

BOOK37R

Notes:

"UO₂ 1973" and "D.W.M." on spine of book

Blank pages: inside front cover sheets, 1-10, 30, 32, 42, 44, 48, 50-306.

- page 12 has 3 graphs taped down
- page 14 has 2 graphs taped down
- page 16 has 2 graphs taped down
- page 18 has 1 graph glued down
- page 19 has 2 graphs taped down
- page 22 has 2 graphs taped down
- page 24 has 1 graph taped and 1 photograph taped down
- page 26 has 2 graphs taped down
- page 28 has 3 graphs taped down
- page 34 has 1 graph taped down
- page 37 has 2 sheets glued down
- page 38 has 1 graph taped down
- page 40 has 1 graph glued down
- page 45 has 1 graph glued down

Scanned by:

Sheila Finch

RSICC /Oak Ridge National Lab.

August 9, 1999



Account Book

No. S 149

NO UNITS

Journal

Ledger, Single Entry . .

Ledger, Double Entry .

Record Ruled (27 Lines)

Made in 150, and 300 Pages

MADE IN U. S. A.

TO REORDER, SPECIFY NUMBER,
RULING AND THICKNESS INDICATED
ON BACKBONE OF THIS BOOK.

EXPERIMENTS WITH

9 ea 5.25 in. o.d. x 10 in. High

Tin cans filled with

17.00 kg of $U(93.15)O_2$
 + 1.073 kg of $C_2H_6O - 5wt\% H_2O$
 (190 proof ethyl alcohol)

Calculated $H/^{235}U = 2.34$ $H/U = 2.18$

Calculated Sphere mass for $UO_2 - H_2O$ mixture
 at theoretical density - interpolated value
 of ~~17.00~~³⁴ kg of UO_2

Experiments to be performed on 5-11

Dw Magnus

J T Thomas

E B Johnson

J L Lynn
 G J Cross

Storage of units on 2 ft centers (greater than
 the 16 in. spacing of M-101 birdcages in which
 the containers were shipped to 9213 from 9212

Dw/M

Instrument Check on 9-27-73 Source M-230

Neutron S.

11

Cobalt source used to check Trip OK

IC-1 275 V. Low Trip OK

Trip OK

IC-1 2X12" Motor Trip OK Fast Trip OK

IC-2 2X15" Motor Trip Scram table with IC-2 OK

IC-3 Resp OK Calibration J.G.S. Bldg. Alarm

IC-4 Resp OK Calibration J.G.S. Red light

Source Interlock Pres. Dif. .19

W-0.100 E-0.100 Expt # 1

SEP. 27 1973

10²⁷

Zea oxide cans Partly Reflected
on a 6" Base of Polyethylene blocks
No Response
Check Alignment and Separate

10⁴⁰

Expt # 2
Zea oxide cans fully Reflected
with 6" of Polyethylene.
W-.100 E-.100

10⁵⁵

No Response
Shut Down

EXP # 3

Hea Oxide cans 11" square reflector cavity
10^{1/2} in. high,

11 32

Super critical on pos Period

Critical

W 323 > 325

E 327

Neg Period

W 345 > 347

E 349

$\Delta S = .022$

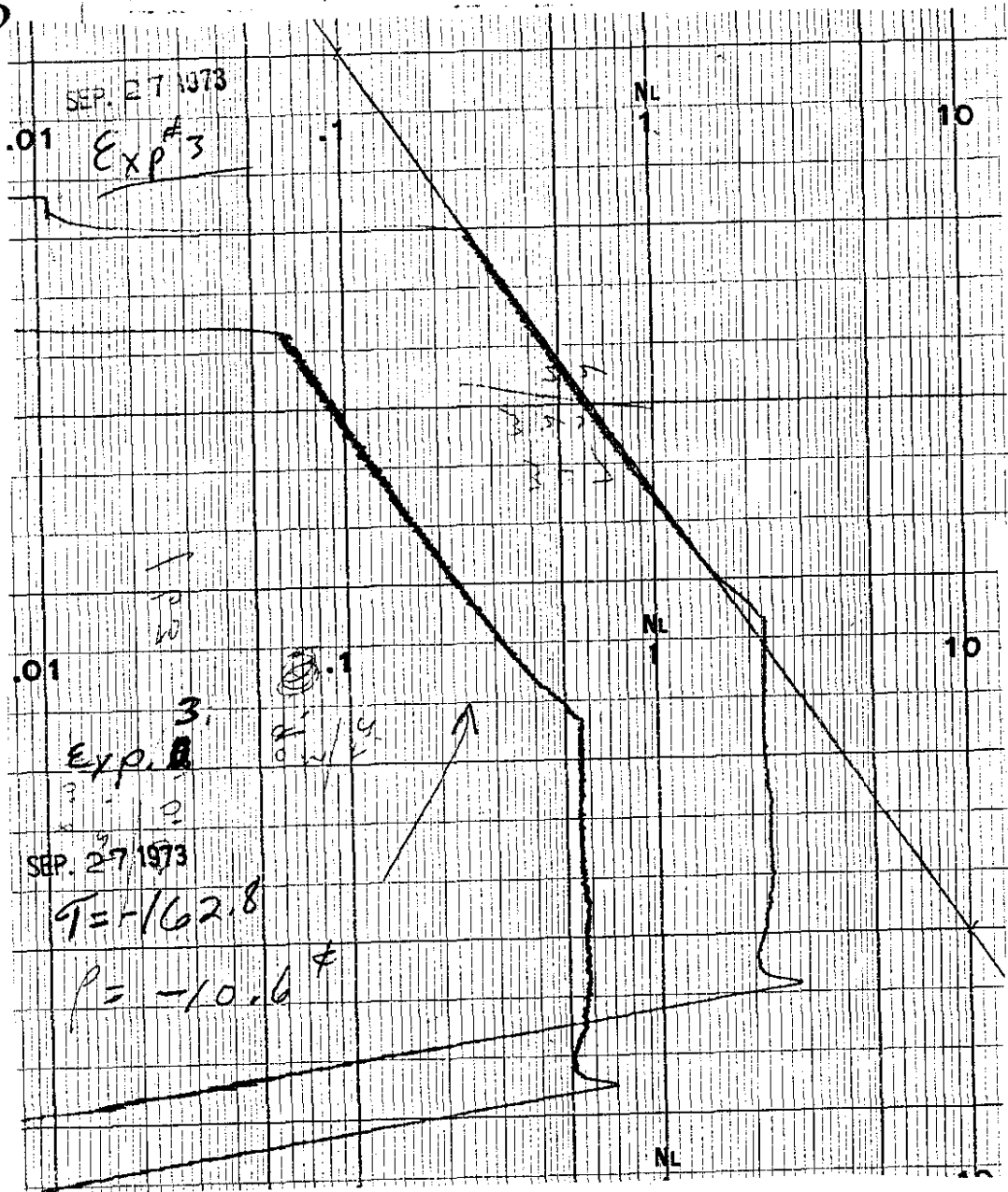
$\rho = -10.6 \%$

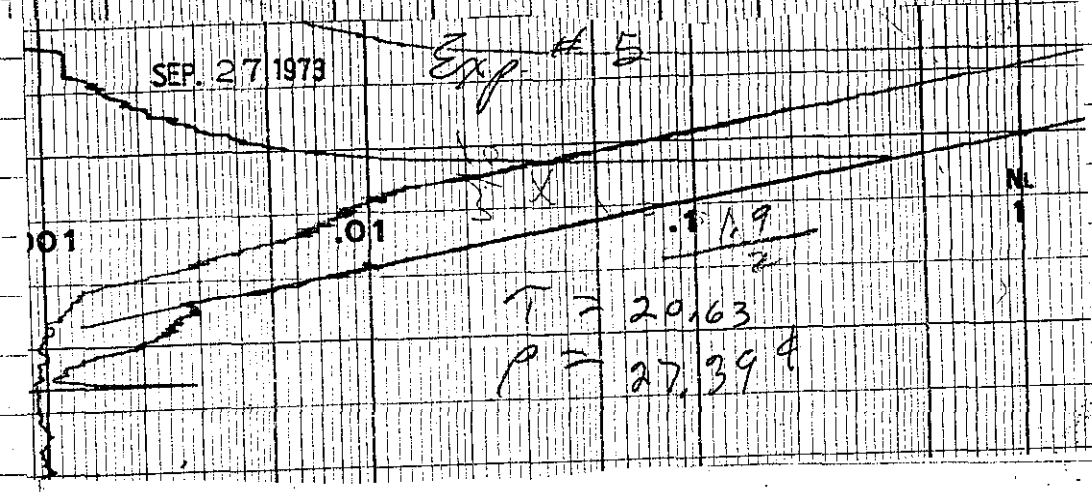
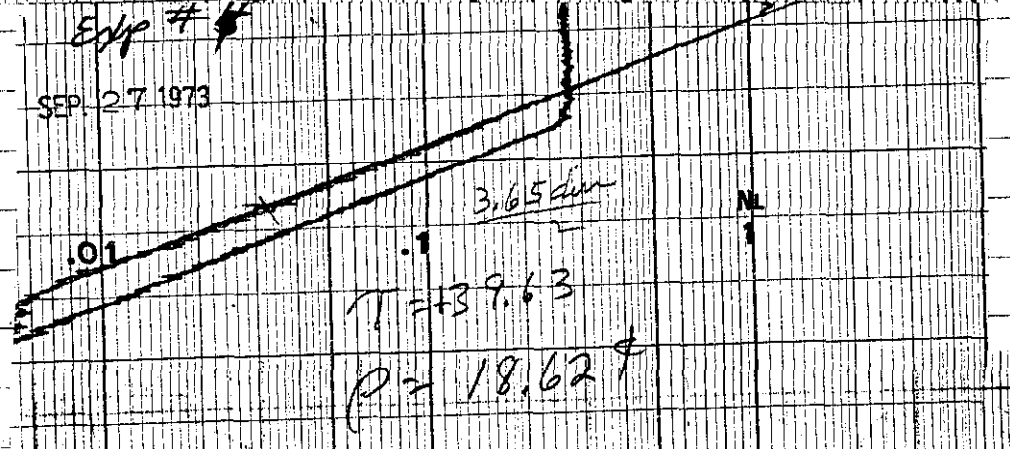
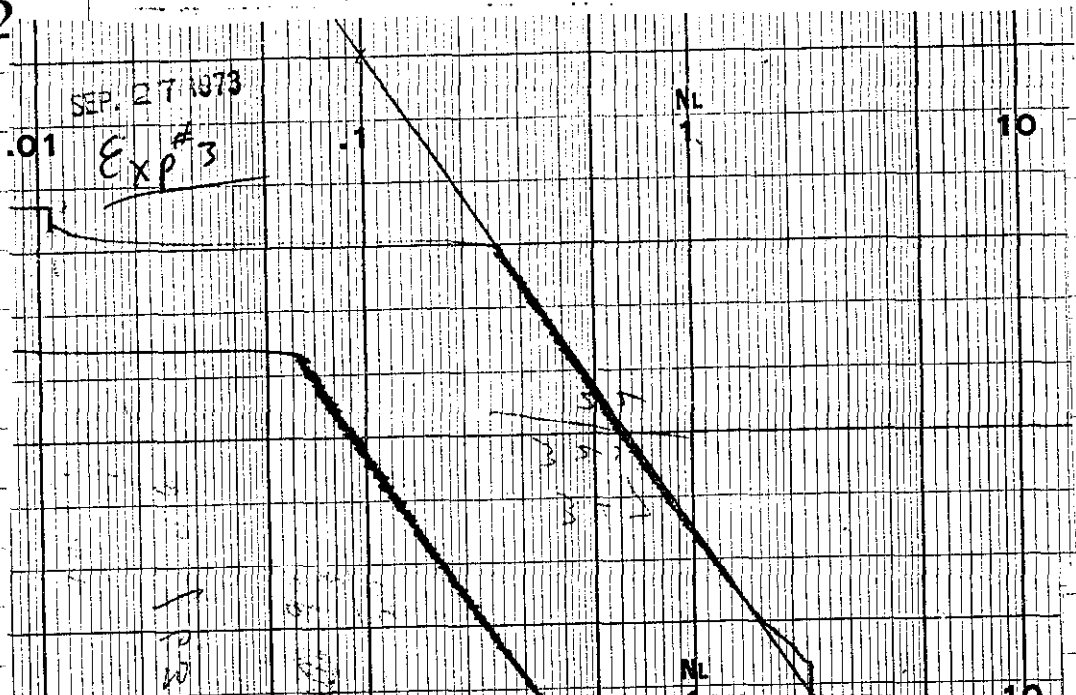
11 35

Shut Down

Change to 11"

$\frac{\Delta \rho}{\Delta z} = 4.82 / \text{in.}$





EXP #4

13²⁰ Start Assembly of 4 units in $11\frac{1}{16} \times 11\frac{1}{16} \times 10\frac{1}{16}$ in with units in corner adjacent to reflector. Rims of cans are separated $\frac{1}{16}$ in.

✓ Source In.
✓ Red Lite
✓ Δp OK

O.P. of can rims are 5.50 inches

13⁴¹ On positive period start to level

W .171 - .100
E .175 - .100 } .073" gap.
ρ = 18.62 #

13⁵⁰ Level - Critical Sheet Down.

W .216 > .218
E .220 } > .118" gap
ΔS = .045
ρ = 18.62 → 4.14 / in

EXP #5

Move Reflector so that 4 units in a $11\frac{1}{8} \times 11\frac{1}{8} \times 10\frac{1}{2}$ Cavity with units centered in $5\frac{9}{16} \times 5\frac{9}{16}$ area cells.

14³⁰ start assembly

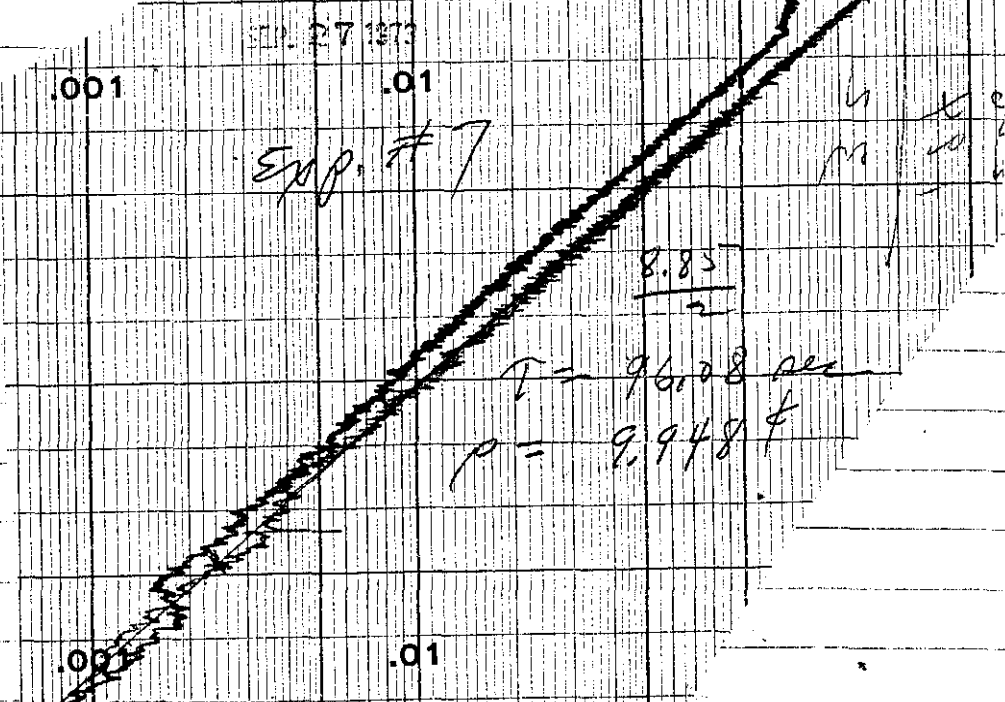
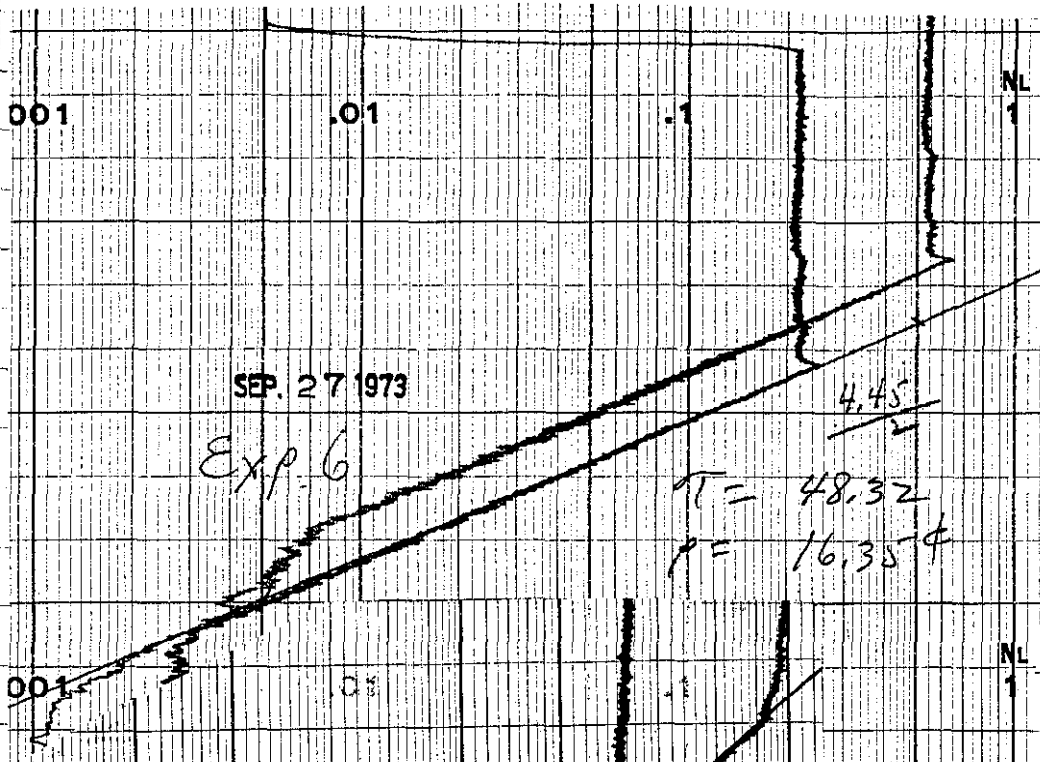
14 On Positive period sheet Down

W = .100
E = .100
ρ = 27.39 #

@ LN-IC4 = 19
Dida's level

~~Revised~~ see P 43

Cell Description	W	R	+Z	-Z	±X = ±Y
UO ₂ - C ₂ H ₆ O - H ₂ O	6.76			-12.57	-
Air	"		12.55	-12.57	-
Fe	6.79		12.60	-12.60	-
Air			12.75	-12.75	14.13



EXP #6

6 units in $6 \times 6 \times 10 \frac{1}{2}$ in cells.

(3 on each Table) 86% of the areal density of the last

	Experiment		Red Lite + Pos. ✓
1507	Start Assembly		Ap OK ✓
			Source Dns ✓
			Bypass ✓
1518	Pos Period	$W = .665$ $E = .669$	$\left. \begin{array}{l} \\ \end{array} \right\} .667$ $P = 16.35 \text{ f}$
1520	Start Level		
1524	∞	$W = .704$ $E = .708$	$\left. \begin{array}{l} \\ \end{array} \right\} .706$ $\Delta P = .419 \text{ f/mil}$ $\Delta S = .039''$
1529	Shut Down		

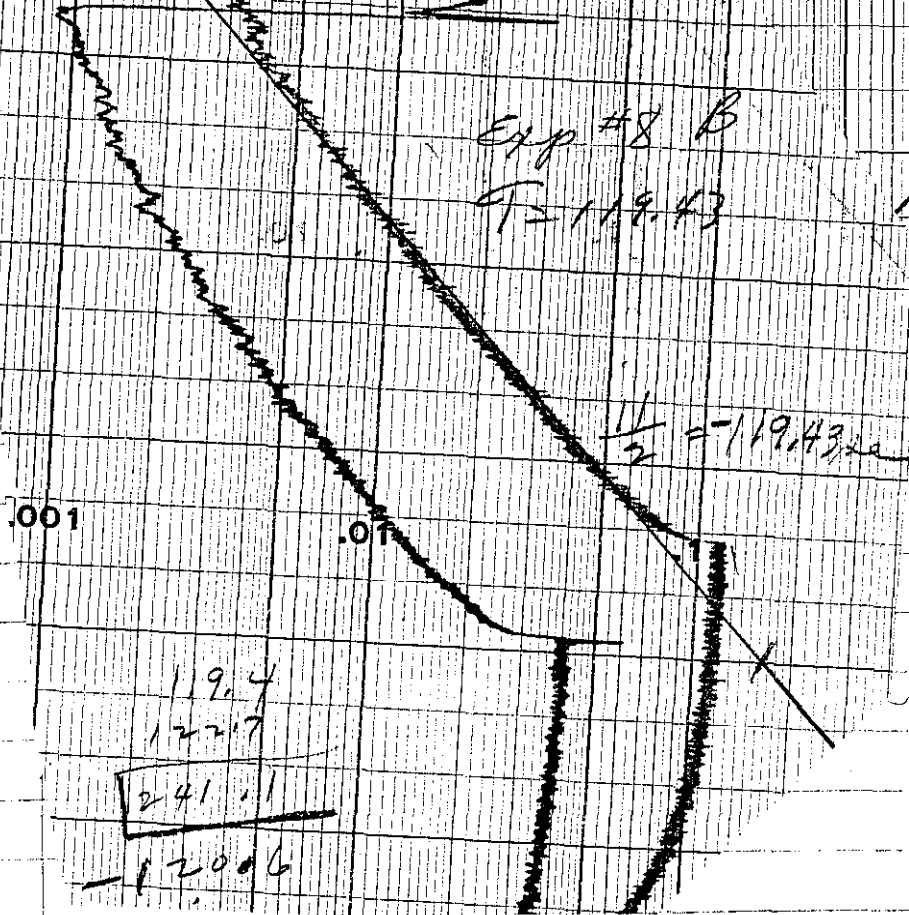
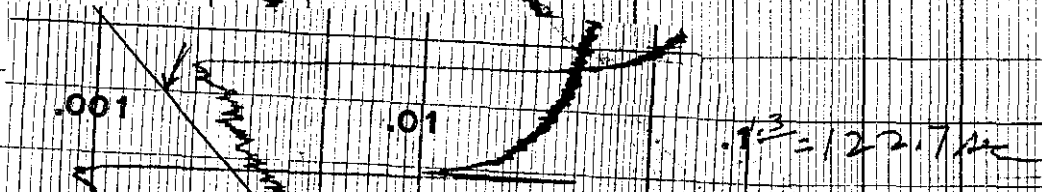
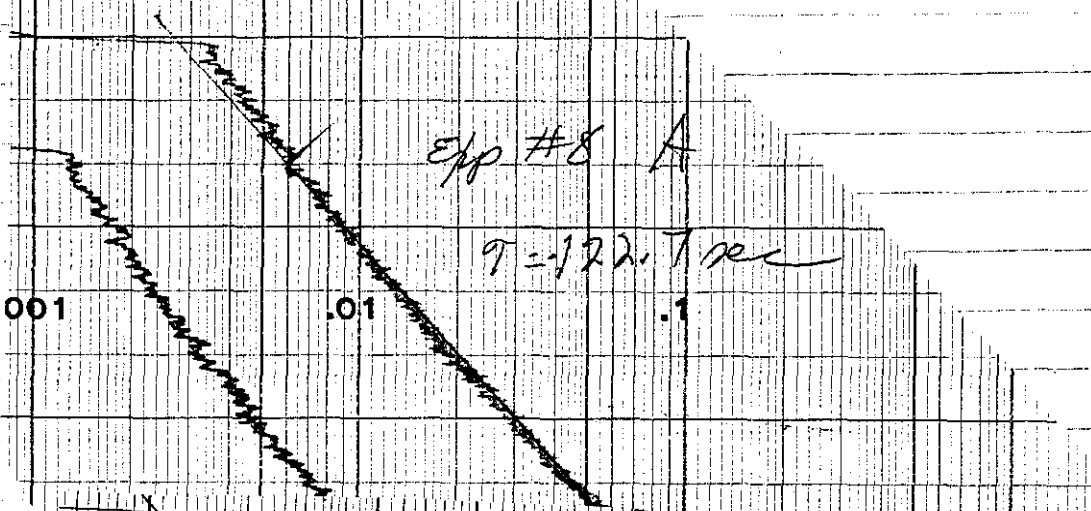
Exp #7

6 units in $6 \frac{1}{4} \times 6 \frac{1}{4} \times 10 \frac{1}{2}$ in cells

(3 on each table)

			Red Lite OK
			Ap OK
			Source OK
1558	Start		Bypass OK
1602	Pos. Period	$W = .190$ $E = .196$	$\left. \begin{array}{l} \\ \end{array} \right\} .194$ $P = 9.95 \text{ f}$
1614	Start Level		
	∞	$W = .222$ $E = .228$	$\left. \begin{array}{l} \\ \end{array} \right\} .225$ $\Delta S = .032''$ $\Delta P = .311 \text{ f/mil}$
1620	Down		

16



119.4
 122.7

 241.1
 - 120.6

Instrument Check on SEP. 28 1973 Source Co⁶⁰ (#20) 17

EM-1	875 V.	Low Trip	OK	Trip	OK
IC-1	3×10^{-10}		OK	High Trip	OK (Scram)
IC-2	3×10^{-10}		OK		Bldg Alarm
IC-3	1.6×10^9	Calibration	JL		A - ✓
IC-4	1.5×10^9	Calibration	JL		B - ✓
AP	1/6		Red Lite - CC		C - ✓

Source in

Exp #8 -

6 units in $6 \frac{5}{16} \times 6 \frac{5}{16} \times 10 \frac{1}{16}$ in. Cells.
3 units on each table.

$$W = .100 \quad E = .100$$

$$k < 1 \quad \rho = -17\%$$

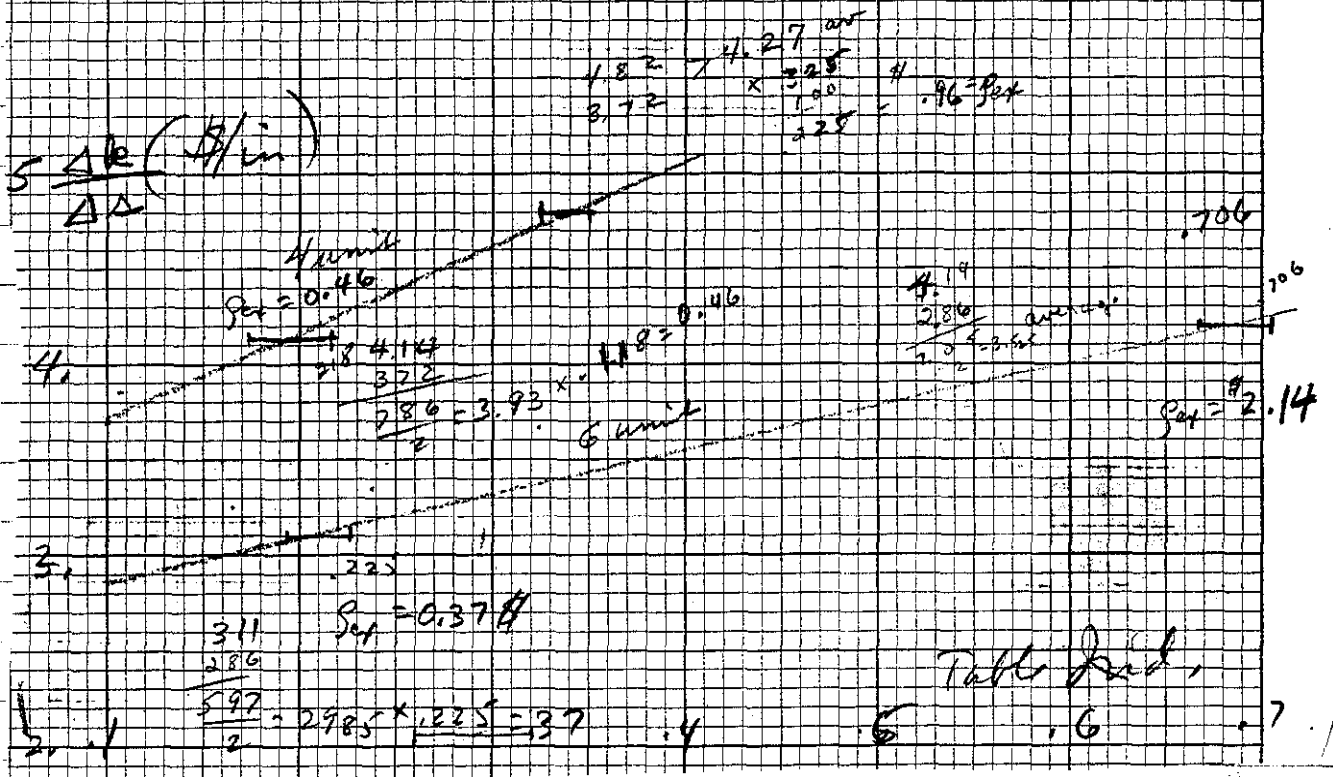
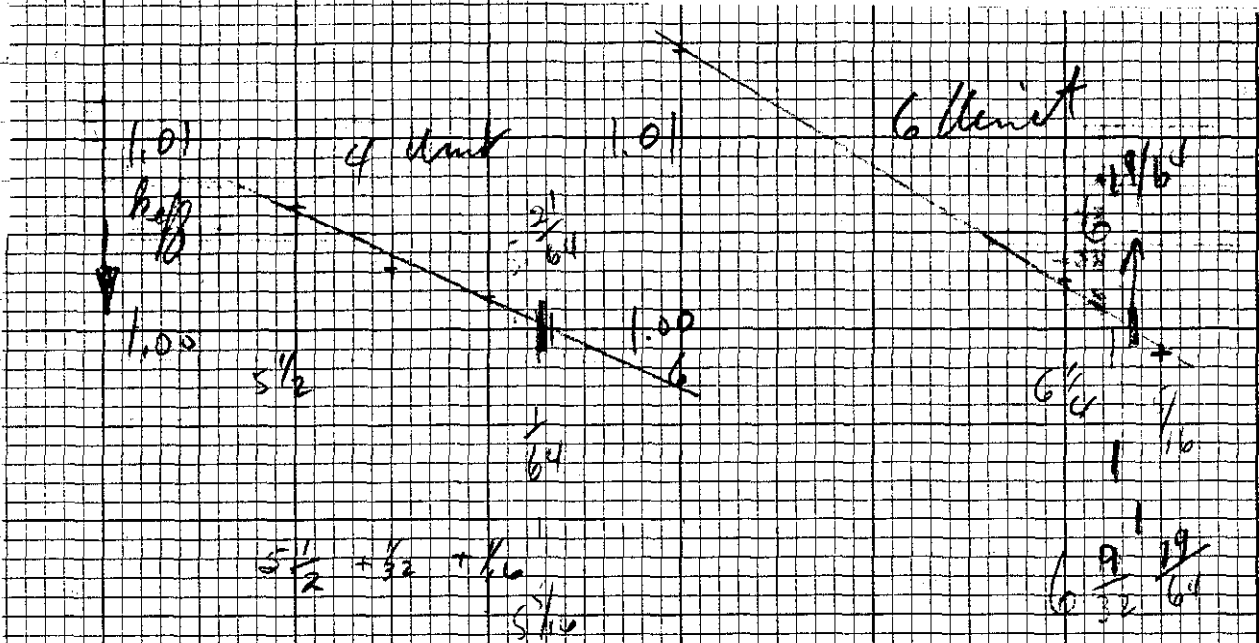
Add Two large sources to raise power IC

9:42 AM Remove sources IC-4 1.2×10^{-10}

$$k < 1$$

9:55 Add sources to raise power

10 IC-4 @ 1.2 for ~ 10'



Summary of array react. vs size

Exp No.	No Unit	Size	Estimated	k
			Per	
4		5 1/2	.96	1.0065
4		5 13/32	.46	.0031
4		5 9/16	.27	.0018
6		6	2.14	1.0146
6		6 1/4	.37	1.0025
6		6 5/16	-.17	.9988
8		6 11/16	+.04	1.0003

Assum $\beta_{eff} = .0068$

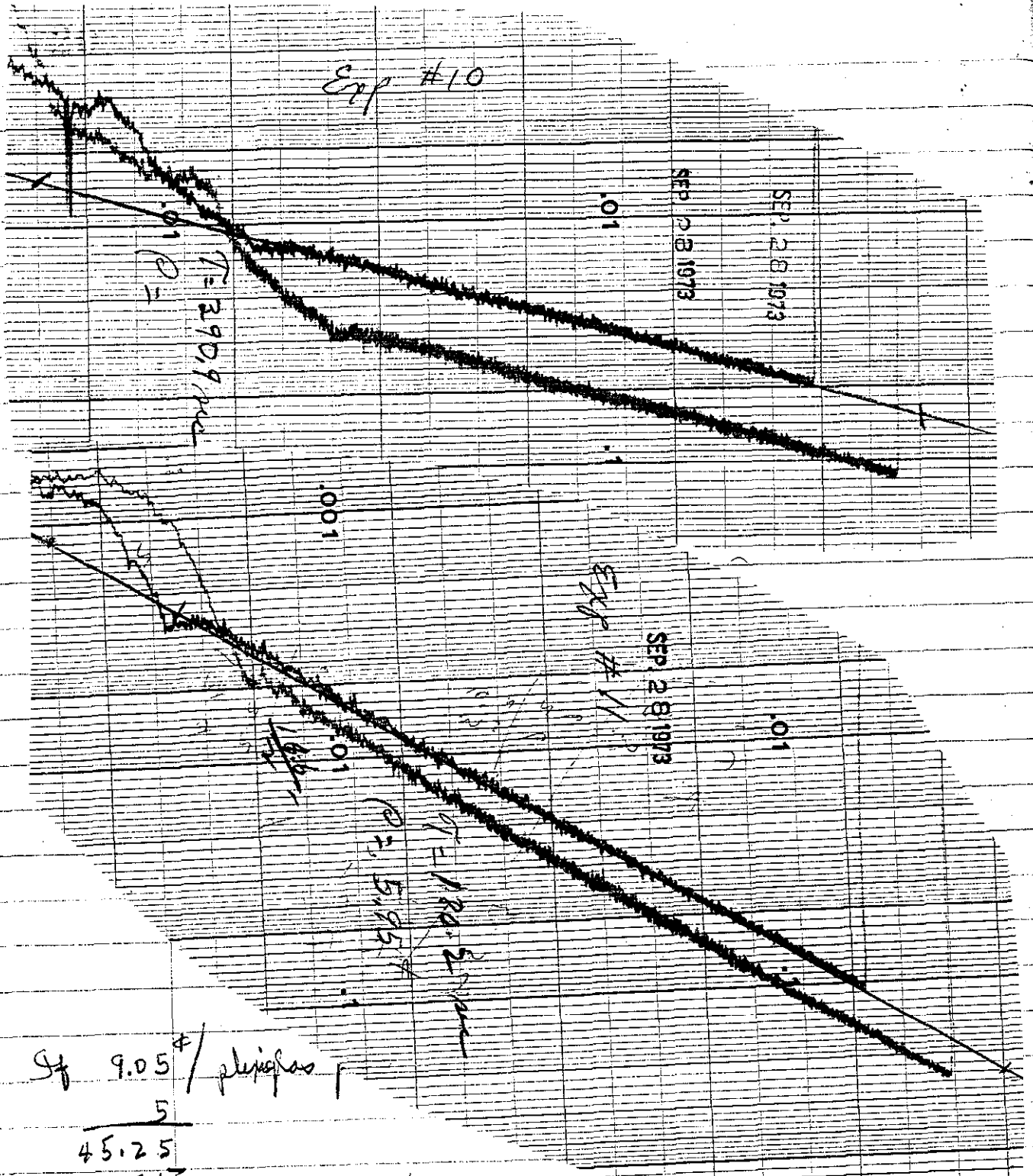
Est Delayed Crit

4	5.328	13.533	D.O	1.00
6	6.297	15.994	0.0	1.00

9	7 1/8		-.064	.9996
---	-------	--	-------	-------

773 g Alcohol

9	6 13/16		-.04	.9997
---	---------	--	------	-------



Sf 9.05 # / plus gas r

5	
45.25	
- 5.95	
- 39.30	for Exp #9

Exp # 9 -

8 units in $6\frac{3}{4} \times 6\frac{3}{4} \times 10\frac{1}{8}$ in. Cells.
(4 units on each table),

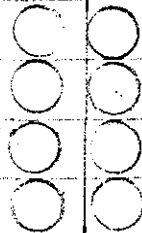
12:50

$W = .100$

$E = 100$

$k < 1$

Est. $S_{ex} = [-0.09]$



Exp # 10 -

added 4 ($\frac{1}{2} \times 2 \times 6$) plyglass
pos in symmetric positions, about bottom
IC-2 out of trip (erratic response)

13:25

$W = .100$

$E = .100$

Pos Period.

$P = + 3.00 \neq$

Cans

Exp # 11 -

added 1 ($\frac{1}{2} \times 2 \times 6$) to a position
symmetric to the 4 pos in Exp 10. ^{at top of Cans}

14:00

$W = .100$

$E = .100$

$k > 1$

$P = 5.95$

14:13

Shut Down

Exp # 9 est. $S_{ex} = -0.09$

(SEE p. 27)

$$\begin{array}{r} 5.95 \\ 3.00 \\ \hline 2.95 \text{ F} \\ \times 3.069 \\ \hline 9.05 \neq \end{array}$$

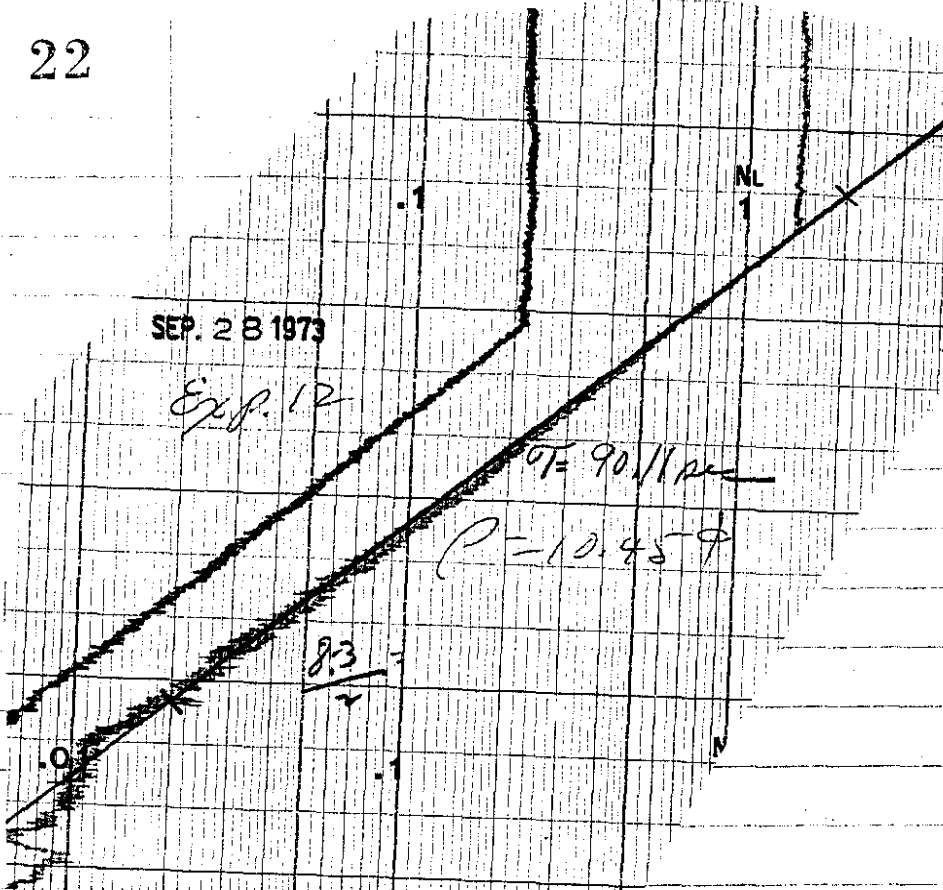
SEP. 28 1973

Exp. 12

$T = 90.11 \text{ sec}$

$\rho = 10.459$

$\frac{8.3}{2}$



.001

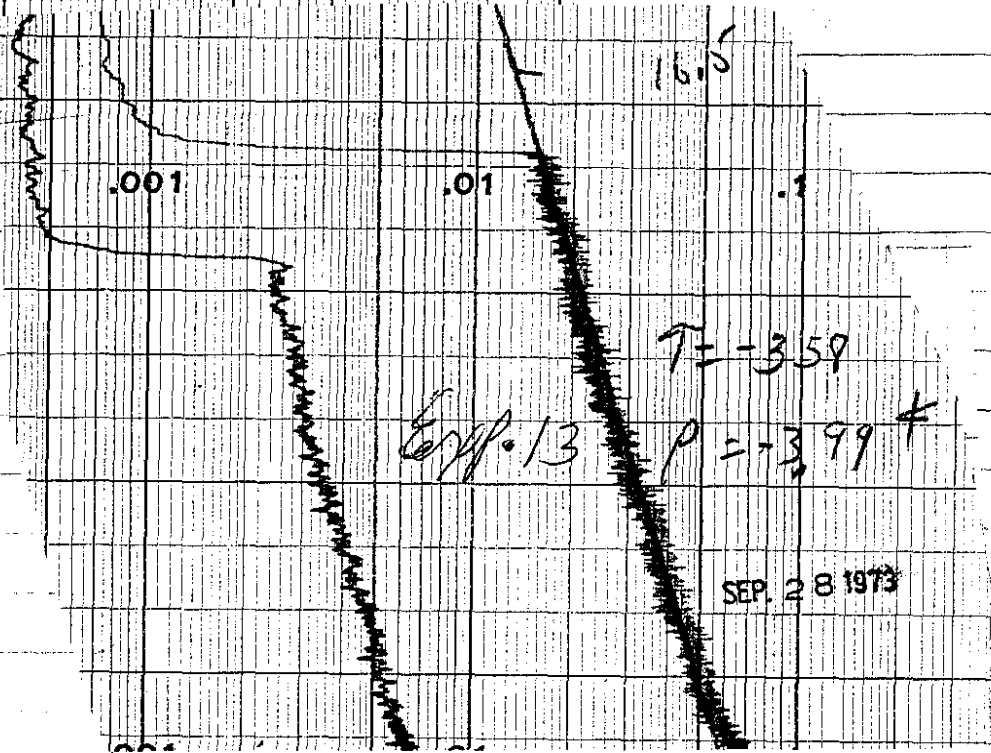
.01

16.5

$T = -359$

Exp. 13 $\rho = -3.99 \text{ K}$

SEP. 28 1973



Exp. # 12

9 units in $7" \times 7" \times 10\frac{1}{16}"$ cells.

3 on fixed table, 6 on movable table.

75:05

Pop Period

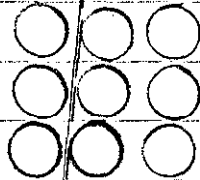
$$W = .533 > .536 \quad P = 10.45 \text{¢}$$

$$E = .540 \quad \Delta S = .041"$$

 ∞

$$W = .524 > .577 \quad \Delta P = .255 \text{¢/mil}$$

$$E = .581$$



Exp. # 13 -

9 units in $7\frac{1}{8}" \times 7\frac{1}{8}" \times 10\frac{1}{16}"$ cells.

(3 on fixed, 6 on movable)

Closed 15 $\frac{5}{16}$

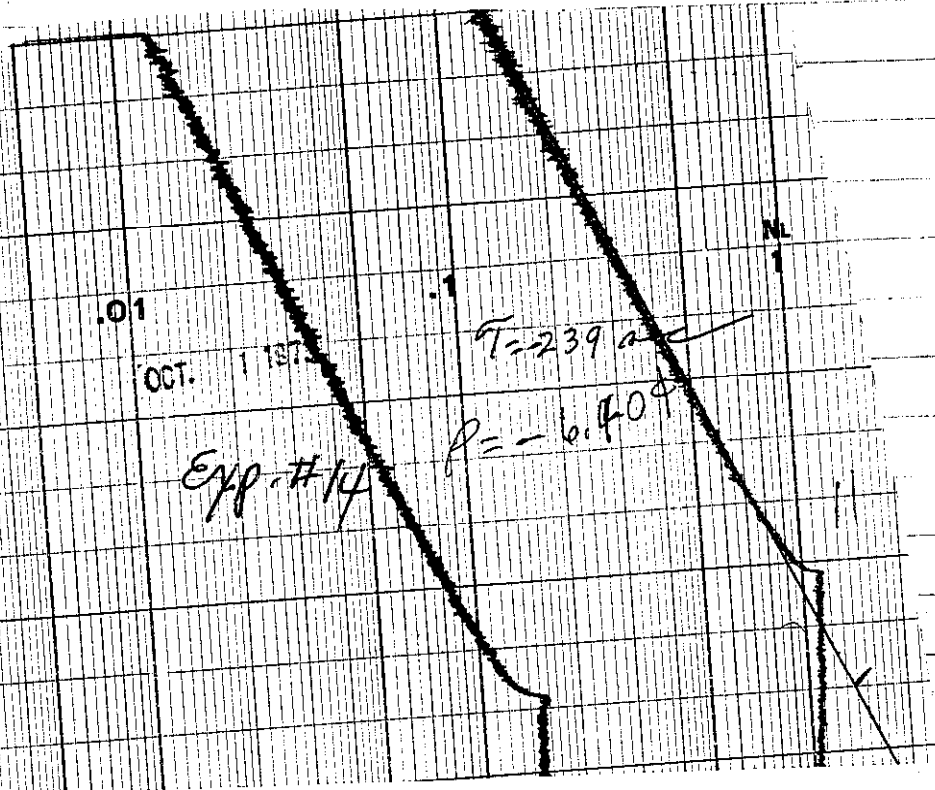
$$W = .100$$

$$E = .1005$$

$$h < 1,$$

$$P = -3.99 \text{¢}$$

N.B. This power level was probably
Too low for accurate period meas.



1972

OCT. 2 1972

OCT. 1 1973

Instrument Check on OCT. 1 1973 Source Q.60 (#20)

IC-1	875 V_c	Low Trip	OK (scam)	Hi Trip	OK
IC-1	3×10^{-10}	Meter Trip	OK	Fast Trip	OK
IC-2	3×10^{-10}	Meter Trip	OK		Bldg Alarm
IC-3	9×10^{-8}	Calibration	JLH		A - OK
IC-4	1×10^{-9}	Calibration	JLH		B - OK
	AP - OK		Red Lite C.C.		C - OK

Source - in

Exp. #14 - Repeat of Exp #13 for
9 units see if there might be
settling of material in the cans.

Cloud

$$W = .100$$

$$E = .1100^{\circ}$$

$$k < 1,$$

$$\log n = .06 \quad P = -4.81^{\circ}$$

$$" = 11 \quad P = -6.40^{\circ}$$

Exp #15 - Placed 4 ($2\frac{1}{2}'' \times 2'' \times 6''$) pcs
plexiglas in symmetrical positions on moveable
table.
2 at top and 2 at bottom.

0955 Pos Period.

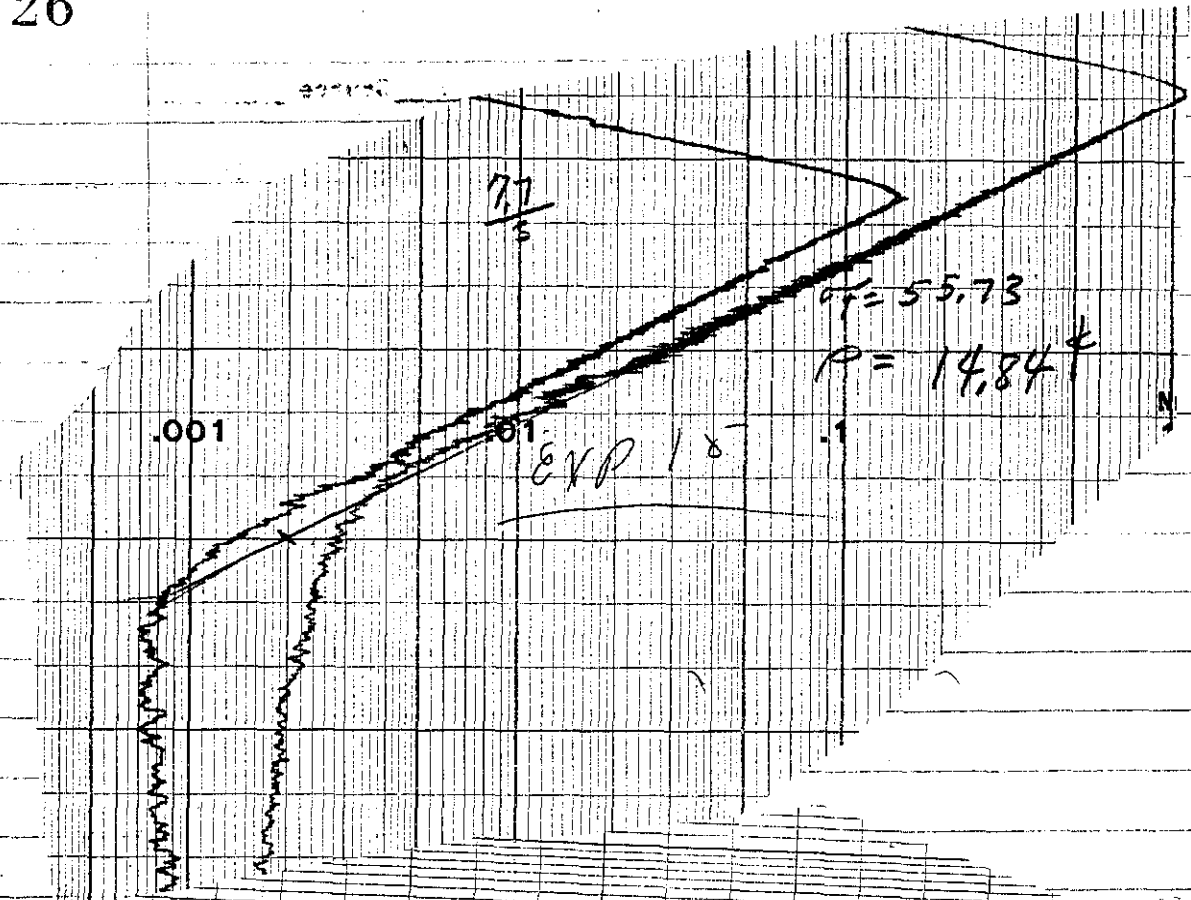
$$P = +14.84^{\circ}$$

$$5.40$$

$$21.24$$

$$4 \text{ pcs} = 21.24^{\circ}$$

plexiglas



Exp #16 - Removed the 2 bottom pcs.
of plexiglas.

10:15

closed

$$W = .100$$

$$E = .1005$$

$$k < 1,$$

$$\rho = -1.18 \text{ \#}$$

$$+14.84$$

10:31

Down

$$2 \text{ bottom pcs plexiglas} = 16.02 \text{ \#}$$

$$\therefore 2 \text{ Top pcs} = 5.22 \text{ \#}$$

$$\frac{8.01}{2.61} = 3.069$$

Exp #17 - Placed 2 ($\approx 1/2" \times 2" \times 6"$) pcs
plexiglas in symmetric positions about
1 can on fixed table.

center can

14:45

closed

$$W = .100 \quad E = .100$$

$$k > 1,$$

$$\rho = +5.91 \text{ \#}$$



Plexiglas pcs

Exp #18 - Removed the piece of
plexiglas from top position.

15:15

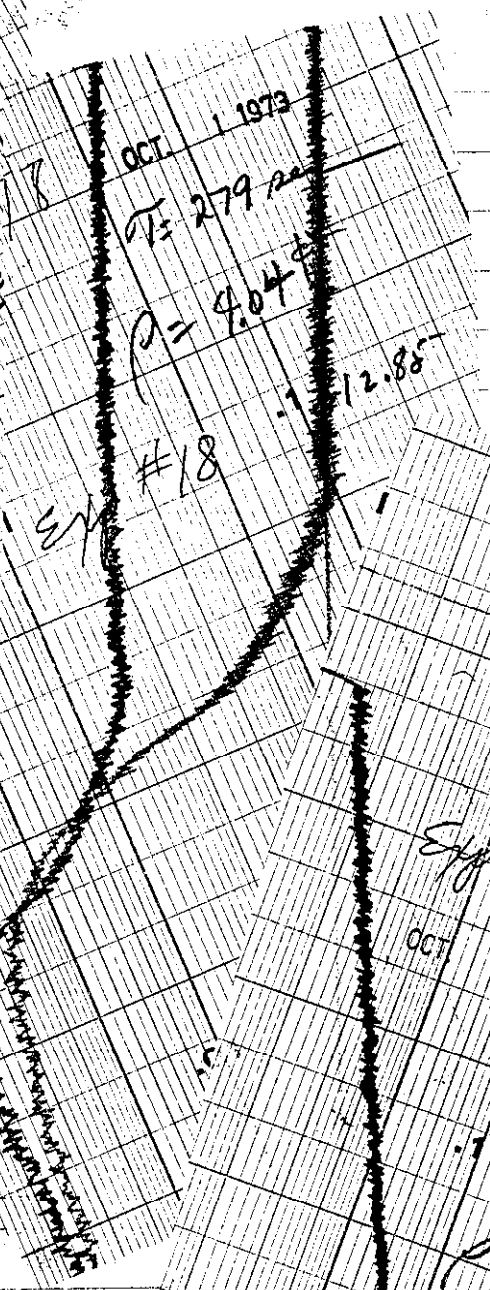
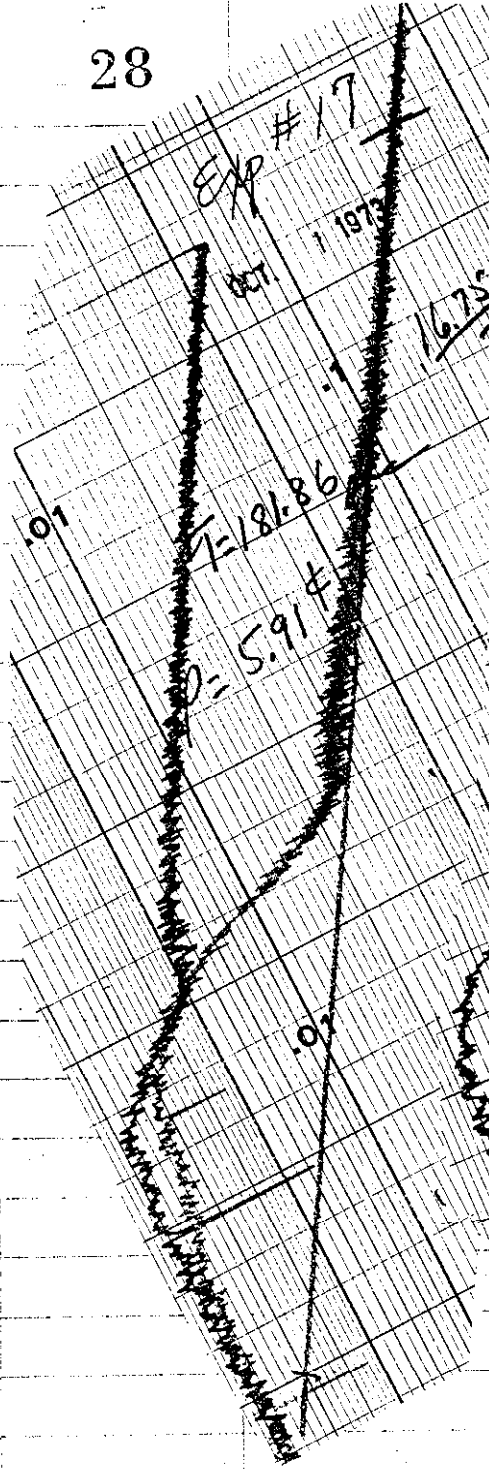
closed

$$W = .100 \quad E = .1005$$

$$k > 1$$

$$\rho = +4.04 \text{ \#}$$

$$\therefore \text{Top pc plexiglas} = 1.87 \text{ \#}$$



Exp # 19 -

Base Run (9 units)

Repeat 7
13 + 14

15 42

Cloud

$$W = .100$$

$$E = .100$$

$$k < 1,$$

$$\log N = 1.0 \text{ (TC-4)}$$

$$\rho = -6.09\%$$

4⁴⁵ PM

Looks Good!

AWM

OCT. - 2 1973

PH-1	875 V.	Low Trip	OK	Trip	OK
IC-1	3×10^{-10}	Meter Trip	OK	Fast Trip	Screen *
IC-2	out	Meter Trip	0		
IC-3	1.3×10^{-9}	Calibration	DL		Bldg Alarm
IC-4	1.0×10^{-9}	Calibration	DL		A - OK
Red Lite	CL		$\Delta P = 1.5$		B - OK
					C - OK

Source - in

Exp # 20 -

First attempt at assembling
of a straight line Array, completely reflected.
3 cans in contact on movable table,
with fixed reflector on fixed table.

10 35

Start Assembly.

10 45

closed - No Response
 $w = .100$
 $E = .1005$

Exp # 21 - 4 Cans.

10 58

start assembly.

11 07

closed - No Response

Exp # 22 - 5 Cans.

11 15

Start assembly -

11 20

closed - No Response

Exp # 23 - 6 cans -

13⁰⁰ Start up.

13⁰⁸ Closed - No Response

$W = .100$

$E = .101$

Exp # 24 - 7 cans.

13¹¹ Start up.

13²⁵ closed - $W = .100$ $E = .101$ No Response -

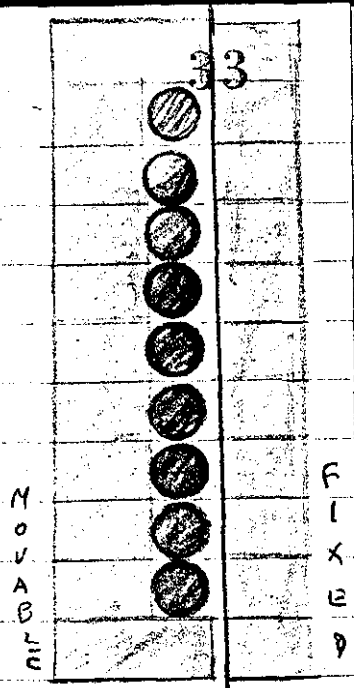
Exp # 25 - 8 cans

13⁴⁰ Start up.

13⁴⁹ closed. $W = .100$ $E = .102$ No Response?
may be

13⁵⁶ Exp # 26 - 9 cans

14⁰⁵ closed - $W = .1005$ $E = .101$ Slight Rise
IC - 4.



OCT. 8 1973

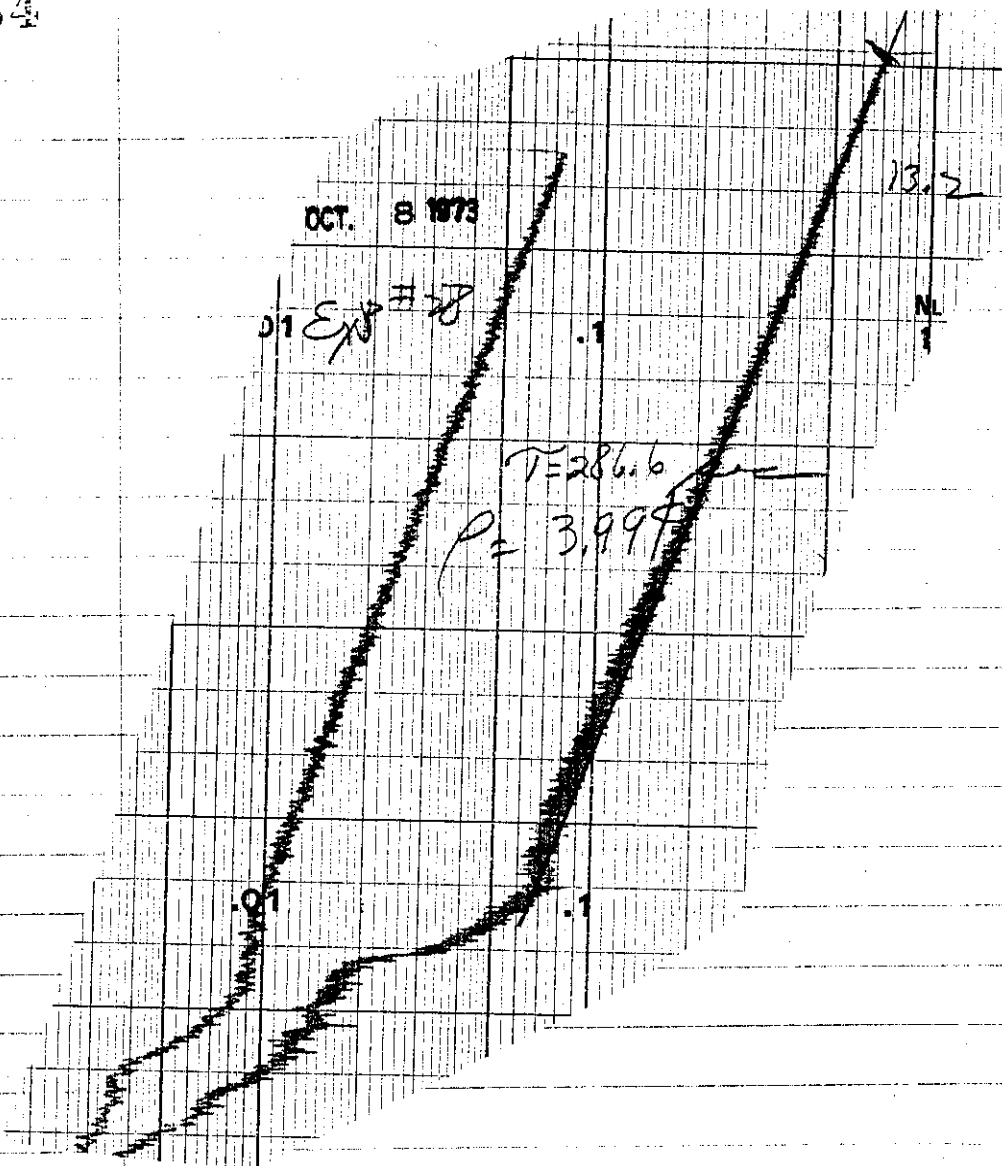
Exp # 28

13.2

NL

$T = 286.6$

$\rho = 3.999$



OCT. 8 1973

Restack 2×4 (5 units) planar array in
 $6 \frac{1}{16}$ " cell.

OCT. 8 1973

Instrument Check on Oct 8, 73 Source 70W @ 60C

IC-1	875 V	Low Trip	OK	Trip	OK
IC-1	3×10^{-10}	Meter Trip	OK	Fast Trip	OK
IC-2	3×10^{-10}	Meter Trip	Source Table		
IC-3	5×10^{-10}	Calibration	SWM	A	OK
IC-4	1.2×10^{-9}	Calibration	SWM	B	OK
				C	OK

EXP #27

Red Kit + Pns Check

Purpose: Alignment check of Δp
 $2 \times 4 = 8$ unit Array @ $6 \frac{1}{16} \times 6 \frac{1}{16}$ Source
 Cell Size (Repeat of #9 with Bygone
 cell size reduced) No Top Reflector

13³² Start Assembly13⁴⁰ Tables Together - Subcritical $W = .100$ $E = .100$

Check Alignment of Unit and Separations.

Exp #28

14⁰⁶ Start assembly - 2×4 (8 unit)14¹⁵ Closed - $W = .100$ $E = .101$ $k > 1$, $P = 3.99 \neq$

Void

10.063	10.063	10.063
1.235	<u>1.643</u>	<u>2.878</u>
8.818	9.420	7.185

10-9-73 opened all cans and measured distance from Top of can to alcohol level and to oxide level

10-10-73 with vacuum flask, siphoned off 300g of alcohol from each can while can was on scales.

10-9

10-10

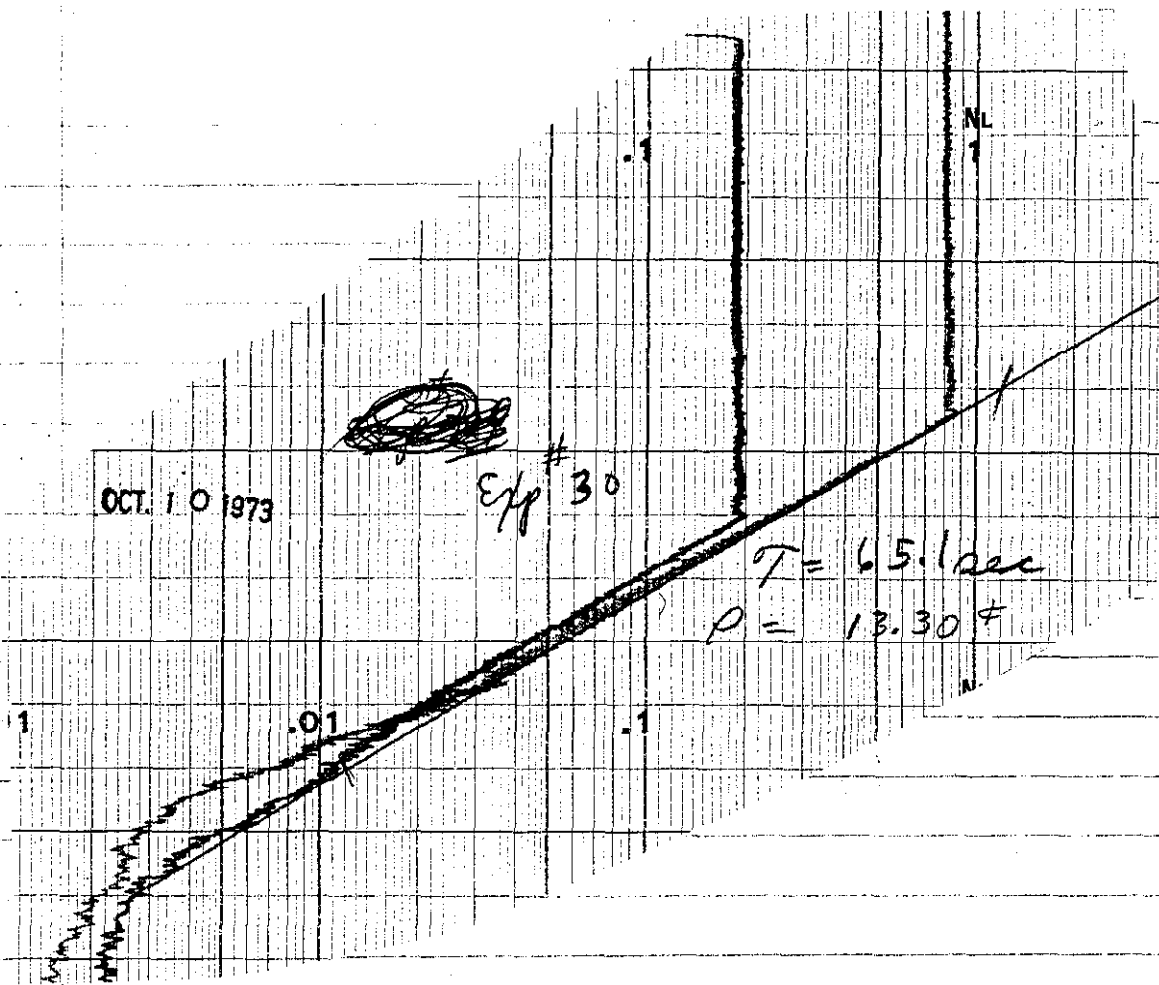
Alcohol

300 g Removed

Depth Measurements

Can No.	Weight, g	9213 Weight	9213 Weight	To Alcohol	To oxide	Liquid layer	
6238	18418	18422	18122	1.545	2.843	1.298	.063
		+4					
6240	18415	18421	18121	1.636	2.828	1.192	.043
		+6					
6242	18415	18417	18117	1.642	2.874	1.232	.003
		+2					
6244	18418	18419	18119	1.577	2.804	1.227	.008
		+1					
6246	18410	18408	18108	1.592	2.831	1.239	.004
		-2					
6248	18414	18418	18118	1.663	2.922	1.259	.024
		+4					
6250	18418	18424	18124	1.716	2.957	1.241	.006
		+6					
6252	18411	18413	18113	1.757	2.970	1.213	.022
		+2					
6254	18409	18409	18109	1.660	2.874	1.214	.021
		0					
				1.643	2.878	1.235	.022

$\frac{+23}{9} \approx 2.55 \text{ g}$



Instrument Check on Oct 10, 73 Source 20mc ⁶⁰Co

IC-1	875V	Low Trip	OK	Trip	OK
IC-1	3×10^{-10}	Meter Trip	Screen Tables	Fast Trip	OK
IC-2	3×10^{-10}	Meter Trip	OK		
IC-3	5×10^{-10}	Calibration	OK	A	OK
IC-4	1.3×10^{-9}	Calibration	OK	B	OK
				c	OK

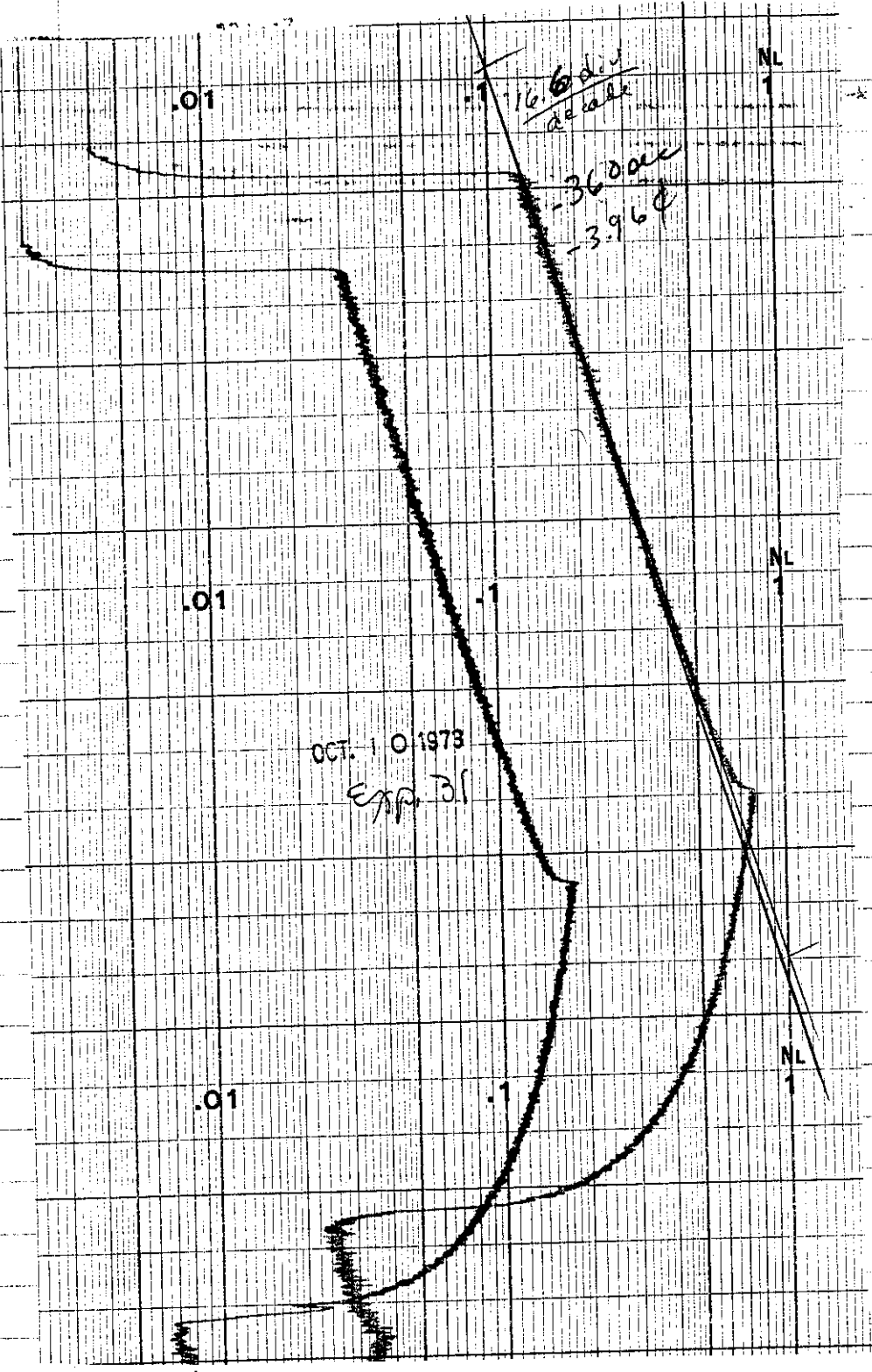
PM
2⁰¹ EXP # 29 Red hits + plus ck OK
Start Assembly of 3x3=9 unit Source Insulator OK
array on 7 in. Centers Response OK
Bypass Panel OK
(Previous spacing, 7 1/8 in., see #13 & #14) ΔP OK
Units now have 773 g of Alcohol
PM
2¹⁰ Tables closed $W = .100$ $E = 102$
Very little multiplication!

avg 2×10^{-12} IC-3 = 2×10^{-12}
 6×10^{-13} IC-4 = 2×10^{-12}

EXP # 30

Change Cell size to $6 \frac{3}{4} \times 6 \frac{3}{4}$ in. for the 3x3=9 unit array.
PM
2⁴⁸ Start Assembly
3⁰⁰ On Positive Period $W = .257$ $E = .263$ $k > 1$
3⁰³ Start to level $P = 13.3 \pm$
3¹⁰ $k = 1$ $W = .322$ $E = .328$ $\Delta A = .065$

$\Delta P = .205 \pm / \text{min}$
Average worth is $\frac{.175 + .205}{2} \times .325 = .6175 \times 10^{-6} = .0042$ $k = 1.0042$



EXP #31

Change spacing $6\frac{1}{16} \times 6\frac{1}{16}$ in. for an $3 \times 3 = 9$ unit array3³⁸ Start Assembly3⁴⁸ Tables CloseNear Crit $W = .10 \bar{T} E .100$ 3^{48 1/2}Remove Source slightly out - $k < 1$ 3⁴⁹

Add large sources, Raise Power

3⁵⁵

Remove Sources for next Period

4⁰⁵

Down

Note: Temp = 22.3°C

See page 19 for summary of cell size

and p 37 for measurements of oxide liquid levels.

Can Description

Height $10\frac{1}{16}$ in. = 10.063 " = 25.560 cm

Average Depth to

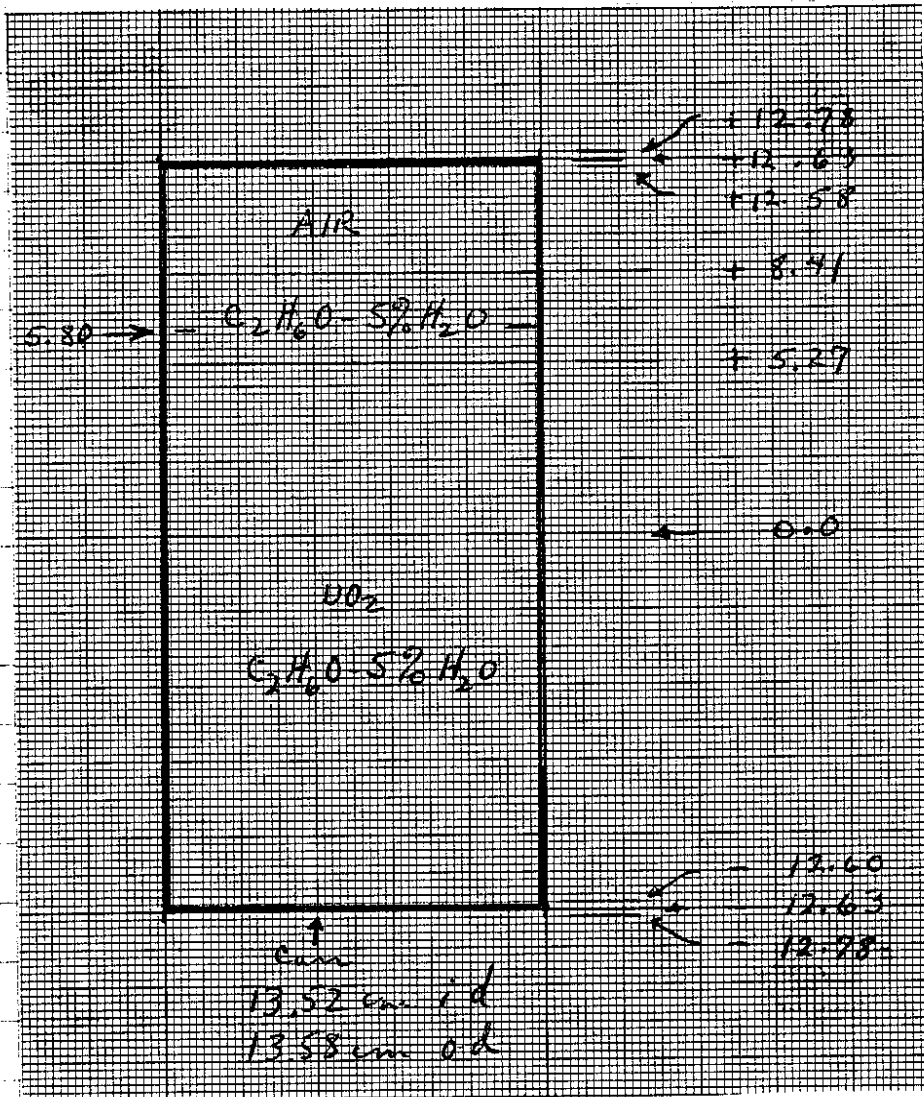
Liquid 1.643 " = 4.173 cm

oxide 2.878 " = 7.310 cm

Average Liquid

Thickness 1.235 = 3.137 cm

alcohol
layer reduced
to 5.80 cm
for final
experiment
(Removed
300 g of
190 proof
alcohol.)



Note: Top thickness is 0.05 cm to account for
extra mass of Fe for friction closure lid.

$CO_2 - C_2H_2O - H_2O$ 2565.5 cm^3
 $C_2H_2O - H_2O$ 450.8 cm^3 and 76.7 cm^3
 Total volume of can 3614.9 cm^3

8/12/57

$H_2O @ 25^\circ C, \rho = .99707$

8/12/85

711.46 g $C_2H_6O - 5\% H_2O$

$$.95 \times 47.07 =$$

$$.05 \times .99707 =$$

.9

$$H_2O = \frac{2.016}{18.016} = .1119 \quad \left(\times \overset{.0401}{.05 \times .802} \right) = .004487 \text{ g H}$$

$$\frac{16}{18.016} = .8881 \quad \left(\times \overset{.0401}{.05 \times .802} \right) = .03561 \text{ g O}$$

$$\frac{6.048}{46.07} = .13128 \quad \left(\times \overset{.7619}{.95 \times .802} \right) = .100027 \text{ g H}$$

$$\frac{16}{46.07} = .34730 \quad \left(\times \overset{.7619}{.95 \times .802} \right) = .264606 \text{ g O}$$

$$\frac{24.022}{46.07} = .521424 \quad \left(\times .7619 \right) = .39737 \text{ g C}$$

$$H_T = 0.1045 \text{ g/cm}^3$$

$$O_T = 0.3002 \text{ g/cm}^3$$

$$\left(\frac{711.46}{.802} = 887.1 \text{ cm}^3 \right)$$

[Signature]

8/12/85

UO_2 @ 93.15 wt% ^{235}U

$$M.W. = \frac{237.21}{32} = 267.21$$

$$\rho = 10.9 \times \frac{267.21}{270.03} = 10.786$$

$U(Nat)O_2$ @

$$M.W. = \frac{238.03}{32} \quad \rho = 10.9$$

$$\frac{270.03}{270.03}$$

1 g (93.15) O_2 @ .87799 g U/g of oxide

$$.81785 \text{ g } ^{235}U \rightarrow 2.096 \text{ E-3 } \times 10^{24}$$

$$.06014 \text{ g } ^{238}U \rightarrow 1.522 \text{ E-4 } \times 10^{24}$$

$$O \rightarrow 4.496 \text{ E-3 } \times 10^{24}$$

X17000 Total atoms Atom Density
vol = 2565.5

^{235}U	35.632×10^{24}	1.389 E-2
^{238}U	2.587×10^{24}	1.008 E-3
O	76.438×10^{24}	

C_2H_6O @ .8020 g/cm³ @ 22.3°C

$$450.8 \times .802 = 361.54 \text{ g}$$

$$1073 - 361.54 = 711.46 \text{ g of } C_2H_6O - 5\% H_2O$$

$$1 \text{ g } C_2H_6O - H_2O \rightarrow .1304 \text{ g H} \rightarrow 7.794 \text{ E-2 } \times .802$$

$$.4953 \text{ g C} \rightarrow 2.484 \text{ E-2 } \times 1.992$$

$$.3743 \text{ g O} \rightarrow 1.409 \text{ E-2 } \times 1.130$$

Total Atoms	H	55.451	2.161 E-2
$C_2H_6O - H_2O$	C	17.673	6.889 E-3
	O	10.024	3
	O _T	86.462	3.370 E-2

$$\frac{17000}{10.786} + \frac{711.46}{.802} = \frac{1576.1}{887.1}$$

$$\frac{2463.2}{2565.5} = 0.9601 \therefore 4\% \text{ voids}$$

$$\text{UO}_2 \text{ density} = \frac{17000}{2565.5} = 6.6264 \text{ g/cm}^3$$

$$\div 10.786 = 0.6144 \text{ of theoretical density}$$

$$\text{U density} = 6.6264 \times .87799 = 5.818 \text{ g/cm}^3$$

$$^{235}\text{U density} = 5.818 \times .9315 = 5.419 \text{ g } ^{235}\text{U/cm}^3$$

$$\frac{4}{235} = 1.556$$

Check
OK
8/12/05

Oct 1973

65

Instrument Check on _____ Source 20 mc Co

#1 875V Low Trip Scramtable Trip OK

IC-1 3×10^{-10} Meter Trip OK Fast Trip OK

IC-2 3×10^{-10} Meter Trip OK Bldd Alarm

IC-3 1×10^{-9} Calibration OK A OK

IC-4 1×10^{-9} Calibration OK B OK

C OK

~~2/4
2/1
2/1
2/1~~

Neutron Source

Op

Red hite + Pers.

Inst. Bypass Panel