BOOK53R

Notes:
10150 on bottom edge

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Sheila Finch
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August 16, 1999

COMPUTATION BOOK

NAME	Number
F-05	25

Course Solution Experiments #151 —— #192.

Used from 5/12/48 19..., to ..... 19.....

HARVARD COOPERATIVE SOCIETY
Cambridge, Massachusetts

14-2-2

SECRET

150

Inv. 60

Inv 58

Inv 52

CLASSIFICATION CANCELLED
DATE 6/3/60
For the Atomic Energy Commission
Jack K. Kohn for the
Chief, Declassification Branch

RESTRICTED DATA
This document contains restricted data as defined in the Atomic Energy Act of 1946.

This document consists of 152 pages,
No. 1 of 1 copies, Series A.

SECRET

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TABLE OF CONTENTS

Experiment 151 — H/X = 500 — Beck 5/12/48

20" UnTamped, Stainless Steel — Pressy, McLendon, Fox.

Instruments: #50K. -2 scale; 30n 100 scale; 4 on 10 scale; #1, #2, OK. Reed, and Process monitor OK.

Trip Points: #3 - 86, #4 - 6.5; Source at 8 cm.

Time:	Sol. Level.	Rate #1	Rate #2	Ratio #1	Ratio #2	
9:35	Background	39.	13.5			
	zero. 0.3.	43.	13.5			
		~~45.5~~	13.			
		44.0				
	10.3	27.0	11.0			#8, 4, 7, 6 cylinders empty.
	13.4	60.	22.0	.73	.51	
10:40	16.7	105.5	51.	.42	.265	
10:51	18.0	173.5	87	.25	.15	
11:00	19.1	299.	153.	.16	.088	
11:16	20.0	714	362	.062	.037	
11:22	20.4	824	714	.053	.019	
11:30	20.6	Not Critical.				
11:39	20.9	Critical				

Conclusion: Critical at 20.95* ± .05.
However - see Exp 160 - sight glass may have read 0.5 cm too high thereby reducing Hc to 20.45 cm.
Distance from bottom of reactor at periphery to dried "high water" mark = 20.2 cm (= 20.3 from center of bottom of reactor due to pitch ~~to~~ in reactor bottom).

11/17/48 DC
20.2 + 0.2 = ~~20.4~~ 20.5 cm = Hc bottom corrected
H/X = ~~494~~ 499
20" Stainless Untamped
ρpg = 1.07
wt% X = 4.88
= 0.0522 gm X/cc
Vc = 41.54 ℓ
Mc = 2.17 Kg

	for 20" reactor	Drainback	
#1	3.4 cm	3.5 cm	= 14.0 cm in 10" Reactor
2	3.25	3.3	= 13.2 "
3	3.55	3.3	= 13.2 "
4	3.25	3.3	= 13.2 "
5	3.25	3.3	= 13.2 "
6	3.25	3.3	= 13.2 "
7	2.4	3.3	= 13.2
8	.75 + D.V.	D.V.	
9	60 4/x		

*NOTE: REACTOR BOTTOM SEEMS TO BE 5-7 MM. High so, APPROX 6 mm should be subtracted for ZERO. Height WAS measured by meter stick. MAX. Ht. 20.2 cm

6

5/17/48 — Experiment 152

Pressey — 10" Aluminium Reactor. Tamped. H/X = 493.6. Reactor painted with Bakelite.

Fox
Cronin
Cathcart

TRIP POINTS - #3 - 95 x100 ; #4 - 6.5 x100

CONTROL ROD - Cd Sheet; Scale = 7 cm with sheat lower edge at reactor bottom

Source - Zero = 33-; Set - 15 cm from reactor bottom.

Scales - 3 x100, 4 x10, 5 x 1, R.E. 25 m.s.

Filling from #8

			I	II	M⁻¹	
12:30 P	H=0.1 cm.	4.0	2.0			
		3.5 / 3.8	2.0			
	=1.3 cm					#8 Empty - Filling from #7
:38	=5.0			I 0.534	II	Checked tamper.
:52	=12.1	6.5	3.5	0.534	0.571	#7 Empty. Filling from #6.
1:00	=16.0	10.0	5.5	0.380	0.364	
07	=20.0	16.0	9.0	0.240	0.222	stopped filling from #6 (~8 cm left). filling from #5
20	=24.0	27.0	15.0	0.141	0.133	
26	=27.0	42.0	25.0	0.091	0.080	
34	=30.0	81.0	45.5	0.047	0.042	stop filling from #5 (~3.2 cm left) filling from #3
47	=32.1	164.0	91.5	0.023 0.237	0.022	
50	=34.1	884.0	747	0.004	0.003	
2:05	=34.1	1344.7	72	0.024	0.028	Cd rod in. (= 2.2 cm).
:08	=34.3	Just critical -				

DRAIN BACK - #3 as before

#5 - - to 13.2 cm, this overflowed #5 as there is some question as to cylinders' contents. No vacuum was applied during this procedure however.

Conclusions: ① 10" Al reactor, H/X = 494, tamped critical at 34.3 cm.

② Cd control "sheet" = 2 cm of solution - near critical

③ Poisoning effect of stainless steel wall of reactor = (39.6 - 34.3) = 5.3 cm of solution

11/17/48 DC
11/28/48 JC

34.3 + 0.9 = ~~34.2~~ 35.2 cm = Hc bottom corrected

H/X = ~~494~~ 499

10" Al. Tamped.

$\rho\rho_f = 1.07$

Wt % X = 4.88 = 0.0522 gm/cc.

V_c = 17.83 ℓ

M_c = 0.93 kg.

5/17/48

EXPERIMENT 153

For Cronin Pressey Calthon –

10" Aluminum Reactor. H/x = 493.6

Untamped

Experiment started with 13.2 cm solution in reactor.
Background count taken here – good relative to subsequent ones – absolute values to be determined at end of experiment.

Trip points – same as before
Scales #3 × 10, #4 × 20, #5 × 2, R.E – 50 mv.
Source ~~#3~~ 14 cm above bottom of reactor – at solution surface.

		I	II	$(M^{-1})'$ I	$(M^{-1})'$ II	True M^{-1} I	True M^{-1} II	
2:50 P	H = 13.2 cm	22.0	14.0					
		22.5	12.0					
		22.3	13.0					
55	= 15.2							#8 Empty (#7 ~~empty~~).
59	= 20.0	49.0	30.5	0.454	0.427	0.918	0.952	#6 Empty, filling from #5.
3:07	= 27.5	74.0	47.0	0.303	0.277	0.608	0.617	
14	= 34.5	90.0	54.0	0.248	0.241	0.500	0.537	#5 Empty, filling from #4
25	= 42.3	99.5	64.0	0.224	0.206	0.455	0.453	
32	= 47.7 = 61.0	103.0	65.0	0.217	0.200	0.435	0.446	#4 Empty, filling from #3
43	~~= 61.8~~	110.5	70.0	0.202	0.186	0.407	0.414	#3 Empty
4:32	In pit.	45.0	28.0					
		45.0	30.0					
		45.0	29.0					

CONCLUSION: 10" Al reactor, H/x = ~~494~~ 499 untamped, probably not critical at infinite length. The corresponding experiment in stainless steel was done in a short reactor & was taken to 45 cm height. The reactivity, at same height, in aluminum cylinder is somewhat greater – for instance at H = 42.5, M^{-1} = 0.5" in stainless / 0.05" aluminum –

INVENTORY:

		15" reactor Empty
1	~14 cm in 10" Reactor, H/x = 493.6	
2	~13 " " " "	5.8
3	1.5 + DV " " "	0.66 + DV.
4	8.6 " " "	3.8
5	10.1 " " "	4.5
6	-13.7 " " "	6.1
7	-13.6 " " " "	6.1
8	-14.2 " " " "	6.3
9	Empty – needs to be leak tested.	empty.

11/30/48C
H = 61.0 + 0.9 = 61.9 cm
H/x = 499 (see preceding page).
V = 31.36 R
M = 1.64 Reg.

Estimated
$H_c = V_c = M_c = \infty$

Experiment 154 - 15" Reactor - Aluminum - Untamped 5/19/48

Beck
Fox
Cronin
Pressey

H/X ≅ 500.

Instruments

those showing normal response: 1, 2, 3, 4, 5, Recd, Proc. monitor - all OK.

Trip Points #4: 6.5, #3: 9.5.

Source Position: 12 cm from bottom.

Time	Soln Level	Counting Rate #1	Counting Rate #2	Ratio c/co #1	Ratio c/co #2
11:10	Lead Vol. full	27.5	17.5		
		28.5	18.5		
		28.5	18.5		
11:40	15.0	26.5	19.0		
	21.0	113.	74.5	.252	.248
11:58	24.0	288.5	198.	.094	.092
12:04	25.0	452.	305.	.063	.061
12:12	26.0	990	705	.029	.026
	26.7	not critical but almost.			
	26.8	not critical but allmost.			
	26.8+	not critical but allllmost.			
	26.9-	not critical but allllllmost.			
	26.9+	not critical but allllllllllmost.			
	27.0	Critical!!!			

Conclusion: Critical at 26.95 ± .05 cm.

Drainback

15" Reactor.

9	empty	—	
8	6.3	6.3	
7	6.1	6.1	
6	6.	6.0	
5	6.	6.0	
4	6.	6.0	
3	~~14~~	4.0	6.0
2	D.V.	D.V.	
1	empty		

11/17/48 DX 26.95 + 0.41 = $\overset{27.4}{27.3}$ t Cm = Hc bottom corrected

11/28/48 DX H/X = ~~494~~ 499

15" al untamped.

ρ_{Pu} = 1.07

wht % t = 4.88 = 0.0522 gm Pu/cc

V_c = 31.24 ℓ

M_c = 1.63 kg

Experiment 155 - 15" Reactor Aluminum - Tamped 5/19/48 -

H/X = 500 ?

Book for Cronin Pressey Huber Humes.

Trip Points: #4: 6.5⁻; #3: 80; Other Instruments. O.K.

Source Position: 7 cm.

Time	Solu. Level	Rate #1	Rate 2	c/c 1	c/c 2
2:25	Zero.	6	4		
		7	3		
		6	3.		
2:50	10.1	20.	11.	.3	.26
	12.7	41.	22.5	.145	.135
	14.1	70	42.	.086	.071
	15.0	116	67	.051	.045⁻
	16.1	463	273	.013	.011
	16.4	not critical			
3:40	16.5	Critical			

put in 4 = 2.3 cm

11/17/48 DC 16.5 + 0.4 = 16.9 Cm = Hc before Corrected

11/28/48 DC H/X = ~~494~~ 499

15" al tamped.

Dpp = 1.07

with 9X = 4.88 = 0.0522 $\frac{gX}{cc}$

Vc = 19.27 l

Mc = 1.01 kg

Conclusion: Critical at 16.5 ± .05 cm.

Drainback

9	~~empty~~ 2.5 + D.V.
9	4.0
7	4.0
6	4.0
5	4.0
4	4.0
3	4.0
2	4.0
1	~~empty~~ 4.2

Cyl.	HT.	cc	Vol. to Add	Final Hgt.
1	~~empty~~ 62.5⁻	5020	2510 cc	~~DV~~ 6.6
2	62.0	4980	2490	6.6
3	57.8	4650	2325⁻	6.0
4	60.0	4820	2410	6.3
5	60.6	4870	2435⁻	6.3
6	62.3	5010	2505⁻	6.6
7	58.2	4680	2340	6.2
8	57.8	4650	2325⁻	6.1
9	59.0	4750	2375⁻	~~4.0~~ 6.1

Exp 156 - 15" Reactor - Aluminum Tamped 5/20/48 — Cronin

H/X ≃ 750 — For Moffitt

Pressy

Source 8 cm from bottom of cyl.

12:40 Start

Instruments — Trip Pt.
#3 - 100 X — 83
#4 - 10 X — 6.1 (100 X)
#5 - 2 X
Reed - 25 X

Time	H.	#1	#2	C_0/C_1	C_0/C_2	From	Remarks
				6.0	3.0		
12:45	0	6.5	8.0			Cyl #9	
		5.0	3.5				
		5.5	3.0				
		6.0					
1:05	3.0	—	—	—	→	#9 MT	
1:22	8.67	8.0	4.0	0.75	0.75	#8 MT	
1:35	14.4	20.5	10.0	0.293	0.30	#7 MT	
1:45	20.1	52	26.	~~0.1[illegible]~~	0.115	#6	Stopped filling from 6
				0.145			
2:00	22.1	87	45	0.056	0.066	#5	
2:05	23.5	155	78.8	.0383	.0379		
2:12	25.0	456	250	.0131	.012		
2:25	25.5	not critical					
2:30	25.7	Critical with Rod out					

Critical at ~~[illegible]~~ 25.65 ± 0.05 cm

Sampled for H/X Sp Gr. = 1.044

Drained back into #5 + 6 ~~[illegible]~~.
#5 - 6.3
#6 = 6.3

11/17/48 DC 25.65 + 0.41 = ~~26.06~~ 26.1 cm = Hc bottom corrected
H/X = 755
15" al tamped.

11/24/48 DC Apparent = 1.04
wt % X = 3.30 = 0.0343 gm X/cc
Vc = 29.75 ℓ
N/c = 1.02 Bg.

11/28/48 DC
A bound note book called "Record" gives on page 22, in a tabulation of shipments of material, under date of 5/27 as samples 156 and 157-8*, each having 3.53% U (assumed) by weight. These may be the data on solution used in Exp 156 ff. No lab report can be found. This value corresponds to
H/X = 755
3.30% X by weight
if app. = 1.04
3.30% by wt = 0.0343 gm U/cc

*See SF Sample Transfer + Requisition #710009 ~~#7000~~ quoted for this analysis
also *710013, 5/27/48

Exp 157 Untamped 15" Cyl Al.

HX = 750

Source 18 cm from bottom

Morfitt
Primary
Fox
Cronin

3:15 Start

Co taken as count at HH = 14.4

	HH.	#1	#2	Co/C_1	Co/C_2	Cyl
	14.4	13.5	9.0			
		12.5	8.0			#4
3:30	20.4					#4 MT
3:35	27.2	72.0	47	.181	0.181	#3 MT
3:43	33.8	179.0	120	.072	0.075	#2 MT
3:53	36.1	270	178	.048	.048	#1
4:00	39.3	554	364	.023	.023	#1 stopped filling from #1
4:10	41.1	Not Critical				#5
4:13	41.3	"	"			
4:16	41.5	"	"			
4:20	42.0	"	"			
4:24	42.3	"	"			
4:27	42.7	"	"			
4:30	43.0	"	"			
4:33	43.3	Super Critical	Rod 10 cm in			

Critical at 43.15 ± 1 mm

Drain back

#1	Dead Vol + 1 cm
#2	6.5
#3	6.5
#4	6.5
#5	6.3
#6	6.3
#7	6.3
#8	6.5
#9	6.5

	#1	#2
Count at zero =	6.5	8

11/17/48 DC 43.15 + 0.41 = 43.6 cm
= Hc bottom corrected

HH = 755

15" Al untamped -

11/28/48 DC $\rho f = 1.04$

Wt% Y = 3.30 ≡ 0.0343 gm Y / cc

V_c = 49.70 L

M_c = 1.70 kg.

12 5/21/48

Expt'd 158 – 15" Reactor Untamped H/X = 750 Stainless Steel

For Mackin Moffitt (Cronin) On lab till near critical

Note: Light glass reads 0.6 cm at Reactor zero (See expt'd 149)

#3 trip at 82
#4 " " 6.2
#3 on hundred scale
#4 on ten scale
#5 on two scale
Radon 25 scale

Source at 15 cm.

	Ht Std	#1	#2	c/c1	c/c2	Cyl.
11:15						#1
11:25	0.6	21.5, 22.5	17.0, 16.0			#1
11:30	2.3					#1MT #2S
11:38	9.0					#2MT #3S
11:44	15.0	15.5	11.0	1	1	#3MT #4S
11:57	21.8	35, 0 34.0	26	[illegible]	.42	#4MT (#5S)
12:10	28.5	82.0	61	.19	.18	#5MT (#6 S)
12:20	33.0	156	115	.100	.096	~~#6MT (#7S)~~
12:30	~~34.7~~ ~~37.1~~ 39.7	~~328~~	~~239~~	~~.047~~	~~.046~~	#6 MT (#8S)
12:45	37.1	528	239	.047	.046	~~Stopped~~
12:50	39.9	789	578	.0195	.0192	~~Stopped~~ #8 (9S)
PM 1:00	41.0	Not Critical				
1:07	41.3	Not Critical				
1:10	41.7	Not Critical				
1:13	42.0	Critical with Rodout				

Critical at 41.9 ± 1 mm
less zero correction of 6 mm
gives **41.3 ± 0.1** cm

11/17/48 DC 41.3 + 0.4 = 41.7 cm = Hc Bottom corrected
H/X = 755
15" Stainless untamped.
$\rho_{Agg} = 1.04$
$\rho_{Mix} = 3.30 = 0.0343$ gm/cc
Vc = 47.5 ℓ
Mc = 1.63 kg

Experiment 159 — 15" Stainless Steel Reactor

5/24/48

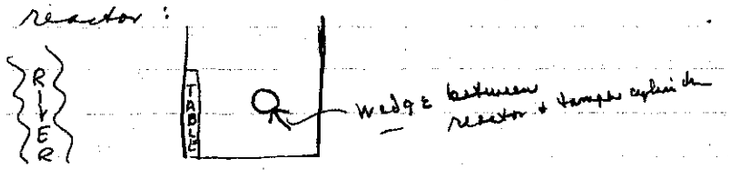
H/X ~ 750 – Tamped

Pressey

For Cronin (at K25).

Callihan

Considerable difficulty was encountered in obtaining free motion of safety rod through top damper. After removing damper & filing burr out of weld in tube it was found necessary to improve alignment by wedging reactor reactor:



in direction shown – displacement from free position ~ 1/4"
This may be accomplished by adjustment of flange bolts.

Instrument dip panel: #3×100, #4 – 5.8×100
Instrument scales: #3×100; #4×10, #5×2, #6×25/50 mv.
Source: 8cm from reactor bottom – (1cm brass sphere containing ca 1/2 c).
Control Rod: Large sheet of Cd; Scale = 7cm with lower edge sheet at reactor bottom.
Safety rod: Zero with hole in guide in unit sheet at 10cm

1:27P	Filling from #1.					
33	H = 1.9 cm	I 3.5	II 2.0	M^{-1}		#1 EMPTY.
		4.0	2.0			
		3.8	2.0	I	II	
:45	= 8.3	5.0	2.0	0.760	1.0	(Filling from #2) #2 EMPTY; Filling from #3.
55	= 11.7	7.5	3.5	0.506	0.571	
2:03	= 14.8	12.5	5.5	0.304	0.364	#3 Empty. Filling from #4
:11	= 15.2					Changed from 4 to 5 – Feed from 4 slow.
:14	= 18.1	18.5	8.0	0.206	0.250	~~#5 Empty~~
:23	= 21.8	32.5	15.5	0.117	0.129	#5 Empty. Filling from #6
:32	= 24	52.5	23.5	0.072	0.085	
:39	= 26.0	97.0	42.5	0.039	0.047	
		83.0	36.0	0.046	0.055	Control rod in (23 mm) Stopped filling from #6; Filling from #7
:55	= 27.0	157.0	68.5	0.024	0.029	
3:02	= 27.7	220.0	101.5	0.017	0.020	
09	= 28.2	505	226	0.008	0.009	
19	= 28.61	Not critical				
30	= 28.8	"	"			
31	= 29.0	Slightly super critical with control rod out.				

over.

Exp 159 (Cont).

Inventory

1 - 6.5	cm in 15" reactor.	= 3.6	cm in 20" reactor
2 - 6.3	" " " "	= 3.5	
3 - 6.5	" " " "	= 3.6	
4 - 6.1	" " " "	= 3.4	
5 - 2.5	" " " "	+ Dead Volume + 1.4 cm in 20" reactor	
6 - 6.3	"	= 3.5	" "
7 - 6.3	"	= 3.5	" "
8 - 6.5	"	= 3.6	" "
9 - 6.5	"	= 3.6	

Conclusion: MX=750, 15" STAINLESS REACTOR, TAMPED.
CRITICAL AT 29.0 cm ± 0.5cm -

CORRECTED HEIGHT = (29.0 - 0.6) = 28.4 cm -
corrected for sight glass zero.

11/17/48 DC 28.4 + 0.4 = 28.8 cm = Hc to Hom Corrected
HX = 755
15" Stainless tamped.
11/18/48 DC ρ_c/ρ_x = 1.04
Wt% X = 3.30 = 0.0343 gm/cc
V_c = 32.83 ℓ
M_c = 1.13 kg

EXPERIMENT 160

5/25/48

20" STAINLESS REACTOR, H/X = 750, UNTAMPED.

PRESSEY
FOX
CRONIN
CALLIHAN.

Instrument Trip points - #3-78 x100 #4 - 5.7x100
Instrument Scales - #3 x100 #4 x10, #5 x 1, #6 x 25 mv.
Source - 10 cm from reactor bottom.
Control Rod - 3/8" rod in solution, Zero = Zero.
Safety Rod - - 35 cm from bottom of reactor - Zero: Rule = 10 cm.

		I	II			
10:50A	Filling from # 5.					
11:00	H = 0.5 cm	43.0	23.0			Solution height = 0, i.e sight glass reading is 5mm too high.
		42.5	21.0			
		42.8	22.0			
07	= 1.5 cm					I M+ II #5 Empty, filling from #3.
13	= 5.4 cm	27.5	15.0			# 3 Empty. filling from # 2.
22	= 8.9	25.0	15.0			#2 Empty filling from #1
30	= 12.5	39.0	20.5			#1 Empty filling from #6
37	= 14.0	52.5	29.0	0.816	0.759	
44	= 15.9	74.0	40.5	0.578	0.544	#6 Empty filling from #7.
56	= 18.2	111.0	61.5	0.386	0.358	
12:06P	= 19.7	142.0	81.0	0.302	0.273	#7 Empty filling from #8
17	= 22.0	255.0	140.5	0.168	0.157 0.142	
26	= 23.1	337.5	186.5	0.127	0.118	Stopped filling from #8; filling from # 4
47	= 24.1	470.0	258.5	0.091	0.085	Stopped filling from #4 (slow valve); filling from #9.
59	= 25.6	1000.0	569.5	0.043	0.039	
1:05	= 26.5	NOT CRITICAL.	Located source at surface of solution.			
15	= 26.7	"	"	"	"	
20	= 26.9	"	"	"	"	
27	= 27.1	CRITICAL WITH 7CM CONTROL ROD BELOW SOLUTION SURFACE.				

Conclusion: 20" STAINLESS Reactor H/X = 750, untamped, critical at 27.0 - 0.5 = 26.5 cm corrected for sight glass zero.

Inventory				for 12"	
	1	3.6 cm in 20" Reactor H/X = 750		10.	11/17/48 DC
	2	3.5 3.7	✓	9.7	26.5 + 0.2 = 26.7 cm = Hc bottom corrected
	3	~~3.9~~	✓	10.3	H/X = 755
	4	3.4	✓	9.4	20" Stainless untamped.
	5	1.7	✓	4.7 +D.V.	+Dead Volume.
	6	3.4	✓	9.4	11/23/48 DC Opq = 1.0 V
	7	3.8	✓	10.5	Wt% X = 3.30 = 0.0343 gX/cc
	8	3.6	✓	10.	Vc = 54.10 ℓ
	9	~~3.6~~	✓	10.	Mc = 1.86 Kg.

Experiment 161. 12" Stainless Steel Cadmium Shielded, Water Tamped.

H/X ≅ 750. 5/26/48

F. Pressley
L. Beck
F. Crown
J. Fox
J. McLendon.

Trip Points: #3 : 80 ; #4 : 5.5.
Instruments: #3, #4, #5, #1, #2, Reel and Process Monitor, all normal.
Source: 8 cm from bottom.

Time	Addition Level.		Counting Rate #1	Counting Rate #2	Counting ratio		
8:45.	Background		11.0	6.0			
			10.	6.			
			7	4.			
			5	2			
			5	2.5			
			5	2			
9:03.	0.2 cm.	(#5)	5	2.5			
	3.5	(#5)	~~11.5~~	~~5.0~~	DV		D.V. + 3.5 from #5.
9:16.	13.5	(#3).					10. from #3
9:26.	23.8	(#2)	11.5	5.0	~~.45~~	~~.5~~	10.3 from #2.
	33.	(#1)	15.	6.0	.33	~~.42~~	9.2 from #1.
9:46.	42.9	(#6)	19	8.5	.26	.295	9.9. from #6
10:56	53.1	(#7)	23	10.6	.22	.25	10.2 from #7
10:06	57.6	(#8)	22	10.0	.23	.25	4.5 from #8.

Conclusion: (1) At 57.6 cm height a flattening curve at 0.23 $^{Co}/_{c}$ ratio indicates that criticality would not be reached at indefinite extension.

Drain check:

#9		10
#8	~~#5~~	10
#7		10.1
#6		10.0
#5		DV. + 3.5
#4	~~10.5~~	9.4
#3		10.0
#2		10.2
#1.		9.2

11/30/48 JC

H = 57.6 + 0.7 = 58.3 cm
H/X = 755 (see following page)
V = 42.53 ℓ
M = 1.46 kg

Estimates $H_c = V_c = M_c = \infty$

Experiment 162 - 12" Stainless Tamped. 5/26/44

$H/x \simeq 750$

Both Dr. Cronin Mechanical Pressey.

Trip Points: same as 161
Instruments: same as 161
Source: ~~same as #161~~ 80 cm from bottom.

Time	Solution Level	Cylinder*	Counting Rate #1	Counting Rate #2	Co/c #1	Co/c #2
11:10	13.6*		6.5	3		
			8	3		
			7.5	3.		
	22.7	#1				
11:20	32.8	#2				
11:35	39.9	#6	56.5	27	.097	.092
	~~39.9~~ #31	#6.				
	44.0	#7	108.	565	.051	.048
	46.5	"	266	127	.021	.02
	47.7	not Critical.				
	47.9.	Not Critical				
	48.0.	Critical.				

* Drainback from #161 not carried to zero.

10.2 from 6.

Conclusion: Critical at 48.0.

11/17/48 DC 48.0 + 0.7 = 48.7 cm
~~48.0 + 0.4 = 48.4 cm~~
= He bottom corrected

$H/x = 755$
12" Stainless tamped.
$\rho/\rho_w = 1.04$
$N_{at}\%_x = 330 \simeq 0.0343$ gm x/cc
$V_c = 35.53$ l
$M_c = 1.22$ kg

Drainback:

1	~~10.1~~ 9.1
2	10.1
3	10.1
4	9.4
5	3.5 + D.V.
6	10.2
7	10.2
8	10
9	10

Experiment # 163 10" Aluminum Tamped
H/X ≃ 750 5/27/98

Morpitt
Pressey
Fox

source at 15 cm.

Trip points: #4 - 5.9 #3 - 80
Instr.: #3 on 100 scale, #4 on 10 scale, #5 on 2 scale

Time	Sol. level	Counting Rate #1	Counting Rate #2	Ratio 1	Ratio 2	
1:15	4.6	3.75	1.5			(5 empty filling from 1
1:17		3.5	1.3			(# empty)
1:25	18.8	7.0	3.0	.30	.30	filling # 2
1:40	28.5	12.0	4.0	.28	.25	#2 empty
1:45	33.0	14.5	6.5	.24	.23	filling #3
2:00	47.0	18.0	9.0	19.4	.17	#3 empty
2:10	55.5	20.0	8.5	.175	.17	filling #4

Conclusion 10" Cylinder Water Tamped @ H/X=750
Not critical @ 55.0 cm. Appears safe at ∞ height.

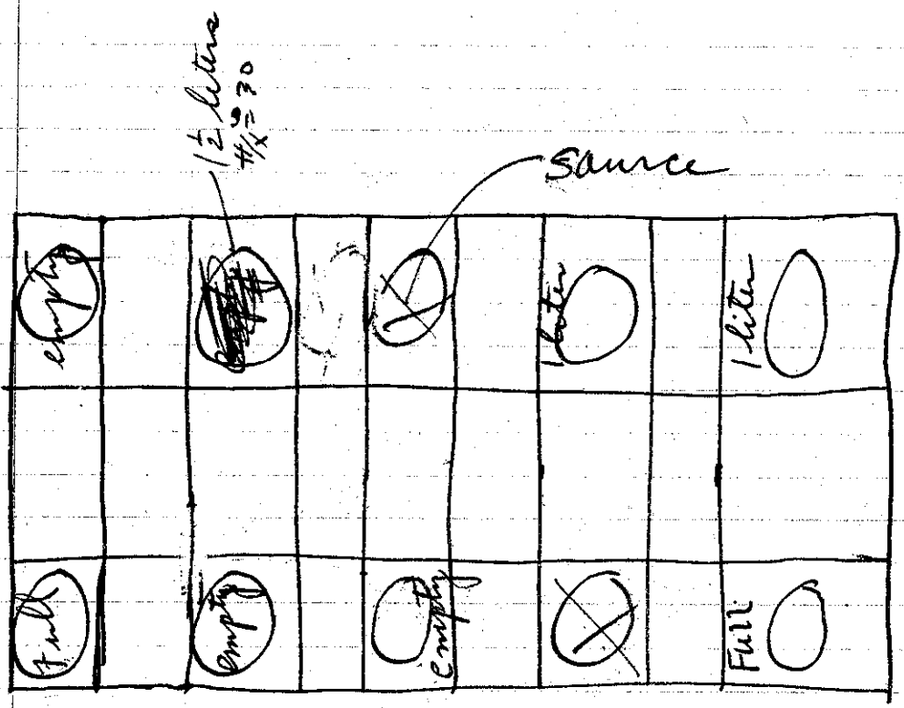
11/30/48 DC H = 55.5 + 0.9 = 56.4 cm
H/X = 755 (See preceding page).
V = 28.5 ℓ.
M = 0.98 Kg.

Estimated He = Ve = Mc = ∞

Solution inventory

	at start (calc)	Drain back.	
1	13.1	14.2	
2	14.5	14.2	
3	14.5	14.0	
4	13.5	13.5	
5	D.V. + 9.6	D.V. 49.6	
6	14.7	14.7	
7	14.7	14.7	
8	14.4	14.4	MT
9	14.4	14.4	MT

Storage Cylinder Rack Multiplication Check.



H/X = 25 in all cylinders except as noted

Counts with cylinders in as shown above:

#1	#2
	129.
107	125.5
348	127.5

After removal of empty cylinders:

#1	#2
out of order	130
	132

After removal of all cylinders:

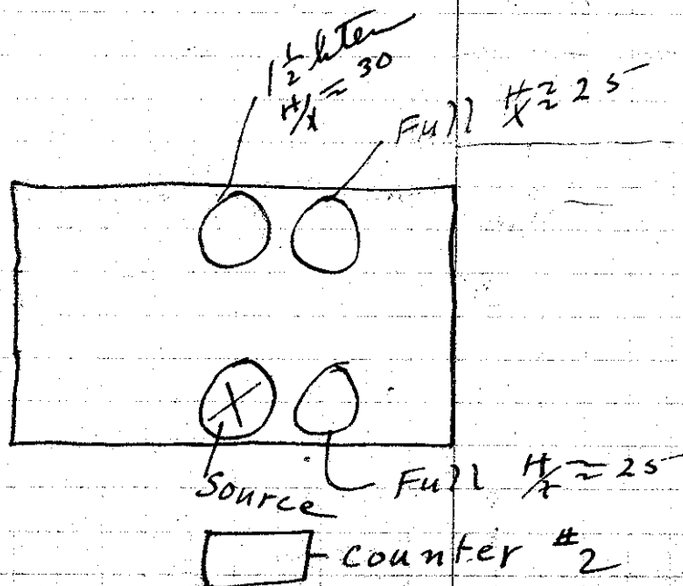
121.5

120.5

As shown opposite! →

101.5

109.5



6-1-48

Redistribution for dilution

			Vol. by drain-back	sight-glass differential	calc Vol. by sight-glass	Vol of H_2O	Total Vol.	
Cyl. #1	=	10.2 10" cm	= 5.18 l.	22.4 cm	5.11	1.72	6.82	3.2
2	=	10.2	"	23.2	5.30	1.72	6.82	
3	=	10.2	"	23.2	5.30	1.72	6.82	
4	≈	10.2 + .8 = 11	~~4.97~~ 5.00	24.5	~~5.59~~ 5.00	1.655	6.625	
5	=	3.2 + 0 V	= 5.18 l.	21.5	4.91	1.72	6.82	
6	=	10.2	"	23.2	5.30	1.72	6.82	
7	=	10.2	"	23.7	5.41	1.72	6.82	
8	=	10.2	"	23.4	5.35	1.72	6.82	
9	=	10.2	"	23.6	5.39	1.72	6.82	

11/28/48 x Re- diluted solution:

pg 25 - this book gives sp gr = 1.03

D Lab Report 1813 (1846) gives Sample 167 - analysis = 2.70% V.

On these bases:

H/X = 999

wt % X = 2.52 ≡ 0.0260 gm x / cc sol.

$30 \times \frac{400}{225}$

Experiment 164 20" Stainless Steel, Untamped - 1000 H/X. 6/2/48

Book for Pressey Crouse McLendon.

Trip Points #3, 9.2 ; #, 6.1

Instruments: #3 on 100, #4 on 20; #5, #1, #2, Prox. Mon. all performing normally. Reed is out of Commission.

Source Position: 8 cm from bottom.

Time	Solution Level	cell #	Counting Rate #1	#2	C/C #1	#2.	
1:31	Background		15.5	17.0			
			15.	15.5			
			15.	16.			
1:50	0.4 - Zero Correction						D.V. + 1.9 cm from #9.
	1.9 -	#9					3.8 from #8
2:00	5.7 -	#6					
2:12	8.8	#7					3.1 from #7.
	12.3	from 6.					3.5 from #6.
	15.4	from 5					3.2 from 5
	18.9	from 3					3.4 from 3.
2:35	22.7	from 2	36.	39.5	.416	.393.	3.8 from 2.
2:50	26.0	#1	49.	56.	.306	.277	3.3 from 1.
3:59	29.3	#4	78.5	86.5	.19	.18	3.3 from 4

Not critical: all of Solution

Conclusion: Extrapolation of multiplication curve indicates criticality would be reached at 39 ± 3 cm.

11/30/48 DC H = 29.3 + 0.2 = ~~39.5~~ 29.5 cm

MX = 999 (see preceding page).

V = 59.77 ℓ

M = 1.55 kg

Estimate of Hc = 36 cm

Vc = 73

Mc = 1.9 kg.

Drainback: 2 inch

#1 3.4

2

3

4

5

6

7

8

9

Sp. Gr. 1.030

22

6.1

Experiment # 165 15" Aluminum Tamped 1000 H/X Conc. Fox Mark II Pressy

6/3/48

Trip Points #3 - 90 #4 6.1

Instruments #3 100 scale, #4 on 10 scale, #5 on 2 scale
Process Monitor (OK), Reed N.G.

Source Position 8 cm from bottom

Time	Solution	Counting Rate #1	Counting Rate #2	Multipl. #1	Multipl. #2	Remarks
9 ~~45~~	2 cm.					#1 Empty
10 ~~04~~	7.5					#2 Empty.
10 ~~09~~	13.6	6.0 wet 5.0		1.0	1.0	
10 ~~12~~	19.0	(5.5)	(5.5)			#3 Empty
		Read now expanding.				
10 ~~25~~	20.2	11.0	10.0	.50	.55	#4 Empty
10 ~~36~~	26.3	19.0	16.0	.29	.34	#5 Empty.
10 ~~50~~	32.3	30.5	28.0	.18	.196	#6 Empty.
11 ~~04~~	38.6	69.0	64.0	.080	.086	#8 Empty
11 ~~19~~	41.0	128.	113.	.043	.049	Stopped from #7
11 ~~31~~	43.0	Not Critical		(Est C.t. 44.0)		From #9
11 ~~41~~	43.6	Not Critical		(" " 43.9)		
11 ~~54~~	43.9	Critical with Cd @ ● with 5 cm vane below soln level.				

Conclusions:

Cylinder is critical @ 43.85 cm. ± 0.5

Drainback #1 #2 #3 #4 #5 #6 #7 #8 #9
D.V + 1.8 ← ~6.1 each →

Other Projects: - Changed two cylinders - finished evaporation of dilute soln. - new stubs for Reed - oxide samples to lab - procured supplies - plotted graphs of data - cleaned air line. - made new key tags for storage cylinders - intercom Tubes found N.G.

11/7/48 DC 43.85 + 0.41 = ~~44.26~~ 44.3 cm = Hc (to Hom. Cemented); Wt% U = 7.52 = 0.0260 gm U/cc Vc = 50.50 ℓ
H/U = ~~1000~~ 999, 15" tamped, al.; Appr = 1.03 Mc = 1.31 kg.

6/4/48 23

Experiment #166 15" Stainless Steel 1000 H/X Cronin
Tamped For Mackin Moffitt

Trip Points #3 97 #4 6.2

Instruments: #3 100 scale, #4 10 scale #5 25 scale
#6 25 scale ~~#4~~ on P.M ok

Source Position 8 cm from bottom.

Time	Soln.	Counting Rate		Mult		Remarks
2:26	—	(Approx. B.G 3.5 3.0)				Filling #1 & #2 =
2:26	—	—	—	—	Ave 3.25	#3 & #4
2:30	13.0	3.5	3.5	3.5	3.0	1.0 1.0 " "
2:44	23.5	9.0		8.5		.39 .38 5 empty
2:55	27.6	11.5		10.0		.30 .32 6 empty
3:10	35.1	18.5		17.0		.19 .19 7 ~~empty~~ filling
3:47	45.0	45.5		43.0		.078 .076 Filling from 8
3:47	50.2	221.		206.		.016 .016 Filling from 9.

No more soln. could be safely added beyond this point because cylinders in pit too near empty.

Conclusions: Critical height as obtained by extrapolation is 52.0 ± 1.0 cm last soln added @ 50.2 cm.

Other projects- Started on last batch for burner (burner) instrument trouble with #3 repaired by Olson. When #3 counter is running Brown circular counter must also be running or be completely disconnected by removing plug in on #3 Brown in control room.

11/7/48 DC 52 + 0.4 = 52.4 estimated Hc bottom corrected
11/26/48 DC HK = ~~1000~~ 999
15" Stainless tamped.
ρ_{app} = ~~1.031~~ 1.03
wt% X = 7.52 ≡ 0.0260 gm X/cc
V_c = 59.74 ℓ
M_c = 1.55 kg

24 6/[illegible]7/48

Experiment 167 – 12" Stainless Reactor.

Tamper) H/X ≅ 1000

For Pressey Cronin Callen

Trip Points – #3 – 85 X100, #4 – 6.2 X100
Source – 12 cm from bottom –
Det. Scales – #3 – 100; #4 – 10, #5 – 2, #6 – 50 mv.
Zero of Safety rod = 6 cm on scale – top edge of guide in unit stud.
" " control " = 10 cm on scale

10:15A. Filling dead volume from #9.

		I	II	I	II	
10:20A	H = 0.2 cm.	1.5	1.5			
		[9.5] 2.5 ~~2~~ (2.0)	1.5 (1.5)			
:35	= 5.8 cm					#9 Empty – Tamper ex. filling #8
:40	= 16.1 cm.	2.5	2.25	.80	~~.665~~	#8 Empty, filling from #7.
:54	= 20.0	3.25	3.0	.61	.50	
11:00	= 21.7	—	—			#7 Empty, filling from #6.
:05	= 27.5	4.5	4.5	0.445	0.333	(#6 Empty, fill #5 from #5)
12	= 29.0	—	—			
15	= 35.2	5.0	5.0	0.400	0.300	
20	= 38.5	—	—	~~0.400~~	~~0.300~~	#5 Empty, filling from #4 #3 (#4 volume stuck –).
27	= 45.3	7.0	~~5.5~~ 5.5	0.286	0.273	
		~~6.5~~ 6.5	6.0	0.308	0.250	
44	~~49.5~~ = 49.5	—	—	—	—	#3 Empty, filling from #2.
48	= 55.1	6.5	6.5	0.304	0.231	
		7.0		0.286		
:59	= 59.2					#2 Empty, filling from #1.
12:04P	= 68.3	7.5	7.0	0.235	0.214	

Conclusions: Probably not be critical at ∞ height.
There is considerable scatter in the data due to low background count.

Inventory: H/X = 1000

1	9+ cm in 12" Reactor	June 19	#1	empty
2	9.0 " "	"	2	"
3	9.0 " "	"	3	"
4	? probably ≈ 9 cm	—	4	"
5	9.0 " "	June 15	5	empty
6	9.0 ✓	"	6	"
7	9.0 ✓	—	7	"
8	9.0 ✓	—	8	"
9	5.0 + DT ✓	—	9	"

11/30/48 DC
H = 68.3 + 0.7 = 69.0
H/X = 999 (See preceding page)
V = 50.34 ℓ.
M = 1.31 kg.

Estimate
$H_c = V_c = M_c = \infty$

June 14 Inventory

	#1	#2	#3	#4	#5	#6	#7	#8	#9
Liters	—	—	—	ca 6.7	—	6.7	6.7	6.7	7.0

Total = 33.8 liters Sp Gr = 1.03 Wt% = 2.70 U

11/28/48 DX The above Sp Gr = 1.03 presumably refers to solution used in Exp 164-167 inc.

This solution was then either concentrated or removed and a more concentrated substituted.

pg 29, this book gives Sp Gr = 1.98

Sample 171 from Exp 171 had analysis: 44.74 gm U / gm Sample

This value given on "SF Sample Transfer & Requisition" # 710007, 6/28/48 —

From these values:

H/X = 26.22

Wt % X = 41.79%.

or 0.827 gm X / cc.

26

6/24/48 Experiment 168 12" S.S. Reactor – cd shielded

H/X = 28 Exact H/X 26.18

Morfitt
Cronin
Pressey
Fox

Trip points: III – 90, IV 6.5; Source at 5 cm.
Shot scale: IV – 10, III – 100, V – 2 Rod – 25

Time	Sol. Ht.	I	II	1/c.	1/c	
8 55	System empty	6.0	5.5			
9 07	2.8	5.5	9.0	Background		Filling from #2
9 21	4.3	6.0	5.0	.92	.80	#2 empty Filling from #1
9 35	7.2	9.0	7.0	.61	5.7	
9 49	8.3	10.5	9.5	.52	.42	
9 56	9.4	13.0	11.0	.42	.36	
10 08	11.2	20.0	17.25	.275	.23	
10 08	13.2	41.0	35.0	.139	.114	System Empty.

Ht. after mixing 12.8 cm.

Conclusions: Not critical @ 13.2 cm height.
Est. Criticality by extrapolation 14.8 cm
± 0.2 cm.

Drainback Schedule

#1	#2	#3
6.1	6.1	D.V.

11/17/48 DC 14.8 + 0.7 = ~~15.5~~ cm estimated Ht bottom corrected
HK = 26.2
12" Stainless, Tamped, cd shield.
11/28/48 Wt% x = 41.79 = 0.827 gm x/cc Apr = 1.98
V_c = 11.31 ℓ
M_c = 9.35 Kg.

6-24-48 Exp. 169 10" S.S. REACTOR UNTAMPED H/X ~ 25

PRESSEY Exact H/X 26.1P

For MORFITT * Trip points same as Exp. 168
ORONIN in at 1:20p. Inst. 3 = 100X, 4 = 10X, 5 = 5X, Reed = 25X
Murray in @ 1:35p

Time		Filling D.V. from #3.				
	Sol. Ht.	I	II	C_0/C_1	C_0/C_2	
12:40						
12:50	0.5	$20\frac{1}{2}$	19	1	1	
		$19\frac{1}{2}$	19	1	1	
		20	19	1	1	
1:00	8.4	$19\frac{1}{2}$	$15\frac{1}{2}$	—	—	#2 MT
1:05	A.R. compressor failed. Pushed reset button - all is well.					
1:15	Filling again from #1.					
1:20	13.5	35	32	.57	.595	
1:25	16.1	48	42	.42	.45	
1:30	18.1	60	55	.33	.345	

Conclusion: Not critical @ 18.1 cm. extrapolation shows probable criticality occurs at 25.5 cm ± 0.5 cm

The zero on this cylinder was 5-6 mm off - lower than scale reading.

H = 18.1 + 0.9 = 19.0 cm -
H/X = 26.2 (see preceding page
V =
V = 9.62 ℓ
M = 7.96 kg

Estimated Hc > 25 cm
Vc > 12.7 ℓ.
~~Mc~~
Mc > 10.5 kg.

H/X ≈ 25

6/25/48

Experiment #170 6" Aluminum Tamped

Trip Points: Same as #168 Exact H/X 26.18

Cronin
Fox
Mart.ff

3=100x 4=10x 5=5x Read=25

Preasy & Manley on reports.

Time	H	#1	#2	#3	C_1/C_0	C_2/C_0	
2:30		Filling	DV from				
2:35	2.3	3.0, 3.0	3.0, 3.0		1.0	1.0	
2:53	18.1	9.0, 9.0	.90 ~~.88~~		.33	.33	
2:58	25.6	15.0 ~~14.5~~	14.5		.20	.21	
3:07	36.2	23.0	20.0		.13	.15	
3:15	44.8	30.0	26.0		.10	.115	
3:20	49.0	39.0	30.0		.085	.10	All out of soln.

Conclusion: Not critical @ 49.0 cm. Probably ~~infinite~~ safe at infinite height though this is doubtful. Straight line extrapolation of last 3 points shows an estimated criticality of ≈ 75 cm.

Drain back:

#1	#2	#3
24 cm	24 cm	D.V.
= 13.5 cm in 8"	= 13.5 cm in 8"	

11/30/48 DC

H = 49.0 + 2.6 = 51.6 cm
H/X = 26.2 (see following page)
V = 9.41 ℓ
M = 7.78 kg

Estimated Hc > 75 cm
Vc > 13.7 ℓ.
Mc > 11.3 kg

6/28/48

EXPERIMENT 171

8" al Tamped H/x = 25 - Exact H/x 26.18

For Pressey Callihan.

TRIP POINTS - #3 - 83x10, #4 6.5x10

Scales #3 x100, #4 x10, #5 x2, RE - 25 mv.

Source - Small brass sphere, 12cm from bottom.

Control Rod - Cd sheet.

2:15P Started filling from #3 - I 3.5 II 3.5

2:27 H = 0.4 cm 3.5/3.5 3.0/3.3

#3 EMPTY.

Filling from #2.

		I	II	M^{-1} I	M^{-1} II
2:27					0.825
32	= 5.0 cm	5.0	4.0	0.700	0.830
41	= 10.1 "	9.0	9.0	0.389	0.366
47	= 13.1 "	17.5	14.0	0.200	0.235
—					
55	= 15.3 "	30.0	26.5	0.117	0.125
3:02	= 17.6 "	76.0	66.0	0.046	0.050
10	= 19.1	229.0	190.0	0.015	0.017
20	= 19.9	~~Slight~~ Critical with control sheet (bottom edge) Cd 5cm above top of solution.			
30	= 19.7	Slightly Sub-critical -			

#2 Empty. Filling from #1.

Conclusion: 8" al reactor, tamped, H/x = 25 - critical height = 19.8cm uncorrected

~~= 20.~~

= 20.0 cm when corrected for sight glass zero. This correction was re-evaluated today and agrees with previous value - DC.

Sp. Gr. = 1.978

Inventory

	8"		
#1	13.5 cm	=	3.8 cm in 15" Reactor
#2	13 cm	=	3.70 cm " "
#3	D.V.		

11/17/48 DC - 20.0 + 1.5 = 21.5 cm = He bottom corrected

H/x = 26.2

8" al tamped.

$\rho_{pp} = 1.98$

wt % x = 41.79 ≡ 0.827 gm x/cc

Vc = 6.97 ℓ

Mc = 5.76 kg

30 6/29/48

Experiment 172 — Exact H/x 26.1?

Cronin

15" al Reactor Tamped H/x = 27.

Fox
Pressey
Callihan
Haycock
Owen

Trip Points – #3 - 5.95 x100, #4 - 6.7 x10⁶
Scales – 3 x100, 4 x10, 5 x 2. R.E. – 25 mv.
Source – 5cm from bottom –
Control Rod – Cd Shut –

11:09 A – Filling dead volume from #3 –
11:26 H = -0.1 cm

	I	II
	9.5	7.5
	[illegible]	8.5
	9.0	8.0
	9.0	8.0

#3 Empty.
E

Source placed 3cm from bottom. Recount of zero: –

11:34 A H = -0.1 cm

	I	II
	8.5	8.0
	9.5	9.0
	9.0	8.5

12:00 #5 Instrument out of order –

		I	II	M^{-1}	
12:17 P	H = 3.0cm	17.0	15.0	0.529	0.568
~~12:26~~	~~3.5 = 4.5~~				
12:26	= 4.5	26.5	24.5	0.340 0.0	0.347

Filling from #2.

#2 Empty. Filling from #1

#4 to 50 x; #3 to 10X

35	= 5.5	41.5	35.5	0.217	0.239
46	= 6.5	73.5	60.5	0.122	0.141
1:00 P	= 7.1	120.0	99.5	0.075	0.085
1:05	= 7.5	209.0		0.043	0.048

Drain back #1 – ~~4~~ – 15" cm ~~= 1~~ = 14 – 8" cm
#2 – 3.5 – 15" cm = 12½ – 8" cm
#3 – D.V.

Sightglass reads 2 mm low –

Conclusion – System not taken to critical because of lack of solution.
Extrapolation of curve = Critical height = 8.0 cm uncorrected
= 8.2 cm when corrected for sight glass zero.

11/7/48 8.2 + 0.4 = 8.6 cm estimated Hc bottom corrected.
H/x = 26.2
#15" al tamped –
Vc = 9.80 ℓ
Mc = 8.10 kg.

11/14/48 DC ρ_{app} = 1.98
Wt% X = 41.79 ≡ 0.827 gm/cc.

Exact H/X 26.18

EXPERIMENT 173

6/30/48

McLendon
Pressey
Fox
Cronin } Lab
Callihan

8" STAINLESS REACTOR (35") long
H/X = 27; Tamped

TRIP POINTS: #3 96 x100; # 4 - 6.5 x100
Scales #3 x100, #4 x10, #5 x2, RE - x 25 mv.
Source 8 cm from bottom of reactor.
Control Rod - Cd sheet - 0 = 7cm on scale -

2:05P Filling dead volume from #3.

		I	II	M^{-1} I	M^{-1} II	
2:10	H = 0.9cm	5.0	4.0			* 3 EMPTY - Filling from #2 -
		4.5	4.0			
		5.0	4.0			
	→	4.8	4.0			
24	=6.2	~~6.0~~ 6.0	~~5.5~~ 6.0	0.800	0.728 0.667	
30	=10.0	11.5	9.5	0.417	0.421	
37	=13.5	19.0	15.5	0.253	0.258	#2 EMPTY - Filling from # 1
43	=16.6	35.5	29.5	0.135	0.135	
49	=18.6	56.5	48.5	0.085	0.082	
55	=20.4	127.5	109.5	0.038 0.044	0.037	
3:03	=21.3	300.5	250.5	0.016	0.016	
11	=21.8	NOT QUITE CRITICAL WITH CD OUT.				
22	=22.0	Slightly Super CRITICAL WITH CD ROD ~~(Bottom Edge)~~ COMPLETELY OUT.				

TAMPER WATER DRAINED TO HEIGHT USED WITH SHORT 8" REACTOR.

3:32 = 22.0 Still slightly super critical with H_2O at lower level & Cd rod out. Drained water to 28 cm above bottom of reactor (22.0 cm = solution level) before reactivity decreased with power removed.

254
354
2774

Conclusion - 8" - 35" long Stainless Reactor critical at H = 22.0 cm - Reactor Tamped with water height greater than cm.

Sight glass zero was checked on drain back and zero on sight glass equals zero on reactor within 1 mm. JP.

11/17/48 DE 22.0 + 1.5 = 23.5 cm = Hc bottom corrected
H/X = 26.1
8" Stainless Tamped.
V_c = 1.62 L
M_c = 6.30 Kg.

4/28/48 DE ρ_{av} = 1.98
Wt % X = 41.79 = 0.827 gm/cc

32 | 7/1/48 | Exp 174 | Exact H/X 26.18

Morfitt | 6½" Aluminum Reactor | H/X ≃ 27 | TAMPED

Fox
Cronin
Pressey

Trip Pts. #3 = 80, #4 = 6.8 x100
Scales #3 = 100x, #4 = 10x, #5 = 2X, #6 = 25x
Source @ 15 cm
Rod. ~~Cd sheet~~ Cd. Rod

	Soln. Ht.	#1	#2	C_0/C_1	C_0/C_2	
9:50A	1 cm	3.5	3.5			#3 empty
		3.0	3.5			
10:10A	20.7	17.5	14.0	0.20	0.25	#2 M.T.
10:17A	26.1	31.5	28.5	0.11	0.12	
10:25A	30.2	44.5	43	0.079	0.081	
10:35A	36.0	101.0	91.0	0.035	0.039	
10:47A	38.1	163.5	146.0	0.021	0.024	
10:57A	39.6	285	255	.012	.014	
11:11A	41.1	Not critical, but close. (out of Soln.)				#1 M.T.

Conclusion: Extrapolation gives 41.8 cm as best estimate of critical height. [redacted] possible Critical height lies between 41.2 & 42.4 cm

NB Correction must be made to all heights due to variation in height of reactor All readings reported above are too low by 0.5 cm.

Best estimate of critical height is therefore

42.3 ± 0.6 cm.

Drainback:

#1	#2	#3
20.4	20.7	D.V.

11/17/48 DC ~~Est~~ 42.3 + 2.2 = 44.5 cm ~~Estimated~~ No bo Ao Corrected.
#H = 26.V
#6½ al stamped.

11/28/48 JC Dpg = 1.98
Wt% U = 41.79 = 0.827 gm U/cc
Vc = 9,562
Mc = 7.91 kg.

7/6/48.

Cronin
Fox
Morfitt

Exp. 175

8" Short S.S. Cylinder H/x = 27 Tamped Exact X/X 26.18

1 Cd Rod

	Trip. Points Sola Hgt.	#3-80 #1	# 4 #2	6.8 c/c.	c/cm	
9 24	0.7 cm.	4.5 5.0 5.0	4.5, 4.5	1.0	1.0	#3 M.T. @ 2cm.
9 47	13.2 cm.	23	21	.22	.21	#2 MT.
10 00	16.0	45	40	.11	.11	
10 03	18.0	93	84	.054	.054	
10 15	19.5	299	263	.017	.017	
10 25	20.0	750 NG.	1357	—	.0033	
10 35	20.2	Critical with Cd rod @ 15.5 cm up from bottom				

Drain back

#1 = 6.6 8" cm
#2 = 6.7
#3 = 6.7
#4 = MT
#5 = 7.5
#6 D.V.
#7 MT.
#8 MT.
#9 M.T.

Note:- Zero of 8"ϕ checked and found to be 1 cm low therefore 1 cm must be added to the critical height.

Conclusion:

Best estimate of critical height 21.1 cm ± .05

11/28/48 DC

21.1 + 1.5 = 22.6 cm = He correction for bottom.
H/X = 26.2
~~SS~~ Stainless, 8", tamped
Appx = 1.98
Wt % X = 41.79 ≡ 0.827 gm/cc.
Vc = 7.33 ℓ
Mc = 6.06 kg

Dilation Data

Original Conc. by analyses 44.74 g U / 100 Gm Soln.

$44.74 \times \frac{305}{235} = 58.1$ g UO_2F_2 / 100 g. sample.

100.00
58.1
41.9 g H_2O / 100 g sample or

$\frac{41.9 \text{ g } H_2O}{44.74 \text{ g U}} = \frac{41.9 \text{ g } H_2O}{41.8 \text{ g X}} =$

$\frac{41.9/9}{41.8/235} = \frac{4.65 \text{ moles H}}{.1778 \text{ moles X}} = 26.18$ #/X

DFC/JWM

Amounts to be added

#/cyl. 2.140 l | 1.978 Kg = 4.23 Kg solution
2.95 Kg UO_2F_2
1.78 Kg H_2O

2.95 Kg UO_2F_2 | 238 | Kg T | Kg X
305 | .934 = 1.77 Kg X
238/305

$\frac{60 \times 1.77}{26.11} = 4.07$ Kg H_2O_n (needed) $- 1.78$ Kg H_2O_n (present) $= 2.29$ l. H_2O to add

✓ #2	2.61 l	1.92 Kg U	2.49 Kg UO_2F_2	4.12 l needed
	4.29 Kg soln.	1.79 Kg X	1.80 Kg H_2O	−1.80
				2.32 l. H_2O to be add'l
✓ #3	2.67 l → 2.32 l. H_2O to be added			
✓ #5	2.40 l	2.13 Kg U	2.77 Kg UO_2F_2	4.6 l. needed
	4.75 Kg soln	2.00 Kg X	1.98 Kg H_2O	2.98
				2.62 l. H_2O to be add'l
#6	2.5			6.65
	~~3.5~~ l	3.09 Kg U	4.0 Kg UO_2F_2	2.9
	6.9 Kg soln.	2.89 Kg X	2.9 Kg H_2O	~~3.75~~ l H_2O to be added
				2.68

Experiments Still to be done

Dilution H/X	Cylinder Sizes		
60	Untamped	S.S.	15" x 20" No gc.
60	Tamped	S.S.	8" (Repeat) Maybe both lengths, 15"
60	Tamped	Al.	6½" 15"
60	Cd Shield	S.S.	12"
60	Tamped	Al	5½" ?
125	Tamped	Al	6", 6½", 5½" (?)
225	Tamped	S.S.	15"
225	Untamped	S.S	15" 20"
225	Tamped	Al	6½", 15"
225	Cd Shielded		10"
400	? H/X to give min. crit. mass ?		

11/28/48 gc The solution used in exp 168 to 175 inc was diluted:
page 37, this book – spgr = 1.51
"SF Sample Transfer & Requisition" # 710019 – Sample 176 ≡ 0.3009 gm U/gm sol.
These data correspond to:

H/X = 56.7
Wt % X = 28.10 ≡ 0.424 gm X/cc.

Experiment 176 7/6/48

Cronin

8" STAINLESS REACTOR (35" TALL) TAMPED

Fox (Lb)
Pressey
Cecchini

H/X = 60 - actual 56.5

TRIP POINTS #3 - 82 x 100; #4 - 6.3 x 100
Scales #3 x 100, #4 x 10, #5 x 2. Read Slug-out Jarden
Source - 8 cm from reactor bottom -
Control Rod - 3/4" S. Steel covering Cd. 0=0 -

1:20 P.M. Since it is not possible to determine the contents of the solution cylinders it is believed best to put all solution into an untamped 8" reactor cylinder, & then drain back known volumes into the cylinders. This will also mix the solution. However background counts will be taken with tamper at H=0 in order to enable further experimenting, tamped, without having to drain all way to zero.

Filling from #1

		I	II	
1:25 P	H = 0.0 cm	4.0	3.5	Tamped.
		4.0	3.5	

Drained tamper. Raised top tamper maximum distance possible.

1:35 P	H = 0.0	37.5	34.0	Untamped
		37.5	34.0	

				I (#1-1)	II	
1:40 P	H = 4.8					#1, Empty - Filling from #2.
1:47 P	= 21.2	69.0	61.0	0.544	0.558	#2 Empty, Filling from 3
:55	= 30.0	87.0	80.0	0.430	0.425	
2:01	= ~~38.0~~ 38.1	99.5	89.0	0.375	0.382	#3 Empty, Filling from #5
:09	= 51.4	108.0	98.5	0.347	0.342	
	= 52.5					#5 Empty, Filling from #6
20	= ~~56.5~~ 57.0	108.5	101.0	0.345	0.337	#6 not empty but stopped flow in order to mix by blowing through #5 -

DRAIN BACK - #1 - 16 - 8" cm
#2 - 16 - 8" "
#3 - 16 - 8" "
#5 5 - 8" cm.

~~H/X/H=0C~~

Drain back to H = 4 cm - Filled tamper, lowered top tamper.
Now filling from 6 to determine volume of solution available & to further mix it.

7/6/48

51
27.5
27.5
30.20

#176 Cont.

M-1 ($\frac{I}{II}$ ~~$C_o = 4.0$~~ $C_o = 7.5$)

		I	II	I	II
2:40	H = 10.2 cm	8.5	8.0	0.471	0.437
:50	= 14.2	19.0	18.0	0.210	0.195
56	= 15.2				
28	= 16.4	32.0	29.0	0.125	.0121
3:04	= 18.3	58.0	53.5	0.069	0.06
08	= ~~19.7~~ 19.6	194.5	128.0	0.028	0.027
:14	= 20.2	301.0	282.0	0.013	0.012
:21	= ~~20.5~~ 20.4	NOT CRITICAL			
:26	= 20.6	NOT QUITE CRITICAL			
:31	= 20.8	Critical with - 3.8 cm Cd control rod below solution surface -			

#6 Empty. filling from #3

Conclusion - 8" STAINLESS REACTOR (35°) Critical at 20.7 cm - H/V = 60; TAMPED -

INVENTORY

#1	1 -	16 -	8" cm	34	4.5
	2 -	16	8" cm.	34	4.5
	3 -	16	8" cm.	34	4.5
	5 -	16	8" cm.	34	4.5
	6	4.2	"	+ D.V. 8.9.	1.2

$\frac{6Y}{225}$

Specific GRAUITY = 1.5105

11/17/48 DC 20.7 + 1.5 = 22.2 cm He bottom corrected

11/28/48 DC H/V = ~~56.5~~ 56.7

8" Stainless Tamped.

Sp gr = 1.51

Weight % Y = 28.10 ≡ 0.424 gm Y/cc.

Vc = 7.20 ℓ

Mc = 3.05 kg.

July 7, 1948

Experiment #177. Aluminum Reactor 5½" - Tamped H/X = 60 ~~56.5~~ 56.5

Buck for Crow Pressey McFarland

Instruments: #1, #2, #3, #4, #5, Rad, Proc. Monitor all OK.

Trip Points #3: 8.5", #4: 6.5"

Source Position 15 cm from bottom

Experiment

	Initial Level		Counting Rates #1	Counting Rates #2	C/C# #1	C/C# #2	
Background	12:42		2.5	2.			
	12:45	"zero" 0.2	3.0	2.5			D.V. + 11.2 from 6
		11.2					
		42.7	12.5	11.5	.24	.22	31.5 from 5.
		55.1	13.5	12.0	.222	.208	
		65.0	14.5	12.5	.207	.200	
		71.2	15.	12.5	.200	.200	

Conclusion Infinite extrapolation without intersection — will not become critical

11/30/48 DC

$H = 71.2 + 3.1 = 74.3$ cm

$H/X = .567$ (see following page).

$V = 11.4 R$

$M = 4.83 \, B_0$

Estimated $H_c = V_c = M_c = \infty$

Experiment # 178: 15" Aluminum Tamped, $H/X = 60$. July 7, 1948

30,000
3,000

~~56.5~~ 56.5

For McLendon Penney Beck

(Cranking back to near critical point.)

Instrument
Trip Points } Same as 177.

Source Location 3 cm from Bottom.

	Experiment Solution Level	Counting Rate. #1	#2	C/C #1	#2	
2:50 P.	~~Background~~	7.0	6.5			
	Zero:	7.5	7.5.			D.V. + 1.1 out of 6. 4.5 of 5
3:10	4.1	18.0	18.0	0.41	0.41	
3:15	7.0	91.5	80.5	.08	.087	
3:26.	7.5	191.	171.	.039	.041	
3:31	7.75	353.	312.	.021	.022	
4:42	7.95	not critical				
	8.05	not critical				
4:50	8.1	Critical with fog tamper on, but Cal. rod not removed.				

DC-JTT 9/1/58

Conclusion at 8.075 ± .025 cm.

11/17/48 DC 8.1 + 0.4 = 8.5 cm = ~~He~~ bo How Corrected

11/28/48 DC H/X = ~~46.5~~ 56.7

15" al tamped.

$\rho_{pp} = 1.51$

Wht% X = 28.10 = 0.424 gm/cc.

$V_c = 9.69 f$

$M_c = 4.11$ kg

40 July 8, 1948

CRONIN
FOX
MORFITT
PRESSEY

Experiment 179 15" Stainless Tamped. H/x ≈ 60

Instruments all ok.

Trip points # 3 - 82, # 4 - 6.5

Scales. # 3 - 100x, 4 = 10x, 5 = 2x, REED = 25x

Source @ 3cm.

Time	Height	Counts #1	Counts #2	1/M #1	1/M #2	
10:37 Am	4.4 cm.	9.5	9.0			
10:40 A.	Reed misbehaving.					
10:47 A	6.6	19	17	.5	.53	# 5 MT. @ 6.6
10:55 A.	7.5	26	24.5	.37	.37	Filling from #3
11:05 A	8.5	47	41.5	.20	.23	# 4 erratic
11:15 A	9.4	149	131	.064	.069	Filling from #2
11:25 A	9.7	259	226	.037	.04	
11:37 A	9.9.	NOT CRITICAL				
11:42 A	10.0	CRITICAL ! with 5 cm of rod left.				

Sight glass 3mm high; 50:

Conclusion: 15" stainless steel cylinder at H/x ≈ 60 is critical at a height of 9.65 ± .025 cm.

Drain back to D.V same as exp 179.

11/17/48 DC 9.65 + 0.4 = 10.1 cm = He bottom Corrected

H/x = ~~56.5~~ 56.7

15" Stainless Tamped.

11/28/48 DC opg = 1.51

Wt% x = 28.10 = 0.42x gm/cc.

V_c = 11.51 ℓ

M_c = 4.88 kg.

July 8. 1948

~~Cronin~~
Fox
Morfitt
Grossey

Experiment 180 15" Stainless Untamped H/X = 60

Instruments all O.K. except Reed ~~58.45~~ 56.5

Trip points as before. Scales as before
Source 7 cm

Time	Height	Counts #1	Counts #2	1/M #1	1/M #2	Remarks
1:20	1.1	—	—	—	—	# 6 MT
1:30	8.1	16.0, 17.0	17.0, 17.0	1.0	1.0	# 5 MT @ 6.5
1:43	13.1	68.2	68.7	.250	.250	Instrument Trouble
1:55	14.5	118.	117.	.145	.145	on #4. Fuse blown
2:03	15.5	226.	218	.075	.078	#3 MT. #2 MT.
2:17	16.5	755	824	.022	.021	
2:30	16.8	Not crit.	est. critical	17.0		
2:40	16.9	"	"	"	"	
	16.92	"	"	"	"	
	16.95	"	"	"	"	
	16.98	"	"	"	"	
	17.0	Critical with control in.				

Sight glass 3mm high so.

Conclusion: 15" stainless steel gl. @ H/X = 60 is critical @ a height of 16.7 ± 0.25 cm.

Draw back some as exp 178.

11/17/48 DE 16.7 + 0.4 = 17.1 cm = Hc bottom corrected
Hx = ~~56.5~~ 56.7
15" Stainless untamped
ρ_{pg} = 1.51
wt% X = 28.10 = 0.424 gm X/cc
Vc = 19.49 R
Mc = 8.26 kg

42 July 9

Exp 181 6½" Aluminum Tamped H/x ≈ 60

Cronin
Fox
Macklin
Moffitt.

Instruments all OK. 56.5

Trip points #4 6.5 ; #3 8.2

#3 scale 100 ; #4 - scale 10 ; #5 scale 2
Read a 25 all OK.

Time	Height	Counts #1	Counts #2	1/M #1	1/M #2	Remarks
11:05	—	—	—	—	—	from 6
11:13	5.2	3.5, 3.5	3.0, 3.0	1.0	1.0	6 M.T.
11:29	18.0	13.5	12.5	.26	.24	from 5
11:30	23.2	25.0	22.5	.14	.13	
11:40	29.3	52.0	47.5	.067	.063	stopped #5
11:53	33.2	103.5	94.5	.034	.032	from #3
12:02	35.6	246.	228	.014	.013	stopped #3
12:18	36.5	Not critical. estimated critical			37.0	
12:24	36.9	" "		"	37.1	
12:26	37.1	" "		"	37.3	
12:36	37.4	" "		"	—	
12:38	37.7	Critical with 4 cm rod in.				

Conclusion: Critical @ 37.7 ± .1 cm
Ht corr — .50 (from Exp 174
3.82

Drain base as taper out.

#1	#2	#3	#5	#6
24.0	24.0	24.0	28.5	D.V + 5.2

in terms of 6½" gal.

Not used value taken from previous inventory.

≐	7.0	7.0	7.0	8.3	DV + 1.5 cm in 12" reactor.

11/17/48 DC

38.2 + 22 = 40.4 cm = He to bottom corners
H/x = 1.7 ; 6½" all tamped
Apq = 1.51
Wt% X = 28.10 ≡ 0.42 gm X/cc

Vc = 8.65 ℓ
Mc = 3.67 Kg.

EXPERIMENT 182

7/17/48

12" Reactor - Stainless, Cd Covered.

Cronin
Pressey
~~Fox~~ (~~Mc Lb~~.)
Callahan
Beck

H/X = 60 - ~~5 8 5~~ Tamped 56.5

TRIP POINTS - #3 - 82×100 ; #4 - 6×100 -
Source - ~~#~~ 5 cm from bottom of reactor
Scales = #3 × 100, #4 × 10, #5 × 2. R.E. 25 mv.

10:05A Filling dead volume from #6.

		I	II	
10:17	H = 1.8 cm	3.5	3.5	#6 EMPTY.
		3.0	3.5	
		3.3	3.5	Filling from #1
10:25	= 8.2			#1 EMPTY.

Callahan left - Beck took over.

		12	10	.29	.35
10:32	10.9		{13.5 / 140}	#1 Failed	.26 from #2.
11:05	13.0		32		.109
11:12	13.9		52		.067
	15.2	above critical			
	15.1	below critical			

Conclusion: Critical at 15.15 + .05

Approach to critical was erratic. #1 Counter failed during the experiment.

Drained back 7 cm into #2

7 into #1
1.1 + DV into #6.

11/17/48 DE 15.15 + 0.65 = 15.8 C_R = Hc by Horn Corrected
11/28/48 RC H/X = ~~5~~ 56.7
12" Stainless Tamped Cd shield
$\rho_{Pu} = 1.51$
Wt% X = 28.10 ≡ 0.424 gm X/cc
Vc = 11.53 ℓ
Mc = 4.89 kg

7-13-48

Re-distribution of Solution

Cylinder No.	Liters of $^{NH}/_{Nx}$ = 60	Liters of H_2O added	Total volume. l.	
9	2.63	2.55	5.18	
8	3.48	3.37	6.85	3.4 in
7	3.48	3.37	6.85	3.4
6	3.47	3.36	6.83	3.3
5	3.40	3.30	6.70	3.3
4	None			
3	3.40	3.30	6.70	3.3
2	3.40	3.30	6.70	3.3
1	3.34	3.24	6.58	3.3
			52.39 l.	

Approx. $^{H}/_{x}$ = 125

Cylinders # 1 & 2 empty 7-15-48
Schedule for Friday 7-16-48
Empty cyl. # 3, 5, & 9 & evaporate.
Redistribute soln in cylinders 6, 7, & 8 into 6 cylinders & dilute to $^{H}/_{x}$ 225 assuming present $^{H}/_{x}$ = 120.

Referring to solution after dilution
pg 47, this book, $\rho_{pg} = 1.26$
"SF Sample Transfer & Requisition" # 7v048 - Sample 184 ≡ 0.1804 gm U/gm soln - 1.227 gm/cc

These correspond to: H/X = 118.7
Wt% X ≡ 16.85 ≡ 0.212 gm X/cc. solution - 1.168 gm X/cc

Experiment 183 20" Stainless Steel, Untamped H/X ≈ 125. 7/14/48.

110.88

Back for Bussey McLendon Visitors Conyboeur Echole.

Instruments #1, 2, 3, 4, 5, Rad and process Monitor, all OK.

Trip Points #4 : 6.5; #3: 82.

Source 5cm from bottom, Safety rod at 20.cm.

Time	Solution Level	Counting Rate #1	Counting Rate #2	C/C #1	C/C #2
10:30	Background	15	13.		
10:42.	Zero 0.2.	15	11.		
11:00					
11:05	10.0	38	30	.39	.40
11:15	12.0	89	74.5	.17	.16
	13.0	186	153	.08	.08
11:31	13.5	413	357	.036	.034
	13.7	not critical.			
	13.8	not critical			
	13.85	not critical			
	13.95	not critical			
	14.05	" "			
	14.10	not critical			

#1 D.V. + 1.5.
#2 3.1
#3 3. (7.6)
#5 3.1 10.7
#6 2.3 13.0
#7

7.6

Conclusion: Critical at 14.1 ± .025 cm.

The last point, at 13.5 indicated criticality at 13.7 — ∴ the instrument approach to criticality was not too good; on safe side.

11/17/48 DC 14.1 + 0.2 = 14.3 = Hc bottom corrected
11/28/48 DC HX = ~~111~~ 119
20" Stainless untamped.
ρpgv = 1.26
Wht % X = 16.85 ≡ 0.212 gm X/cc
Vc = 28.98 ℓ
Mc = 6.14 Kg

Experiment 184. 6½ Aluminum, Tamped, H/X = 125. 7/14/48.

Beck
Fox
Pressey
McLendon
Cowan
Conneghean.

Instruments: all OK.

Inj Points: same as for 183.

Source: 10 cm.

	Solution Level	Rate #1	Rate #2	Co/C #1	Co/C #2	
2:31 P.M.	Background	5	3.5			
	zero.	4.5	4.0			#1 12.9 + DV.
	30.1	27.5	23.0	0.16	0.18	#2 - 25.
	35.	36.	31.	0.125	0.13	#3 -
2:58.	39.9	51.	42	.09	0.095	
3:04	44.9	98.5	85.5	.046	.047	
3:08	48.1	243.	213	.019	.019	
	49.9	Critical.				

Conclusion: Critical at $49.85 \pm .05$ cm. 18.04% U/gm soln.
16.85% X

Δt corr = $\frac{0.5\text{ cm}}{50.35}$

11/7/48
11/28/48 DC

50.35 + 2.22 = 52.6 cm = Hc (Bottom Corrected)
HW = H 119
6½" al tamped.
ρ_{pg} = 1.26
Wt% X = 16.85 = 0.212 gm U/cc.
Vc = 11.26 ℓ
Mc = 2.39 Kg.

7/15/48

Experiment 185 6" Aluminum Tamped H/X = 125

Press
Morfitt
Callihan

Instruments: # OR except #3 which is very insensitive the trip point was accordingly set at 65 on the 50 scale, which was about the point the instrument reacted with the large source up against the paraffin.

Trip point on #4 was 6.5 on 10 scale

#1 D.V. +	16.5 cm	
#2	34.5 cm	
#3	33.2 cm	Read on 25 scale

#3 on 50 scale, #4 on 10 scale #5 on 2 scale

Source: @ 15 cm.

	Solution Level	Rate #1	Rate #2	C/C #1	C/C #2	
11 40	0.3	Was 2.0	2.0→2.0 (1.75) 1.5	1.0	1.0	
11 50	16.1	4.5	4.0	.995	.438	#1 Empty.
12 00	26.8	8.5	7.0	.235	.250	
12 09	36.9	13.0	10.5	.154	.152	
12 17	51.3	16.5	13.0	.122	.135	#2 Empty.
12 30	70.0	19.5	17.0	.104	.103	

Curve very flat from 45 to 75

Conclusion: Cylinder is very probably infinitely safe at this H/X. ~~Extrapolated~~ Critical height is >200 cm.

Sample taken for H/X

Specific gravity 1.262

11/30/48 xx

H = 70.0 + 2.6 = 72.6 cm

H/X = 119 (see preceding page)

#V = 13.24 ℓ

M = 2.81 kg

Estimated: $H_c = V_c = M_c = \infty$

48 7/16/48

Solution diluted to H/x of approximately 225 by adding .65 l H_2O to solution of previous concentration.

Solution inventory IN LITERS (after dilution)

#1	5.5	DV + 9cm in 6½" cyl	~~= 0.9 ~~
#2	5.5	25.7 cm " "	
#3	5.5	25.7 " "	
#4	MT	~~25.7~~ " "	
#5	5.5	25.7 " "	
#6	5.5	25.7 " "	
#7	3.9	18.2 " "	
#8	5.9	27.6 " "	
#9	MT		

Approx.

~~#8~~

Total 37.3 Liters.

Also changed to 6½" Al cylinder for next experiment.

11/28/48 Referring to Solution after the above dilution:

pg. 30 this book $\Delta\rho g = 1.14$

"SF Sample Requisition & Transfer" # 710021 dated 7/21/48:

Sample 187 ≡ 0.1086 gm U / gm sample.

These correspond to:

H/x = 221.2

Wt% x = 10.14 = 0.116 gm x / cc

EXPERIMENT 186 — 6½" Al Reactor — 7/19/48

H/X = 225, Tamped.

Ex = [redacted] 206.60

For Dressel, Moonephan, Callihan.

TRIP POINTS #3 - 82 x 100, #4 - 6 x 100

Scales #3 x100, #4 x10, #5 x 2, RE x 25 mc

Source - 15 cm from bottom.

		I	II			
		2.0	1.5			
		2.5	2.0			
		(2.3)	(1.8)	M^{-1}		
11:30				I	II	Filling from #1.
11:36	H = 9.6 cm	3.5	2.0	0.66	0.90	#1 Empty. Filling from #2.
50	= 19.9 (19.4")	6.5	5.5	0.354	0.327	
59	= 25.4	8.5	7.5	0.271	0.240	
12:08P	= 35.0	10.5	10.0 9	0.219	0.180	#2 Empty. Filling from #3.
12:18P	= 45.0	13.5	11.0	0.170	0.164	
:25	= 59.4	14.5	12.0	0.159	0.150	

Conclusion: 6½" Al reactor, Tamped, H/x = 225 - will not be critical at ∞ extension.

INVENTORY: ✓1 DV

2	30 cm in 6½" cylinder	= 3.1 - 20"	cm
✓ 3	30.7 cm. " "	= 3.2	"
4	Empty.	—	—
✓ 5	25.7 cm in 6½" cylinder	2.7	"
✓ 6	25.7 " "	2.7	"
✓ 7	18.2 " "	1.9	"
✓ 8	27.6 " "	2.9	"
9	Empty.	—	—

11/30/48 DC

H = 59.4 + 2.2 = 61.6 cm -

H/x = 221 (see preceding page).

V = 12.71 R

M = 1.47 Reg.

Estimated $H_c = V_c = M_c = \infty$

50

PRESSEY
FOX
MOONEYHAM
CALLIHAN

7/19/48

Experiment 187 20" Stainless UNTAMPED H/X ≃ 225

E_x = 206.60

TRIP POINTS #3 = 82 X 100 ; #4 = 6 X 100

SCALES #3 = X100, #4 = X10, #5 = X2, REED = X50

Source 6 8cm from bottom.

2:15P Filling from #1-

→ Sight glass reading = 2 mm with solution level at grid in reactor.
" " " = 5 mm " " Covering about 50% of bottom of reactor. This is due to dishing of bottom.

Latter selected as zero, i.e. sight glass 0.5 cm too high-

		I	II			
2:20		16.5	14.0			
	uncorrected	16.5	13.5			
	H=0.5 in	16.5	13.8	M		#1 Empty, filling from #7.
	=0.7			I	II	Bottom of reactor completely wet.
:35	=2.4	13.0	10.5			#7 Empty Filling from #8
:43	=5.6	10.0	8.0			#8 Empty " " #6
:55	=8.3	15.5	11.5			#6 Empty " " #5
3:06	=10.9	31.0	22.5	0.532	0.588	#5 Empty " " 3
15	=12.0	43.5	32.0	0.380 ~~0.03~~	0.431	
25	=12.9	63.0	46.5	0.262	0.297	~~#3 Empty " " 2~~
34	=13.9	101.0	73.5	0.163	0.188 ~~0.190~~	#3 Empty " " 2
47	=14.8	194.5	133.5	0.085	0.103	
56	=15.5	~~144.0~~ ~~138.0~~	394.0	0.030	0.035	
4:06	=15.75		NOT	CRITICAL.		
10	=15.9		←	←		
20	=16.0	CRITICAL WITH 4cm Cd CONTROL ROD IN SOLUTION.				

CONCLUSIONS: 20" STAINLESS REACTOR, UNTAMPED, H/X = 225.
CRITICAL AT 16.0 cm - uncorrected.
= 15.5 cm when corrected for sight glass zero.

INVENTORY

1	DV	
2	3.1 cm in 20" cylinder.	= 5.5 in 15"
3	2.9 " " " "	= 5.1 "
4	Empty	- "
5	3.0 " " " "	5.3 "
6	3.0 " " " "	5.3 "
7	3.0 " " " "	5.3 "
8	2.~~1~~ " " " "	3.9 "
9	Empty.	

11/7/48DC 15.5+0.2 = 15.7 cm
= the bottom corrected

11/28/48DC H/X = ~~207~~ 221
20" stainless untamped.
ρ_{gm} = 1.14
Wt% U = 10.14 = 0.116 gm U/cc.
V_c = 31.81 ℓ
M_c = 3.69 Kg

Sampled 7-20-48
sp. gr. 1.144
Analysis 10.86% U/gm sol
= 10.14 % X

7-20-48

EXPERIMENT 188

15" STAINLESS UNTAMPED

PRESSEY'S Prediction = 19.5 cm

PRESSEY
MOONEYHAM
FOX
CALLIHAN.

$H/X \simeq 225$

$\Sigma a = 206.60$

TRIP POINTS - #3-82 x100. #4 5.9 x10⁵

Instrument Scales #3 x100, #4 x10, #5 x2 RE x 50 mv.

Source - 7 cm from bottom.

Control Rod - 3/4" SS with Cd. Zero control rod = 0

11:55A Filling dead volume from #1.

#1 Empty - With half of reactor bottom area covered. sight glass = 0.3 cm.

Therefore - sight glass reading - 0.3 cm high.

Filling from #2.

#2 Empty. Filling from #3.

		I	II	M⁻¹ I	M⁻¹ II	
12:03 P	H= 6.1 cm					
:06	= 8.0	12.0	11.0			
		12.0	10.5			
		12.0	10.8			
:17	=11.2	25.0	24.0	0.480	0.450	#3 Empty, Filling from #5
:27	=13.1	39.5	36.0	0.304	0.300	
:32	=14.2	54.5	47.5	0.220	0.227	
:40	=16.0	96.5	86.5	0.124	0.125	STOPPED FILLING FROM #5 - 4 cm left, Filling from #6.
49	=17.5	197.0	173.0	0.061	0.062	
55	=18.2	345	303.0	0.035	0.036	
1:04	=18.7	571	551	0.021	0.020	
11	=19.1	NOT CRITICAL.				
14	=19.3	NOT CRITICAL				
18	=19.5	CRITICAL WITH CD CONTROL ROD 10cm BELOW SOLUTION SURFACE. -				

CONCLUSION: 15" STAINLESS REACTOR, UNTAMPED. $H/X = 225$ - CRITICAL AT 19.4 ~~19.5~~ cm uncorrected.
= 19.1 cm corrected for sight glass zero.

Inventory - Same as on pg 51

11/17/48 DC 19.1 + 0.4 = 19.5 cm = Hc (bottom corrected)

11/28/48 DC H/X = ~~207~~ 221

15" Stainless untamped.

$\rho_{av} = 1.14$

Wt $U^{235} = 10.14 \pm 0.116$ gm/cc

$V_c = 22.23$ ℓ

$M_c = 2.58$ kg

52
7/20/48

Experiment 189

~~$E_x = 206.60$~~

12.3

15" Tamped Stainless

$H/x \simeq 225$

PRESSEY
FOX
MCCORVEY HAM
CALLIHAN.

TRIP POINTS - #3 - 82 x100; #4 - 5.9 x100
INSTRUMENT SCALES - #3 x100, #4 x10, #5 x 2; R.E. x ~~50~~ 25 mv.
} Same as last experiment - not released.

SOURCE - 4cm from bottom
Control Rod - Cd Sheet 3 lbs = 8 cm on scale.

Dead Volume full from #1.

Zero on sight glass = 3mm

Time	Soln Level	#1	#2	C_o/C_1	C_o/C_2	
2:00 pm		5.5	5.0	} Background counts.		
		6.0	5.5			
		5.75	5.25			
2:20 p.	3.9 cm	6.5	6.0	.89	.87	
2:27 p	6.1 cm	9.5	8.5	.61	.62	#2 MT. filling from #3
2:39 p.	8.9 cm	19.0	16.5	.30	.32	
2:46 p	10.3 cm	32.5	28.0	.177	.187	Filling from #5.
2:53 p	11.5 -	64.0	54.0	.09	.097	
3:01 p	12.2 cm	191.5	119.5	.041	.044	
3:15 p	12.5 cm	275	223	.021	.024	
3:20 p	12.7 cm	Not Critical				
3:25 p	12.9 cm	Critical with 1 cm rod in.				

CONCLUSION: 15" Stainless reactor Tamped with H/x of 225 critical @ 12.6 cm corrected for sight-glass zero.

Soln. Inventory same as page 50.

11/17/48 DC
11/28/48 DC

12.6 + 0.4 = 13.0 cm = Hc bottom corrected
HH = ~~207~~ 221
15" ~~Stainless~~ Tamped
$Sp_{gr} = 1.14$
wht % X = 10.14 ≡ 0.116 gm X/cc
$V_c = 14,82 \ell$
$M_c = 1.72$ kg

Experiment 190 –

$E_+ = 206.60$

15" Aluminum, Tamped, H/X = 225, 7/21/48.

Runs for McLendon Beck

Instruments: #1, #2, #3 #4, #5, Reef & Process monitor all responded satisfactorily
Trip Points: # 3: 63. #4: 61
Source: 4 cm from bottom.

	Solution Level	Counting Rate #1	#2	C_o/C. #1	#2	
10. AM.	Background	10.5	6.5			
		8.	6.5			
		9.	(7.0)			
10:06	Zero.	(10.)	8.			5.4 out of 2.
10:26	7.0	32.	21.	0.31	0.333	
10:36	9.0	86	62	.115	0.112	# from 3.
10.41	9.7	157.	102	0.063	0.068	
10:47	10.1	300	212	0.033	0033	
10:52	10.4	not critical.				
	10.5	not critical				
	10.6	Critical				

Conclusion: Critical at 10.57 ± 0.025.
Sight glass zero 3mm low.
Corrected value = 10.87 ± 0.025 cm.

11/17/48 DC
11/28/48 DC

10.87 + 0.41 = 11.3 cm = He bottom corrected
Hx = ~~207~~ 221
15" Al tamped.
$\rho_{pg} = 1.14$
Wt% V = 10.14 = 0.116 gx/cc.
$V_c = 12.88$ ℓ.
$M_c = 1.49$ Kg.

Experiment 191. 10" Stainless, Cadmium Shielded. $E_f = 206.60$ $H/x = 225$ 7/21/48.

Tamped.

Back Privacy For McLendon Moonglum

Instruments } Same as Experiment 198.
Trig points }

Source: 5 cm from Bottom

	Solution Level	Counting rate #1	Counting rate #2			
1:00 PM.	Background	9.5	7.5	Co/c		
1:10	zero 18.0	(7.5)	(5.)	#1	#2	12.7 from #2.
1:22	~~18.0~~	19.5	14.5	0.36	0.34	~~12.7 from #2.~~
	21.05	27.	20.5	0.26	0.24	10 (22.7) from #3.
1:35	24.4.	55	40	.136	.125	from #5
1:50	26.1	100	70.5	.075	.071	
1:51	27.15	247	181.	.028	.027	
1:56.	27.7.	not critical.				
	27.75	not critical.				
	27.8.	not critical.				
	27.82	Critical				

Conclusion: Critical at 27.82 ± 0.02

11/17/48 DC
11/28/48 DC

27.8 + 0.9 = 28.7 Cm = Hc to Hom corrected
H/x = ~~207~~ 221
10" Stainless, ~~tamped~~ Cd shield
Wht % X = 10.14% ≡ 0.116 gm/cc
Vc = 14.54 ℓ
Mc = 1.69 kg
ρ_{pp} = 1.14

Ex. = 206.60

Exp 192. 15" Stainless H/A 225 7/29/48

The Iron Tamper Tank Removed.

Morfitt
Moorehead
Fox
Pressey
Cronin

Solution
1 - DV
2 - 5.5 cm = 3.1 cm in 20" Previous background taken at 8.0 cm (source covered)
3 - 5.1 " = 2.8 cm in 20"
5 - 5.3 " = 2.9 "
6 - 5.3 " = 2.9 "
7 - 5.3 " = 2.9 "
8 - 3.9 " = 2.2 "

This experiment to determine the effect (if any) of the 1/4" iron tamper tanks. Experiment 188 run under similar conditions (untamped) except with iron tanks in place. Critical Hgt. - 19.1 cm (corrected.)
19.4 cm (uncorrected)

Trip Points:
#3 - 58 (50 scale) (Poor Prec.)
#4 - 5.7 (100 scale)

Source at 7 cm ~~from~~ bottom.

Sight Glass read 0.4 cm @ zero as determined by visual inspection of level in reactor.

	Level	Counting Rate #1	Counting Rate #2	C/Co	
10:30	0.4				D.V. filled
10:47 A	8.0	5.0 ~~6.0~~ 12.5	13.6 9.5 (10.0)		#2 emptied 6.2
10:47A		(5.0) ~~12.0~~	~~15.0~~ 11.0		refilling from #3
11:11 A	11.0	8.5	19	.59	.53 #3 MT @ 11 cm.
11:18 A	14.0	21	36	.24	.28 from #5
11:33 A	16.0	41	66	.12	.15 " #6
11:45 A	18.0	139	191	.036	.052
NOON	18.6	(293)	310.5		.032
12:15	19.2	NOT CRIT.			
12:20	19.35	Critical with ROD out.			

Hc = 19.0 + 0.4 = 19.4 cm.
N/X = 2.21
σ_{f_5} = 1.14
$\sigma_{f_5} \times$ = 10.14
= 0.116 gm/cc
Vc = 22.12 ℓ.
Mc = 2.57 kg.
11/28/48 DC

Conclusion: Corrected for zero, critical height is 19.0 cm compared with 19.1 cm for exp. 188. Variation not believed significant.

Drainback as above.

56
8/3/48

EXPERIMENT 193

Cronin

20" STAINLESS REACTOR — UNTAMPED

Pasesey
Mooneyham
Callihan

FE TAMPER TANK REMOVED - To test effect of former tamper tank. To be compared with Exp. 187 pg 50 this book.

H/X = 206.6

TRIP POINTS #3 - 100x100; #4 - 6x100.
Scales - #3-100; #4x10; #5 x2. R.E out of order.
Source 5 cm from reactor bottom.

9:20 A Filling dead volume from #1.
[Zero = 0.5 cm on sight glass]

:25 H=0.5cm #1 empty; Filling from #2.

:32 =3.6 #2 empty, Filling from #8.

9.9 / 5.4 / 8.3 :37 =5.4 #8 Empty, Filling from #7.

:43 =6.5 I 8.0 II 5.0

		I	II	M^{-1} I	M^{-1} II	
		8.0	4.5			
8.2 / 2.9 / 11.1	:55	=8.2	12.0	7.5	0.667	0.640	#7 Empty; Filling from # 6
	10:08	=10.0	19.0	11.0	0.421	0.436	
11.2 / 2.0 / 14.1	15	=11.2	27.5	16.0	0.291	0.300	#6 Empty; Filling from # 5
	25	=12.3	40.5	23.5	0.198	0.204	
	37	13.3	58.0	34.6	0.138	0.141	
14.2 / 2.8 / 17.0	43	14.2	98.0	55.5	0.082	0.086	#5 Empty Filling from #3.
	49	15.1	226.5	126.0	0.035	0.038	
	54	15.5	370.0	205.0	0.022	0.023	
	11:06	15.8	NOT CRITICAL				
	:11	16.0	NOT QUITE				
	:15	16.1	CRITICAL WITH ROD 7cm IN soln.				

CONCLUSION: UNCORRECTED CRITICAL HEIGHT 16.05 cm.
CRITICAL HEIGHT CORRECTED FOR SIGHT GLASS 15.55 cm

INVENTORY 1 (D.U)
$\nu(3,1)$? cm in 20" reactor.

3	2.8 cm.	X 2027	5.661	Liters
4	Empty (Al)		—	—
5	3.0 cm.		6.070	"
6	3.0 cm.		6.070	
7	3.0 cm.		6.070	
8	2.8 cm.		5.666	
9	Empty (Al).			

5.3 / 2.8 / 2.4

11/7/48 15.55 + 0.23 = 15.8 Cm
DC ~~H/X = 207~~ 221
11/28/48 20" Stainless untamped
Wt% ν = 10.14
= 0.116 gm/cc
ρ_{H_2O} = 1.14
V_c = 32.0 ℓ
M_c = 3.71 kg

9/3/48

Inventory

Cylinder	H_1	H_2	ΔH	Soln Ht
1	43.6	60.7		
2	43.2	61.6		
3	39.0	65.9		
4	Empty	valve stuck		
5	37.3	68.1		
6	38.5	66.2		
7	~~36.3~~	~~70.~~ 66.7	→	line blocked
8	38.0	67.3		
9	49.4	54.7	?	

Pit

Sp Gr 1.194

STORAGE RACK

~~#5~~	16556
#4	13824
	2.732 kg.
~~#6~~	
3 —	18824
	13600
	5.224
~~#8~~	19051
#9	13770
	5.281
#7	19051
	13608
	5.443

Storage Cylinders in racks.

Inventory 9/10/48

Cylinder		
+ 1	43.6	60.4
2	43.0	61.4
3	39.0	65.7
4	(MT)	LINE PLUGGED
5	37.4	67.2
6	37.6 (37.9)	67.0 (66.7)
7		LINE PLUGGED
8	38.1	66.7
9	~~49.5~~ (52.2) JKF	~~54.0~~ (51.2) JKF

Pit

Storage Rack

~~#5~~ #4	16556
	13824
	2.732 kg
~~#6~~	
#3	18824
	13600
	5.224
#9	19051
	13770
	5.281
#7	19051
	13608
	5.443

9/21/48 Inventory

For Cronin

Put

Cyl. No.	1	2	3	4	5	6	7	8	9
H_1	60.4	61.2	65.8	MT	67.5	66.7	67.8	66.9	MT
H_2	43.8	43.1	39.0		37.3	38.2	37.0	37.7	
Δh	16.6	18.1	26.8		30.2	28.5	30.8	29.2	
op. Ht.	1.144								
H/X	206.6	- all	cyl →						
Time H	43.0	46.9	69.4		78.2	73.8	79.8	75.6	
Vol. (liter)	3.48	3.80	5.62		6.34	5.98	6.46	6.12	

Storage Rack.

#3	#4	#8
16.556 Kg.	18.824	19.051.
13.824	~~16.651~~	13770
2.732	~~2.173.~~	5.281
	13.600	
	5.224	

10/6/48 INVENTORY —

For Cronin Moonaghan

	1	2	3	4	5	6	7	8	9
H_1	60.4	62.0	65.6	MT	67.5	66.8	Cylinder Cyl logged	66.6	MT
H_2	43.8	42.3 ~~43.8~~	39.1		37.3	38.1		38.0	
ΔH	16.6	19.7	26.5		30.2	28.7		28.6	

C

Conc: The soln. in cylinders # 1, 2, 3, 5, 6, and 8 gave manometer readings indicating 0.9 cm. increase in x-solution in terms of manometer soln. The difference is probably due to the diffienlty of obtaining precision manometer readings.
Cylinder # 7 is clogged. This is probably due to x salt in the valve.

60 10/5/48

Cyl No	1	2	3	4	5	6	7	8	9
H_1	~~60.3~~	61.3	65.3	MT	47.5	66.9	Clogged (taken out to evap.)	66.4	MT
H_2	43.7	42.7	39.0		37.1	37.8		37.9	
ΔH	~~16.6~~ 16.6	18.6	26.3		30.4	29.1		28.5	

11/9/48 #1 contents removed for evaporation. will then be placed in outside storage

Storage Rack;

3	4	7	9
18824	16,556	19,051	19057
13,600	13,824	13,608	13770
5224	2,732	5443	5,381

11-19-48 10 for all pt cylinders except #8 have been emptied for evaporation JKT.

Test of response time on safety rod & #3 chamber

Trip point 72 X100
10 curie source trips #3, 50 cm from wall of chamber. (wax)
Rod falls 1 foot to stop clock.

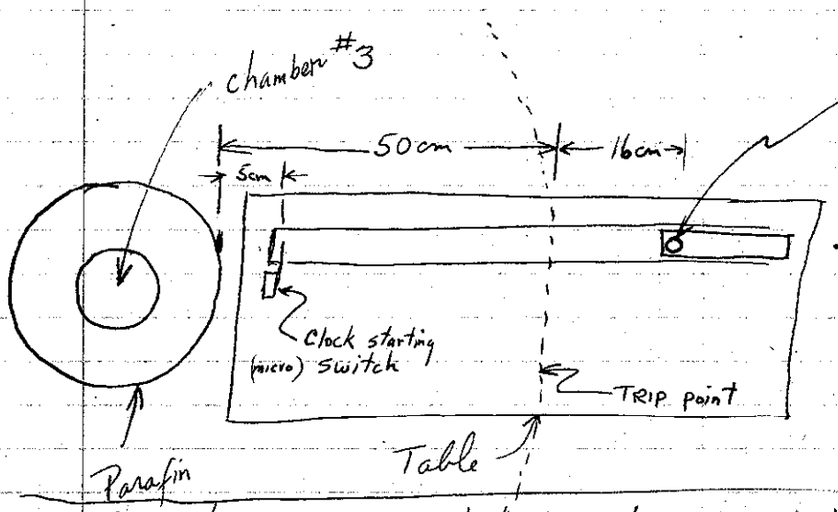
Series 1 Clock starting switch 45 cm from chamber
#3 ~~Reads~~ 25 X100, source 55 cm from switch
#1 3.82 sec.
#2. 1.72 sec.
#1 2.05 sec

Series 2. clock starting switch 22 ± cm from chamber
#3 reads 38X100, source 55 cm from switch.

#1	0.52 ~~sec~~.	5	0.50	(slow)
2	0.68 sec.	6	0.53	(fast)
3	0.70 sec.	7	0.69	
4	0.50 sec.	8	0.62	

Series 3 clock starting switch 5 cm from chamber
#3 reads 45 X100, source 66 cm from switch
#1 ~~55~~ 0.53 sec.
2. 0.41 "
#3. 0.58

Series. starting switch now 41-42 cm from wall of chamber
#3 reads 50X100, source at 166 cm from wall
(1) 0.91 sec..
(2) 0.81 sec. (fast)
(3) 0.77 "



Example of Experimental layout for series #3

When rod falls 1 foot it strikes micro SWITCH which STOPS clock.

11/28/48 Monitored Rack at Guard Post 50 with 263 -:
1:45P On contact with wood -

average - 5 x10
= 0.4 mr/hr
= 3.2 mr/8 hrs
= 0.003r/8hrs.

East wall - storage room - between guard & source -
3 x10
= 0.2 mr/hr -

8 hr tolerance - (8) about 4" outside source barrier (Cd + paraffin)
DC

Pressley
Cronin

12-14-48

Repeat of Experiments on page 61

Trip point 72X100 on #3
" position 48cm from wall of work outside chamber

Series I clock starting switch 43cm from chamber
Source 55 cm from start switch.
#3 on 10 X 100 scale
1. > 10 sec.

Series II clock starting switch 22.5 cm from chamber
Source 55 cm from switch
#3 on 18X100
1. .54 sec.
2. .39 sec
3. .50 approx.
4. .40 approx

Series III
Omitted

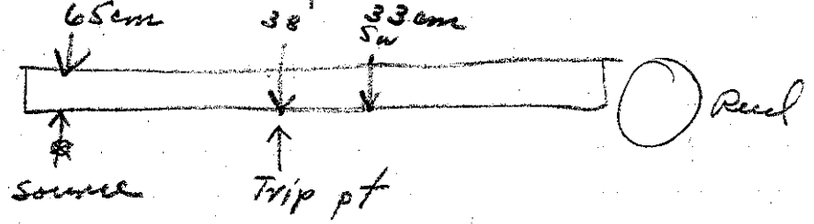
Series ~~IV~~ starting 42 cm from wall
Source 66 cm from wall.
#3 on 45 X100

off Center rad.	1. 0.79 sec.	(1)	0.52
	2. 0.53 sec.	(2)	0.52
	3 0.51 sec	(3)	0.49
	4. 0.52 "	(4)	
	5. 0.51 "	(5)	
	6. 0.51 "	(6)	

Cronin
Pressey

Reed test

Source 32 cm from starting switch



Off-Center Reed on mobile cyl to drop 1 pt + hit micro sw.

#1 0.9 sec
#2 0.8 sec.
#3 0.80 sec.
#4 0.79 sec.
#5 0.75 sec.

Trip Pt 3.5 on 1000 scale (1/2 of full scale using 4.8 mg Ra Source.

Check on Intensity of new Po-Be Source.

#2 counter used.

ave. Background count. 15
ave. With old source 160 cm from chamber (counter) 44
ave. " NEW " 160 " " " 309

$44 - 15 = 29$ mean ave. count for old source.
$309 - 15 = 294$ " " " " new source.
$\frac{294}{29} = 10.14$

New source ~~has~~ 10.14 X the neutron emission of the old source.
Neutron flux of old source was 2.86×10^7 neutrons 492 days ago.
$S_1 = S_0 e^{-\lambda t}$
$S_1 = 2.86 \times 10^7 \times .0871 = 2.5 \times 10^6$ neutrons/sec. now emitted by old source

$2.5 \times 10^6 \times 10.14 \cong \underline{\underline{2.5 \times 10^7}}$ n/sec as strength of new source

Check List

	5/14	5/19	5/20	5/21	5/24	5/25	5/26	5/27	6/2	6/3	6/4	6/11	6/18	6/28	6/29	6/30	7/1	7/2	7/16
1. Check Instrument Response	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2. Measure and Record Trip Points	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3. Automatic Valve and Safety Rod Response	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4. Location and operation of Control Rods	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5. Close Dump Valve and Adjust Spring	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
6. Tamper Water in, Overflow Tube on.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
7. Safety Rod up; Control Rod down.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8. Smooth action Top Tamper; Limit Switches	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9. Set Spring on Dump Valve.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
10. Air Compressor on. Check Air Safety Valve	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
11. Check all valves.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
12. Note location of all sources	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
13. Ventilation (fan & closet door)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
14. Notify guards, check number of personnel, film badges, dosimeters.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15. Barriers; red light.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

SECRET