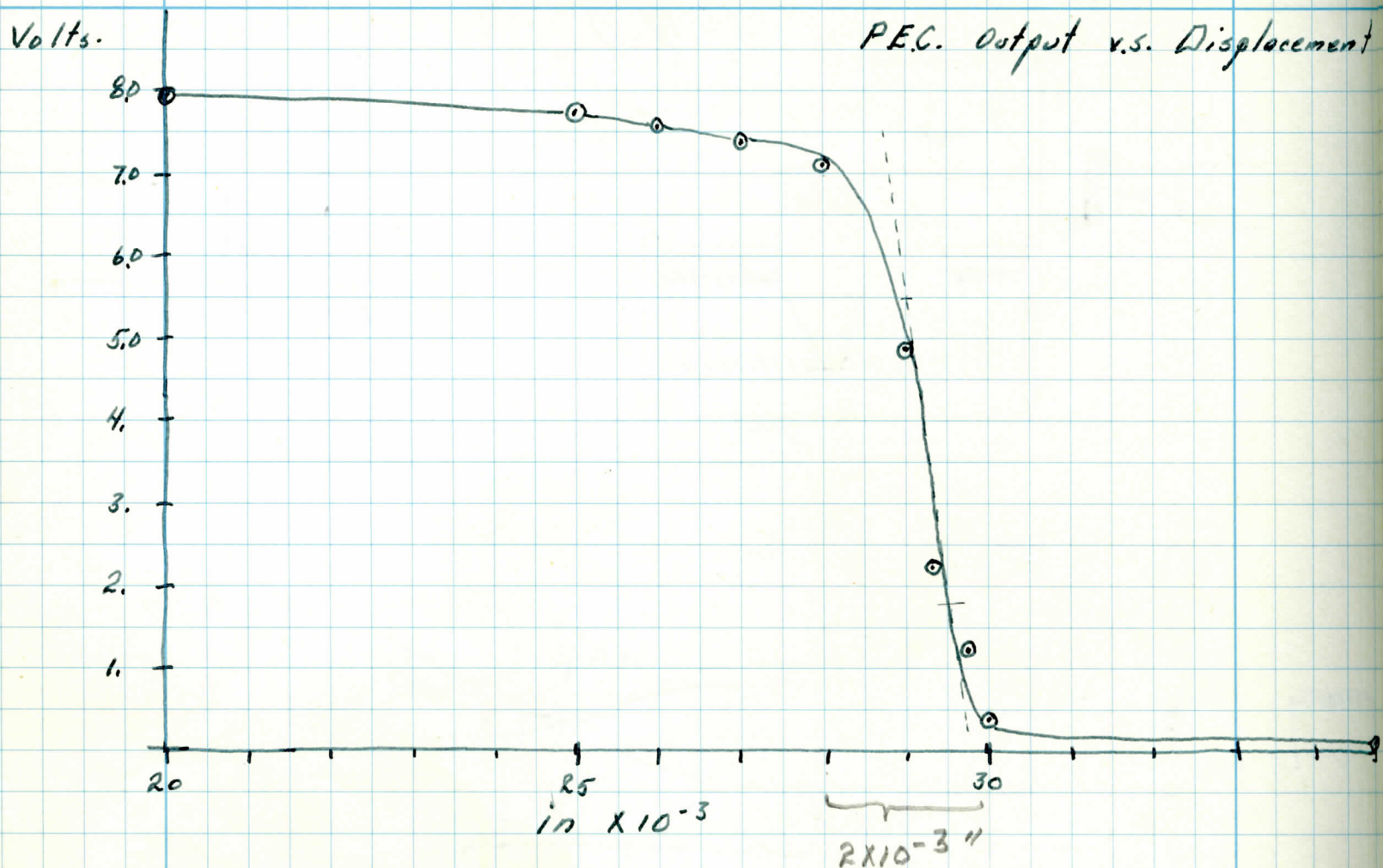


$D = VT$

$$.5 \times 10^{-3} s \cdot 5 \frac{1}{s} = 2.5$$

GE 10V 7.5A
Exciter at
5V + 5A.





$$\text{Slope} = \frac{5.5 - 1.75 \text{ V}}{0.5 \times 10^{-3} \text{ in}} = \frac{3.75}{.5} = 7.5 \text{ V/in} \times 10^{-3}$$

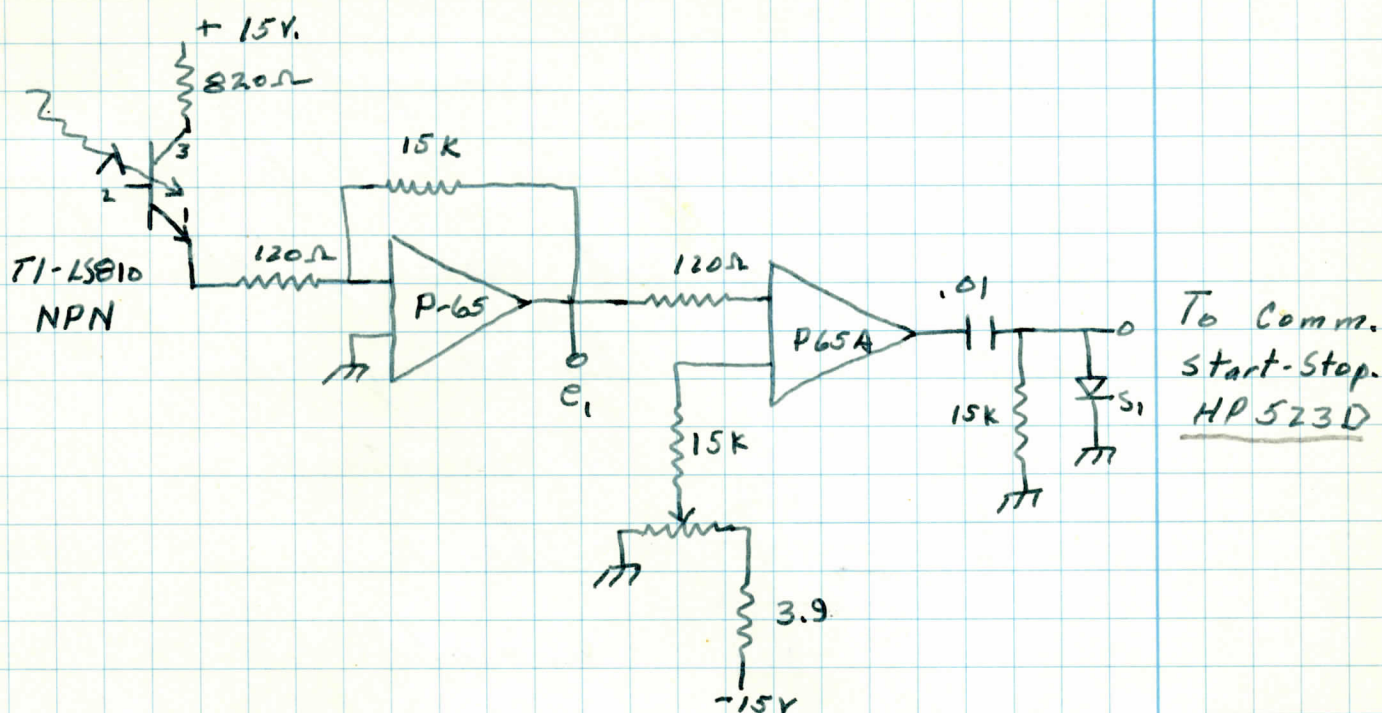
For an output of 20 V + gain of say 10^4 resolution is $\frac{20 \text{ V}}{10^4} = 2 \times 10^{-3} \text{ V}$ - Distance resolution is

$$\frac{2 \times 10^{-3}}{7.5 \times 10^{-3}} \approx .3 \times 10^{-6} \text{ in} \approx .3 \mu \text{ in! } 7.62 \times 10^{-6} \text{ mm}$$

Stability of the amplifier is claimed to be 1 mV.

Hysteresis effects may be present.

Position Pick Off. Ckt.



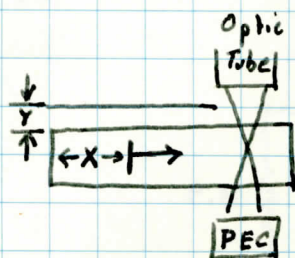
Exciter Power 5V + 5A + detector ~ 1/10" from blade -
See P

X (in $\times 10^3$)	e_1 (-Volts)
0	8.47
5	8.44
10	8.35
15	8.14
20	7.96
22.5	7.75
26.	7.54
27.	7.40
28.	7.09
29.	3.91
29.3	2.25
29.6	1.21
30.0	.361
33.0	.189
35.0	.143
40.0	.073

(Over)

Zero Position Pick Off

The device was arranged as below using the test jig on P-19 to determine the effects of not crossing the focal point. However by adding shims to adjust Y variations in X occurred.

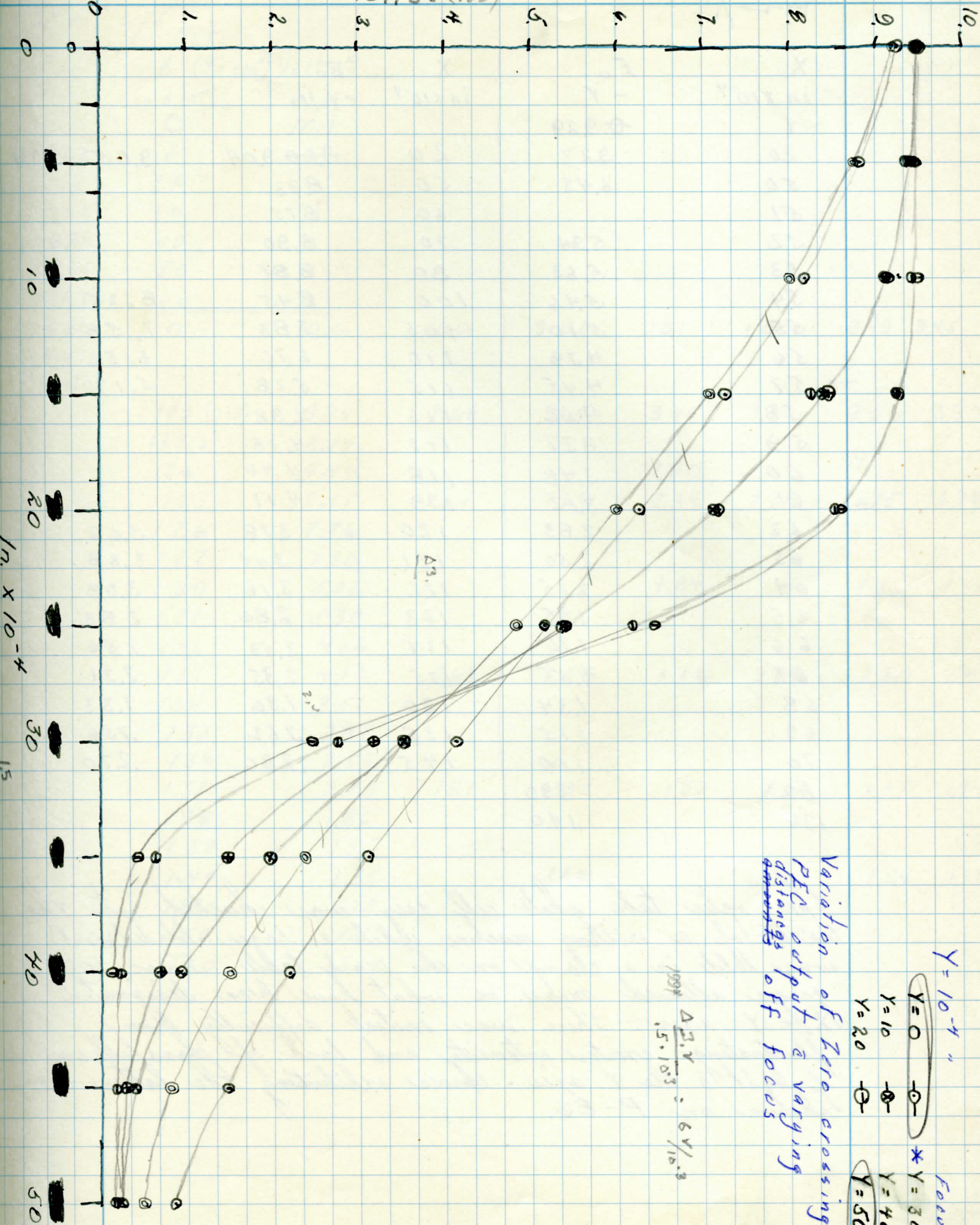


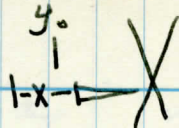
The tables on P-84 were unusable for this reason.

The device was taken to the shop & the idea of adding guides but Mr. M^c Dougal suggested some form of temporary jiggling in an existing machine tool & accurate gauges. This will be tried.

Volts. (1994)

647
525
122
3
4525
20.10





X in $\times 10^{-4}$	E_0 -V	X in $\times 10^{-4}$	E_0 -V ₀ /ts	
1	9.29			
20	9.23	20	9.20 9.04	9.05 (32)
50	6.43	50	8.93	
51		60	8.75	
52	5.94	70	8.90	
53	5.63	80	8.87	
54	5.46	100	8.45	8.35
55	5.10	105	7.83	7.58
56	4.79	110	6.70	6.53
→ 57	4.45	115	5.28	5.17
58	4.12	116	4.98	
59	3.77	117	4.68	
60	3.48	118	4.40	
61	3.12	119	4.11	
62	2.83	120	3.78	3.69
63	2.50	121	3.44	3.38
64	2.25	122	3.16	3.08
65	1.95	123	2.86	2.83
66	1.70	124	2.59	2.56
67	1.55	125	2.35	2.31
68	1.34	130	1.36	1.33
69	1.15	135	.762	.756
70	1.00	145	.280	.270
80	.390			
130	.140			

The optic tube, photo cell assy. was chucked into the turret of a milling machine while a razor blade (Wack) was held in a clamp on the work table. Two 10^{-4} gauges allowed meas. in what have been designated X & Y axes. There was initial difficulty from fluctuating exciter intensity and lack of parallelism of light to the Y axis - curves exhibiting the latter are shown on P-86.

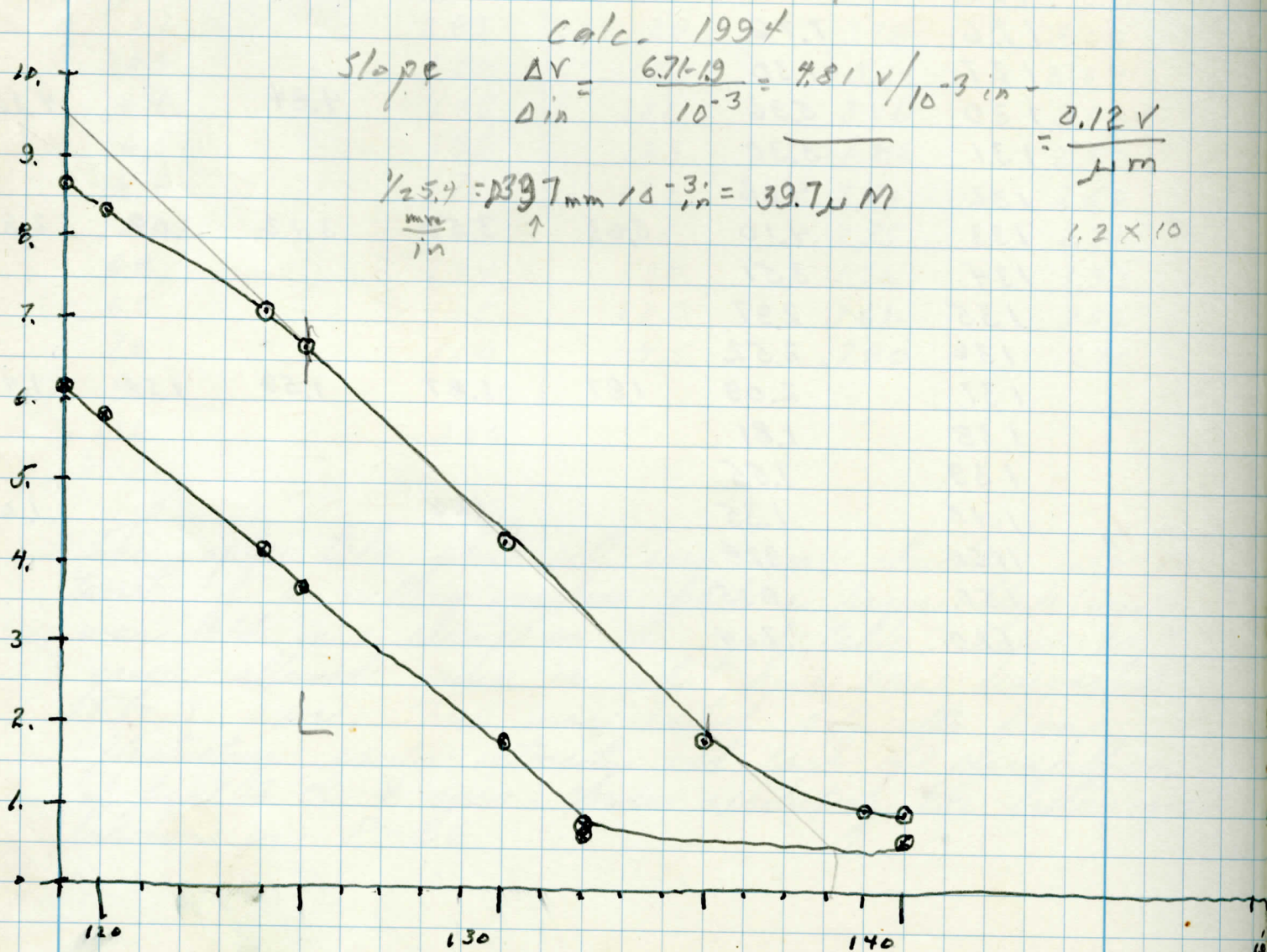
$y_0 + 10^{-2}$

1° Oct.

 E_0 X ($Y = +10^3$) Volts·e
 $i_n \times 10^{-4}$

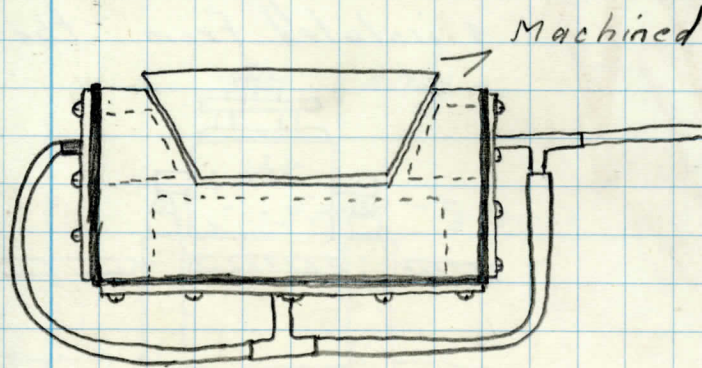
	0	10.1							
0.23	10	"							
	20	"							
9.22	30	"							
8.90	40	"							
8.95	50	"							
7.62	100	"							
6.30	0	10.0	10.0	9.90	10.1	10.0	9.49	9.45	
4.47									
2.49									
	109 (119)	9.84	9.64	9.25	9.45	9.33	8.66	8.90	
	123.2	8.74							
	124.	8.48			7.80				
	125	8.17	7.64	7.68	7.34	7.30	6.75	6.90	
	126	7.76							
	127	7.30							
	130	5.96			4.84		4.36	4.40	
	131	5.30							
	132	4.62							
	133	4.10	3.63	3.58	3.12	3.08	2.80	2.84	
	134	3.51							
	135	2.97							
	136	2.52							
	137	2.09	1.87	1.87	1.59	1.58	1.47	1.44	
	138	1.81							
	139	1.55							
	140	1.35		1.26			1.04	1.04	
	1450	.928							
	150.	.835							
	160.	.764							

$Y = 10^{-2}$		$Y = 1.5 \times 10^{-2}$		$Y = 10^{-2}$	Est.
X	E_0	X	E		
in $\times 10^{-4}$	-Volts				
0	9.45	0	9.45	9.42	
119	8.65	119	6.15	8.25	
120	8.44	120	5.84		
124	7.12	124	4.10		
125	6.71	125	3.65	6.40	
127	5.80	127	2.80		
130	4.27	130	1.84	3.85	
133	2.63	133	1.23		
135	1.90	135	.997		
137	1.41	137	.865		
140	1.01	140	.783	.957	
150	.755				
170	.654				



10 Oct 65 Experimental Work

The shop (Sgt. Benz & Mr. Knight) fabricated in short order a working air bearing roughly sketched below. It worked well as regards



Machined Al.

to friction. It is stable and will operate

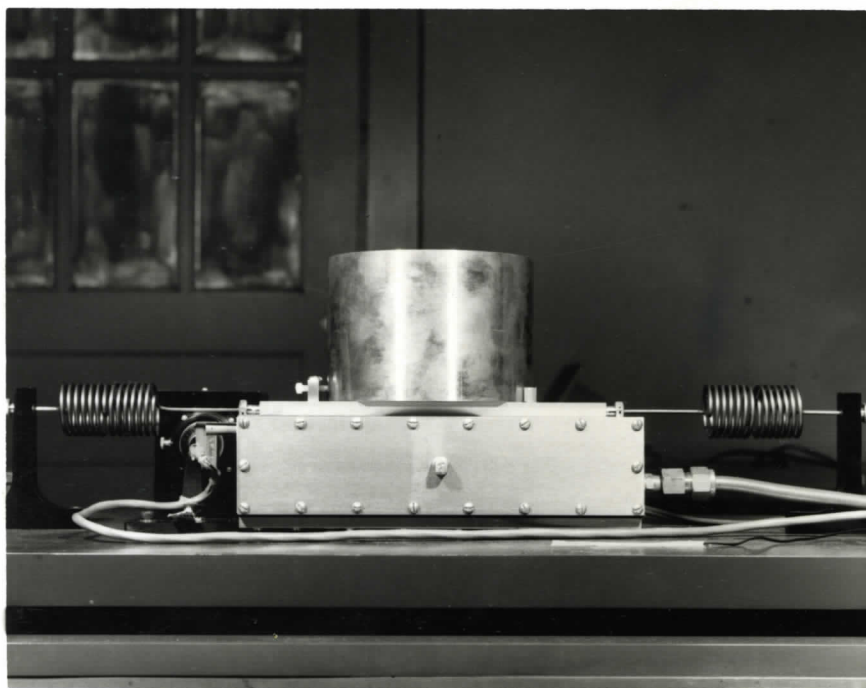
$\bar{c} \sim 100^\circ$

max. load -

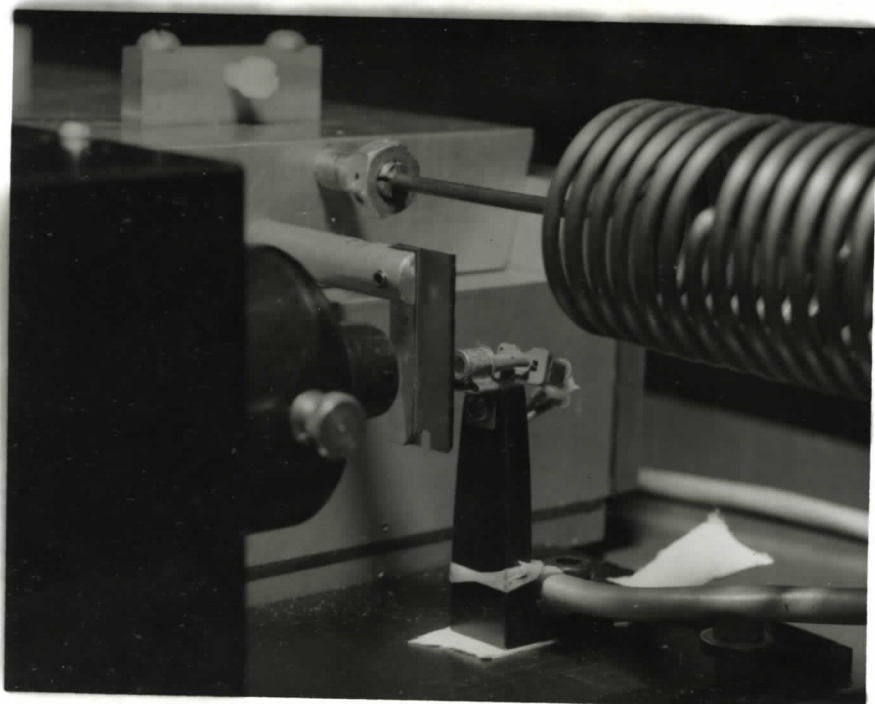
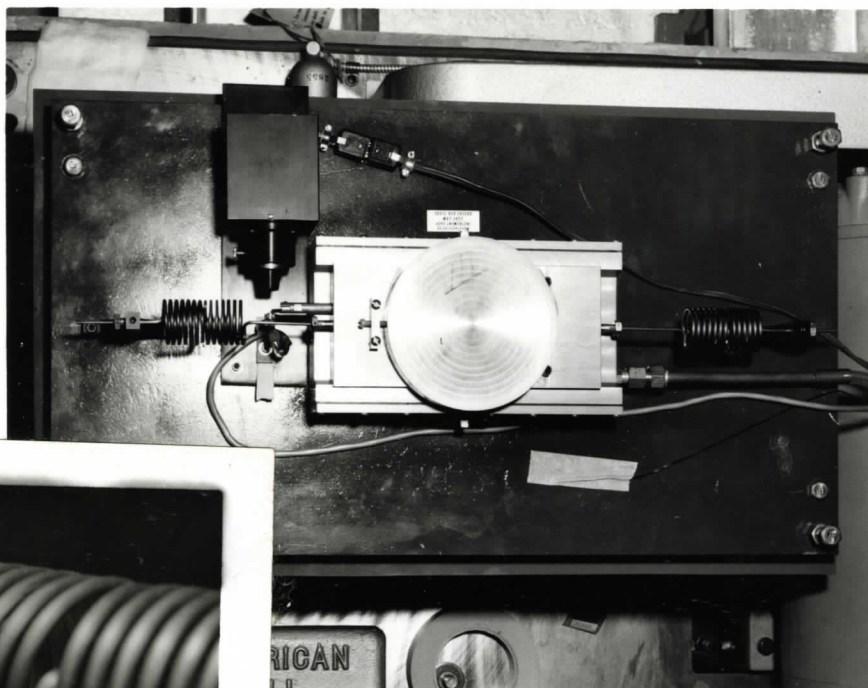
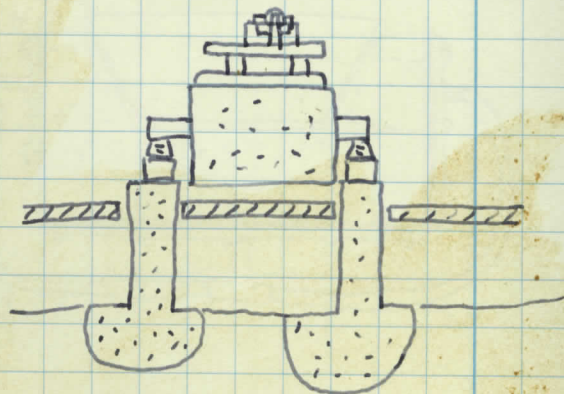
Heavy loads do require centering -

With this bearing and the steel table and scrap steel springs and

the "35 mm" zero crossing detector some runs were made $\bar{c}$ weights determined from a "0.1%" lab scale. This were used in the calculations on P-89.



2^o Version of Air Bearing
Mtd. on ~~the~~ Shake Table
bolted to # of concrete
supported by vibration
isolators on 4-12"
concrete pillar to earth
& isolated from the bldg-



◁ Optical Assy-

$$T = \frac{2\pi}{2\pi} \sqrt{\frac{W}{KG}}$$

$N_0 - 2\pi$
 $\swarrow$
 $9/82$

$$W = KG T^2$$

Using $G = 385.54372 \text{ in/sec}^2$ (Austin, Tex.)
 $1 \text{ in} = 2.540005 \text{ cm}$
 979.283 cm/sec^2 (kg)(cm/sec)² sec dim. OK

pan only: $T = 327.47 \times 10^{-3} \text{ sec} = .32747 \text{ sec}$

$$W_{\text{Pan} + \sim 1/3 \text{ spring}} = K \cdot 385.54372 \times 10^2 \text{ in/sec}^2 \cdot .32747^2 \text{ sec}^2$$

$$2\pi \sqrt{\frac{W}{KG}}$$

$$= K$$

$$\times .1072366$$

$$4\pi^2 T^2 = \frac{W}{KG}$$

$$= 4.1344397 K \text{ lbs}$$

$$W = KG T^2 4\pi^2 \text{ or } W_{\text{kgm}} = K \cdot 979.283 \times .1072366$$

$$= K \cdot .105015 \times 10^3$$

$\bar{c}$.500 kgm added. $T = .39088 \text{ sec}$ $T^2 = .152787$

$$W + .500 = K \cdot 979.283 \times .152787$$

$$1.05015 K + .500 = K \times 1.496217$$

$$K \cdot .500 = \frac{(1.496217 - 1.05015)}{1.05015} K$$

$$.500 = .446067 K \quad 1.391166 K$$

$$K = 1.1209078 \cdot 359.41073$$

$$W = 1.1209078 \cdot 1.05015 = 1.17212$$

$$W = .35941073 \cdot 2\pi T^2 = .35941073 \times 12.5664 \cdot 1072366$$

$$= \frac{4.5165023 \times 1.072366}{2} = 4.843343$$

(corr for 4π)

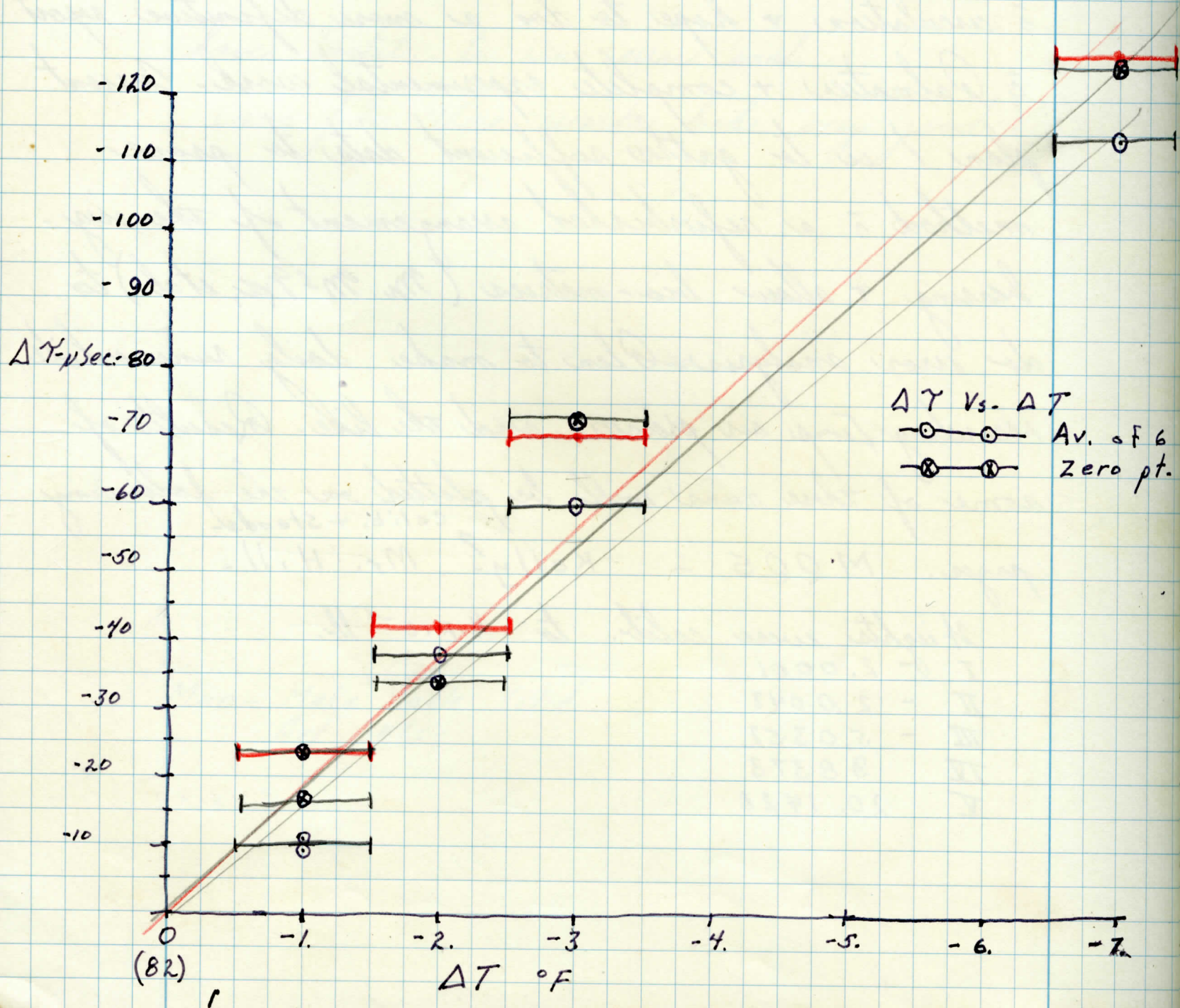
$$\begin{array}{r} 1.496217 \\ - 1.05015 \\ \hline 1.391166 \end{array}$$

17 Nov.

The original bread board demonstrated a time
 *resolution of $\sim 50 \mu s$. but *stability studies were
 only cursory and might amount to $\sim 100 \mu sec.$ over
 several days $\pm$ trend. A man carrying version
 has been fabricated except for optical assay. +
 "seat" - need priority. A brief report has been prepared
 $\bar{c}$ circulation + hope to do a more definitive report
 $\bar{c}$ Palmatier + complete experimental work. Current
 plan 1 is to gather sufficient data to prove
 method $\bar{c}$ a refurbished arrangement of the orig.
 bearing + allow bio-metrics (Mr. McQua, et al) to
 do error analysis. Plan to make daily runs while
 recording temp air pressure and the like. Results of
 some of these runs will be plotted on the following
 pages. M Q Q S - Kelly^{Calib. + Stands.} Mr. Hill.

Weights were calib. to 4×10^{-4} lb.

I	-	2.0001
II	-	2.0043
III	-	5.0352
IV		9.8373
V		20.1428



Date + Time	Wt #						Conditions	
	I	II	III	IV	V	0	μ Sec. (Avg. of 10)	Temp °F PSI Press.
15 Nov.	219415.	2195033	281574	358569	484611.	608. 69. 2°Run 166471.5 484611.6		82. 5.
16 Nov.	373.	470.	281528.	538.	574.	437.		80. 5.
(0800)? m	-42.	-33.	-46.	-31.	-37.	-34.	Av. -37.	-2
1400 m	219401.	497.	561.	572.	615.	457.		81. 5.
	17.	6.	13.	+3	+4	-24	Av. -9.	-1
1600 wt	392. 23	494.	554.	559	586.	453.		81. -1 5
2° 1600 wt	397. 18	488.	556	569	602.	454.		" -1 "
	-10.	-2.	-19.	-5.	-17.	-17.	-11.	
17 Nov. m	343.	446.	513.	527.	552.	398.		79. -3 5.
0815	-70.	-57.	-61.	-42.	-59.	-73.	-60.	

17 Nov.	386	487	551	558	579	446.		*80 5
1615	-29	-16	-23	-11	-32	-25	-22	
18 Nov.	288	392	463	471	497	346		75. -7 5
0800	-127	-111	-111	-98	-114	-125	-114	

* This fig. obtained 2 hrs. after meas.

LABORATORY ANALYSIS REPORT AND RECORD		DATE 18 Nov 1965
TO Aerospace Medical Center		FROM SAAMA MQQS
SAMPLE IDENTITY Weights 5 ea		DATE RECEIVED 18 Nov 1965
SAMPLE FROM Aerospace Medical Center		LAB CONTROL NR
TEST FOR Weight		

7 Apr. 66

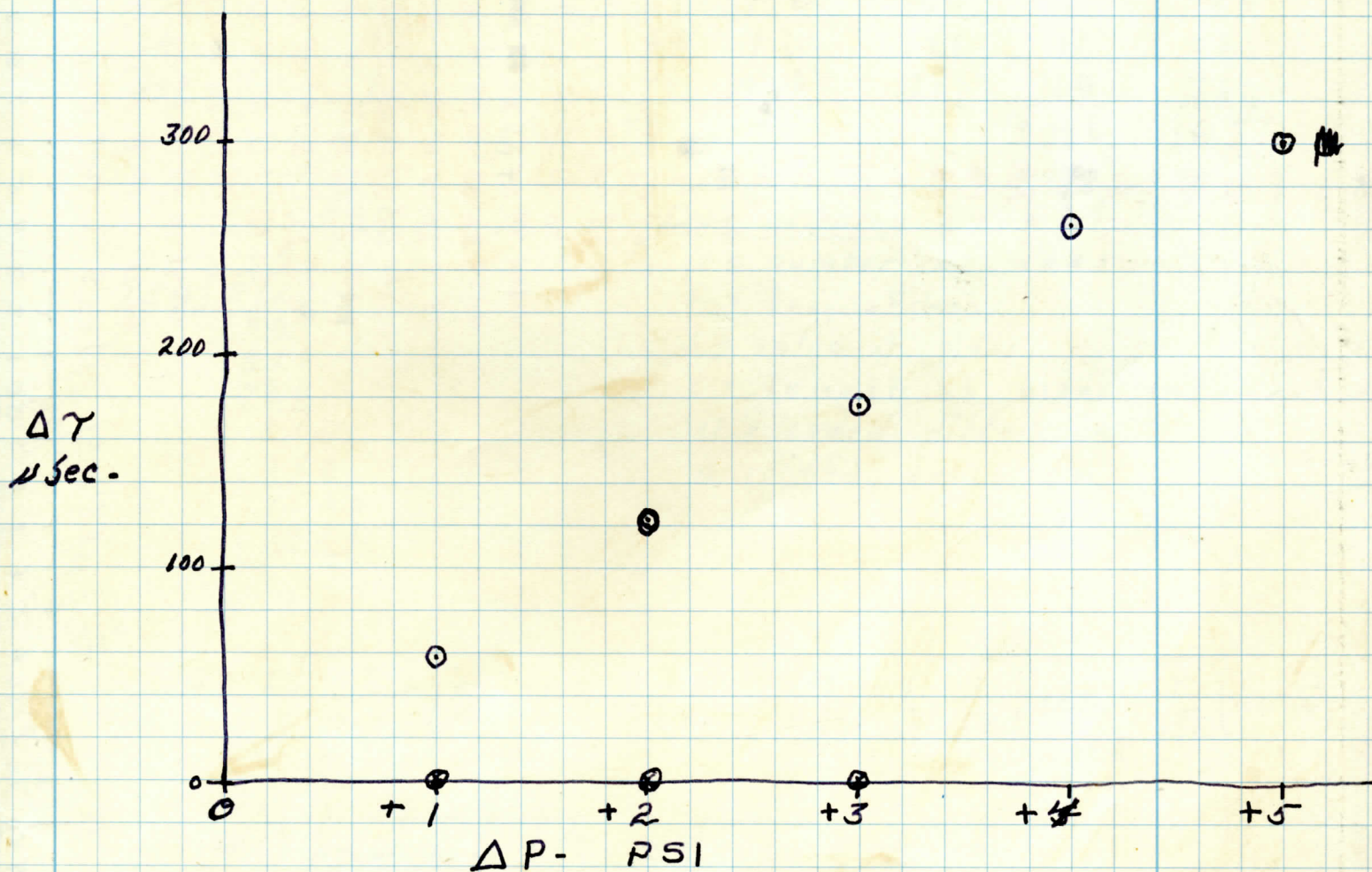
Wt	Avd	AVd.	Weight	%	Metric
I	2.0001 lb	2.0005	$+ 4 \times 10^{-4}$		907.245 Gm
II	2.0043 "	2.0046	$+ 3 \times 10^{-4}$		909.127 Gm
III	5.0352 "	5.0391	$+ 4 \times 10^{-3}$		2283.946 Gm
IV	9.8373 "	9.8391	$+ 2 \times 10^{-3}$		4462.012 Gm
V	20.1428 "	20.1463	$+ 4 \times 10^{-3}$		9136.584 Gm
		15,0060			

H. F. Roemer



Variation of period as $\pm$ of air bearing pressure
and initial displacement -

Bearing Press. PSI	Av. of 10 γ μ sec (0 wt)	Av. μ sec. (20#)	ΔT usec
5	166441	484558	0
	439 0	550	
6	443 2	614	+56
7	439	678	+120
8	439	735	+177
9		820	+262
10		858	+300



$$907.245 \overline{) 22,512,255} \quad \mu\text{sec}^2/\text{gm}$$

~~50713~~

1814490

2279230

1814490

4647408

4536225

1111839

907245

2045945

1814490

2314550

1814490

5000600

4536225

4643750

212,8

$$1882 \overline{) 43,006,516,000.}$$

~~764~~

3764

5366

3764

16020

$$1374.819 \overline{) 22,61} \quad 31,096,564,544,000.$$

2749638

3600184

2749638

8505465

8248914

2575514

-4 -3 -2 -1 0 1 2 3 4

28

-3 -2 -1 0 +1 +2 +3

 $\Delta T \quad \mu\text{sec} \quad - T_0 =$ $F_0 = 0.9994 \text{ Wt} = I \quad 23 \text{ Nov} - T = 24.7^\circ\text{C}$

23 Nov? 1815 Resolution of Pendulum
 Quiet - Air Press had slow variation of possibly
 190 ± 5 mm Hg - F_0 at 1815 999999.4 CPS +
 9999987 at 1845 Temp - 24.7°C
 No Traffic & Air Comp. off during readings -
 On 1st Run there was a slow drift of $\approx 2 \mu\text{sec}$
 during reading - probably electronics stabilizing -

T in μSec

Wt-	T_0 (us)	3	-2	-1	0	+1	+2	+3	+4	Total
I	219305			18	28	27	21	21	7	122
II	219420		30	62	53	28	3			176
III	281500		9	76	48	11				144
IV	358507	7	32	42	39	15	2			130
V	484533		7	17	14	27	5			70
0 $\frac{20}{\text{Run}}$	166426		11	93	130	18				252

Plotted P-106

Linearity CK-

Plot: $T^2 = C + K M$

$C = F(\text{initial Mass}-M_0)$

Linear when plotted $T^2 \propto F(M)$ $K = F(\text{Spring Const})$

From record of 23 Nov 1815 $T = 25.3^\circ\text{C}$ $M = \text{Mass added } \Delta M_n$

$F = 9999985$ $P = 190$ mm Hg

n	T (Avg. 20 n) μsec	T^2	ΔM	$\frac{\Delta M}{\Delta T^2}$
V	484,515	234 754 785 225	9136.584	
IV	358,522	128 538 024 484	4462.012	2.272×10^7
		106216760741	4674.572	
III	281,5 38	79 263 645 444	2283.946	
		49274379040	2178.066	2.2616
II	219,470	48 167 080 900	909.127	
		31096564544	1374.819	2.2618
I	219,372	48 124 074 384	907.245	
		43 006 516	1.882	2.285
0	166,432	27,699,943,489		2.251×10^7
		20,424 130 895	907.245	
III-0	51563701955			22.51

48 167 080

$$\begin{array}{r}
 2178066 \overline{) 49274379040000} \\
 \underline{4356132} \\
 5713059 \\
 \underline{4356132} \\
 13569270 \\
 \underline{130683964} \\
 500884 \\
 \underline{4356132}
 \end{array}$$

$$\begin{array}{r}
 4674572 \overline{) 106216760741000} \\
 \underline{9349144} \\
 12725320 \\
 \underline{9349144} \\
 33761767
 \end{array}$$

.5

.1

.02

Date	Wt #	T- μ sec						T °C	P mm. Hg.	F ML
Time	O	I	II	III	IV	V				
22 Nov. 1515	166	459.7	219401.5	219497	2815755	358585.3	484685.5	25.95	<u>260</u>	- Ar ₂₀
23 Nov. 0900	443.-	382.-	478.-	548.-	529.4 536.4	557.7		24.6	190	.9994 Ar ₂₀
-1600	439	372	470	534	520	503		25.3	190	.9986 Me ₂₀
2000	432	372	474	540	527.	540.		25.15	190	.9985 Me ₂₀
24 Nov. 0830	384	341	440	508	491	489.		25.8	190	.9995 Me ₂₀
25 Nov 0830	343 380 ² run	282	382	444	534 ²	435 ²		18.°C	190	.005 Me ₂₀

Calculation of M_0 -

$$T = \sqrt{\frac{M_0 + \Delta M}{K}}$$

$$T^2 = C + KM = \frac{M_0}{K} + \frac{\Delta M}{K}$$

$$\text{if } \Delta M = 0 \quad T_0^2 = \frac{M_0}{K}$$

$$T^2 = T_0^2 + \frac{\Delta M}{K} \quad T^2 - T_0^2 = \frac{\Delta M}{K}$$

$$K = \frac{\Delta M}{T^2 - T_0^2} \quad \& \quad M_0 = K T_0^2$$

$$T_1^2 - T_0^2 = 20,424,130,895 \quad \Delta M = 907.245$$

$$K = 4442$$

$$M_0 = \frac{1,230.4 \text{ Gm}}{2,137.6}$$

$$\frac{18}{2 \times 10^3} \sim .9 \times 10^{-3} = .9 \times 10^{-1} \%$$

$$= .09 \% (50\%)$$

for ΔT of 100 sec.

$$\frac{.09}{5} = .018$$

$$T = 2\pi\sqrt{KM}$$

$$T^2 = 4\pi^2 KM$$

$$(1994) \quad K = \frac{T^2}{4\pi^2 M} = \frac{.0276}{4 \cdot \pi^2 \cdot 1.23} = 7$$

of
Trial

6

- 0 -

5

4

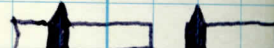
3

2

1

166,393 4 5 6 7 8 9 10 11 12 218,303 4 5 6 7 8 9 10 11 12 13 14 15 16 17

Time μ Sec



6 - III

5

4

3

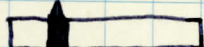
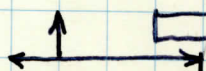
2

1

0

282,505 6 7 8 9 10 11 12 13 14 15 1 2 3 4 5 6 7 8 9 10 1 2 3 4

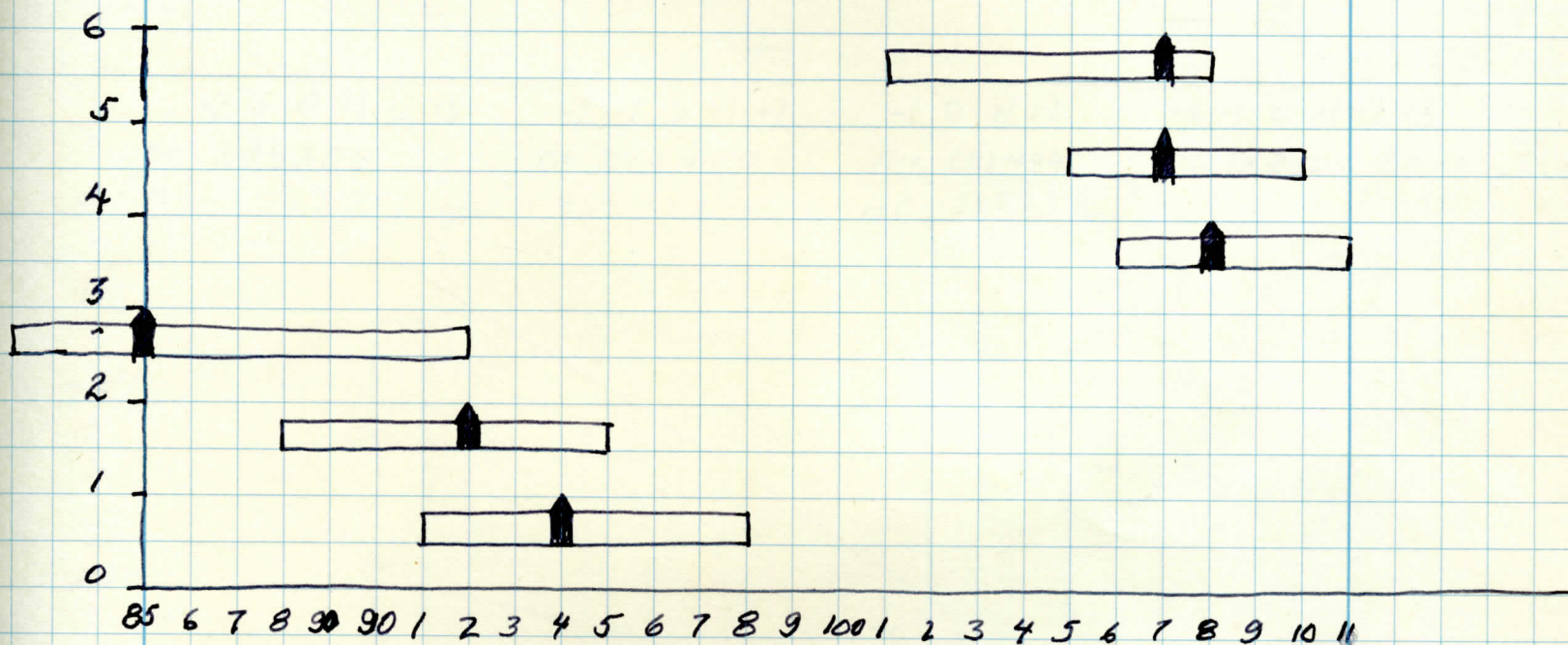
357508 9100



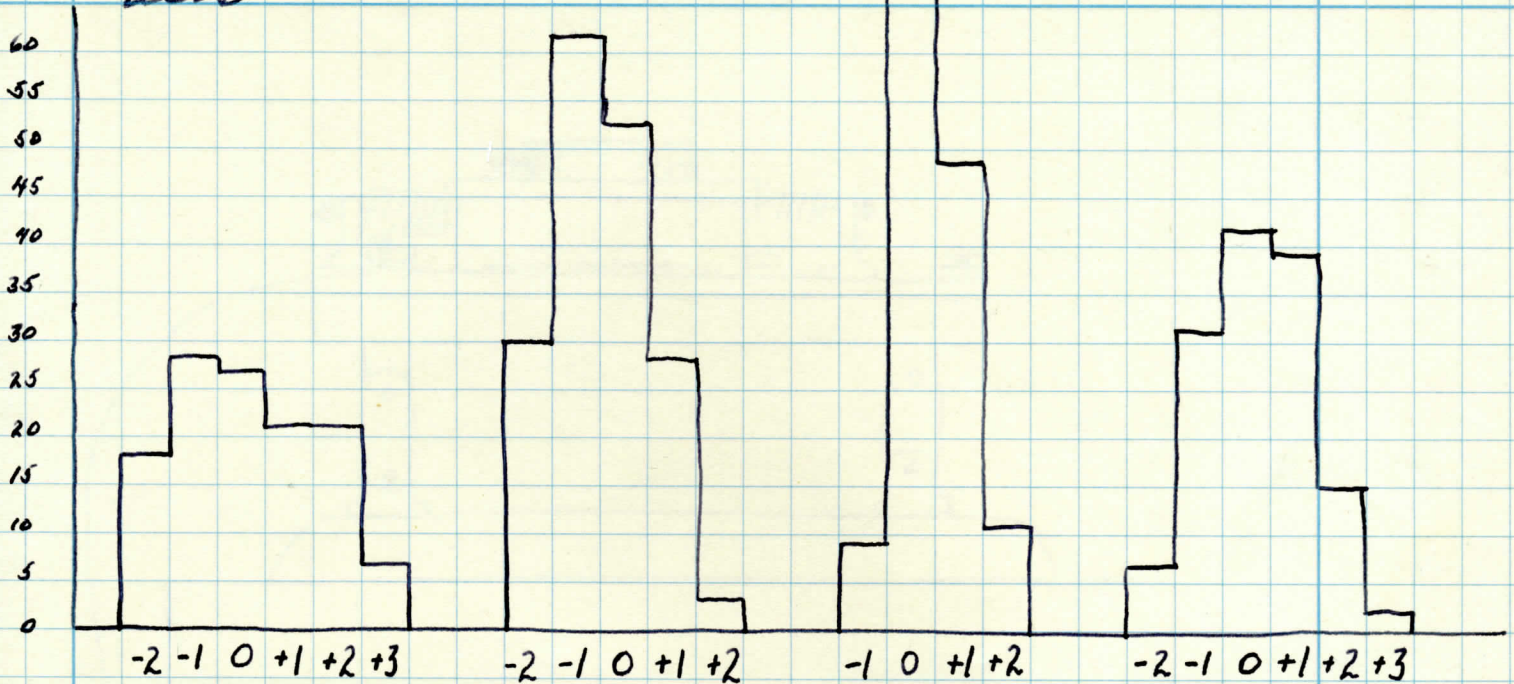
IV

26 Nov. Short Term Stability as f(repeated trials)
 5 runs of 0 + 5 AM (P.94) over 1 1/2 hr. period
 Temp. varied.
 Will take Avg. Max dev. + most Freq.
 The ΔT makes this a poor method

27 Nov. Will make runs of 6 ea. of same value
 recording temp. before + after ea. run. It is obvious
 that some form of fixed mechanical release is
 needed. Results plotted on P-104



Histograms of resolution tests



O = 219306

O = 219420

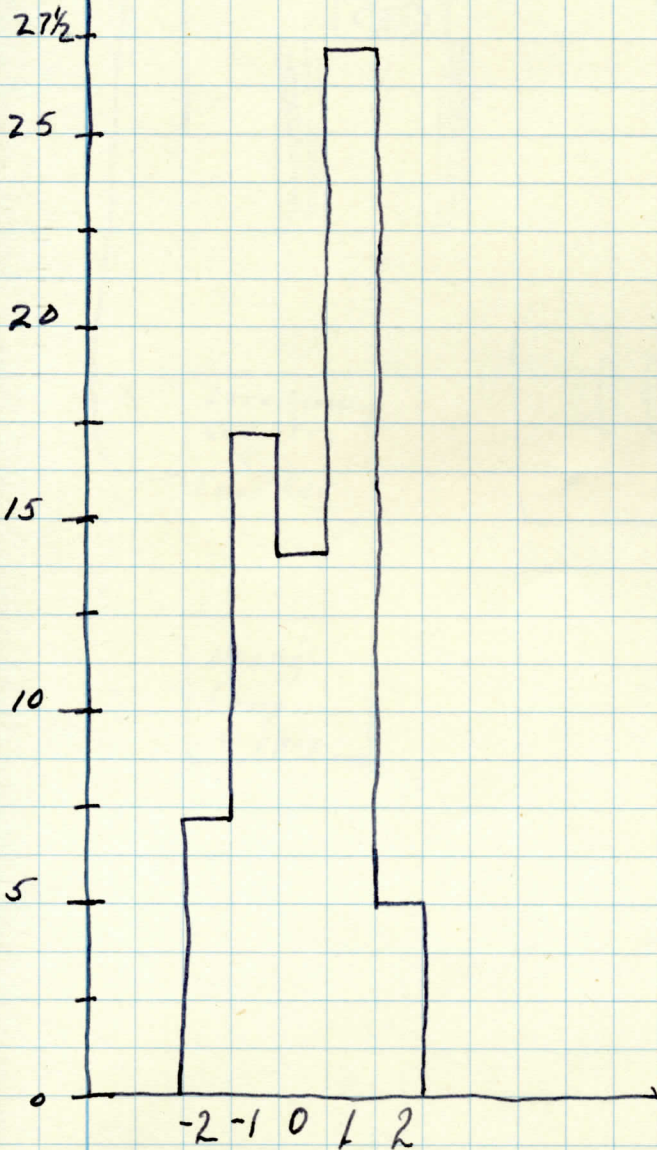
O = 281499

O = 358506 / 4462, 012

1997 M = 907.245 gm

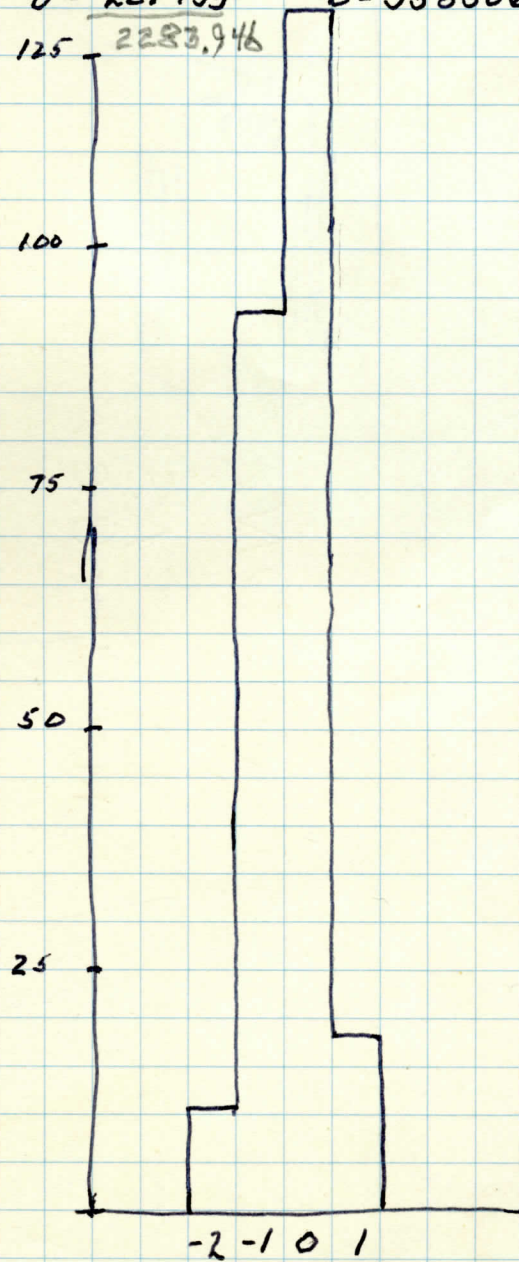
909.127

125 2283.946



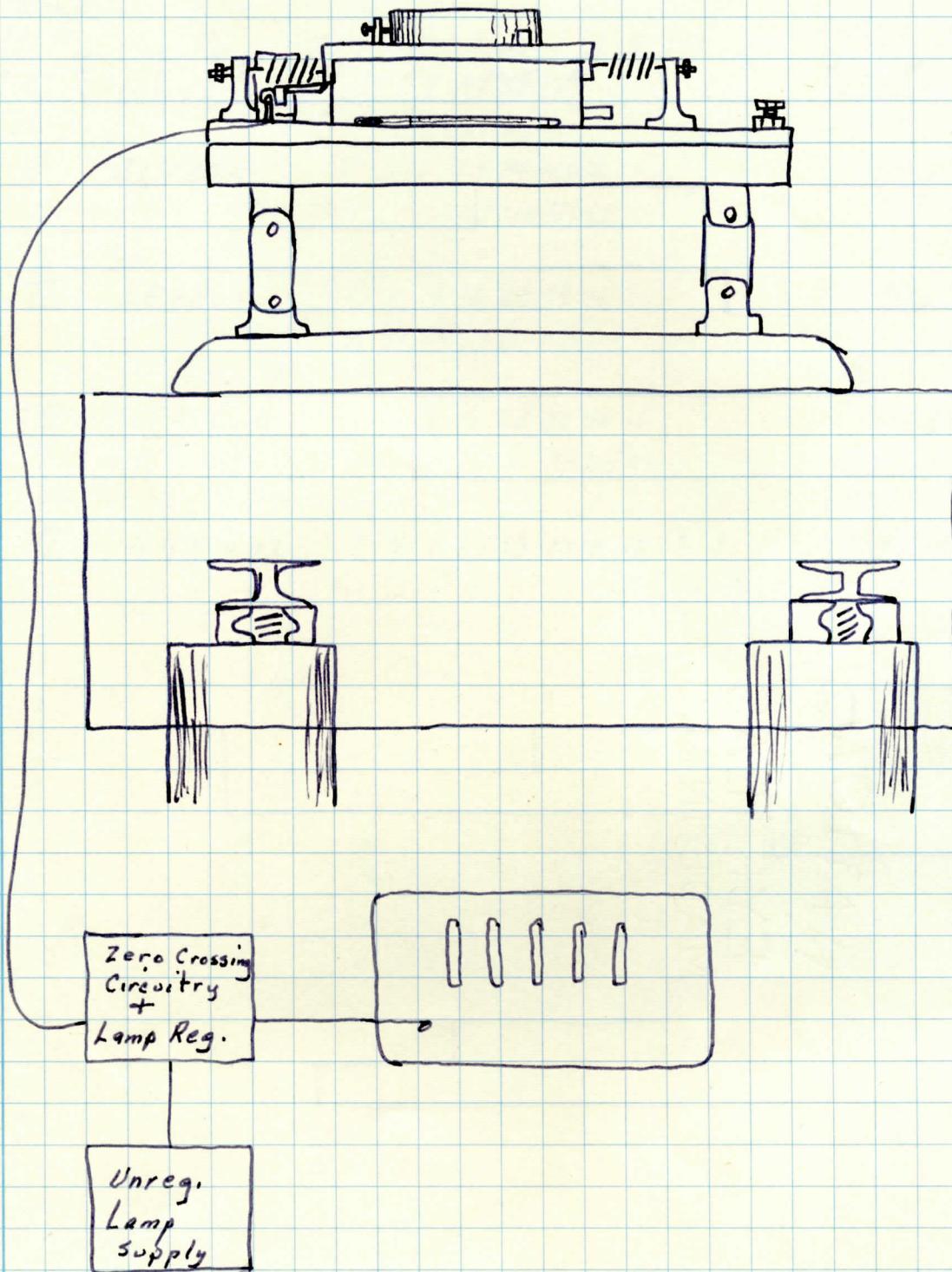
O = 484533

1994 M = 9136.584 gm



O = 166426

0



Histogram of T during continuous oscillation.

Total # of Samples

162

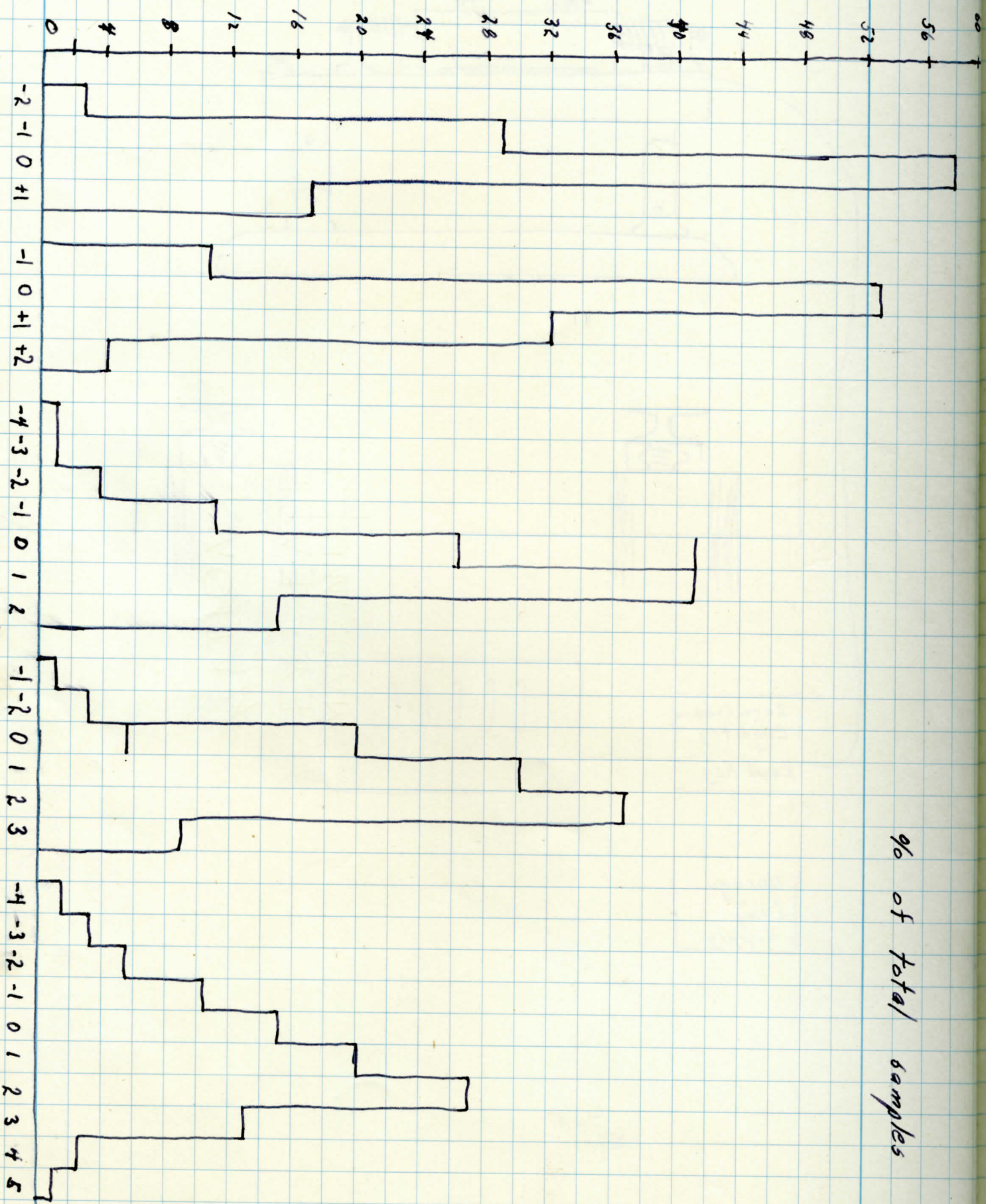
140

106

125

124

$\Delta T = 0.5 \text{ sec}$



% of total samples

Histogram of γ -

Data collected 28 Nov. (evening) $\bar{c}$ relatively constant temp.

Temp	Wt #	T_0	-5	-4	-3	-2	-1	0	1	2	3	4	5	Total	$\bar{x}$	$\sum x^{n-1}$ (1994)
21.1	0	166425				4	47	95	17					162	4.765	.677
						2.47	29	58	105							
	I	219360						15	74	45	6			140		
								10.7	528	32.1	4.3					
	III	281519		1	1	4	12	28	44	16				106		
				.94	.94	3.8	11.3	26.4	71.5	15.1						
20.35	IV	358502					1	4	25	38	46	11		125		
							.8	3.2	20	30.4	36.8	8.8				
	V	484492		2	4	7	13	19	25	34	16	3	1	124	91.895	1.775
				1.61	3.2	5.6	10.5	15.3	22.1	27.4	12.9	2.4	.8			

Slope

$$\frac{\Delta M}{T_m^2 - T_0^2}$$

44.5

44.4

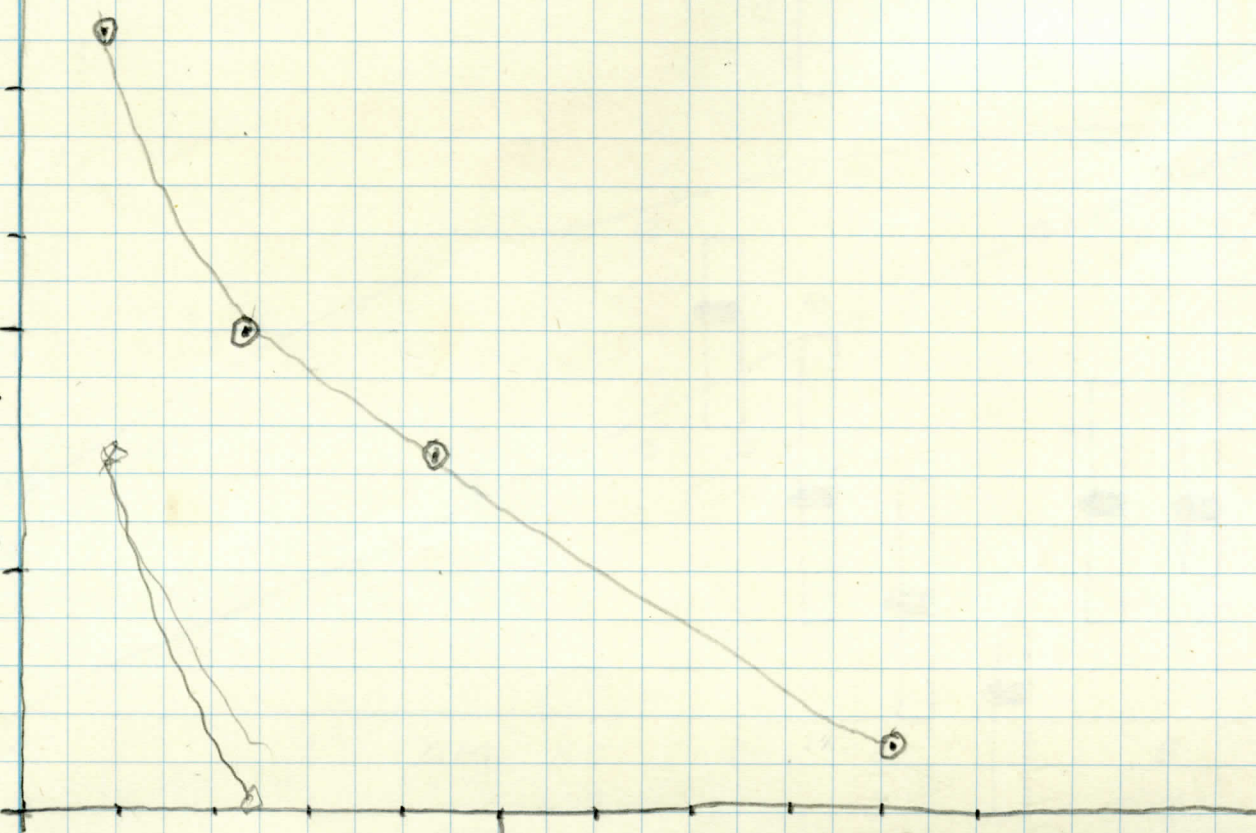
44.3

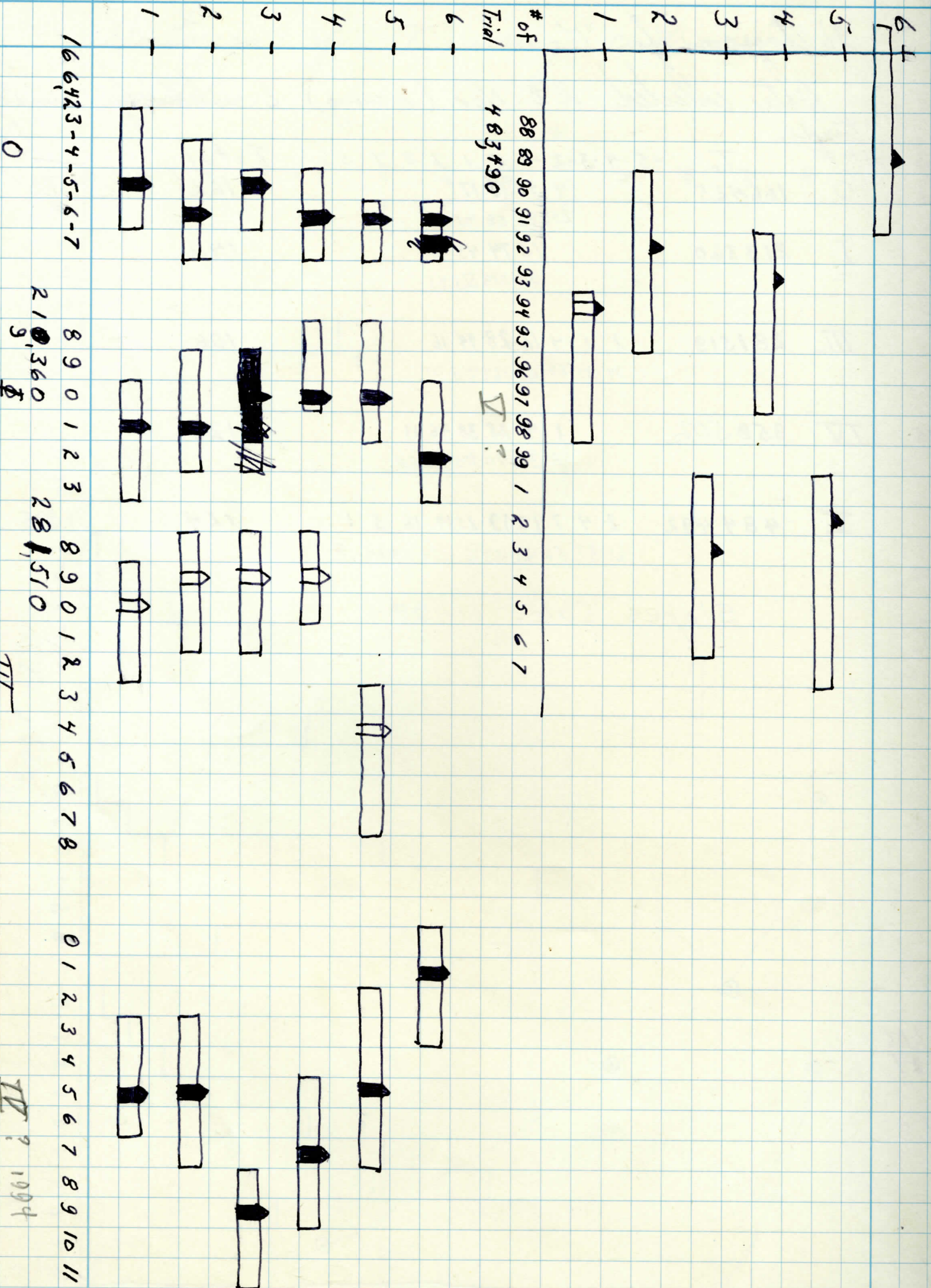
$$\frac{\Delta W}{W} = \frac{2\Delta T}{T}$$

44.21

44.1 0

Slopes Calc. 11-94

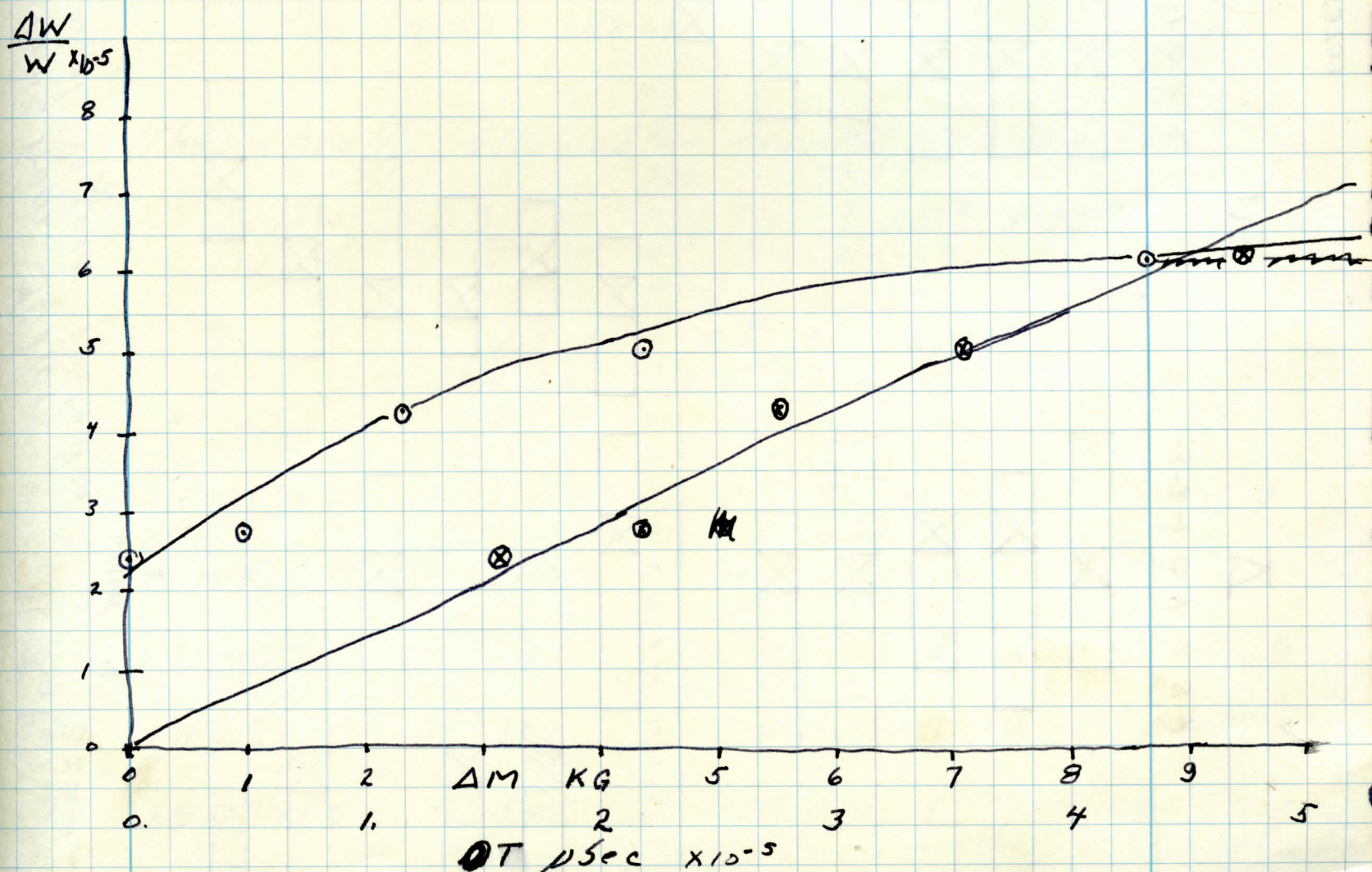




At the same time the records on P-111 were run each long record was followed by 6 samples of 20 + 10 taken in the same wt. but in the wt. unclamped, lifted claw, turned + reclamped between runs. The theoretical time error is -

$$\frac{\Delta W}{W} = 2 \frac{\Delta T}{T} \quad \text{or } \frac{\Delta T}{T}$$

T	Max. of medians.	Max. of all samples	Med.	All
1.66×10^5	2 x 2 = 4	4 x 2 = 8	2.4×10^5	4.8
2.19 "	3 = 6	6 = 12	2.73	5.46
2.81 "	6 = 12	10 = 20	2.13 4.27	7.
3.58 "	9 = 18	12 = 24	5.02	6.7
4.84	15 = 30	23 = 56	6.19	11.57



Histograms from 30 Nov.
 Mechanical Release Installed
 AL Kato Kunitz
 3220

180908

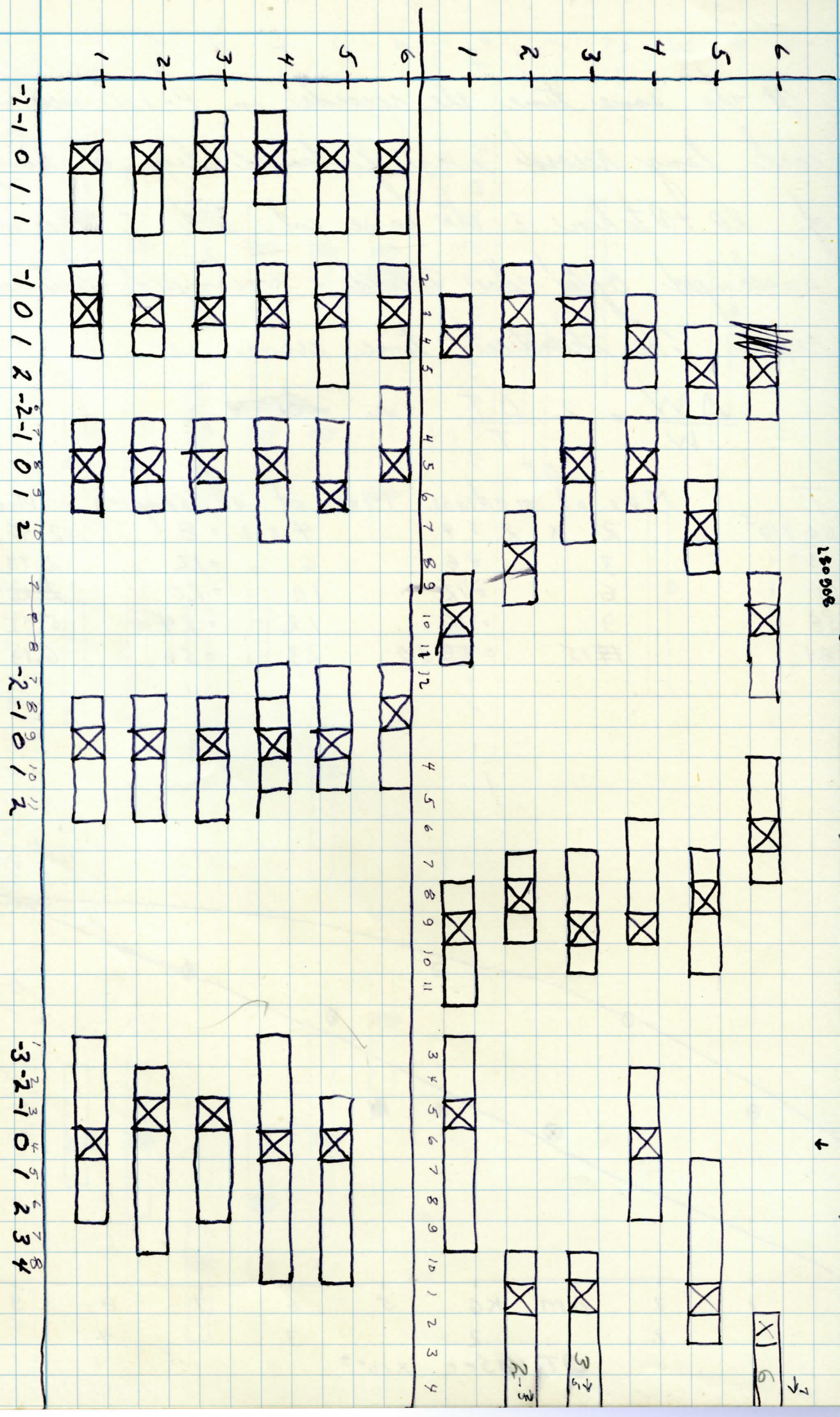
I

II

III

484955

↓



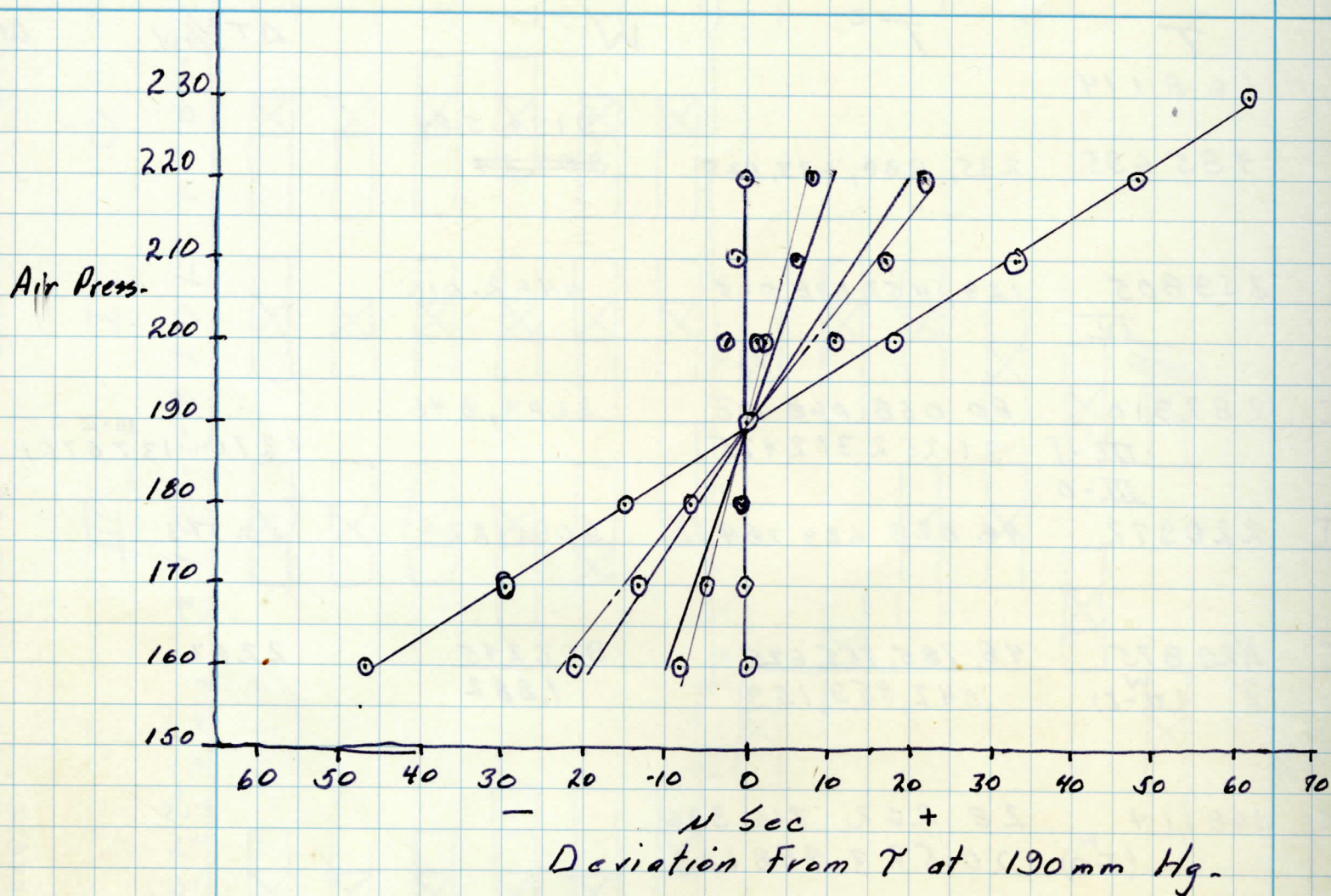
	T	T ²	W	$\Delta T^2 / \Delta W$	ΔW
0	168114				
V	485695	235,809,633,025	9136.584 907.24		
IV	359805 IV	129,459,638,025	4462.012		
III	282910 III-I III-0	8,0038,068,100 31,252,302,475	2283,946	2270	1376701 ^{m-l}
II	220972	48828,624,784	909.127	22773	
I	220875 (II-I)	48,785,765,625 042,859,159	907.245 1.882	2262	
0	168114 (I-0)	2.8 262 316 996 20 523 448 629			

Theoretically allowable error (ΔT) for 0.1 + .01% .001

$$\frac{\Delta W}{W} = 2 \frac{\Delta T}{T}$$

$$\Delta T = \frac{T}{2} 10^{-3} + 10^{-4}$$

	$\frac{T}{2}$	$\frac{\Delta T}{(10^{-3})} \mu\text{Sec}$	$\frac{\Delta T}{(10^{-4})} \mu\text{Sec}$	AIMed. Fix Var.	100% Fix Var	
0	84057	84.	8.4	0	4	
I	110437.5	110.	11.	0 3	4	5
II	110486.	110.	11.			
III	141455.5	141.	14.1	1 6	5	9
IV	179902.5	180	18.	1 4	5	8
V	242847.5	242.	24.	1 7	8	15



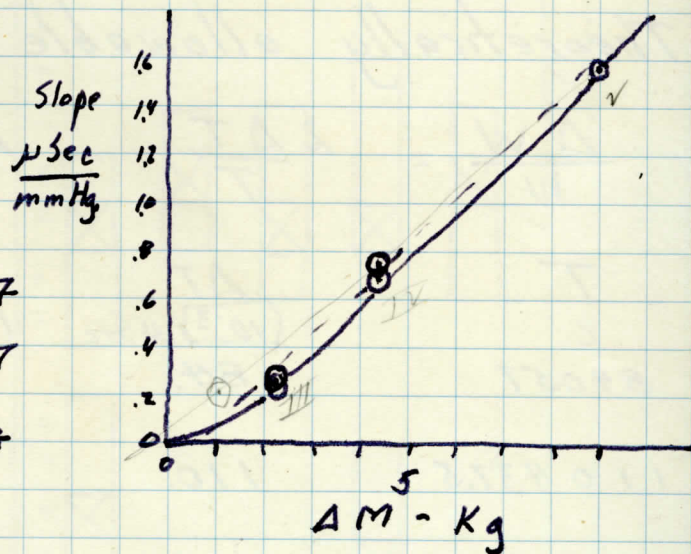
Slope $\frac{\Delta T}{\Delta P}$ — $\frac{\mu \text{ Sec}}{\text{mm Hg}}$

$\frac{\Delta T_1 - \Delta T_2}{\Delta P_1 - \Delta P_2}$

IV $\frac{62 - (-48)}{220 - 160} = \frac{110}{60} = 1.83$

IV $\frac{22.5 - (-22.5)}{220 - 160} = \frac{45.0}{60} = .75$

III $\frac{7 - (-8)}{60} = \frac{15}{60} = .25$



Variation in period as a function of mass weight and air bearing pressure:

On 27 Dec. at ~2200 various wts. were added & continuous oscillation - The bearing press. was varied in 10 mm. increments & contin. recording.

Wt #	Press -	Median (10 samples)	ΔT	$\nu_{sec.}$
190		75	ΔT	
190 200		93	18	
190		76	17	17.5
200		94	18	18
210		110	34	34
190		78	32	
220		126	48	48
190		78	48	
230		140	62	62
190		81	69	
New Cycle				
190		80		
180		66	-14	14
190		81		15
180		67	-13	14
170		51	-30	31
160		33	-47	49
190		80	47	
190		76		
180		68	-8	7
170		62	-14	13
160		54	-21	21
190		74		
200		81	+7	7
210		85	+11	11
220		91	+17	17
230		96	+22	22
190		74		22
180				
170				
160				
190				

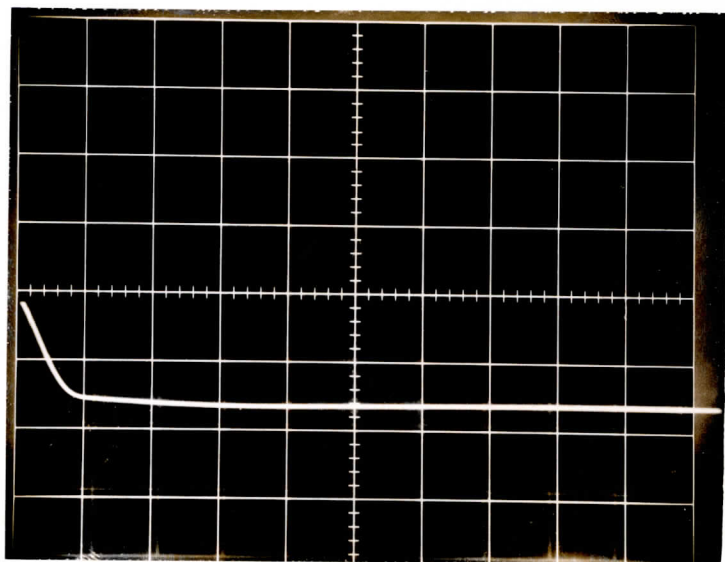
84	
85	1
90	5 6
92	2 8
84	
83	1
79	4 5
76	3 8
83	7

(over)

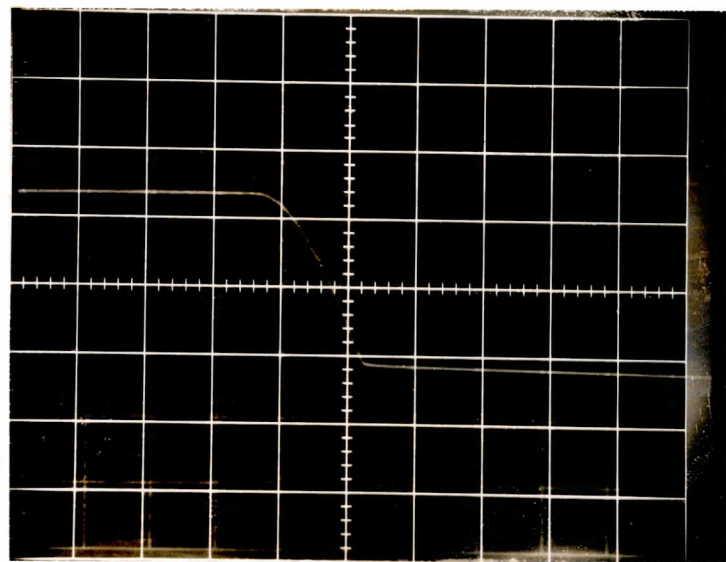
$\Delta M = 0?$

Press Mm. Hg.	T_{OK} μ sec	ΔT	$\Sigma \Delta T$
190	97		
200	95	-2	
210	96	-1	
220	97	+1?	
190	97		
180	98	+1	
170	98	0 +1	
160	97	0 +1	
190	98	+1	

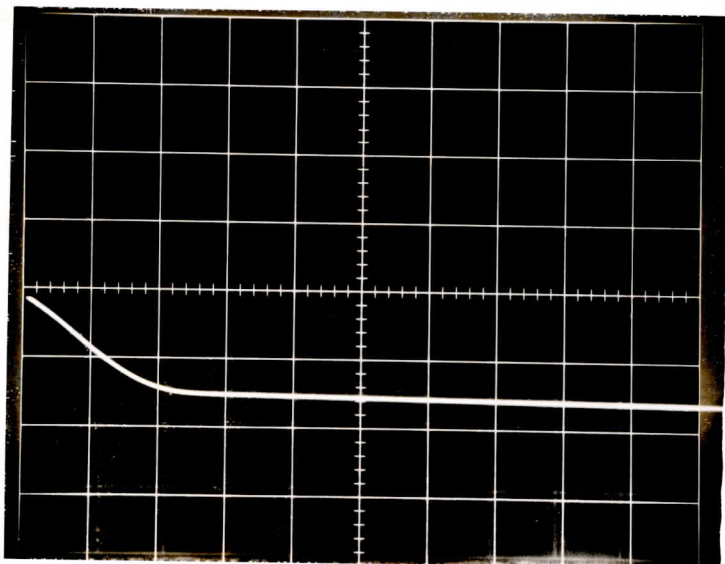
Output of photo-det. Amp-



5 ms
L O ΔM

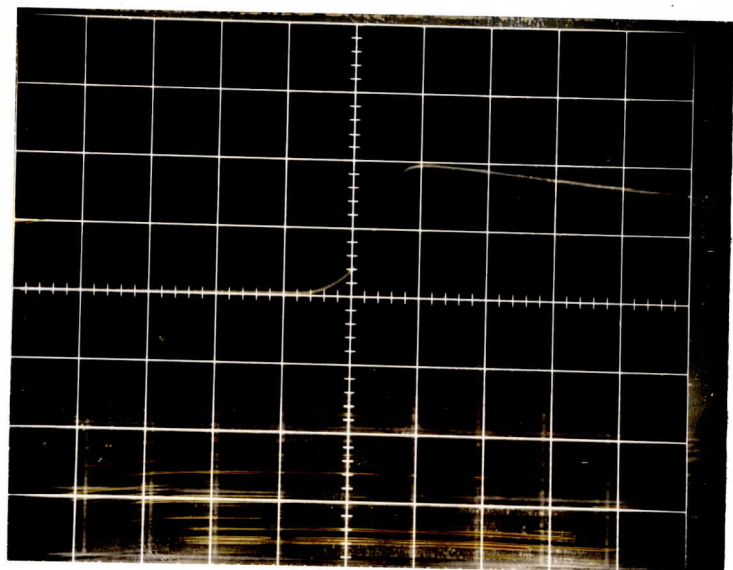


20 μ s
20 μ sec + 10 V/cm



5 ms

2.9 Kg. ΔM
5 m/s cm. + 5 V/cm - 5/8" amplitude



20 μ sec
Trig. out. 5V + 20 μ /5 cm.

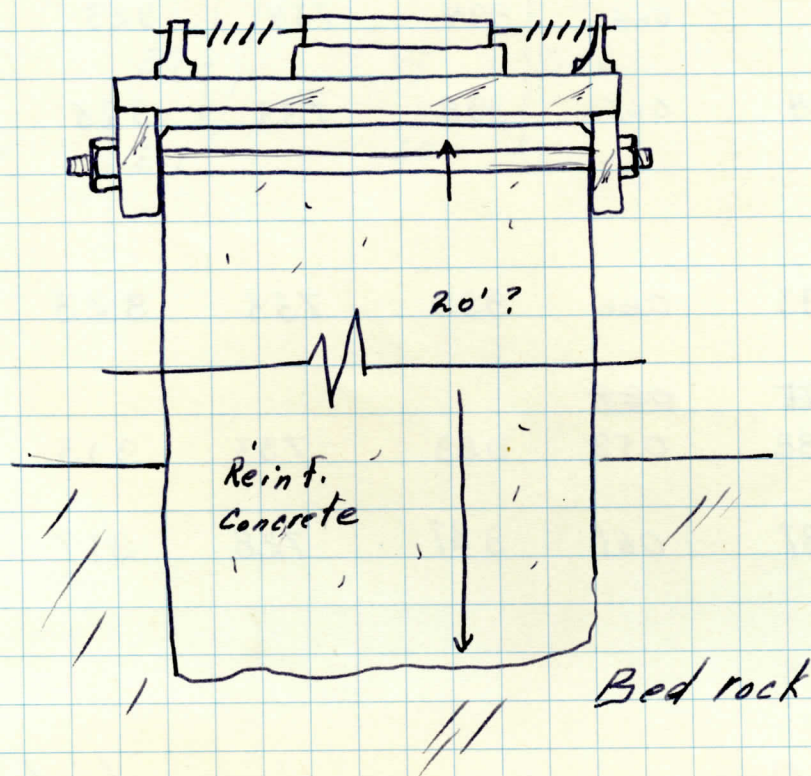
Errors - in timing -

The 523 D uses separate start stop Schmitts in the trigger and the low slope of this waveform may produce errors in trigger drifts.



The P-65 AU has only a max slew rate of $0.6 \text{ V}/\mu\text{sec}$. + replacing this with a P45 A yields a rate of $> 10 \text{ V}/\mu\text{sec}$.

15 Dec. New location of pendulum



The new timing ckt. produces 0-100 rise times of $< 1 \mu\text{sec.}$ at all periods. The slope of the crossing detector was adjusted to $< 1 \text{ msec.}$ at all periods. Has large spread of values at each wt. but is stable. Still made daily runs for biometrics.

All at bearing press of 190 mm. Hg.

Date	Wt#	I	II	III	IV	15#	V	O-Temp.	
Values in μ Sec.									
15 Dec. 1700	220,997			283,070	360,000	427737	485937	168200	? Mod
16 Dec 1700	995	221092		069	997	736	923	199	23.1 ↓
16 Dec 2100	996			066	994	734	923	199	23.2 ↓
17 Dec 1500	997	094		065	998	733	925	199	23.2 Mn 184
20 Dec 1400	997	093		066	999	733	923	199	23.4 Mn
22 " 0900	995 991 ⁻⁶	091 088 ⁻⁵		068 059 ⁻⁷	989 ⁻¹⁰	733	913 ⁻¹⁰	195 ⁻⁴	23.4 Mn 20
" " 1600	990	087		061	987	728	917	195	23.6 Mn 184

23rd Dec - Big Mechanical ϕ error -

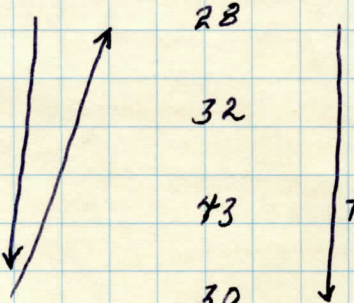
Clamp not on spring loose!

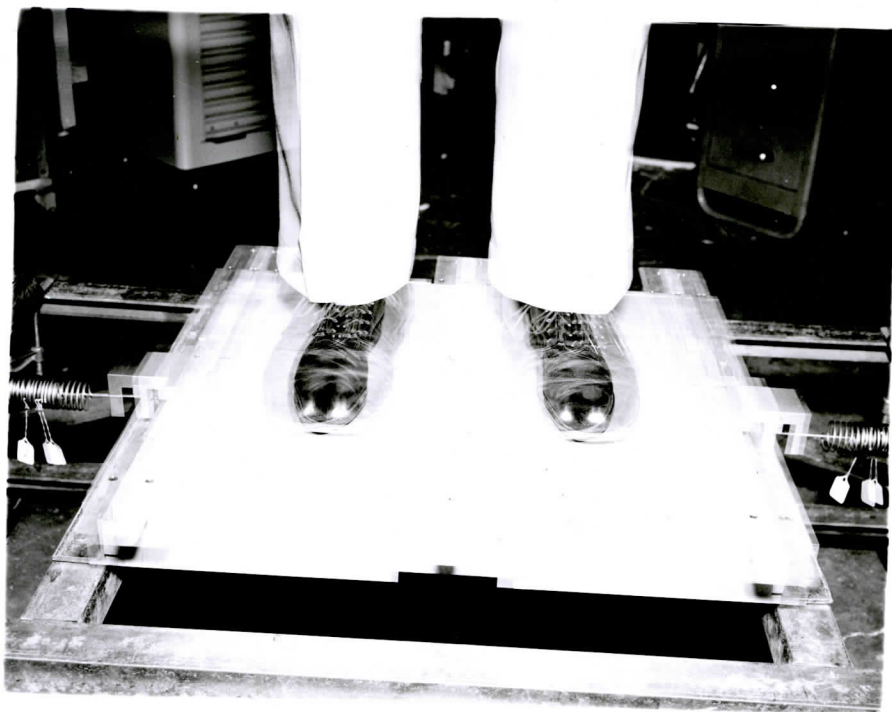
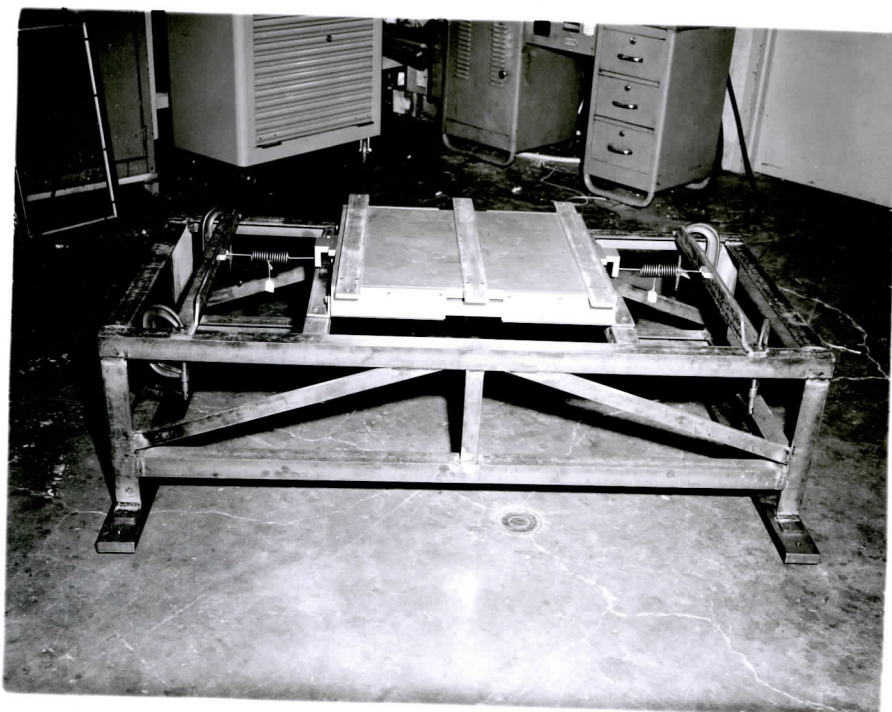
Still delay repeat run (10 days - 2x day)
until? electronics are ready & will use current
electronics on man carrying version.

Effects of rotating wt. V

17 Dec
1500
T-23.2 °C

	5 lifting	lifter	(Mode of 20 by insp.)
0°	485924	28	
90°	25	32	
180°	27	43	Time
270°	27	30	





28 Dec.

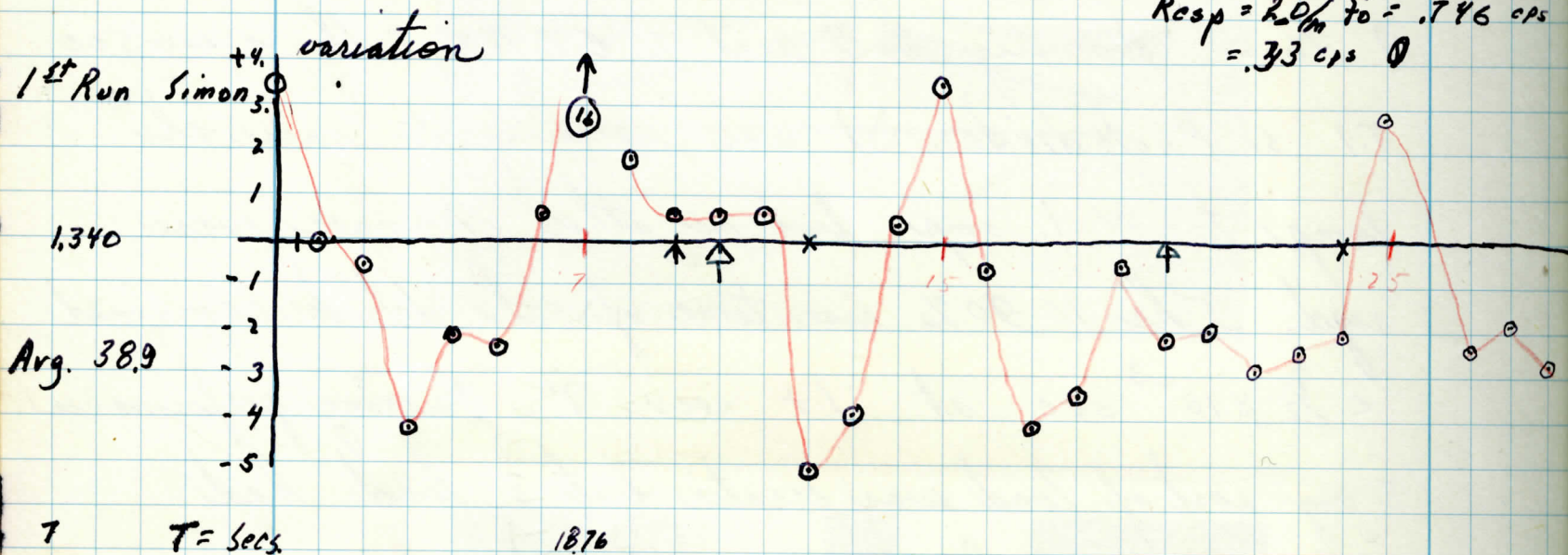
Bearing on opposite page was placed in operation & essentially the same arrangement used in § 1. 4 Al metal pads $\sim 5" \times 5"$ were used for floor pads and the device was levelled on these pads & bolts at 4 corners. $5\frac{1}{2}"$ springs were used & $\sim 3\frac{1}{4}"$ stretch. A 16 mm. optic mag was used & 6BRX bulb + 25500 T.I. Si Photodiode. It was necessary to raise the lamp to ~ 1 amp. but no other changes were reqd. The 10-90% rise time of the detector remained $< \frac{1}{2} \times 10^{-3}$ sec. at 1+ secs. γ . Bearing performance & any sort of load was erratic but $\bar{z}$ load had a resolution of $\sim 10 \mu\text{sec.}$ at ~ 0.5 sec. Placing the wooden pan in place warped the bearing & only 1-2 attack points could be used. It was completely erratic & small men on board but had $\sim 100 \mu\text{sec.}$ resolution & a fixed wt. of $\sim 160^{\#}$. The mass of a quarter could be easily resolved.

29 Dec. In an effort to satisfy myself that the bearing was the at fault Simon wt $\#$ and a dog wt $\#$ were

placed on the scale today.

Slight movements by the dog made period measurements meaningless. There were variations of 30 msec. $\bar{c}$ period of ~ 1.73 sec. With the no load there is $\sim 2.0 \mu$ sec. Max.

$$R_{\text{esp}} = 2.0 \mu / T_0 = .746 \text{ cps} \\ = .33 \text{ cps } \emptyset$$



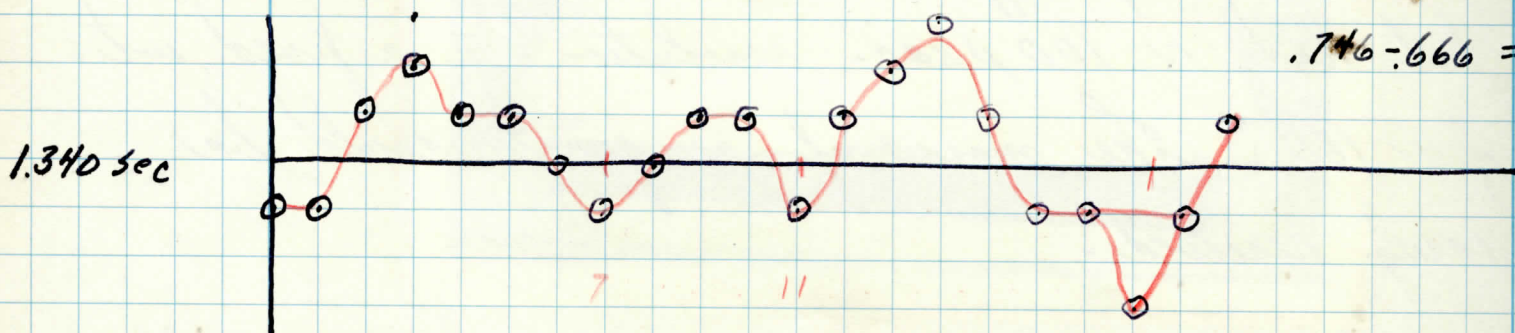
Resp. components. beats?

$$.33 + .746 \approx 1 \text{ CPS}$$

$$.746 - .333 = .413 \approx 1/3 \text{ cps}$$

Doesn't Fit.

$$.746 - .666 = .08$$



In 45° Transverse Posn.

There is improvement here

Total transverse was $-2 + +1$ about $40 = 0$

Fetal longitudinal was approx. same.
Closing eyes was of no apparent benefit.

Period as a function of air bearing press. $\bar{c}$

$\sim 160^\#$ of lead on bearing

Press PSI	Time μsec	Mode
--------------	-------------------------	------

15	1.457890 $\begin{smallmatrix} +23 \\ -20 \end{smallmatrix}$	900
----	---	-----

10	90 $\begin{smallmatrix} +10 \\ -6 \end{smallmatrix}$	895
----	--	-----

20	900 $\begin{smallmatrix} +10 \\ -13 \end{smallmatrix}$	919
----	--	-----

30	980 $\begin{smallmatrix} +36 \\ -24 \end{smallmatrix}$	980
----	--	-----

20	900 $\begin{smallmatrix} +16 \\ -00 \end{smallmatrix}$	900
----	--	-----

Shift $160^\#$ wt. along long. axis $4''$ produced ~ 20
 μsec ΔT

Bearing alone $\bar{c}$ req. air supply. max $\Delta T = 8 \mu\text{sec}$
at $\gamma = .764932$ sec ~~At~~ Typ ≈ 5

30 Dec.

I increased air vol. by eliminating regulator + $\uparrow$
hose size. Bearing seems normal now as compared to
previous intermittent operation $\bar{c}$ frequent seizing
when unbalanced. Zero was rerun $\bar{c}$ weighing pan (P.)

in place

Press	P.S.I.
-------	--------

30

40

20

Time $\text{Sec} \times 10^{-5}$ (Mode₁₀) $\uparrow$ wooden pan in place.

23 $\begin{smallmatrix} +6 \\ -3 \end{smallmatrix}$

33 $\begin{smallmatrix} +3 \\ -10 \end{smallmatrix}$
--

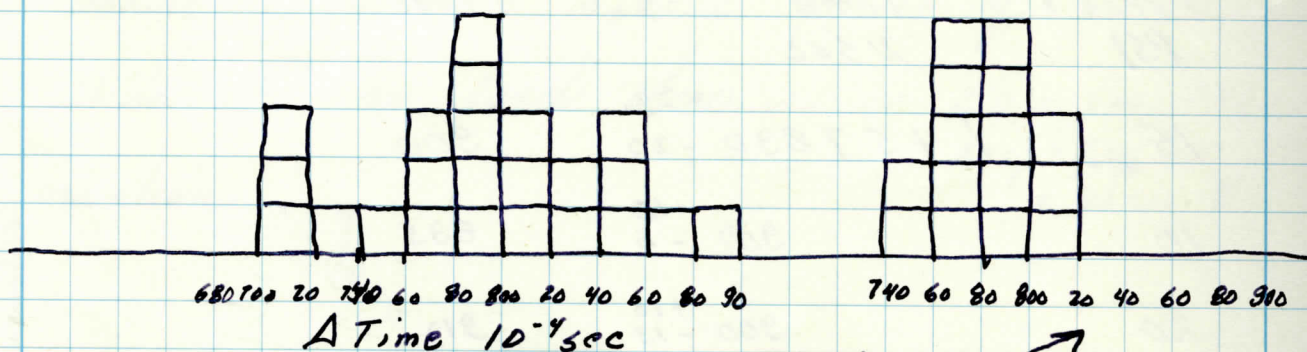
14 $\begin{smallmatrix} +5 \\ -2 \end{smallmatrix}$

$$\frac{\Delta T}{\Delta P} = \frac{33-14}{40-20} = \frac{19}{20} = 10^{-5} \text{ sec}/\#$$

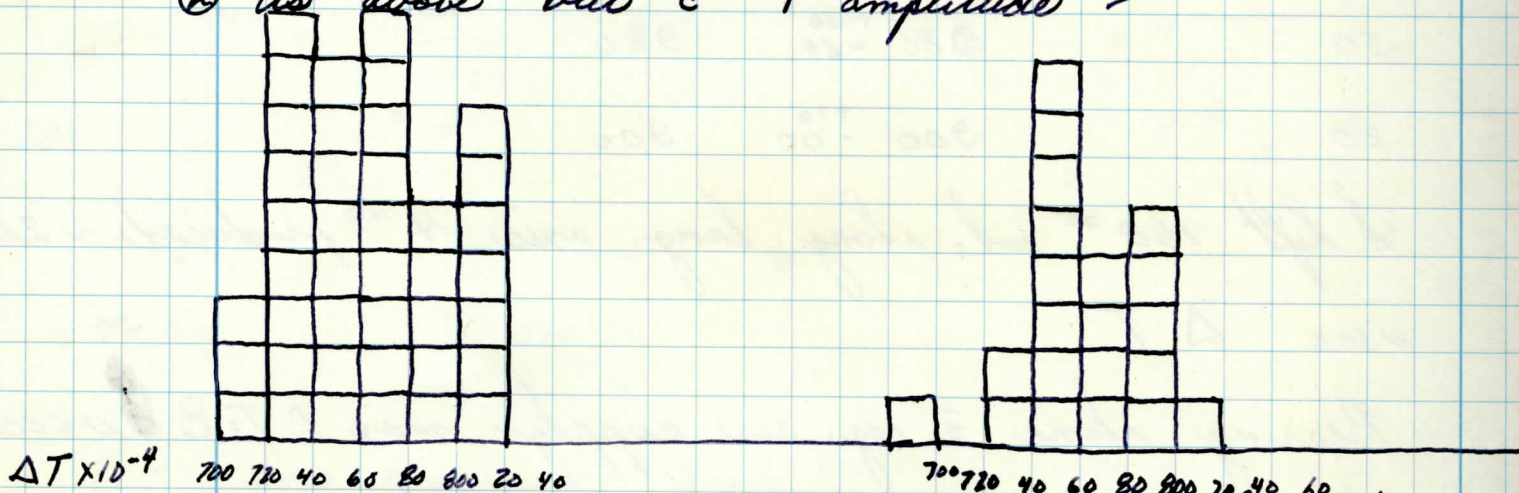
Results $\bar{c}$ Man (175# 5'3" - Mr. Garbitch)

lying relaxed - Press $\sim 30 \pm 10$ PSI (line fluct.)
 Ampl. $\leq 3/4"$

①

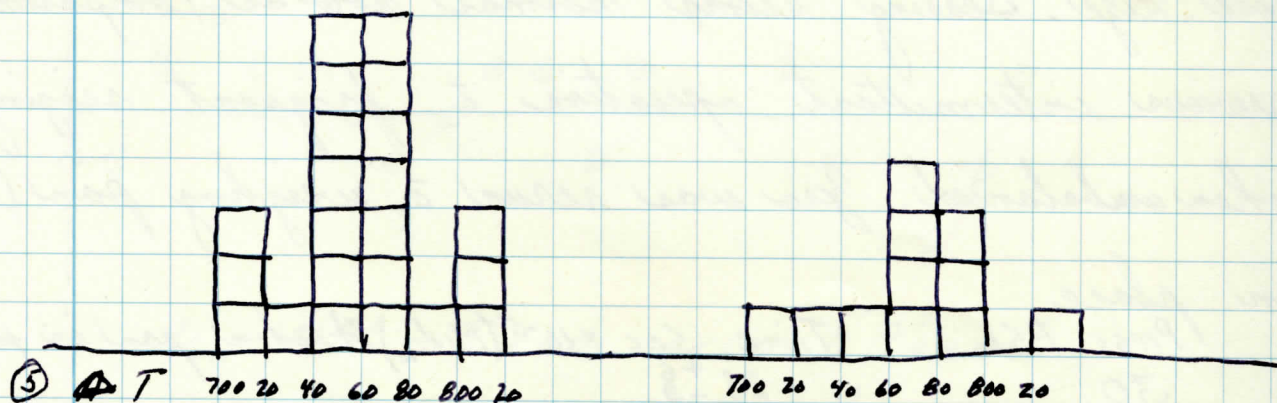


② as above but $\bar{c} \uparrow$ amplitude



③ Amplitude incr. to $\geq 1"$

④ As in ③ but tense

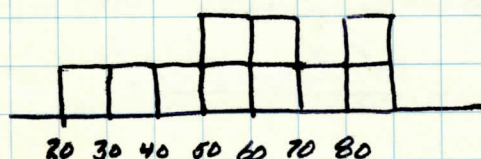


⑤ As in ④

⑥ As in ⑤ + 50 grams

Afternoon of 30th Dec.

①



$\Delta T \times 10^{-4}$

Subj. 186# 5'10"
Relaxed



② as in ① but
Tense

From this it appears that some benefit accrues from exerting tension in the major musculature and that $\uparrow$ amplitude may have some benefit.

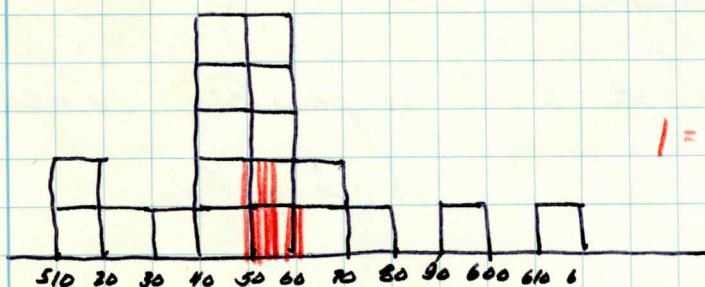
Next subj. 175# 6'2" breathed in synchronism with the osc. and increased the amplitude of osc.
Source of variation now illustrated.

With voluntary apnea the subj. decreased the spread as below.

Holding breath	
Trial #	Cycle
1	555, 554
2	555, 559, 553
3	560, 561, 554
4	550, 551, 549, 549
Shifted Posn. on Pan.	
5	554, 43, 48, 45, 44, 47
Added 0.6	
6	557, 553, 53, 51, 52, 52
7	43, 45, 47, 41, 37, 40, 39

1 = Held
Breath
Removed
Mass

③



Dramatic demonstration of effects of respiration which while expected were not expected to be of this magnitude. Many people had expressed concern over

the ballistocardiogram but these components are small and rapid as compared to the slow massive movements of the viscera. Schematic!

$$\frac{d^2v}{dt^2}$$

Pulse Rate
60 Min



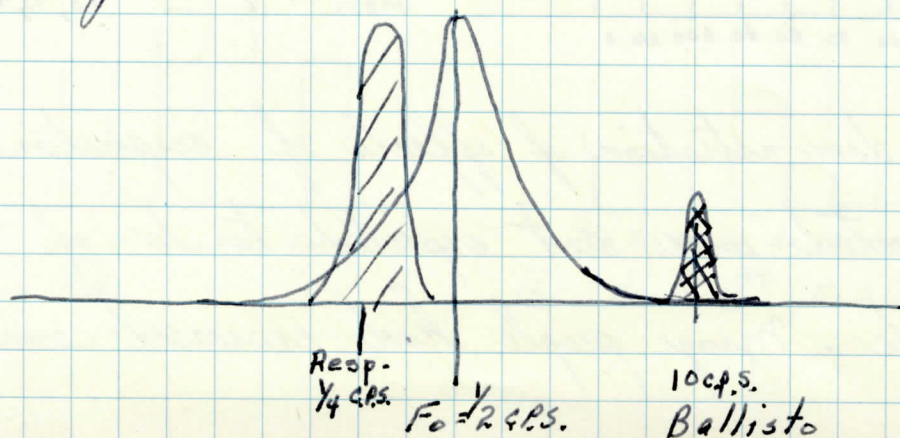
Resp. Rate
15 Min
 $\frac{d^2v}{dt^2}$



Pendulum
1/2 CPS
 $\frac{d^2v}{dt^2}$



An alternative approach is to treat this in terms of frequency response. The 'Q' of the pendulum is very high but respiratory components are very near this. Schematic.



It seems unlikely that anything like complete elimination of this effect will be possible. Rather than attempt a rigorous mathematical analysis in which there are many unknowns, it will be much simpler to make empirical determinations. I will try to delegate this to Bio-engineering & the shop.

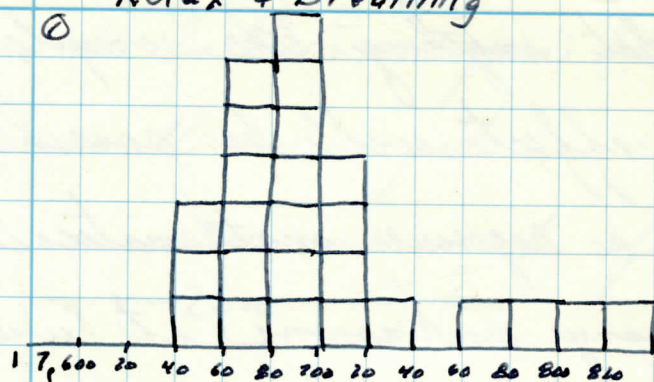
Jan 3 Mr. Bittle in BME has found diff. trans. & is building ch't to ~~test~~ measure effects of resp. Have started M.E.D. on pendulum. Will run series as on following pp. Plan to use M.E.D. as subj. Need accurate scale. Dayton agent has 250 lb. unit graduated to $\frac{1}{4}$ # and guaranteed to $\frac{1}{10}\%$ $\pm$ resolution of 1 oz. This scale can be read to 2 oz. $\pm$ ease.

Routine measurements were made $\pm$ M.E.D. as subj. in both long. & transv. pos. There is obvious roll in transv. posn. but in spite of this, a relatively good result. Will try ^{styro}foam to dist. wt. and lower freq.

Called Bill Martin of Astro-Space who claimed resp. effects were not noted. BCG here (SAM) has $\sim$ period of .18 sec. and a radius of 24'.

3 Jan. M^s Doug.Longitud-
Relax + Breathing

①

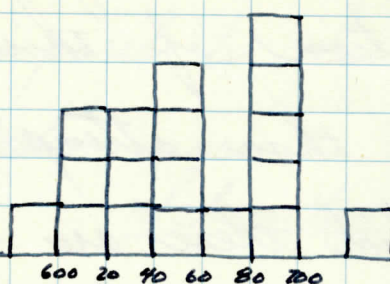


①A

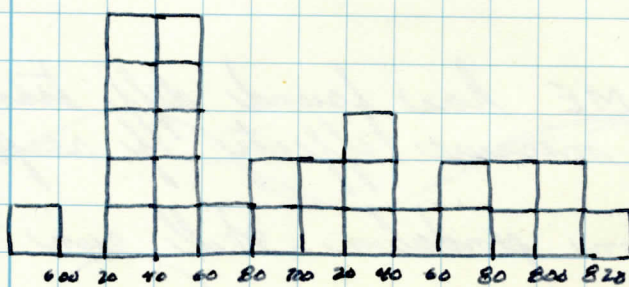
A 7×10^{-4} sec.

②

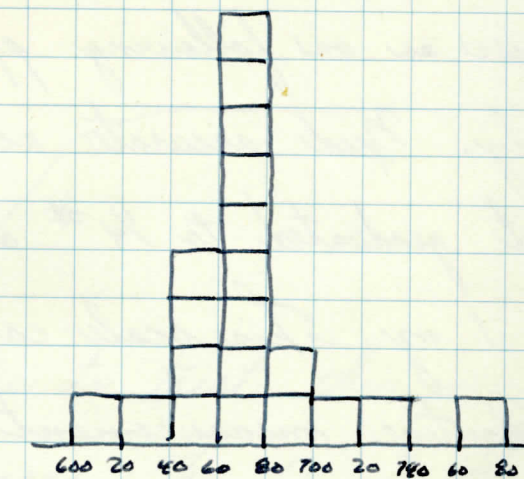
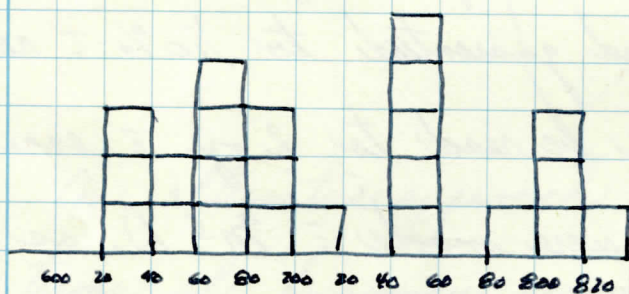
Rigid + Breathing



②A



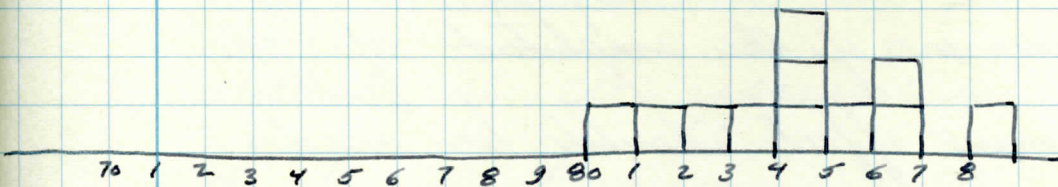
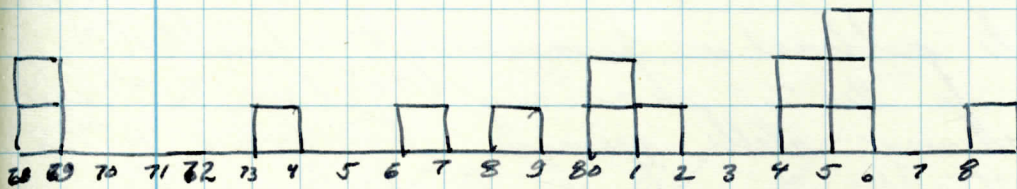
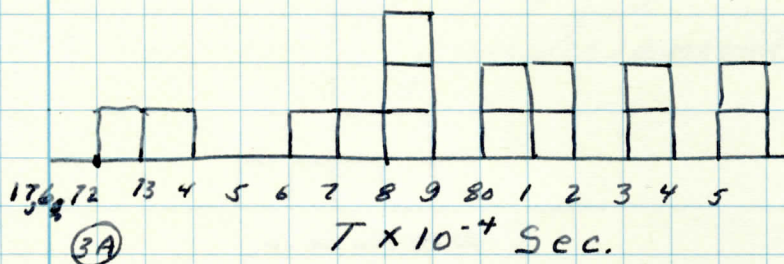
①B



M = D.

Relaxed + not Breathing

(3)

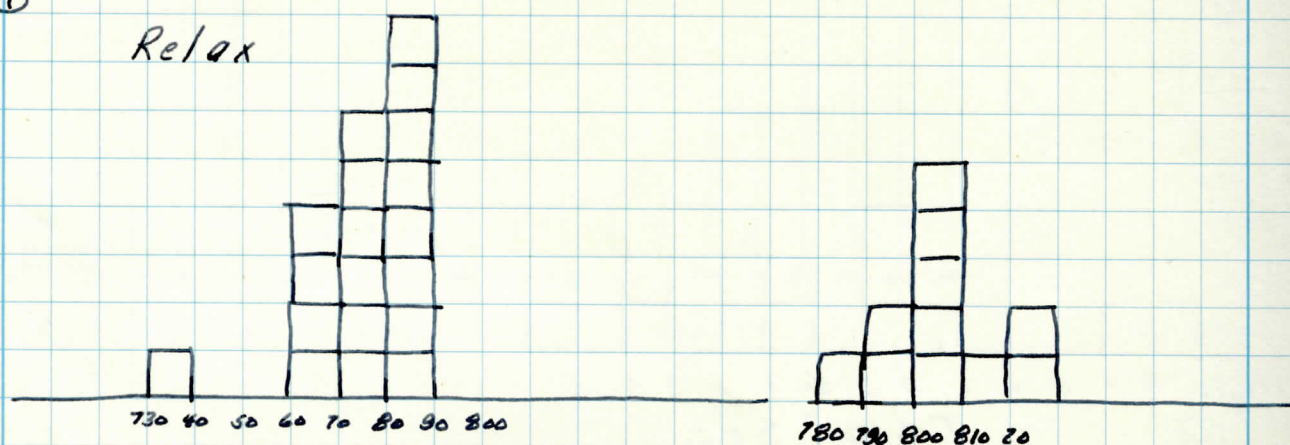


M & D.

Trans v. Mtg.

①

Relax

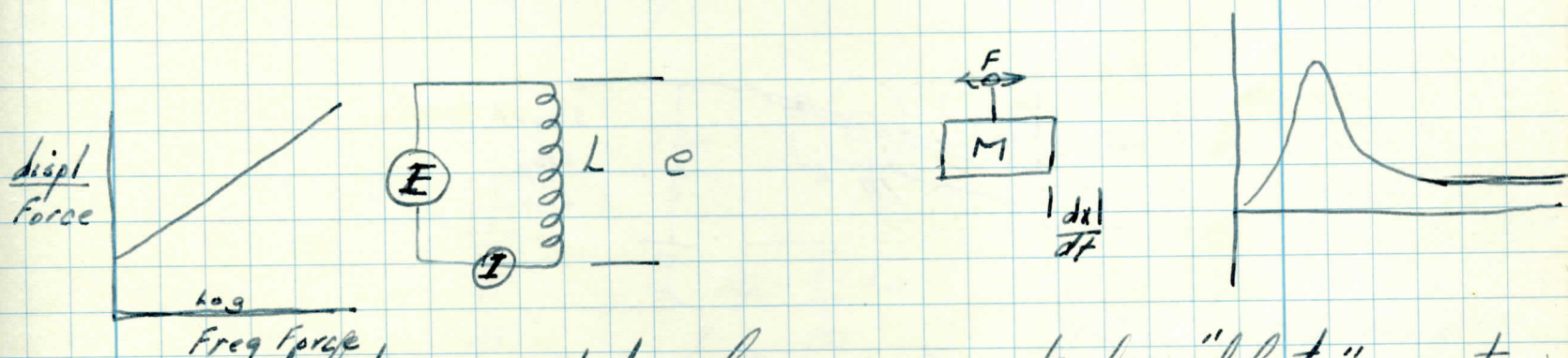


after the usual problems in procurement finally (?) obtained scales of $\frac{1}{10}\%$ accuracy (F.S.) in $\frac{1}{4}$ " calib. Have ordered ordinary steel springs at 4 3 2 1 #/in k. The differential transformer arrangement for meas. of displacement is complete.

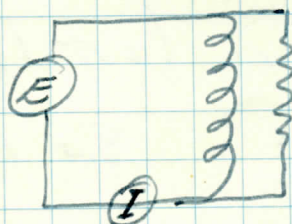
Some measure of the ^{magnitude} amplitude of the ballisto-pulmonary effect should be made. A simple approach is to simply vary the springs (+ their constants) such that the resonant frequency is varied across the freq. of respiration. As the resonant frequency approaches the dominant components of the BPG an increase in amplitude should be noted. There will be little in way of quantitation and gross distortion of the record. An alternative is to use a much lower resonant frequency in

which system the mass reactance is predominant.

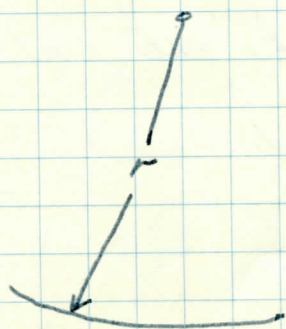
In such a system the displacement/force will be a log function of frequency. This is equivalent to an L & generator current (volt.)



What is wanted here is a truly "flat" system. This may be achieved by heavy damping & mechanical resistance if the apparatus is sensitive enough or the force great enough.



Another alternative is to use the BCG in SAM. This is an air bearing ground on a 24' radius

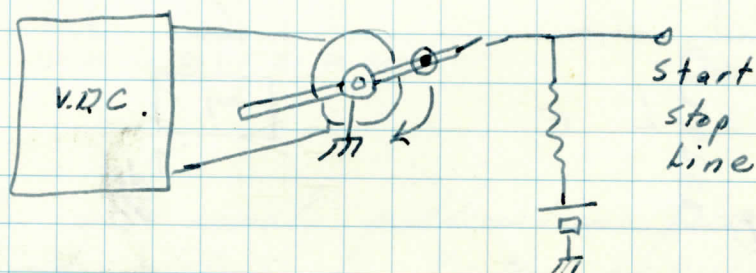


$$r = 24' \\ = 7200 \text{ cm}$$

$$T = \sqrt{\frac{L}{G}} = \sqrt{\frac{7200}{980}} = \sqrt{7.34}$$

$$\approx 2.7 \text{ sec.}$$

A rotating bob wt. has been constructed from a d.c. current motor, gear box and bob weight. Motor speed may be controlled by ~~bob~~ varying the volt.



This motor will supply a force

$$F = I \frac{d\phi}{dt}$$

$I =$ moment of inertia

In a linear plane this will be $F = M A$

$$A = \frac{d^2x}{dt^2} = -X_0 \omega^2 \sin \omega t$$

* peak acceleration is $(2\pi f)^2 X_0$

$$\text{For } X_0 = K \quad \frac{d^2x}{dt^2} \sim f^2$$

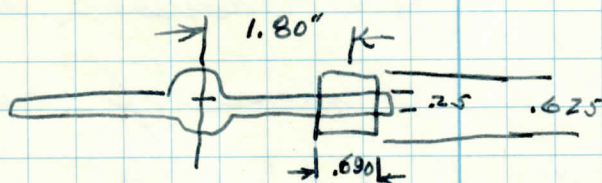
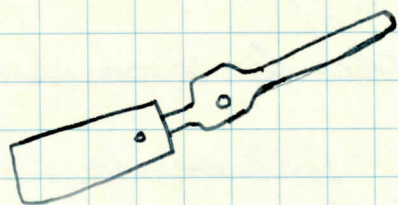
$$\text{For } A = K$$

$$K = 2\pi f^2 X_0$$

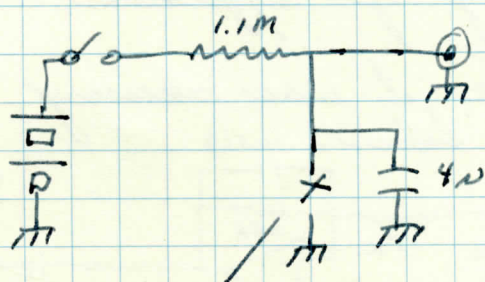
$$* X_0 = \frac{K}{2\pi f^2}$$

Plan: Set up bob weight + dash pot on bearing & smallest K spring and run BPG curves.

11 Jan '65.



This needs modification to a ^{Bob Weight} circular weight.

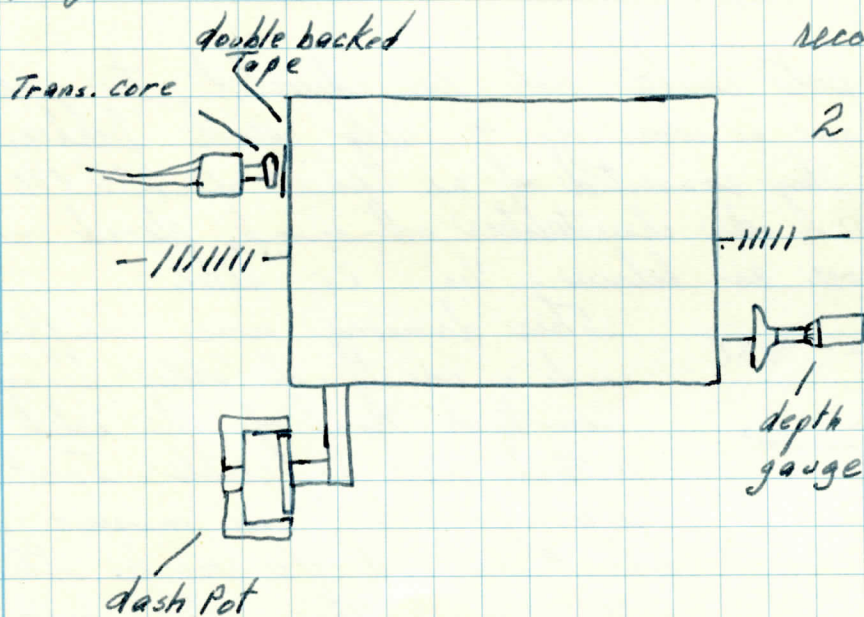


To Counter

T.C. is too long

contact on Gear

The differential transformer ckt. on the following page was used followed by a differential analog + recorded on a Sanborn 2 channel direct writer.



The dash pot demonstrates damping nicely. This almost flattens the response curve. Response to

a step function will be recorded + freq. response to sine waves.

$$F = R \frac{dx}{dt}$$

$$F = M \frac{d^2x}{dt^2}$$

$$F = CX$$

$$\frac{dx}{dt} = \frac{F}{R}$$

$$dx = \frac{F dt}{R}$$

$$X = \frac{F T}{R}$$

$$R_0 C_0 = 1$$

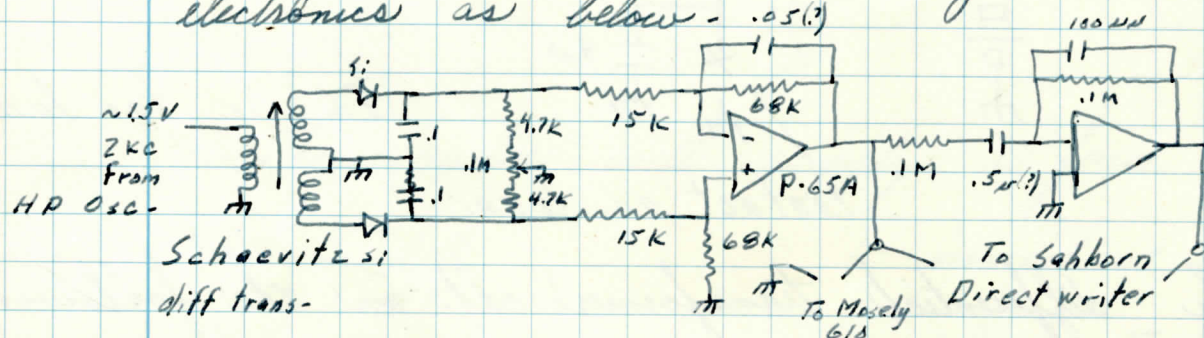
$$\frac{3.3 \times 10^{-3}}{1}$$

$$3.3 \times 10^{-3}$$

In addition, the dash pot will provide a means of varying the Q & checking effects of R on period. A considerable amount of noise is present on the diff. channel.

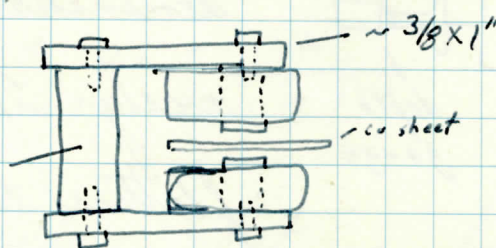
At 100 mm/sec there are 60 $\sim$ 100 - pwr line.

14 Jan - After a variety of difficulties in the electronics including oscillation it was necessary to rebuild the electronics as below - .05(?)



Above ckt. rolled off at ~ 60 CPS. but was flat thru de/c to < 5 C.P.S. on low side.

The dash pot could not be adjusted to give reliable operation so a series of 4 eddy current brakes was constructed. They consisted of a pair of 230 VAC motor controller coils, turn of other characteristics unknown, placed on a soft iron 'C' core as below - $\frac{1}{16}$ " C.S. sheet



This damping was insufficient and a variety of other schemes were tried. None of the solid friction methods were acceptable. Two Al. plates of ~ 8 "² were immersed in oil #300 and the records obtained were run in this. The mag. damping will be retained for damping studies in

the period timer.

Ht. of top of bearing $5\frac{9}{10}$ #

" " wooden pan.

17 Sept. '66 - Usual omission - did not analyze data while fresh - can't recall pan wt. may have been 60#

- ① may have been i mag. damp. only - MSD
- ② " " " " Roland
- ③ Oil & " " MSD

2 Feb

Plan for investigation of man carrying bearing -
 Attempting to get a M.E. from SV & R. Hand
 ordered springs -

Air Bearing Resolution

T as F(R)

$\frac{\Delta W}{W}$ as F(Rate and restraint) $\bar{c}$ man

$\frac{W_{meas}}{W_{abs}}$ as F(Rate) $\bar{c}$ man

Restraint

Table only

'ball'

Table $\bar{c}$ hand holds

Form fitted table

14(?) Jan '65

A series of meas. were made in the 5#/in springs.
 The table used was a honeycomb alum. structure weighing
 borrowed from the ballistics table.

All bearing @ table trans. to bearing motion
 press. 80# 178 3/4# wt.

T - (Mode)

$$159612 \pm 2 \times 10^{-5}$$

$$+506m \left. \begin{array}{l} 159647 \pm 2 \\ (.11^*) \end{array} \right\} \quad \Delta T = 35$$

$$CK \quad \frac{\Delta T}{T} = \frac{2\Delta T}{T} + \frac{\Delta W T}{2W} = \Delta T = \frac{.11 \cdot 1596}{179.75} = 97 ?$$

7 Feb. Mr. Peterson of Douglas A/C (Phd. Physics) has made the following derivations and from the results concludes that a long, very slow osc. system is the approach.

ϕ = phase

$$\frac{\Delta X}{X_0} = \Delta \phi$$

X = amplitude

This gives a fractional error of:

$$\frac{\Delta T}{T} = \frac{\Delta \phi}{\phi} = \frac{\Delta X}{n 2\pi X_0}$$

n = no. of
timed cycles

$$\text{and: } M = \frac{K}{\omega^2} = \frac{K T^2}{4\pi^2}$$

$$\Delta M = \frac{K 2 T \Delta T}{4\pi^2} + \text{subs.}$$

$$\frac{\Delta M}{M} = 2 \frac{\Delta T}{T}$$

$$\text{and } \frac{\Delta M}{M} = \frac{1}{n \pi} \frac{\Delta X}{X_0}$$

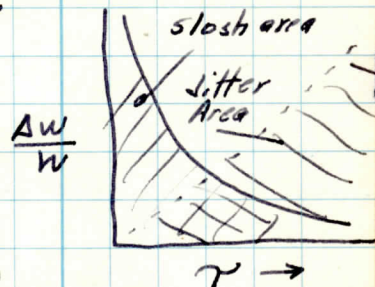
From this we may conclude that $n + X_0$ must be as large as possible. Since the time that a person can restrain resp. really sets the total time the same effect should be achieved by counting a large number of cycles. The effects of a cyclic variation in the frequency range of the system are not clear to me at this time.

The need for measurement of the perturbations are obvious. Another approach is to treat the system in terms of electrical analogies.

At this time there appears to be 2 problems -

1. The first is that of the non rigid nature of man and his behavior as a system of damped oscillating sub-units. This is a frequency dependent function which at this time appears to $\downarrow$ rapidly as period $\uparrow$. "Slosh"

2. Small erratic vibrations or rather movements on the part of the subj. appear to form another source of error as $\tau \uparrow$. Jitter



No real attempt has been made to place a value on #2 which would include respiratory & ballistic effects. To judge from the records run (P-137-8) these effects are very small. In addition from some of the later records the resolution is adequate but there is an appreciable slosh error -

One way of getting at the jitter error

NB:
effect
of
acceleration
vs freq.
is unknown

21st Mr. Oakley of Southwest Research was started today - Spent day in review - Plan to -

- 1) Run stability tests on small bearing
- 2) Note effect of R on large bearing while running resolution tests.
- 3) Delat determine effects of Shock
- 4) " " of jitter

24 Mar. The following plan + events have evolved + transpired.

In view of our results + the questionable performance of Douglas it now seems reasonable to proceed to a flight test, orbital + manned, of a small pendulum for systems test and utility tests in food, urine, etc. The present plan is as follows:

1. continue existing tests in shock + jitter problems in Mr. Oakley
a 2-30 day contract has been let
2. do feasibility + cost studies - S.H.R. has 30 man/day contract
3. develop air bearing - I in house
II. Rothe has design contract
4. give S.H.R. contract for development + construction of 4 instruments 1. proto 1- qual. test 2- orbital

- A. except electronics build in house
 - B. purchase electronics components
 - C. design & assemble electronics at I.S.R.
5. flt. test prototype at W.P. on trajectory flts. $\bar{c}$ large auxillary mass.
 6. flt. qualify one unit $\bar{c}$ independent lab.
 7. fly 1 of 2 remaining units on early Apollo mission per Dietlein, et al.
 8. consider design of man carrying version -

Oakey has now run:

- A. data for investigation of statistics of bearing
- B. brief resistive + harmonic osc. runs
- C. info. on large table $\bar{c}$ solid wtr { has $\sim 8 \mu$ sec. resolution at ~ 1.5 sec } - and $\bar{c}$ subjs. (has 10 period average $< 1^\circ$ that is consistent - at $\tau \approx 1.5$ sec.)
- D. has design for slosh testing $\bar{c}$ small bearing

The shop has completed a dual bearing $\bar{c}$ movable inner rods connected by a sheet metal pan $\bar{c}$ milled outer plenum chamber - It has slight capacity compared to other bearings and requires ~ 10 PSI for min. operation

and 15 PSI for est. 250 gm. load.

Still have Oakey determine load capacity + flow rate as

F press. $\approx$ dry N_2 .

Now appears that an investigative program may be in order here to determine optimum shape + configuration -

A series of round bearing could be constructed in which load + flow rate were determined as a funct. of hole size + location, auxillary air exhaust + bearing size + shape.

Some work on other than round shapes might well be considered -



θ varies from 90° at BDC to 0° at sides -



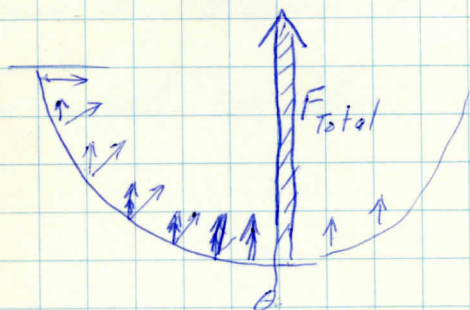
$$y = r \sin \theta$$

force is $dA \times \text{press.}$
or $\text{const}(K_i)$



$$F_i = K_i \sin \theta$$

$$+ \theta = \tan^{-1} \frac{dy}{dx}$$



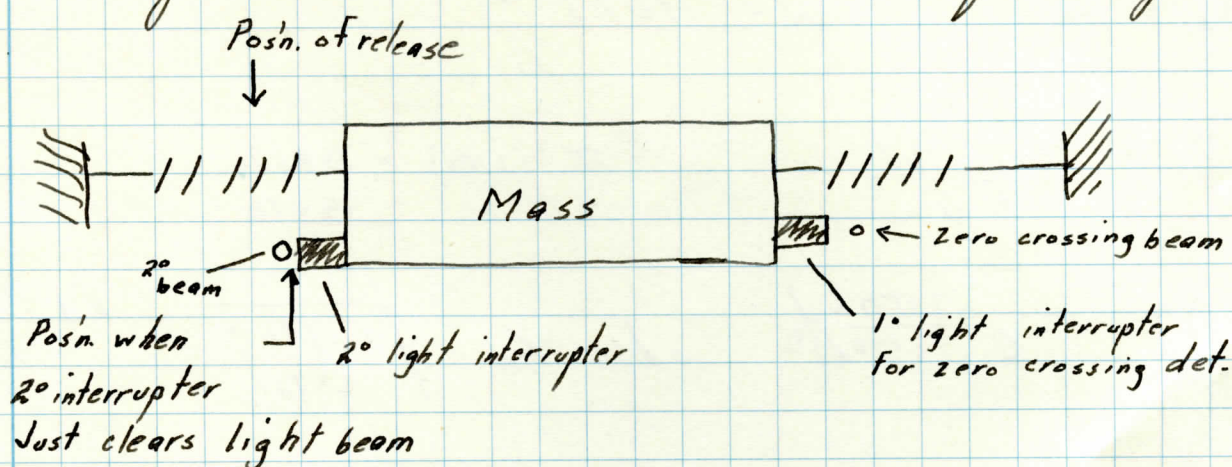
$$\frac{y}{r} \cdot \frac{y}{x} = \frac{y^2}{rx}$$

$$F_{\text{total}} = 2 \sum F_i$$

$$\begin{aligned} 10^3 A / L &= 10^{-10} \\ 10^{-7} \times 10^{-10} &= 10^{-17} \end{aligned}$$

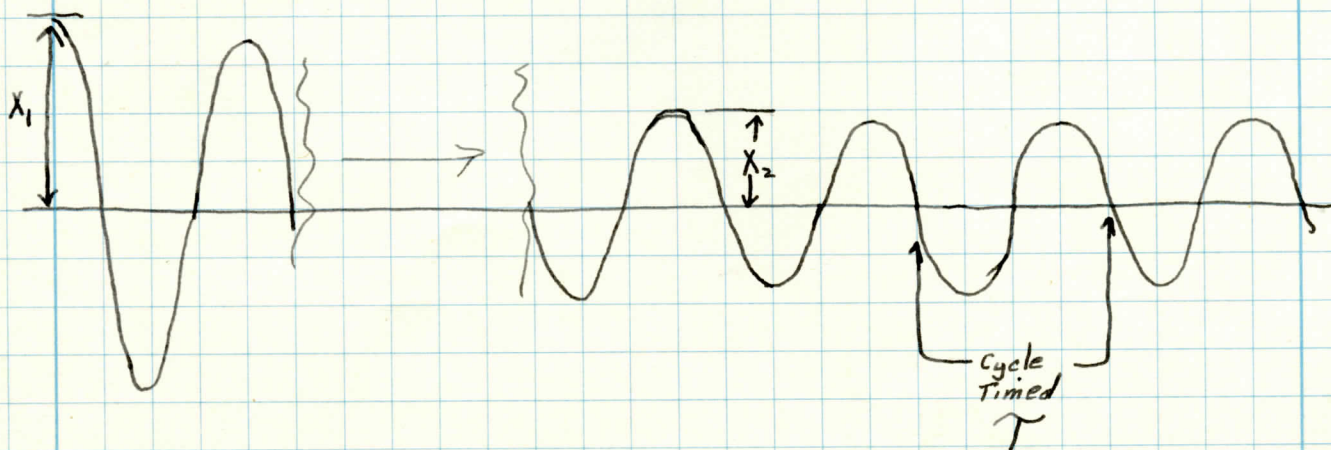
26 Mar.

Effects of R on T :
 O'ahy S. & Q. ran some tests in the following arrangement.



The mass is released from a fixed posn. X_1 , which is the max. amplitude of the 1st oscillation. A 2nd posn. X_2 of decreased amplitude is determined when the 2nd light interrupter completely clears a light beam i.e. this time will be known to $\pm 1T$.

The period is determined by means of the zero crossing detector timing the period of 3 crossings. The period Every other period is counted. ~~Known~~ Fixed amounts of viscous damping by means of a paddle in oil or water is added and the effects determined.



For Runs LP - 10-13

$$X_1 = .75''$$

$$K = 6320 \# (\text{steel springs})$$

$$X_2 = .625''$$

$$W = 167.1 \#$$

$$T^2 = \frac{4\pi^2 W}{K G}$$

$$\pi^2 (3.1416) = 9.8696$$

$$4\pi^2 = 39.478$$

$$\frac{X_n}{X_0} = e^{-\frac{2\pi n K_d}{(1-K_d^2)^{1/2}}}$$

$$\text{also } K_d = \sqrt{1 - \left(\frac{T_n}{T_d}\right)^2}$$

$$K_d = \frac{R}{2\sqrt{KM}}$$

Run
LP-

T

R-

Avg.

11-

.9215086

only coincidental
to springs + bearing

10-

Calibration of Chatillon Springs (Co. calib.)

Spring Force Lb.		Deflection	2 [#] /in Force lb.		Force lb.		Force lb.	
	dark	<u>in.</u>						
.501	.499	1	2.017	2.013	2.973	3.000	4.070	4.075
1.003	.988	2	4.035	4.033	5.953	6.010	8.160	8.158
1.506	1.499	3	6.060	6.056	8.940	9.033	12.260	12.250
2.010	2.001	4	8.088	8.088	11.945	12.065	16.375	16.365

Calibration of J. Chatillon springs (calib. supplied)

Defl. ins.	Gr Force pounds	Spring 1 (bright) Rate - 16/10	Force pounds	Spring 2 (dark) Rate
f 1	.984	.984	.995	.996
2	1.970	.985	1.991	.995.5
3	2.959	.986	2.992	.997
4	3.950	.9875	3.994	.9985
5				

1994