

BOOK 109

Notes:

"10143" on bottom spine

Blank pages: inside front cover, 1, 4, 5, 6, 23, 43, 49, 53, 64, 71, 146, and 147.

page 14 has 2 8.5x11 sheets stapled to it

Scanned by:

Sheila Finch

RSICC /Oak Ridge National Lab.

January 9, 2001

10-9-21

10143

10143

10143

No. 18 - Experiments at FOS on Uranium Cubes ✓

C-7

This document consists of 155 pages.
No. 1 of 1 copies, Series A



Standard Blank Book

155

No. 21

Journal	2	Cols. to Right	Units	Single Page Form
"	3	"	"	"
"	4	"	"	"
"	5	"	"	"
"	6	"	"	"
"	6	Divided	"	"
"	8	to Right	"	Double Page Form
"	10	"	"	"
"	12	"	"	"
"	12	"	No Units	"

69 AUG

Single Ledger, Units
Double Ledger, Units
Record
Quadrille

In 150 and 300 Pages
Made in U. S. A.

CLASSIFICATION CANCELLED
DATE 6-3-60
Edgar J. Murphy
COORDINATING ORGANIZATION DIRECTOR
OAK RIDGE NATIONAL LABORATORY
DELEGATED BY AEC 9-10-57

TO REORDER THIS BOOK, SPECIFY NUMBER, RULING AND THICKNESS AS INDICATED ON BACKBONE OF BOOK
A BOORUM & PEASE PRODUCT

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

This document consists of 155 pages.
No. 1 of 1 copies, Series A

5-25-60

EXP.	PAGE	TAMPED T or U	MODERATION H/T	COMMENTS	CRITICAL No. OF TUBES		C.M. DIMENSIONS Kg X
					$\frac{1}{16}$ " Al	No. Al	
1	7	U	0/1	Multiplication	—	—	—
2	9	U	0/1	Multiplication	—	—	—
3	11	U	0/1	Multiplication	—	—	—
4	13	U	0/1	Multiplication	—	—	—
5	16	T	1/1	Too small	—	—	—
6	20	T	1/1	Incomplete.	—	—	—
7	24	T	1/1		506	498	7.66 10x10x10 $\frac{1}{8}$
8	28	T	4 $\frac{1}{2}$ /1		1184	1170	18.0 12x13x11 $\frac{5}{16}$
9	33	T	2/1		303	298	4.58 10x10x9
10	38	T	7/1		406	400	6.15 16x14x14 $\frac{1}{3}$
11	50	T	4/1		265	258	3.97 11x11x11
12	56	T	1 $\frac{1}{2}$ /2		2495	2470	38.0 15x15x14 $\frac{1}{16}$
13	59	T	1/7	Multiplication	— No results		—
14	63	T	2/2	Inhomogeneity	534	527	8.11
15	65	T	4/4	Inhomogeneity	568	558	8.58
16	68	T	8/8	Inhomogeneity	658	646	9.93
17	72	T	1/2	Inhomogeneity	1155	1140	17.52 12x12x12
18	77	T	2/4	Inhomogeneity	1306	1290	19.83
19	82	T	1/1	Cadmium shielded	975	965	14.83 12x13x13
20	84	T	4/1	Cadmium shielded	405	400	6.15
21	89	T	1/4	Inhomogeneity	2420	2400	36.9

EXP.	PAGE	TAMPED T or U	MODERATION H/T	COMMENTS	CRITICAL No		C.H. Kg X	
					OF TEMPER	1/16" A1 Ab A1		
22	91	T	2/1	Geometry	9x9x11.4	307	302	4.64
					8x8x17	364	356	5.47
					8x7x26.5	496	488	7.50
					7x7x59-962T	NOT CRITICAL		
23	95	T	1/2	Geometry	11x11x14.6	1175	1155	17.75
					10x10x19.8	1320	1295	19.9
					9x9x41.3	2230	2150	33.0
24	98	T	1/1	95% X	321	316		
25	100	T	1/2	Cadmium Shielded	2265	2235	34.4	
26	101	T	1/2	61% X 14/1-30/1-95	786	775	25.6	
27	103	T	3/1	61% X 6H/1-30/1-95	204	200	6.6	
28	106	T	1/2	95% X	600	594		
29	107	T	1/2/1	95% X	594	588		
30	110	T	0	30% X / 95% X = 3/1	multiplication		>125	
31	114	T	4/1 to 1AIR	Density	381	378		
32	117	T	1/7	Multiplication			64 Kg	
33	120	T	4/1 to 1/2 AIR	Density	346	341	5.24	
34	122	T	1/4	Multiplication			38	
35	126	T	1/2 to 1 AIR	Density	1828	1807	27.8	
36	128	T	1/2 to 1/2 AIR	Density	1525	1510	23.2	
37	131	U	4/1		470	464	7.13 13x13x14	
38	137	T	1/1	Boron Shielded	1134	1118	17.2	
39	139	U	1/2		2850	2810	43.2 16x16x17-	
40	142	U	1/1	Separation vs CM.	1239	1232	18.9 14x13x13 1/3	

Sept 25.

3:20 PM.

7

Experiment no 1.

Untamped, Unmoderated. 30% Material
 12x12x12. Location of source.
 Chief Experimenters - C. Beck. 7x7x7.

C. Beck, Hull - assembly of cubes.
 Viani - controls
 Callahan, Welbourn, Murray, non participating.
 Schmidt, Leland, Ibrin - instruments.

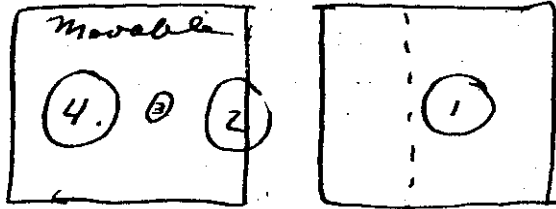
Stacking finished 3:58 PM.

Instrument Monitoring

Insts.	Counts/ min	thru min	Time	Rows	
3	252 $\frac{10}{64}$	2	3:55 assembled. & 32" apart.		
2	151	10			
3	260 $\frac{19}{64}$	2	3:57		22" apart $\pm \frac{1}{16}$
3	277 $\frac{24}{64}$	2	4:10		12" apart $\pm \frac{1}{16}$
3	274 $\frac{2}{64}$	2	4:15		7" apart $\pm \frac{1}{16}$
3	266 $\frac{64}{64}$	2	4:20		5" apart $\pm \frac{1}{16}$
2	174	10			22.5" apart $\pm \frac{1}{16}$
3	248 $\frac{34}{64}$	2			4" apart $\pm \frac{1}{16}$
3	232 $\frac{30}{64}$	2	4:25		3" apart $\pm \frac{1}{16}$
3	223 $\frac{22}{64}$	2			2" apart $\pm \frac{1}{16}$
2	181	10	4:26		5-2" apart
3	205 $\frac{63}{64}$	10.2	4:33		1" apart $\pm \frac{1}{16}$
3	198 $\frac{36}{64}$	10.2	4:36		0" $\pm \frac{1}{16}$
3	272	2			7" apart $\pm \frac{1}{16}$

Disassembly started at 5:00 PM.

location of instrument
exp. no 1.



① Prop. count

Sept 26,

Experiment 2.

Unramped, Unmoderated, 30% Material
 12 x 12 x 12 cubes.

Source: 7 from bottom,
 6 from end,
 6 from west.

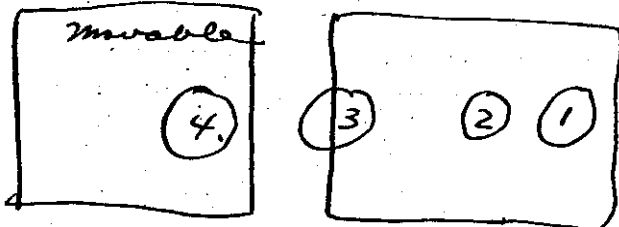
People Present

- Callahan - chief experimenter, controls.
- Bech - Williams - calculator
- Vlonei - data taking
- Schmidt - Jenkins - instruments

Instruments re-arranged. #3 directly under source.

Instruments (Prog Counters)				Time	Rows	Dist. tables apart.
#	1	#	3			
Counts	min.	Counts	min.			
50	2	231	2	4:15	Assembled,	Scale 32 1/2" + 1/16.
51	2	239	2	4:22.	"	29" + 1/16.
50	2	231	2	4:25.		26" + 1/16.
51	2	238	2.	4:27.		23" + 1/16.
53	2	244	2	4:31.		17" + 1/16.
54	2	265	2	4:35		11" + 1/16.
59	2	282	2	4:39		7" + 1/16.
62	2	289	2	4:45.	Instrument checked, OK.	5" + 1/16.
68	2	291	2	4:47.		4" + 1/16.
62	2	301	2	}	repeat.	3" + 1/16.
69	2	306	2			
74	2	312	2			2" + 1/16.
76	2	311	2	5:09.		42 1/4 1" + 1/16.
				magnet uncoupled		0 + 1/16.
				Cable reconnected		
				67 cubes fell on floor.		

Location of Instruments
Exp. no 2.



Sept. 27, 1946.

Experiment No. 3

Untamped, unmoderated material, 30%
12 x 12 x 12 cube.

Persons present:

Carpenter - Experimenter in charge.

Dyer - second experimenter - Recording data

Schmidt at controls

Visque - Assistant in stacking

Lykins - Instruments Mrs Smith.

Williams

All have film badge + dosimeter.

Checks made - Emergency disassembly Ion chamber 4 OK

Ion chamber 2 OK

Power failure OK

Air failure OK

Source check of both counters and ion chambers.

Speed reports 5 people present.

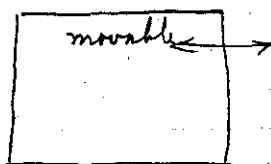
Red light at 11:45 AM.

Control office notified. Both Carter + Knapp out. Secretary took message.

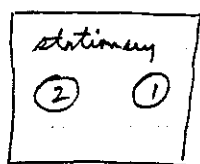
Time out for lunch. Red light on again at 12:25 PM

Stacking begun at 12:35 P.M.

Location of instruments:

#3 Counter set on top
of table

④



③

Readings taken on #3 at 2-min. intervals.

#1 clicks continuously in experimental room.

Source is behind Al jig at about
5" above table level.

#3 299

287

233

157

157

151

155

160

Instrument check 4+ layers

Almost 6 layers.

Source moved into position 7 from bottom, 6 from south, 6 from west.

331

7 layers complete

386

429

4 layers complete

467

10- layers

496

511

11+ layers

502

12 layers finished

496
502
478

Backstop put in place behind stack on movable table

Instrument check.

Distance	Multiplication	measured on approach of table		Counter # 3. + # 1.	
		#1 $\frac{1}{2}$ min	$\frac{100}{c/m}$	#3 $\frac{1}{2}$ min	$\frac{100}{c/m}$
32.5" + $\frac{1}{16}$ " Al.	55	36.4	463	4.32	
22"	54	37.0	456	4.39	
17"	58	34.5	469	4.26	
15" 12"	61	32.8	486	4.12	
9"	64	31.2	492	4.06	
6"	68	29.4	510	3.92	
4"	73	27.4	544	3.68	
3"	77 76	26.3	558	3.58	
2" 161 div.	80	25.0	576	3.47	
1" 80	81	24.7	634	3.15	
0.5" 40	86	23.3	655	3.05	

Attempting to come to zero, the magnet let go at 4 div. from zero. Repeating the approach while an experimenter stationed outside the building and fence observed with field glasses: - It was seen that the Al-shield touched the cables above the table at a scale reading of 4 div., while light could still be seen between the two segments of the table.

Repeated approach to congruence.

1" 80	85	23.5	643	3.11
0.087" 7	86	23.3	699	2.86

Removed cables-

Lead source in position & secured during the above measurements. Source mounted atop of $\frac{1}{2}$ " Al tube, 6" long, tube mounted in base $2\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{2}$ of Al. Movable table in contact with stationary one.

Counts / two minutes:

~~70~~ # 1

70

69

~~447~~ # 3.

447

454

Sept. 30, 1946.

13

Experiment no. 4.

Untamped, unmoderated, 30%. 12x12x12.

People present:

Murray	-	Chief experimenter	} stacking
Callahan	-	second experimenter	
Vesuvio	-	record data.	
Beck	}	Lubricant.	
Lewis			
Smith			

Location of instruments same as exp. no. 3.
All have film badges & dosimeters.

#1 count/mi.	Time AM.	#3 count/mi.	Exp. Set-up.
110		307	No cubes on table
109	10:33	310	source in position
119	10:38	329	atop 1/2" at top, 6" long.
114	10:39	328	Tables together.
+	11:03	366	556
112		364	
Table check	11:10		Forward & back motion. pressure, power, and source trip.
Counter check.	11:45		
Dial indicator check.			Tables together.
	110		
	PM.		
Stacking & start of	12:15		Source on fixed table
207	12:22	426	5 layers stacked.
	12:32	462	6 layers stacked
Source moved into position: 9 from bottom, 6 from south, 6 from west.			
78	12:37	329	
89	12:42		9 layers stacked.
		421	12x12x12"
91	1:02	416	3 1/2" x 1/16" apart.
	1:05		Counters checked

Sub. of Tables inches + 1/16"	Dial	# 1 Counter		# 3 Counter		Time
		#/2min	1000/#/min	#/2min	1000/#/min	
32.5		91	22.0	416	4.81	
17"		90	22.2	421	4.75	1:10.
7 1/4"		105	19.1	452	4.43	1:17
3"		122	16.4	503	3.98	1:24
5/10	104.6	146	13.7	710	2.82	
0		147	13.6	708	2.83	1:35
	108.5	146		709		1:38
		Table	apart.			1:40

Started adding cubes,
13 X 13 X 13 finished
Counters checked. OK

32 1/4"		90	22.2	414	4.83	2:15
17"		95	21.1	425	4.71	
7"		110	18.2	466	4.29	2:23
3"		133	15.0	stopped.		2:30
32 1/4"		98	20.4 17.5	342	5.85	
7	108.	114	17.5	383	5.22	2:40.
3		137	14.6	427	4.69	
0	108.	160	12.5	572	3.50	2:55.
		162		585		tables apart.

All distances except 0 should be increased by 1/4"

32 1/4"		102	19.6	456	4.39	3:10
17"		107	18.7	470	4.26	3:25
7"		129	15.5	511	3.91	3:26
3"		154	13.0	588	3.40	
0"	106 1/2	181	11.0	785	2.55	
		181		783.		3:55.

started adding cubes.
14 X 14 X 14 finished
counters checked OK.

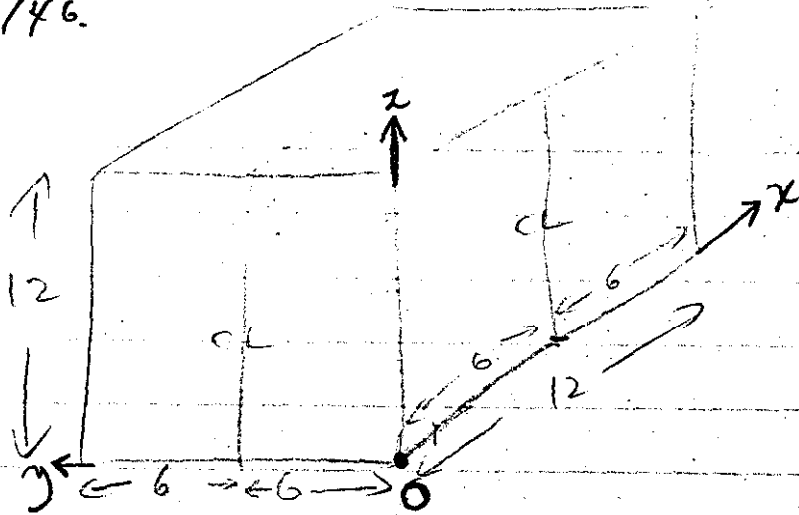
32 1/4"		107		stopped.		4:10
32 1/4"		106	18.9	320	6.25	4:25
17.		110	18.2	331	6.05	
7		137	14.6	370	5.41	4:40.
3"	107.	163.	12.3	427.	4.68	4:43
0"	107	197	10.2	597	3.35	4:50
		193		609		

table apart
started adding cubes.
15 X 15 X 14 22/25 on top. finished
counters checked.

5:00. tables apart.

9/30/46.

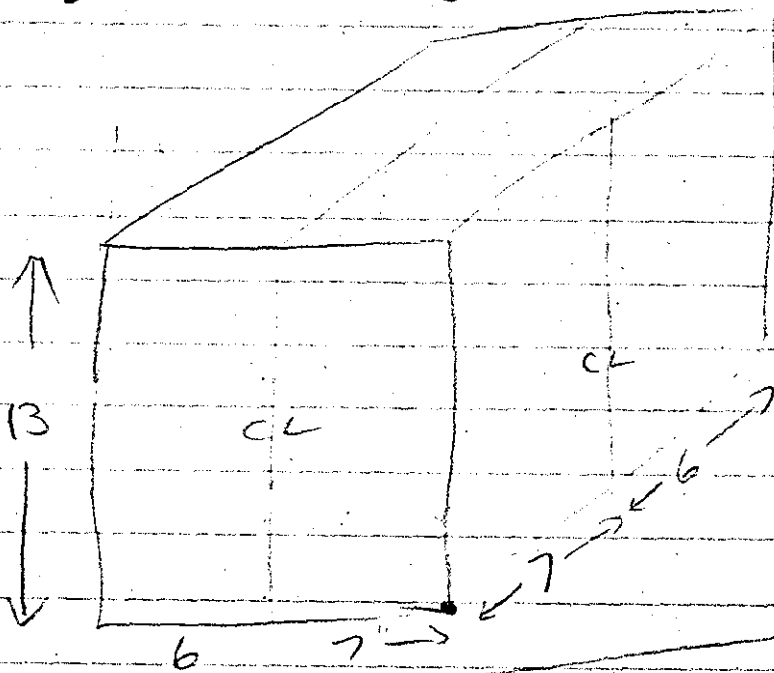
12x12x12



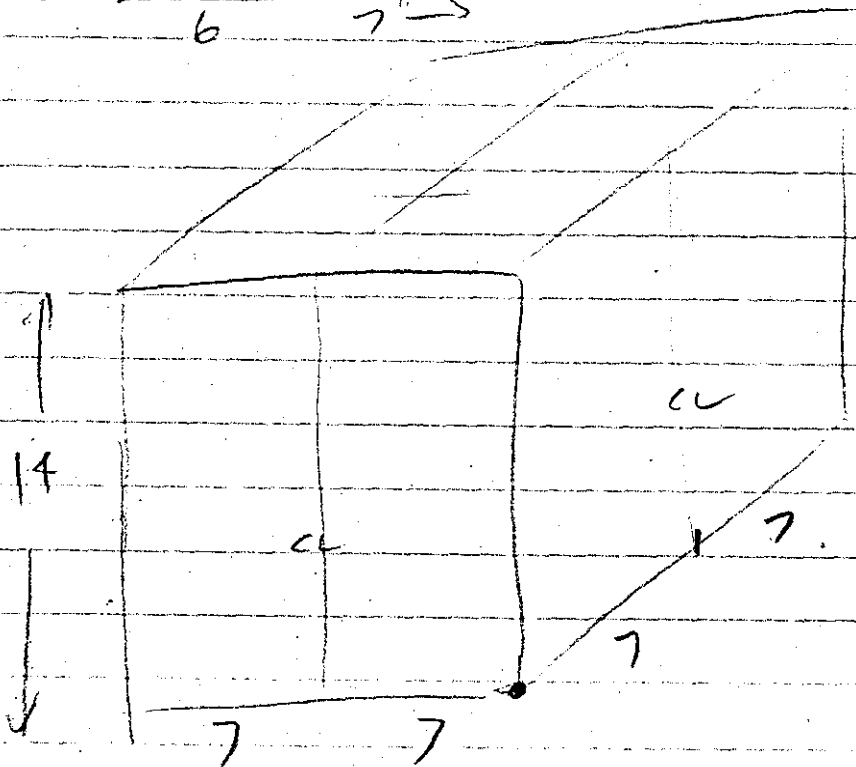
View from
SW corner

Source in $x=6$
 $y=6$
 $z=7$

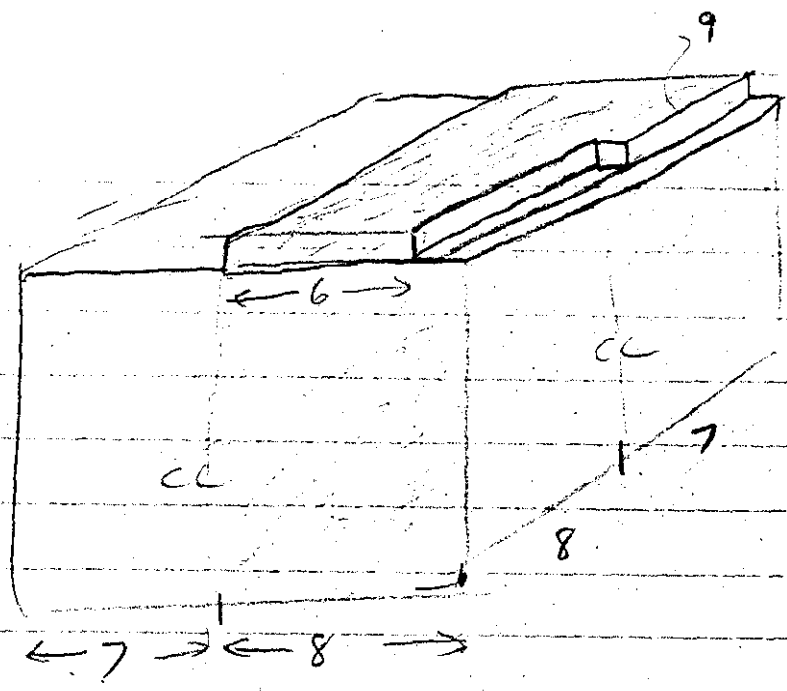
3x13x13



6x14x14



5x15x15



Bad cubes

99 bad cubes on top

15
14
2100

12
225
14
900
225
3150
199
3249
-15
3298

Sep of tables with + 1/8" al.	Dial	#1 counter		#3 counter		Time	
		#/2min	1000/4hr	#/2min	1000/4hr		
						5:15.	additional 1/16" al. sheet inserted between tables.
7"		146.	13.7.	484	4.13.	5:25	
3"		169.	11.8.	543	3.68		
0"		magnet unconf. d.					tables reassembled
1/16"	96.	195	10.2.	689	2.86.	5:45.	tables separated.
		192		704		5:46	one sheet of 1/16" al removed.
+ 1/16" d.							
3"		169.		554.			
0	105	206		758.		5:53'	
		199		751			
						5:55	Tables apart - Disassembly - started
	105			417		6:30.	Cubes taken away, source alone, on al. tube.
	100			413			

16

October 2, 1946

Experiment No. 5

tamped; 1:1 mixture, 30%.

8 x 8 x 8

People present:

Hull: Chief Experimentator } stacking
 Callahan: 2nd " }
 Visner: assisting, stacking
 Williams: assisting stacking and
 Lykins: instruments - ready
 Smith: instruments - left at 1242
 recording data

Location of instruments: same as Exp. No. 3 (p 11)
 Check list: see p 148

all table separations given here do not include the 1/16 in. Al.

(2 minute counts)

⁶⁴ Counts/min, No. 1.Finish
Time⁶⁴ Counts/min, No. 3.

Remarks on Setup, etc.

1138	21 1/2	Stacking, 1 st layer.
1141	20	" "
1201		Inst. check: all o.k.
1205	21	Stacking 3 rd layer
1207	21 1/2	" 4 th "
1209	22 1/2	" 5 th "
1210		Inst. check: all o.k.
1212	26 1/2	Stacking 6 th layer
1214	26	" 7 th "
1216	29 1/2	" 8 th "
1218	27 1/2	" 8 th "
1220	27	Finished Stacking; Tables apart
1222	30 1/2	Source moved during count
1224	24	Putting paraffin in place
1226	23	" " " "
1228	26 1/2	" " " "
1229		Inst. check: all o.k.
1232	46 45 1/2	Placing tamper (paraffin)
1234	47	" " " "
1236	47	" " " "
1238	28	" " " "
1239		Placing source in final position
1242	22 1/2	Tamping
1245	22	" " " "
1248	24	Stat. table tamped 2 sides & top Mov. " " 2 sides halfway

18

counts/2min No. 1 Recip.

Finish
Time

No. 3
counts/2min Recip.

Remarks

1525

53

Source in place; tamping continue.

1528

46

"

1531

42

"

1534

34

stat. table completely tamped

1537

34

1541

37

1544

34

ALL TAMPING COMPLETE.

1547

34

9 x 9 x 9 ; 1:1
(30%) mixture

1550

34

1552

Inst. Check: All O.K.

18

111

1555

36

556

Table Separation: 30 ⁵/₈ in.

91

1617

Inst. check: All O.K.

22

~~455~~

1622

40

500

Table Separation: 4 in.

17

118

1628

48

417

Scale Rdg. 110 (1/16 in)

~~Oct. 7, 1946~~

~~Experiment 6~~

19

~~Purpose: to determin-~~

in

TE,

in

20

October 3 1946

Experiment No. 6

Tamped 1:1 mixture: (30%) UF_6 & polyethylene
 Total separations do not include Al shield

(11 x 11 x 11 stack)
 666 cubes Green
 665 " white

People present:

Chief Experimenters: Callahan
 Other " : Beck
 Other " : Huel
 Assistant : Vianer
 " : Williams
 Instruments : Lykins, Smith

Location of instruments: same as for Exp. No. 3 (p 11)
 Check list: see p. 148

No. 1		Finish Time	No. 3		Remarks, etc.
$\frac{1}{2}$ M	Recip.		$\frac{1}{2}$ M	Recip.	
		10 36	12 4		
		10 38	12 8		Stacking 1 st layer
		10 41	13 5		Stacking 2 nd layer
		10 43	14 3		Stacking 3 rd layer
		10 45	14 5		
		10 47	15 3		Stacking 4 th layer
		10 49	15 6		
		10 51	16 8		
		10 53			Inst. Check: All O.K.
		10 55	17 4		Stacking 5 th layer
		10 57	17 9		
		11 00	18 2		
		11 02	18 6		Stacking 6 th layer & 7 th layer
		11 04	19 4		Stacking 6th layer 7 th layer
		11 06	19 4		Stacking 8 th layer
		11 08	19 5		
		11 10	20 1		
		11 12	20 2		Stacking 9 th layer
		11 13			Inst. Check: All O.K.
		11 15	21 0		
		11 17	20 9		Stacking 10 th layer
		11 20	21 2		Stacking 10 th & 11 th layers
		11 22	21 1		
		11 24	22 9		Source was moved during count
		11 27	17 2		" " " " 6 "
		11 30	18 5		" " " " "

No. 1

Finish
Time

No. 3

1/2M Recip 1/2M Recip

Remarks, Etc

Stacking Completed 11X11X11; ^{Tamping} Beginning.

Tamping

" , Source moved

" " "

" " "

Source in position; Stat. table ^{being} ~~completely~~ tamped
Tamping continues.

Much paraffin between source & No. 3 counter

Tamping completed on Stat. Table

Tamping of Mov. Table

" " " "

" " " "

" " " "

" " " "

" " " "

" " " "

" " " "

TAMPING COMPLETED

TABLE SEPARATION 32 1/2 in.

" " 32 1/2 in

Inst. check: All O.K.

TABLE SEPARATION 20 in.

" " 7 in.

" " 6 in.

" " 5 in.

" " 4 in.

Inst. check: All O.K.

TABLE SEPARATION 4 in.

" " 2 1/2 in.

Scale Rdg 89 (2 in.)

Scale Rdg 106 (1 3/4 in)

Scale Rdg 001 (1 1/2 in)

Scale Rdg 010 (1 3/8 in)

Scale Rdg 020 (1 1/4 in)

Scale Rdg 025 (1 3/16 in)

Scale Rdg 025

Scale Rdg 032 Source Jerk - slow

Scale Rdg 034.5 COUNTS MAINTAINED

off by 1/16"

1132 191

1134 194

1136 208

1138 265

1140 262

1142 241

1145 297

1147 405

1150 415

1152 440

1154 377

1156 94

1159 77

1201 79

1205 81

1207 80

1210 80

1214 80

1216 82

1219 77

1222 78

1227 80

1226 75

1238 73

1240

1247 96

1250 101

1255 116

1320

1326 128

1331 175

1335 229

1341 285

1349 420

1354 539

1401 904

1412 1359

1415 1369

26

770

267

274

43

465

208

44

455

198

49

408

172

49

408

156

64

313

114

84

238

87.4

96

208

70.2

136

147

47.6

177

113

37.1

288

69.5

22.1

431

1412

1.46

435

46.0

x

x

x

BLOCKS
CRITICAL

recovery
Source Jerk - slow
COUNTS MAINTAINED

No. 1

Finish Time

No. 3

1/2M Recip

1/2M Recip

Remarks
605 cubes white
605 cubes green

Rebuilt to 11 x 11 x 10 & Tamp
Inst. Check: All O.K.

25	800	1559	64		
25	800	1603	64	313	
38	527	1606	73	274	
39	513	1611	80	250	
45	444	1615	97	206	
55	364	1619	129	155	
		1621			
66	303	1625	166	120	
81	241	1630	213	94.0	
120	167	1635	325	61.5	
		1645			
		1646			
		1647			
		1648			
		1649			

TABLE SEPARATION	32 1/2 in.
"	7 in
"	5 in
"	3 in
"	2 in

Inst. check: All O.K.
TABLE SEPARATION

Scale	021	(1 1/4 in)
"	039	(1 in)
"	048 1/2	
"	058	
"	060	(3/4 in)
"	061	
"	062	
"	064	
"	065	Source OK
"	066	No 4 steady
"	067	
"	068	CRITICAL

Rebuilt to 11 x 10 x 10 & Tamp
550 green & 550 white

Inst. check: All O.K.
Table Separation 32 5/8 in.
7 in. } Table OUT
5 in. }

15	1330	1727	55	364	
16	1250	1735	60	333	
16	1250	1740	59	339	
		1741			
24	834	1749	63	318	
25	800	1753	68	294	
27	741	1758	91	220	
28	715	1804	104	192	
35	571	1808	128	156	
79	253	1814	315	68.5	

Inst. Check:	All O.K.
Table Separation:	7 in.
"	5 in
Scale Rdg.	088 (2 in)
"	000 (about 1/2 in)
"	036 (1 in)
"	076 (1/2 in)
"	087 (3/8 in)
"	092 S.I. falling
"	093 source out
"	095 (1/4 in)

1823

CRITICAL

24 Oct. 7, 1946.

Experiment No. 7.

Tamped and moderated; notes of 1:1 cubes
Purpose: to find more accurately the value of M_c . (previously ~ 510 by extrapolation)
Persons present.

Beck	-	Chief Experimentals	-	stacking
Murray	-	Ind. Experimentals	-	stacking
Vesni	-	Assist stacking	-	note-book!
Lewis	-	Instruments		

Location of instruments; same as exp. 3. (p. 11)

Stacking started 2:20 PM
First assembly 10x10x10
Finished 2:50 PM

Sep. of Tables	#1 counter	#3 counter	Time.	Conditions
inches. Deep	#/2min. ^{100%} / _{8min.}	#/2min. ^{100%} / _{8min.}		

32 1/16	-	311	1442	7 layers
		337	44	
		345	46	
		334	49	9 1/2 layers
		337	51	10 "
		338	53	started placing tamper
		335	55	
		289	58	moving source
		242	1500	
		245	04	
		245	07	
		207	09	moving source
		291	11	
		156	14	
		141	16	
		189	17	
		260	20	Source in, tamping continuing
		264	23	
		271	25	
		249	27	
		181	30	
		55	33	
		24	35	
		26	37	
		24	48	

The above data were taken in the process of tamping.

Separation of tables		# 1 counter		# 3 counter		Time	Conditions
inches	dial	C/2min.	recip.c	C/2min.	recip.c		
32 1/16	-	-	-	24	42	15 48	Completely tamped halves, separated. <u>500 T's</u> , <u>500 H's</u>
20	-	21	48	25	40	15 54	
7	-	29	34	30	33	15 57	
5	-	30	33	32	31	16 01	
3	-	29	34	34	29.5	16 04	
2	79	29	34	36	27.8	16 08	
1	28	32	31	44	22.8	16 11	
≈ 1/2	67.5	41	24.5	58	17.2	16 15	
≈ 3/8	85.5	54	18.5	75	13.3	16 20	
≈ 1/4	97	74	13.5	105	9.5	16 23	
≈ 1/8	107	118	8.9	164	6.1	16 27	
≈ 1/16	112	188	5.3	260	3.9	16 33	
≈ 1/32	114	201	5.0	280	3.6	16 40	
0	117.5	245		337	3.0	16 43	
Continued to add 1/16" of inch to sep.						16 55	NOT QUITE CRITICAL Exp. 7 B. Al. shield removed.
32		18	56	27	37.	16 58	
20		21	48.	27	37	17 02	
7		29	34.5	31	32.3	17 05.	
4		31	32.3	33.	30.3	17 09.	
2.	80	30	33.3	36	27.8	17 10.	Instrument check.
1	35	34	29.4.	45	22.2.	17 14	
≈ 1/2.	80	47	21.3	64	15.6.		

26 Separation of Tables.		#1 Counter		#3 Counter		TIME
INCHES.	DIAL	$\frac{1}{2}$ mm.	Rec.	$\frac{1}{2}$ mm.	Rec.	
1/4 +	97	64.	156.	88	12.9.	1720
1/8 +	107	95	10.5	131	7.6	1726
0 +	117 1/2	241	4.2	334	3.0.	1735
-1/32	120	572	1.7	761	1.3	1745
Al shield put back. Add 1/16 to all distances						1748.
						1810
						1812
7.		29	34.5	30.	33.3	1816.
2.	80.	32	31.2	37.	27.0	1820
1	35	39	25.6	50.	20.0	1823
1/2 - 3/16.	76	60	16.7	81	12.4.	1825
1/4	97	123	8.1	160	6.3	
1/8.	108	509	2.0 1.9	681	1.5	
1/16.	112					

Tables making contact.
Dis-assembled. Not Critical
12 green cubes added
to south face
Instrument check,
Exp. 7C.
512 green cubes.
512 white cubes.

source out. Critical

Conclusions of the experiment.

- The critical assembly for tamper and moderated ($H/T = 1$) contains about 506 ± 6 green cubes. 7.84 Kg X
- The 1/16" Aluminum guard is equivalent to a 1/16" air space.

$$M = \frac{S}{c}$$

$$C = cM^{-1} =$$

112

28 Oct, 8, 1946 Experiment # 8

Conditions: Tamped, Moderated, Ratio H/T cubes = $\frac{1}{2}$.

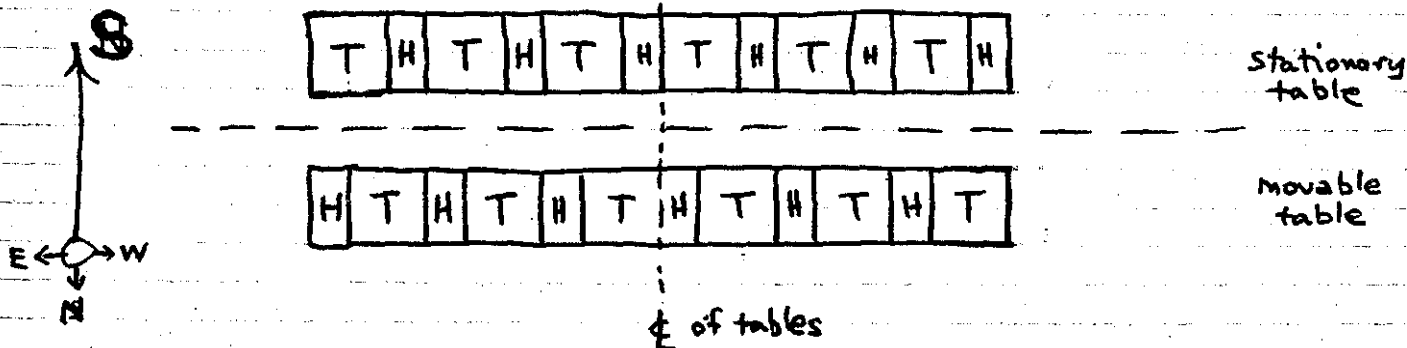
Initial trial dimensions 10 x 9 x 9

Persons present: Callihan - chief experimenter, stacking
Murray - experimenter, records
Visner stacking
Williams assist in stacking
Smith - instruments

Location of instruments: same as in experiment 3, p. 11.
Stacking started at \approx 10:25 AM.

Method of construction:

Bottom layer composed of alternating rows of these types:



Successive layers composed of alternating rows, in the vertical plane, of the same two types.

when assembled, complete layers look as follows:

stationary

T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T

Layers 1, 3, 5, 7, 9

$$T's = 60$$

$$\frac{1}{2}H's = 60$$

$$(H's = 30)$$

$$total = 90$$

movable

⊕

stationary

H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H
H	T	H	T	H	T	H	T	H	T
T	H	T	H	T	H	T	H	T	H

Layers 2, 4, 6, 8

$$T's = 60$$

$$\frac{1}{2}H's = 60$$

$$(H's = 30)$$

$$total = 90$$

movable

Array as a whole:

$$no. of layers = 9$$

$$T's = 540$$

$$\frac{1}{2}H's = 540$$

$$(H's = 270)$$

$$total = 810 = 9 \times 9 \times 10$$

Exp 8, Oct. 8, 1946

counts while initial stacking in progress:

Instrument # 3, time interval 2min., counts x64.

time	C	time	C	time	C	time	C
10 30	315	10 51	363 (4 layers)	11 17	167	11 43	139
32	308	53	364	19	164	45	143
35	319	56	367	21	163	48	112
37	333	58	373	24	165	50	75
37½	(source moved)	11 00	374	26	164		
39	354	11 03	380	29	175		
41	356	11 05	381	31	171		
44	357	11 08	381 (8 layers)	33	164		
46	360	11 10	384	38	171		
48	363	12	386	41	173		
		14	378				

(source moved here)

* does not include 1/16" Al.

Separation of tables		#1 counter		#3 counter		Time PM	Conditions
inches *	dial *	c/2min	recip.c	c/2min	recip.c		
32.	77 1/4	19		26		12:35	Cables apart.
15		24		28		12:42	↳ Exp. 8 A
7		28	35.7	30	33.3	12:47	
3		22	45.5	29	34.5	12:52	
2 1/16.		21	47.6	28	35.7	12:56	Instrument checked
1	37.0	16	62.5	27	37.0	1:05	
1/2	77.5	14	71.4	26	38.5	1:10	
0	116 1/2	11		26	38.5		NOT CRITICAL Tables Apart. Exp. 8A & B Added two layers, each containing 60 T's, 60 1/2 H's to whole assembly. Now 660 T's, 660 1/2 H's or total of 990 = 11 x 9 x 10 Assembly complete. bot. Check.
32.		18		25		1:55	
15.		24		28		2:00	
7.		26	38.5	31	32.3	2:04	
3.		22	45.5	30	33.3	2:07	
1	37.	17	55.9.	29	34.5	2:10	
1/32.	115					2:18	Magnet detached. Tables separated.
0	116	13		27	37.0		Tables brought together. NOT CRITICAL

Exp 8, Oct 7, 1946

31

Separation of tables		#1 counter		#3 counter		Time (pm)
inches	dial	1/2 min	recip. c	1/2 min	recip. c	
		Finished washing & ramping				3:15
32		21		29		3:19
15		27		31		3:22
7		34	29.4	35	28.6	3:26
3		30	33.3	34	29.4	
~1/16	113	24		44		3:35
	115 1/2					
32						
32		27	37.1	25	40.0	4:34
15		35	28.6	29	34.5	4:39
7		43	23.3	31	32.3	4:43
3		45	22.2	34	29.4	4:47
1	37	59	17.0	43	23.3	4:50
1/2	77	86	11.6	62	16.1	4:54
1/4	97	138	7.2	89	11.2	4:59
1/8	108	192	5.2	127	7.9	5:04
0	115	276	3.6	179	5.6	5:09
		INSTRUMENT CHECK			O.K.	
32		27	37.0	25	40.0	5:20
7		45	22.2	33	30.3	5:25
3		47	21.3	37	27.0	5:28
1	37	69	14.5	50	20.0	5:32
1/4	97	232	4.3	156	6.4	5:36
1/8	107	514	1.9	337	3.0	5:40
0	115	176/min		161/min		5:44
0	115 1/2	349		318		5:53
						5:54

Conditions
Exp. 8C

Added 3 layers to side, containing 220 T's, 220 1/2 H's, whole assembly. Now 880 T's, 880 1/2 H's or a total of 1320 = 11 x 12 x 10
H E-W N-S.

Exp. 8D

Added 3 layers to back, on stationary table, each containing 88 T's, 88 1/2 H's. Now, 1144 T's, 1144 1/2 H's, or a total of 1716 = 11 x 12 x 13
H E-W N-S

Tables separated
NOT CRITICAL

Exp. 8E

Added 1 layer to top of moveable table. 40 T's, 40 1/2 H's Now 1184 T's, 1184 1/2 H's or a total of 1776
12 E-W, 13 N-S, 11 2/3 High

SOURCE REMOVED

Counts for ONE MIN
TWO MIN

CRITICAL

Tables separated

Oct 8, 1946

Conclusions: The critical mass of a tamped, moderated assembly composed of H cubes and T cubes in the ratio of $1/2 / 1$ is, in Tube units, 1184 ± 2 . Result determined by reaching criticality with complete closure ($-1/8$)
 Assembly had 1184 T's

1184 $\frac{1}{2}$ H's (592 H spaces)

total 1776 cube units = $12 \times 13 \times 11 \frac{5}{13}$
 E-W N-S height

This is about 18.5 kg of X.

18.2 kg

Assume assembly would be critical at zero closure with 10 green cubes less -

CM = 1174 green cubes = 18.1 kg U235

De

1184
 - 10
 1174

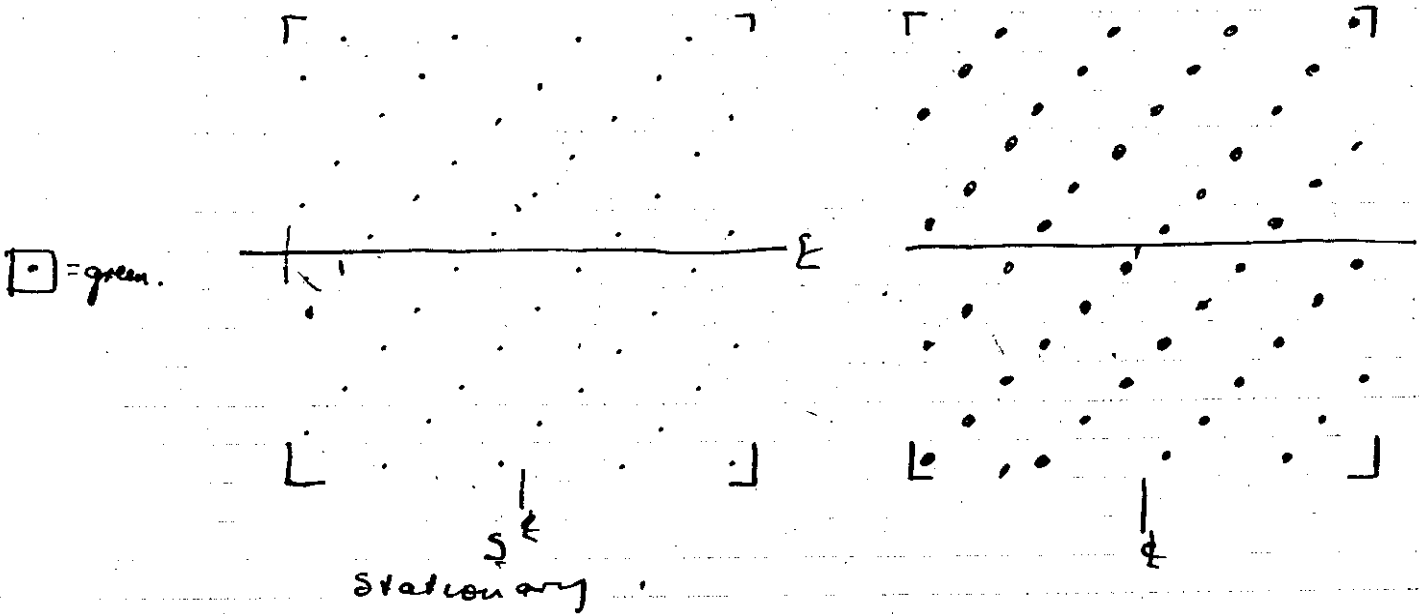
Experiment 9

Oct. 9, 1946.

Stacking started 9:30 A.M.

Conditions: Tamped, moderated. H/T cube ratio = 2/1

Initial dimension 12 x 12 x 12
N



Bottom layer
also 4, 7, 10

Second layer
also 5, 8, 11.

Persons Present:

- Beck.
- Hull
- Viner.
- Williams.
- Zikus.

experiment
experiment

stacking.
records.
stacking.
instrument.

Location of Instrument

Same as in experiment 3, p. 11.

Successive layers are built by advancing the previous layer one row to the East.

No of cubes in initial assembly.

4 x 12	= 48	T cubes	per layer.
48 x 12	= 576	T cubes	in assembly.
	96	H cubes	per layer
	1152	H cubes	in assembly.

34

Counts while initial stacking in progress

Instrument # 3. Time interval

EXPERIMENT 9A

Separation of tables Inch.	DIAL	#1 Counter.		#3 Counter.		Time	
		c/2min	1000/c/m.	c/2min	1000/c/m.		
32.		28		39		11:10	Assembly 12x12x12 completed. 576 T cubes = 8.93 kg X 1152 H cubes. 8.84
20		38		44		11:15	
10.		58	34.5	54		11:18	
7		75	26.7	66	30.3	11:22	
5		116	17.2	101	19.8	11:25	
4		227	8.8	193.	10.3	11:30	
3 5/16.						11:35	<u>Critical Disassembly</u> EXPERIMENT 9B. Removed top layer and west layers on each table. Removed 92 T cubes (184W)
	11 High	}		484	T = 2.50	11:45	
	12 N-S.			968	kg X		
	11 E-W.						
32.		21		28		24:33	11 x 11 x 2 H E-W N-S CRITICAL Disassembly Experiment 9C. Removed 2 layers on south side. Removed 80 T cubes, and 162 H cubes. New assembly is - Contains: 404 T cubes = 6.25 kg X 806 H cubes Assembly complete.
20		27		30		24:37	
10		36		36		24:40	
4		61	32.8	57	34.5		
2 1/2.		215	9.3	203	9.9	24:55	
2 3/16							
						13:25	11 High. 10 N-S 11 E-W.
20		20	53.3	27	32.2	13:28	
7		30	66.7	31	64.5	13:32	
3.		35	57.2	37	54.1	13:38	
1 1/4.	17	172	11.6	161	12.4	13:43	
1 1/10"	29 1/2						<u>Critical Disassembly</u>
		Removed	71	T Cubes; one layer from top.			140 H cubes - one layer from west side.

36 operation of Tables.		#1 Counter		#3 Counter		TIME.	
rch.	Dial.	c/am.	Rec.	c/am.	Rec.		
New assembly is							Experiment 9D.
		393	T cubes.	5.78	Kg X	14:20	10 high
		666	H cubes.			14:24	10 N-S.
						14:27	10 E-W
7		28	35.7	32	31.3	14:30	Instrument check.
2	90.	31	32.3	37	27.0		
1	37 1/2	43	23.3	51	19.6		
1/2"	77 1/2	58	17.3	170	5.9		
3/8"	88					14:36	CRITICAL. Disassembly.
Removed one layer from West side of moveable table.							Experiment 9E.
Removed 20 T cubes.							
Removed 40 N cubes.							
New assembly contains.							481
						313	T cubes. 4.85 Kg X.
						626	H cubes.
							10 high
							10 N-S.
							9 E-W moveable; 10 E-W stationary.
						14:55	Instrument check.
3"		26	38.5	33	30.3	15:00	
1"	38.	30	33.3	42	23.8		
1/2"	77	47	21.3	63	15.9	15:06	
1/8"	107 1/2					15:10	CRITICAL
Removed 10 T cubes from West side of stationary table and replaced with white.							Exp. 9F.
New Assembly contains.							466
						303	T cubes 4.70 Kg X.
							10 high
							10 N-S
							9 E-W moveable; 10 E-W less 10 T cubes, stationary.
						15:21	Instrument check, OK.
2"		25	40.0	35	28.6		
1/2"	78	39	25.7	56	17.9		
1/4"	97	71	14.1	99	10.1		
	114.						Closest tables can approach.
0	117						considered critical

Conclusions of Experiments 9 A-F

303 T cubes with moderation $H/T = 2/1$
 will go critical with $1/8"$ Al between
 tables.

Result determined by approaching within
 $3/8"$ of closure with 303 T cubes and reaching
 the verge of criticality.

This is
 all points taken lie on a straight
 line (c.m. vs. separation of tables).

10.

9X.

ing.

K.

act.

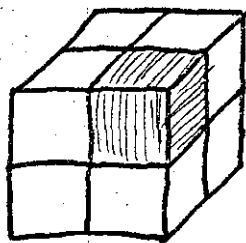
Conditions: Tamped, moderated, ratio $H/T = 7/1$,
 Initial trial dimensions $14 \times 14 \times 14$.

Persons present Callihan - chief experimenter
 Murray - experimenter
 Visner
 Williams
 Smith - instruments

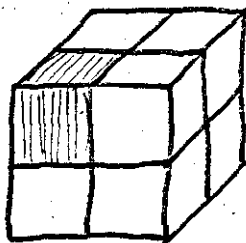
Location of instruments same as experiment 3, p. 11.

Method of construction

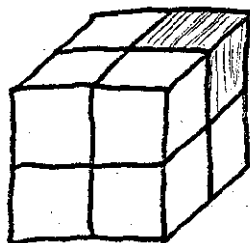
Consider a cubical array of 8 cubes ($2 \times 2 \times 2$) as the "unit." Four types of units were used, each having a bottom layer of 4 all white, with the top layers having the green cube in the 4 possible orientations.



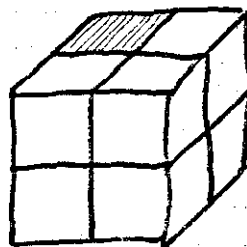
TYPE A



TYPE B

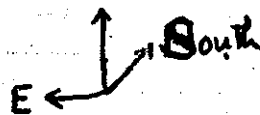


TYPE C

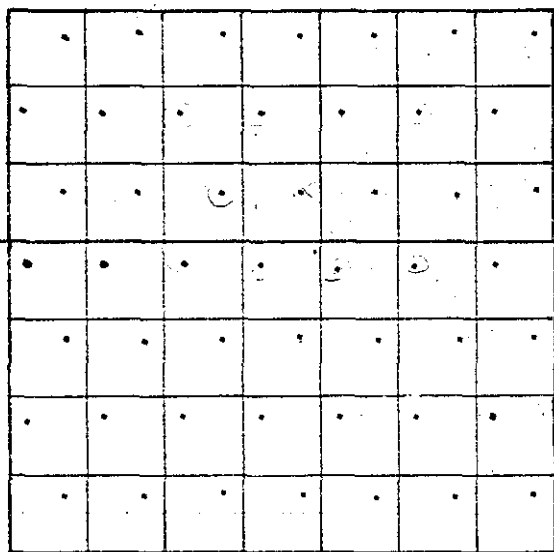
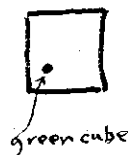


TYPE D

This view is as from the control room, i.e.
 "Layers" are composed of arrangements of
 these units in a horizontal plane.



the initial array was thus

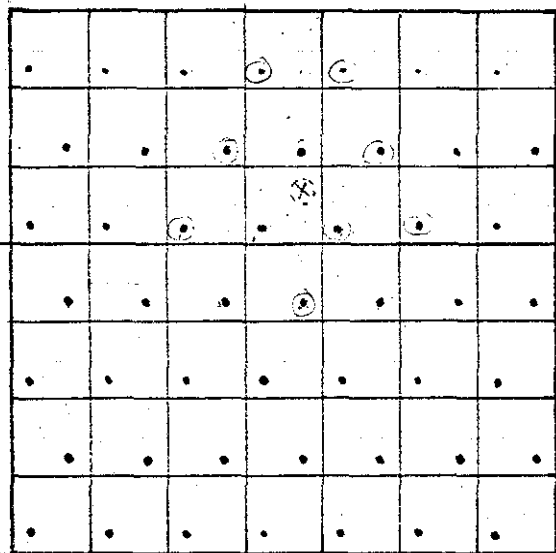


"layers" 2, 4, 6

each contains 49 T's
 $7 \times 49 = 343$ H's

total of 392 = $2 \times 14 \times 14$ cubes

⊥ of table



"layers" 1, 3, 5, 7

each contains 49 T's,
 $7 \times 49 = 343$ H's

total of 392 = $2 \times 14 \times 14$ cubes

Array as a whole contains

$$7 \times 49 \text{ T's} = 343 \text{ T's}$$

$$7 \times 343 \text{ H's} = 2401 \text{ H's}$$

2744 total cubes

$$= 14 \times 14 \times 14 \text{ (cube units)}^3$$

H E-W N-S

Counts on instrument # 3 during stacking:
(2 minute intervals) Started 10:54 A.M.

time	C	time	C	time	C	time	C
10 54	50	12 36	46	14 32	39		
56	51	38	48	35	41		
58	53	41	47	37	39		
11 01	52	44	54	39	39		
03	53	46	55	41	38		
05	52	48	53	43	59	{ source removed	
08	54	51	53	46	111	{ source removed	
10	54	53	53	51	29	{ source back	
12	56	56	53	53	28		
15	55	58	55	56	24		
17	54	13 01	57	58	23		
19	51	03	54				
21	52	05	54				
24	53	08	52				
26	57	11	53				
29	59	13	55				
31	58	16	55				
33	58	39	54				
36	56	42	55				
38	56	45	52				
43	54	47	52				
46	55	50	52				
49	55	53	53				
52	58	56	53				
56	57	59	58				
59	59	14 01	55				
12 06	33	03	55				
08	40	05	56				
10	41	07	55				
12	42	10	55				
15	41	12	55				
17	43	14	45				
19	42	16	42				
22	44	19	42				
24	43	21	41				
26	45	23	42				
29	47	25	41				
31	47	27	41				
33	48	30	40				

{ 10
layers
done

{ stacking
done

{ stamping
started

Crew assembled at 3:05 pm

Separation of tables		#1 counter		#3 counter		Time (pm)	Conditions
inches	dial	c/2 min.	recip. c	c/2 min	recip. c.		
	117.5						Experiment 10A
32		16		23		305	
15		21		26		308	
7		22	45.5	26	38.5	313	
3		17		26		318	
1		14		25			
0	113	16		31			
							very far from critical. Decided to tear down and go home, owing to the lateness of the hour.

Oct. 11, 1946.

Conditions: Tamped, Moderated ratio $H/T = 7/1$

Initial dimensions for day N-S = 16
E-W = 16
High = 16 (effective).

Persons Present

Hull	- Chief experimenter	- stacking
Callahan	- Second experimenter	- stacking
Vasni	- records	
Williams	- assist stacking	
Lewis	- instruments	

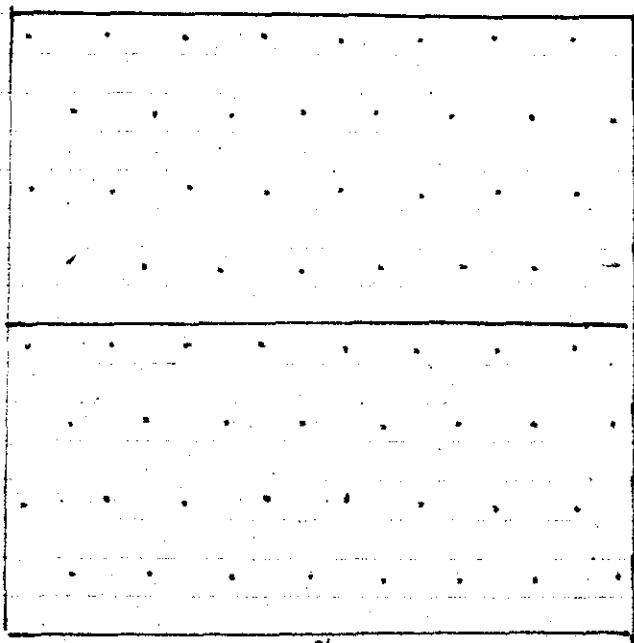
Location of Instruments. Same as exp. 9. p. 11.

Method of construction.

The types of cube units (8 cubes) described p. 38 exp 10. were used.

The first layer of white cubes were omitted and the tamped on the bottom was considered to also act as a layer of white moderator.

Layers are composed of arrangements of 8 cube units.



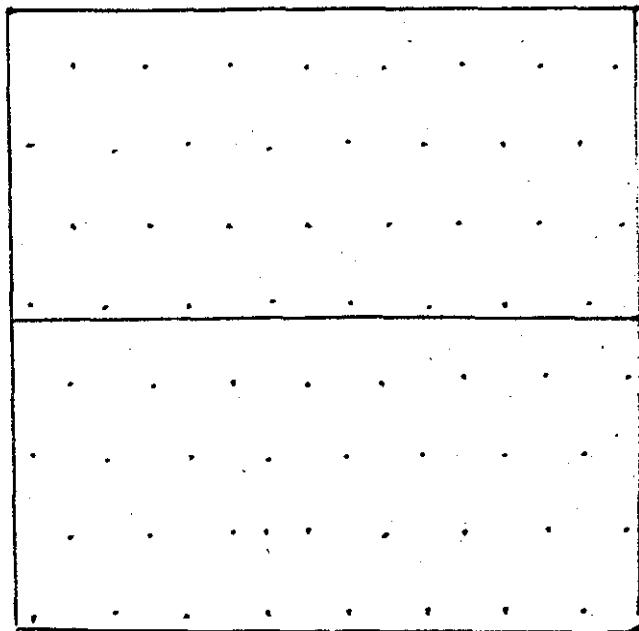
Layers 1, 3, 5, 7, 9

S
N

S

$\frac{64}{8}$
512

45



Layers 2, 4, 6, 8

E

N

$$\begin{array}{l} \text{T cubes} = 8 \times 8 \times 8 = 512. \\ \text{H cubes} = 3584. \quad (3328 + \text{finger}). \end{array}$$

16-16-16
H N-S E-W

Counts on Instrument # 3 during stacking
2 minute intervals.

Counts	Time	
314	0915	stacking started.
287	0925	
297	0936	
311	0956	5 th "Layer"
209	1003	6 th "Layer"
120	1011	7 th "Layer"
122	1017	
145	1028	8 th "Layer"
154	1033	
225	1035	stacking completed
209	1037	
188	1039	
186	1041	
186	1043	
182	1045	tamping started
218	1047	source moved
302	1051	" "
295	1053	" "
320	1055	" "
151	1057	
151	1100	source moved
331	1103	tamper removed
340	1105	
25	1109	Counts on Instrument # 1 stacking completed + tamper nearing completion
22	1112	
23	1115	
24	1117	
21	1119	
22	1121	
22	1123	
22	1125	
22	1132	
23	1137	
23	1139	
24	1141	
22	1143	
23	1145	
22	1147	
24	1149	assembly finished.

Sep. of Tables Inch.	Dial.	#1 Counter		#3 Counter		Time
		1/2 min	Rec.	1/2 min	Rec.	
32.		22		31.		12:35
15		31		39		12:40
7		37	27.0	42	23.8	12:45
4		38	26.3	47	21.3	12:50
1.85	94			65	15.4	12:54
0.85	48					13:20
0.85	49.					

Conditions
 Exp. 10 B.
 Just checked OK.
 (SIT)
 #1 counter not working
CRITICAL.
 Dis. assembled.

32.	Removed Removed Assembly	17	top layer 64 T cubes contains 448 cubes.	4	of each table.	13:50
76						13:52
7"						14:00
5/16	90.					14:10
						14:12
						14:17

Exp 10 C.
 16 x 16 x 14
 E-W N-S H
 Instrument check, OK.
 source jerked, cable stuck.
 tables apart. released cable.
CRITICAL.
 Dis-assemble

0.116	Removed vertical layer New assembly EW 16	111	contains N-S 15			14:50
0.06"						15:00
0.04"	112					15:03
	Estimate 114 on dial					15:05
						15:14

Experiment 10 D
 on south side; 32 T cubes
 412 T cubes, = 6.39 Kg.
 10 gm 14 real
 Assembly complete,
 Magnet uncoupled,
 Magnet reassembled,
 Exp. resumed,
 Almost critical,
 to critical

15
 16 x 14 x 14
 E-W N-S H

Conclusions:

For a tamped assembly moderated at a ratio of $H/T = 7/1$ the critical mass is estimated at 406 T cubes = 6.29 Kg. X. with a $1/16$ " al sheet in assembly.

EXPERIMENT 11

Oct 12, 1946

Conditions: Tamped moderated, ratio $H/T = ca \frac{4}{1}$
 $N_H/N_x = 114/1$
 Initial trial dimensions: 12 N-S
 12 E-W
 11 High

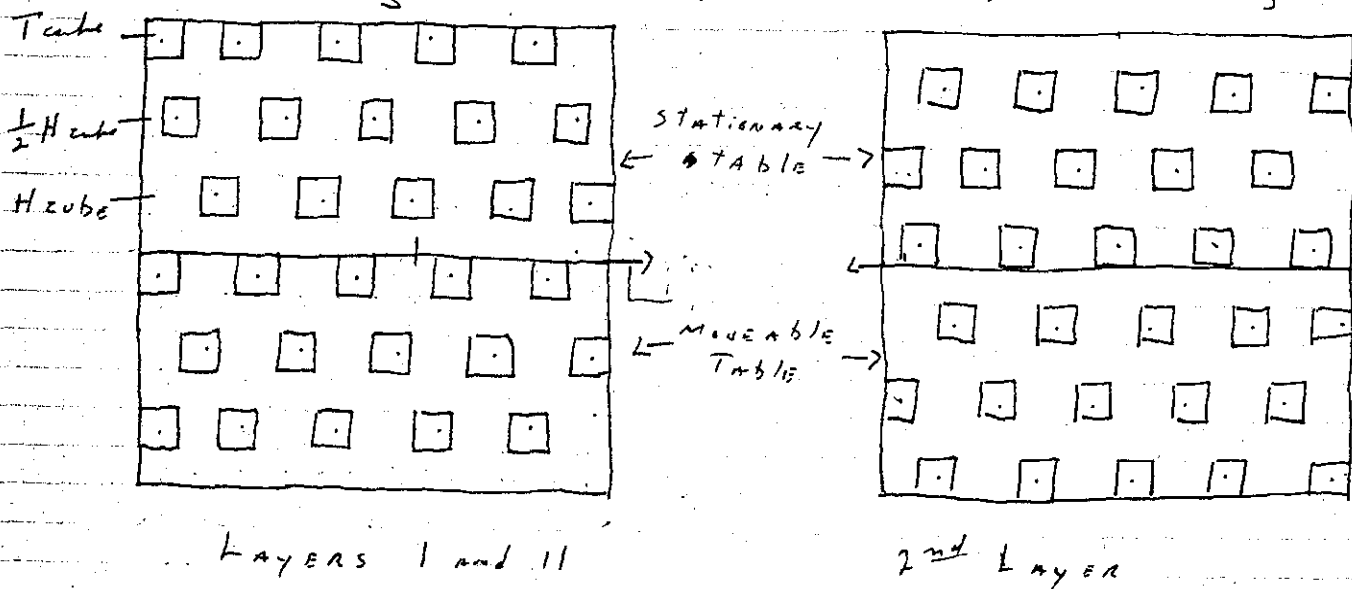
PERSONS PRESENT:

Zalligan: Chief experimenter
 Beck: experimenter - stacking
 Schmidt: stacking
 Smith: instruments
 Williams: Records

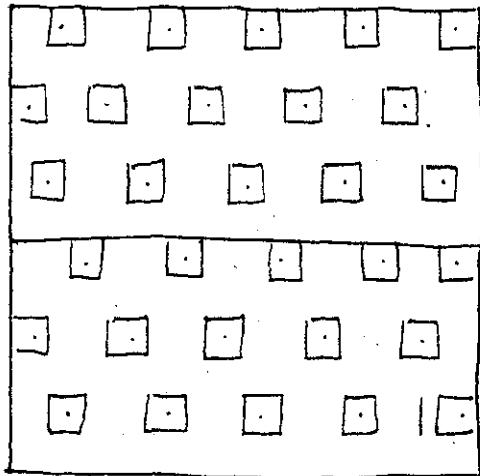
Locations of instruments same as experiment #3
 p. 11

Method of construction:

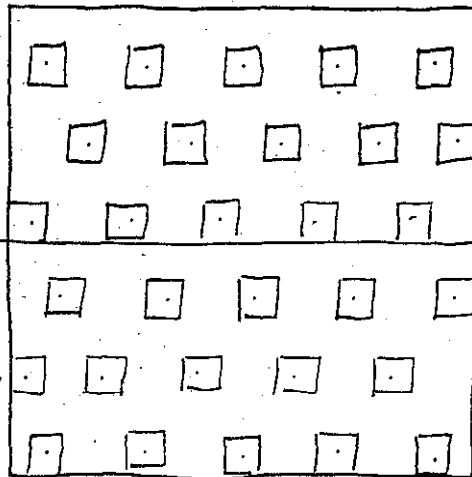
THE LAYERS, FROM BOTTOM UP WERE AS FOLLOWS:



N

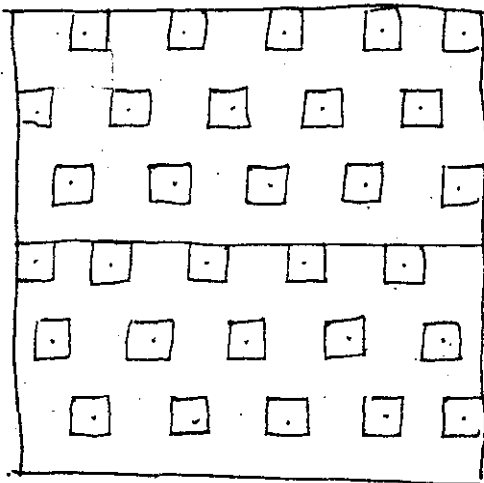


5th LAYER

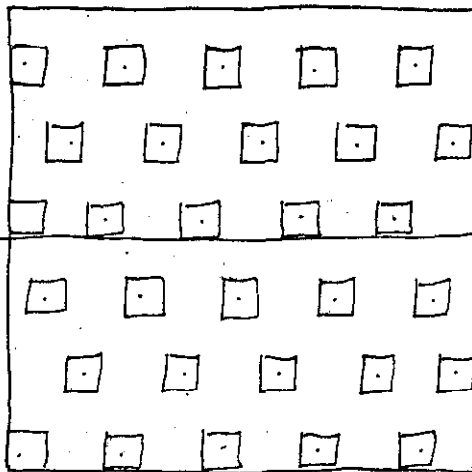


4th LAYER

← Movable Table →



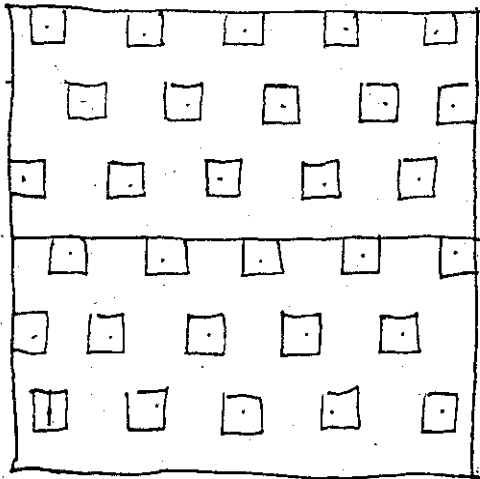
3th LAYER



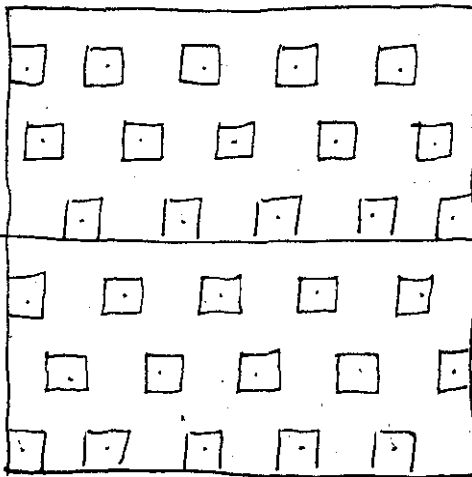
6th LAYER

E

W



7th LAYER

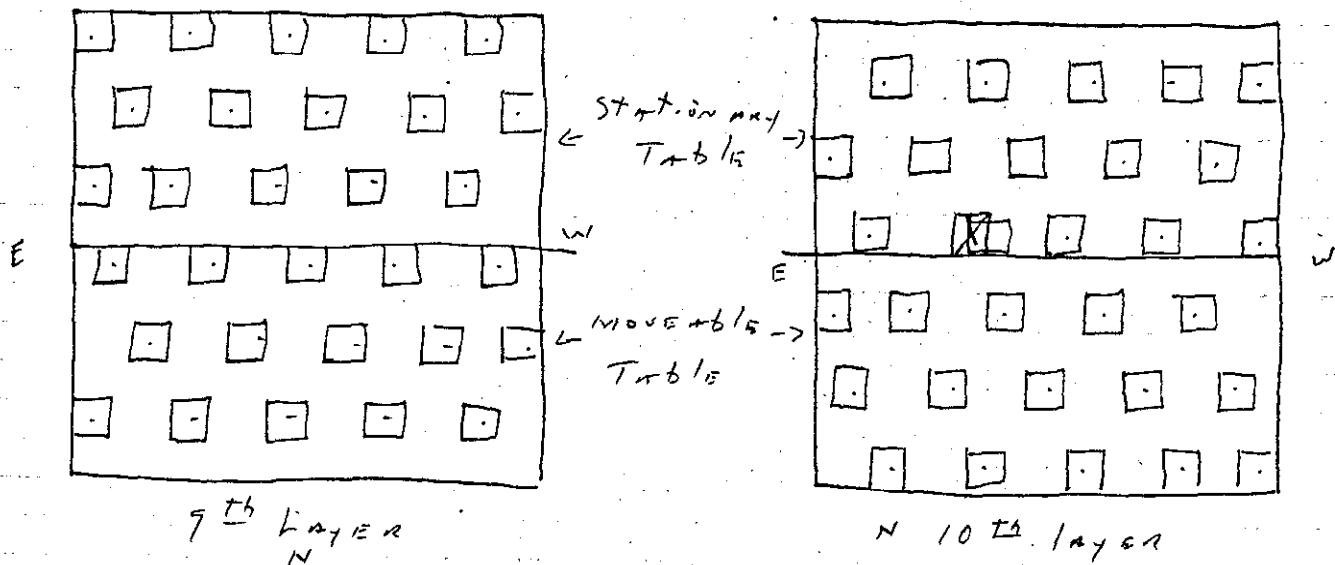


8th LAYER

X

S

S



Counts on No 1 instrument during stacking:

Time	Counts PER 2 MIN	Remarks	Time	Counts PER 2 MIN	Remarks
0838	7		1035	21	
841	6		1039	21	
855	42	POT SOURCE ON TABLE	1042	18	
858	40		1046	17	
905	39	Stacking	1049	17	
911	37		1054	18	
918	40		1100	18	
924	40		1103		
932	41		1106	17	Inst. check OK. Tamping comp.
937	40				
942	41				
979	41	Laying 6 th layer			
955	41				
1001	41				
1007	42				
1012	42				
1016	43				
1021	42				
1024	42				
1032	34	Stacking Comp. Tamping began SOURCE in PLACE			

Separation of Tables		#1 Counter		#3 Counter		Time	REMARKS
Inches	Dial	1/2 min	Recip L	1/2 min	Recip L		
32		18	5	24		11:19 AM	Exp. 11 A 330 = Total T's 1254 = Total H's $N_H/N_T = 114/1$ ARRAY = 11 x 12 x 12 <u>Critical</u>
15		22		27			
7		26	38.5	30	33.3		
3		28	35.7	32	31.3		
1"	38	83	12.05	79	12.7	11:41 AM	
0.67"	64						
							Exp. 11 B 300 T cubes 1152 H cubes 30 T cubes removed from south side. Net the array is 11 x 11 x 12 Instrument check O.K.
7		21	47.6	28	35.7	12:40	
3		23	43.5	27	37.1	12:42	
1"	38.5	34	29.7	35	29.6	12:45	
0.42"	85.25					12:53	
						1:00 P.M.	<u>Critical</u>
							Exp. 11 C 264 T cubes 1067 H cubes ARRAY = 11 x 11 x 11 Removed 36 T cubes from West side of array. (Replaced T cubes with H cubes) Instau. check O.K.
7		22	45.5	27	37.1	1:28	
3		19	52.6	25	40.0	1:40	
1"	38	19	52.6	24	41.6	1:47 P.M.	
0.05"	115					1:54	
						1:55	Instau. check O.K.
							Not ^{that} critical (indication was it was almost critical)
							Exp. 11 D 270 T cubes 1061 H cubes ARRAY 11 x 11 x 11 Replaced 6 H cubes with 6 T cubes on west side in original T cube position Instau. check O.K.
0.6"	112.5					2:20	Instau. check O.K.
						2:30 PM	<u>Critical</u>

Conclusion:

For a stamped, moderated assembly with a
 H/T_A ratio of T_1 , the critical mass as determined by the
 extrapolation of the "Mc vs Dist. of SEPARATION" CURVE, is
 265 30% extra or 4.1 Kg of X when separated
 by a $1/16$ " Al sheet.

Experiment 12. Monday Oct 14.
 Tamped, Medicated, 1/2:2 white to green.

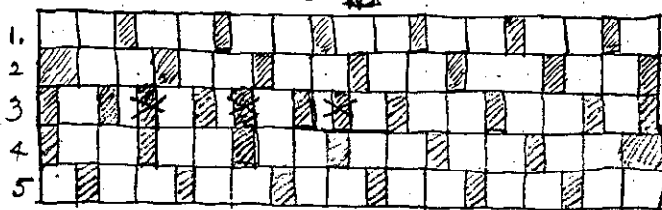
People Present.

Beech - Chief Experimenters
 Murray -

Viani
 Williams

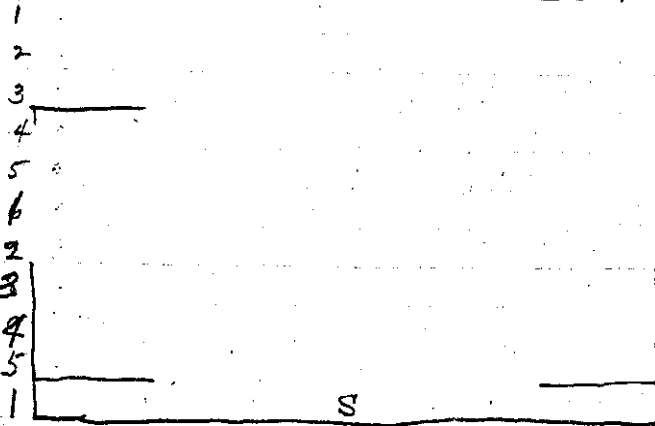
Fisher

A. Beginning Assembly 16" x 16" x 16" (height).



▨ = 1/2 white cubes.

E



W.

Tier 1

E-W Rows

Tier 1	Tier 2	Tier 3	Etc.	Greys
1	5	4	3	2
2	1	5	4	3
3	2	1	5	4
4	3	2	1	5
5	4	3	2	1
6	5	4	3	2
2	1	5	4	3
3	2	1	5	4
4	3	2	1	5
5	4	3	2	1
1	5	4	3	2
2	1	5	4	3
3	2	1	5	4
4	3	2	1	5
5	4	3	2	1
1	5	4	3	2

16
 16
 16
 16
 256

In each successive tier, the E-W rows shift 1 row North.

EW Row	contains	greens	whites
1		13	3
2		12	4
3		12	4
4		12	4
5		13	3

Tier	contains	greens	whites	total
1		91	21	112
2		8	108	116
3		78+120	18+40	198
4				198
5				198
6	repeats			198

794
 3175 T cubes.

Time	Count	Monitoring	during	stacking	(2 min intervals)
1155	32	4 th Layer		1427	48
1247	32	10 th Layer			
1308	45	15 th Layer	Source Moved	1452	46
1345	44	Stacking	complete		

Separation Of Tables		#1 counter		#3 counter		Time	Conditions
inches	Dial	1/2 min		1/2 min			
Experiment 12A							
3 1/2		25	30.0	29	65.9	15:12	
15.		36	55.6	34	58.8	15:18	
7.		48	41.7	43	46.5	15:21	
3		71	28.2	68	29.4	15:26	16 x 16 x 16
2	88	124	16.1	117	17.1	15:32	
1 1/2	101	312	6.4	305	6.6	15:40	
13/2	9	512	3.9	507	3.9	15:47	
1 1/4	19					15:55	<u>CRITICAL</u> . Disassembled
Exp. 12B.							
Removed		568		T cubes		Two layers from top; one layer from South.	
New assembly		2606		T cubes		= 40.4 Kg X	
3		42	47.6	37	54.1	17:00	Instrument check OK
~2	88	48	41.7	42	47.6	17:08	14 x 15 x 16
~1	130	71	28.2	60	33.3	17:15	
1/2	77 1/2	172	11.6	144	13.9	17:20	
0.24"	98 1/2						<u>CRITICAL</u> , disassembled
Exp 12C.							
Removed		121		T cubes		one layer from West face.	
New assembly		2485		T cubes		= 38.5 Kg X	
		1812		Instrument Check OK			
~2	82	41		32	1818		14 x 15 x 15
0.23"	100	173		128	1825		
	113				1830		Tables
	115				1830		Mag. clutch released. offset
					1850		Magnet engaged.
					1840		Tampers re-aligned.
							Tables separated; mag. clutch dis-engaged.
							Almost critical
Beck estimates 2495 cubes as critical.							

5

123

2100

19

14

Conclusion

For a tapered assembly, moderated
 at a ratio of H/T cubes = $1/2/2$,
 The critical mass is estimated at 24.95 cubes
 by extrapolation of CM vs separation curve.
 (1/16" Al separation).

Extrapolation to true zero $\rightarrow 24.50$ cubes = 37.7 Kg @ 0.235

38.3
 $38.9 \text{ Kg} / 1.5$
 25.9
25.9

Experiment 13 Thursday Oct. 17, 1946

Tamped, moderated, H/T cubes = $1/7$
 Initial dimensions 15x15x16.

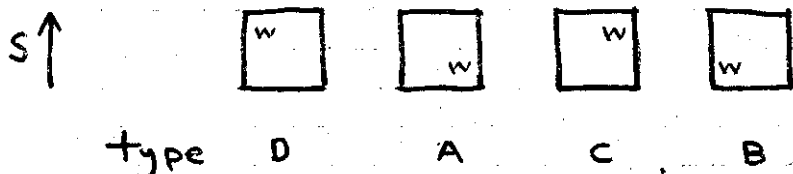
Present - Callihan chief experimenter
 Murray experimenter
 Williams
 Visner
 Smith instruments

In view of the belief that the array could not be made critical, a source was put inside the pile, and multiplication extrapolation measurements planned.

Construction of assembly.

Alternate layers, all green, T cubes, ie 1, 3, 5, 7,

Alternate layers 2, 4, 6, 8, ... one white H cube for each 3 green T cubes, in four configurations



See p. 61 for diagram of these layers

Composition of assembly

	total T's	total H's
8 All green layers each with 16x15 = 240 T's	1920	0
7 mixed layers, each with 180 T's, 60 H's	1260	420
	3180	420
	— Source cube 1	
	3179	420
	16x15x15 = 3600	

to preserve $1/7$ ratio, should consider that a part of the paraffin is the necessary moderator

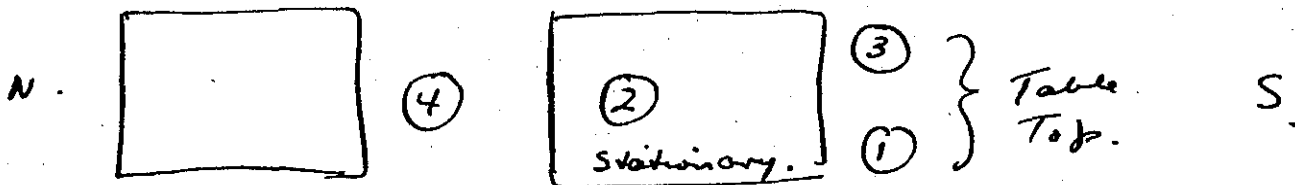
$16 \times 15 \times 15 = 3600$
N-S E-W H

Tamped, moderated. $1/7$ cube ratio H/T .

People present:

Callahan
Murray
Visser
William
Smith

Location of Counters.



#1 Counter c/2min	#3 counter c/2min	Time
243	155	10:36
77	164	10:43
←	165	10:44
	164	10:48
124	164	10:50
	177	10:55
	182	11:06
143	179	11:09
160	182	11:17
168	188	11:14
165	183	11:16
161	183	11:18
165	188	11:20
161	182	11:22
162	187	
162	189	11:26
179	202	11:33
175	205	
175	205	11:36
177	211	11:39
170	204	
170	203	11:44
171	209	
	208	
	201	11:51

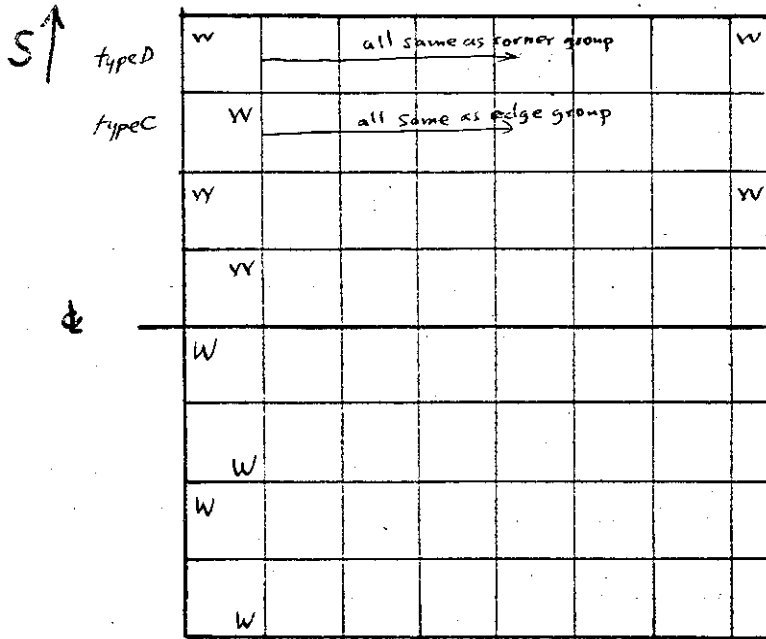
Background Count.

Source alone, in position to be occupied during experiment.

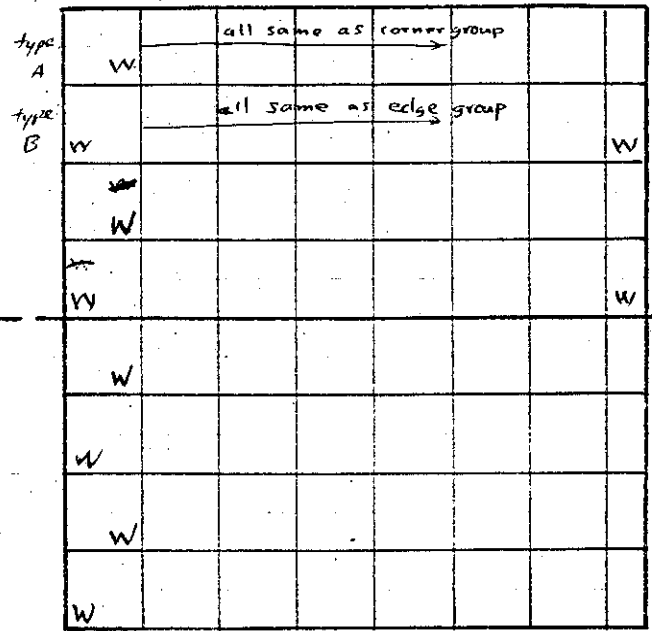
#1 Counter c/2min	#3 Counter c/2min	Time
	207	11:54
	208	11:56
	210	11:58
177	217	12:00
	217	12:02
178	227	12:04
184	223	12:06
178	220	12:10
170	216	12:12
173	225	12:14
	221	12:17
171	227	12:35
171	230	
168	225	12:40
173	235	12:43
177	243	12:45
180	237	12:48
173	233	12:50
179	239	12:52

12:08 opened window to contact room.

Mixed H2T cubes in alternate layers

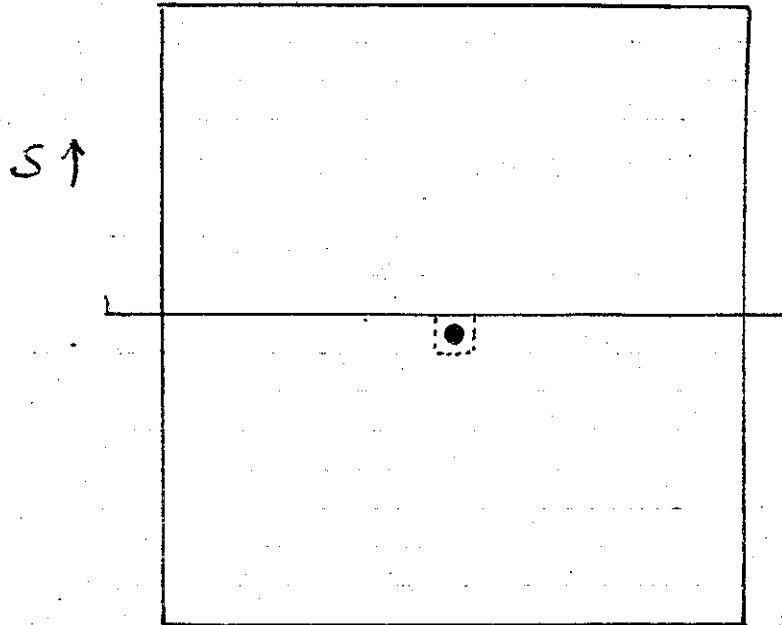


layers 2, 6, 10, 14...



layers 4, 8, 12, ...

Location of source -



62

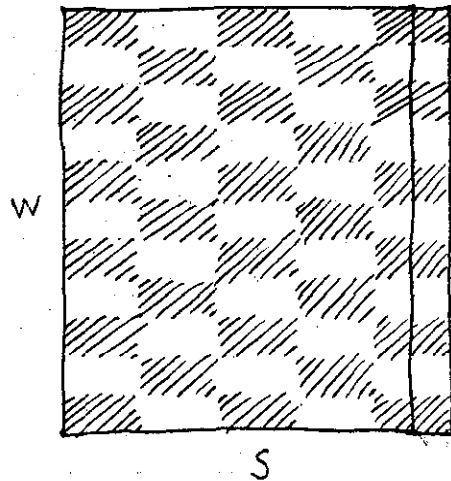
Separation inches dial	#1 counter c/2min recip.	#3 counter c/2min recip	Time pm	Conditions
32	47		3 ²⁵	} N.G.
32	45	45	3 ²⁰	
32	27	31	3 ⁴⁰	} the source is moving all through this. recorders not changing.
32	28	33	3 ⁴⁵	
7	23	33	3 ⁵⁰	
3	25	45	3 ⁵⁷	
1	29	67	4 ⁰²	
1/2	32	87	4 ⁰⁷	} magnet disengaged here. Table added stuck. Found two buckles striking dial mechanism.
0 110 1/2	36	106	4 ²⁰	
0 112	95 (5min)	298 (5min)		
0 112	96 (5min)	296 (5min)		
	Recip mult. ave 1.05	Recip multiplication ave 3.37		} Removed south face - 193 T's. total cubes 295 = 15x15 Put white cubes back in.
0 112	81 (5min)	93 (5min)		
0 112	86 (5min)	89 (5min)		} In view of the discrepancy between counts on #3, replaced the 193 T's, is made the assembly as originally.
	recip mult. ave 1.20	?		
0 110 1/2	85 (5min)	270 (5min)		
	82 (5min)	269 (5min)		
0 109	79 5min	267 5min		

Experiment 14

Friday, Oct. 18, 1946

Tamped, moderated H/T cubes = $2/2$ 30% "25"
 Critical dimensions 11" Vertical 11" N→S 10" E→W.

6" on stationary
 5" on moving



Bottom + odd
 layers
 // = U

E Even layers
 // = H

12th layer
 all H

- 14 A As shown 606 cubes U
 14 B U cubes out of layers 1, 2, 3, 9, 10, 11 in south face. 574 cubes
 14 C All south face off (11x10x10) 550 cubes

Persons present:

Cullihan - Chief Experimentor
 Hull - Experimentor - Data
 Viner - Computer
 Williams - Instruments (Telephone)
 Lykins - Instruments
 Hamrock } USED Visitors Left after 14A was finished
 Stitz }

Instruments located on
 on page 60

Scale distance	Count #1	Rec.	Count #3	Rec.	Remarks
32"	22	45.5	31	32.3	Time 11:25 AM Magnet pulled out at 4". Puffin clamp hit scale support. Aligned & started over.
15"	24	41.7	37	27.0	
7"	26	38.5	42	23.8	
7"	27	37.0	38	26.3	
3"	30	33.3	47	21.3	
37 1"	53	18.9	104	9.6	
78 0.5"					Critical Within out for lunch. Starting 12:40 PM
93 0.31"					Critical Starting 1:30
110 0.10"					Critical

Conclusions:

- (1) The critical mass for a $2/2$ cube ratio is 534 cubes.
- (2) Removal of cubes along the edges of the array affects the distance for criticality less than removal of cubes from the center of a face.

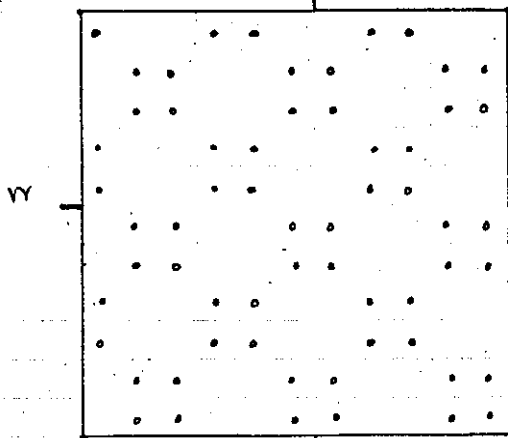
To further test effect on C.M. of inhomogeneity in stacking array by stacking white & green cubes in groups of four each.

H: T cube ratio = 4/4.
30% V35
Fully stacked.

Personnel: Hall - Chief Exp.
Callahan - Bookkeeper.
Milliam -
Smith - Instruments -

Initial Stacking:

N \pm of tables.



Legend:

Green } In 1st, 3rd, 5th etc
White } tiers.

Green } In 2nd, 4th, 6th etc
White } tiers

S.

Dimensions: NS - 11 units
EW - 11 units
VD - 11 units (actual array had 12" tiers all white).

Contents:	6 layers (odd)	each containing	61 Green cubes	=	366	
	6 "	"	60 white "	=	360	
	5 " (even)	"	60 Green "	=	300	
	5 "	"	61 White "	=	305	
			Totals		666 Green	665 White.
			Total		1331	= 11x11x11

Instruments located as shown on pg 60.

Exp 15 (cont)

10/10/46.

#15A-

Time	Distance of Separation	Counts/2'	1000/Count/2'	Remarks
10:01A	32"			Started Exp - Critical - disassembly.
10:2V	71 SD = 0.6"			

#15B-

Removed south face - i.e. removed 61 green cubes - replacing them with white -
Contains 605 green cubes -

10:39A

10:47A

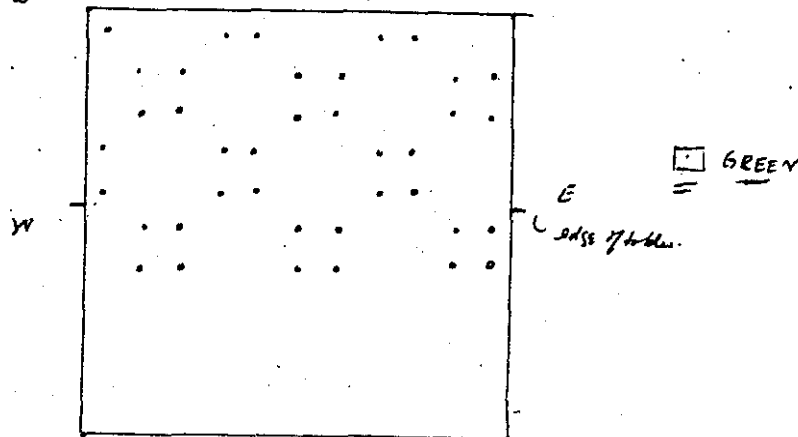
160SD = 0.23"

Instrument check -
Critical - disassembly.

#15C-

Removed 16 green cubes from top tier leaving 589 green cubes

Top tier now is



11:07A

11:12A 1075SD = 0.14"

Instrument check.
Critical.

At this distance the activity was allowed to increase for ca. 2 min until the emergency disassembly mechanism separated the two platforms. Three minutes after this disassembly the γ radiation at the exposed face of the stationary array was measured by the argon pressure chamber to be only 0.4 R/8 hrs.

At the time of disassembly the A chamber, located 14" from the center of the pile, ~~was~~ showed radiation in excess of 0.13 R/8 hrs - the meter being well off scale.

The emergency disassembly mechanism operated at the predicted radiation level.

Exp 15 (cont)

- Conclusion:
- ① Extrapolation of the CM-separation ~~at~~ ^{at} criticality line gives 56.8 gram cubic (= 8.8 Kg₂₅) as the critical mass when the halves of the assembly are separated by $\frac{1}{16}$ " al.
 - ② The counting level disassembly mechanism was tested and by allowing the activity to increase. The mechanism operated satisfactorily and at the predicted level of radiation.
 - ③ The activity at the ^{opposed} face of the separated pile 3 min after separation was measured by the A chamber and found to be 0.4R/8hrs.
 - ④ The CM-separation at criticality curve is quite linear ~~and~~ ^{which} may be due to the more judicious selection of the cubes removed between points, i.e. - first a whole face was removed, then the cubes ~~in a line~~ from an edge of a tier.

68

Experiment 16.

10/21/46

Purpose: To further test the effect of inhomogeneity on critical mass.

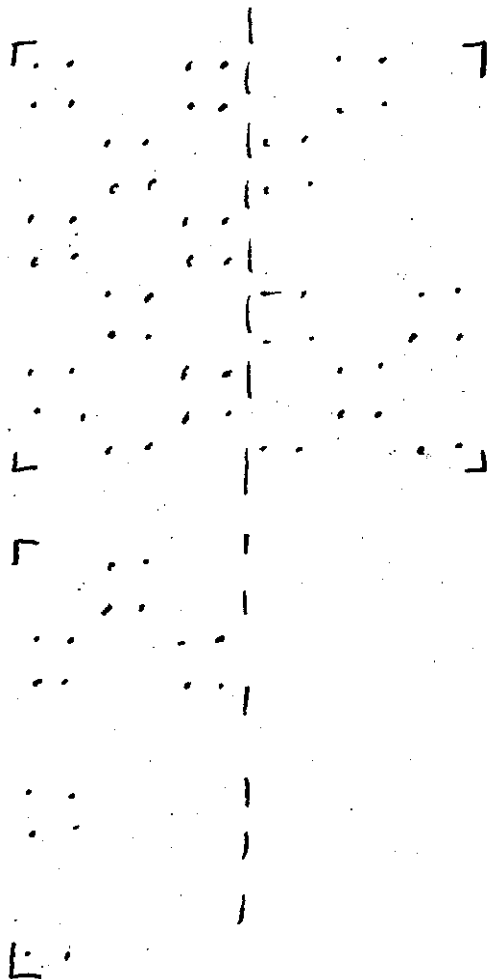
Conditions: Tamped, moderated H/T cube ratio: 8/8

Personnel:

- Beck - Chief Experiments
- Callahan - Second "
- Voss
- Williams
- ~~Johnson~~

First Assembly.

N-S - 12
 E-W - 11
 High - 11



N
 Layers
 1, 2, 5, 6, 9, 10

S.

Stacking and tamping completed at 10:45.

DISTANCE APART.	Counter 1 1/2 min.	Counter 3 1/2 min.
1/4" 98.7		
5 1/4" 76 1/2		
0.14 106 1/2		

Experiment 16A
724 T cubes.

11:08 CRITICAL disassembly

Added top layer =
Assembly new

Experiment 16B.
66 T cubes.

NS - 12 } 790 T cubes.
E-W - 11 }
Height 12.

11:27 Instrument check.

5 1/4" 76 1/2

11:30 Critical - Disassembly

Removed top layer

also 30 cubes from
Removed total of

New assembly.

Experiment 16C.

South face (perimeter).
96 cubes

NS - 11 1/2 } 694 T cubes.
E-W - 11 }
Height - 11

12:00 Instrument check,
CRITICAL Disassembly.

0.14 106 1/2

13
10.4
12.7
13.6
1/80

Conclusion of Exp. 16.

- ① Extrapolation of the CH-separation curve gives 658 T cubes as critical for a tamped assembly, moderated H/T cube ratio = $8/8$ with a $1/16$ " Al sheet in the center.
- ② The values of CH for various inhomogeneities using 30% material are about 2% lower than the values to be expected from the J.A. (95%) data for the same H/T cube ratio.

72

Experiment 17.

10/22/46

Test of inhomogeneity on tamped, moderated array

 $H/T = 1/2$ Initial array $13 \times 13 \times 13$. (See exp 8 for $1/2/1$)

Present - Murray - books - chief experimenter

Likens - instruments

Visner - stacking

Williams - stacking

Callahan experimenter

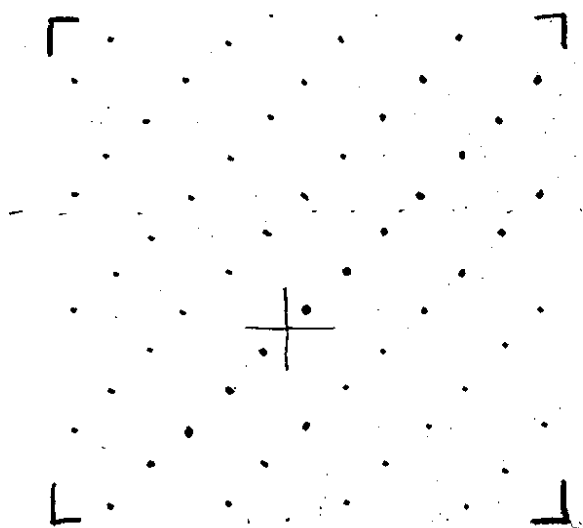
Started stacking 9^{am}

Counts / 2 min

#3

5 c/2 min	9 ⁰⁷	
64 c/2 min	9 ¹²	
61	9 ¹⁸	
69	9 ²⁵	
69	9 ³⁷	
80	9 ⁴²	no change noted on records
93	9 ⁴⁵	
107	9 ⁵⁰	
115	9 ⁵³	
127	10 ¹⁵	
126	10 ²⁸	Stacking finished tamping started
106	10 ⁴⁰	
	10 ⁵⁵	tamping completed

Construction of assembly - The reverse of Exp 9, P 33.



◻ = white cube

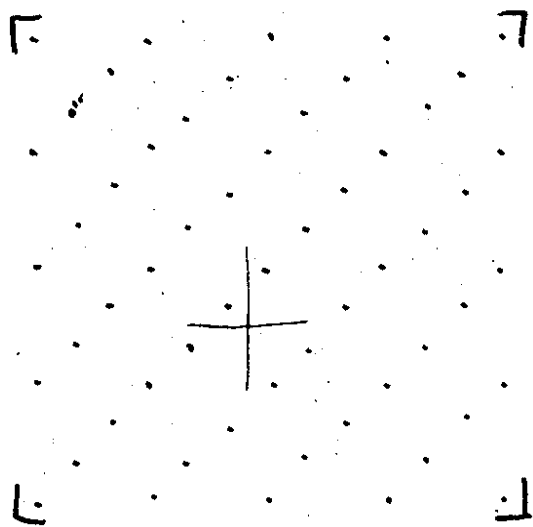
$$T's = 113$$

$$H's = 56$$

$$\text{total} = 169$$

layers 1, 4, 7, 10, 13

Form successive layers by shifting one to the east, (left as viewed).

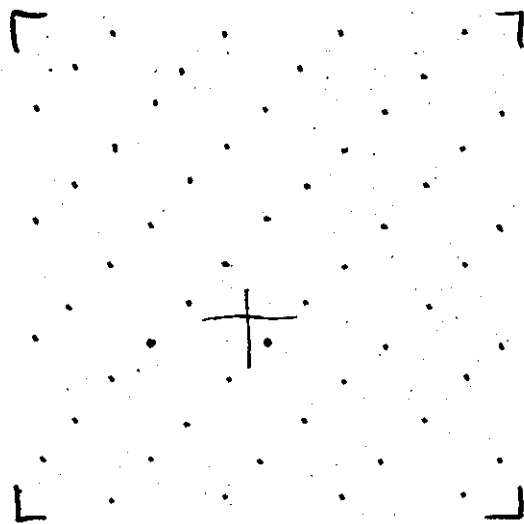


$$T's = 112$$

$$H = 57$$

$$\text{total} = 169$$

layers 2, 5, 8, 11



layers 3, 6, 9, 12

$$\begin{aligned} T's &= 113 \\ H's &= 56 \\ \text{total} &= 169 \end{aligned}$$

Complete array

$$\begin{array}{r} H's \quad 9 \times 56 = 504 \\ \quad \quad 4 \times 57 = 228 \\ \hline \quad \quad \quad 732 \end{array}$$

$$\begin{array}{r} T's \quad 9 \times 113 = 1017 \\ \quad \quad 4 \times 112 = 448 \\ \hline \quad \quad \quad 1465 \end{array}$$

$$\text{total} = 2197 = 13^3$$

cf. Exp. 8 1184 T's at $1/2/1$
increase is 281 T's, or 24%

Exp. 17

75

TIME	separation		Counter 1		Counter 3		Conditions
	Scale	distance (in)	1/2 min	Recip.	1/2 min	Recip.	
1105	—	32	20		33		Exp 17A - ring assembly TS 1465, HS 752, tot 2197 Exp 17B Removed 148 TS, north face (113) and E face on movable table (35) array now 13x12x12 ^{8/13} TS = 1317, HS 659, tot 1976 Exp. 17C Removed 65 TS, top layer (96) and E face on stationary table (69) Array now 12x12x12 TS = 1152; HS = 576, tot 1728 Exp 17D added 20 TS E face, stationary table. array now 12x12x12 ⁺ TS 1172 HS 586, tot 1758 Exp 17E Removed 10 TS, E face, stationary table, array now 12x12x12 ⁺ TS 1162, HS 581, tot 1743 Exp 17F added 44 TS E face stationary table, bring this face to 54 TS. Array now 12x12x12 ^{8/12} TS 1206, HS 603, tot, 1809
1113	—	15	24		38		
1116	—	7	27		47		
1122	91	2.5	64	15.6	107	935	
	30	1.1		critical			
120	82	2.2	41		65		
	66	.65"		critical			
130	116	~1/40"		not quite critical			
150	108 1/2	.12"		critical			
215	113 1/2	.06"		critical			
240	99	.24"		Critical			

S.U
10/23/76

Exp 17

Conclusion -

Critical mass at famped, $H/7 = 1/2$ in Tubes

$$= 1155 \pm 4, \text{ i.e. } \approx 17.9 \text{ kg of X.}$$

Comparison with $1/2/1$, 29 less (1184)At zero separation - $m = 1140$ Cakes

$$= \underline{\underline{17.52 \text{ kg of X}}}$$

 $\underline{\underline{0.0714 \text{ kg of X}}}$

Experiment 18

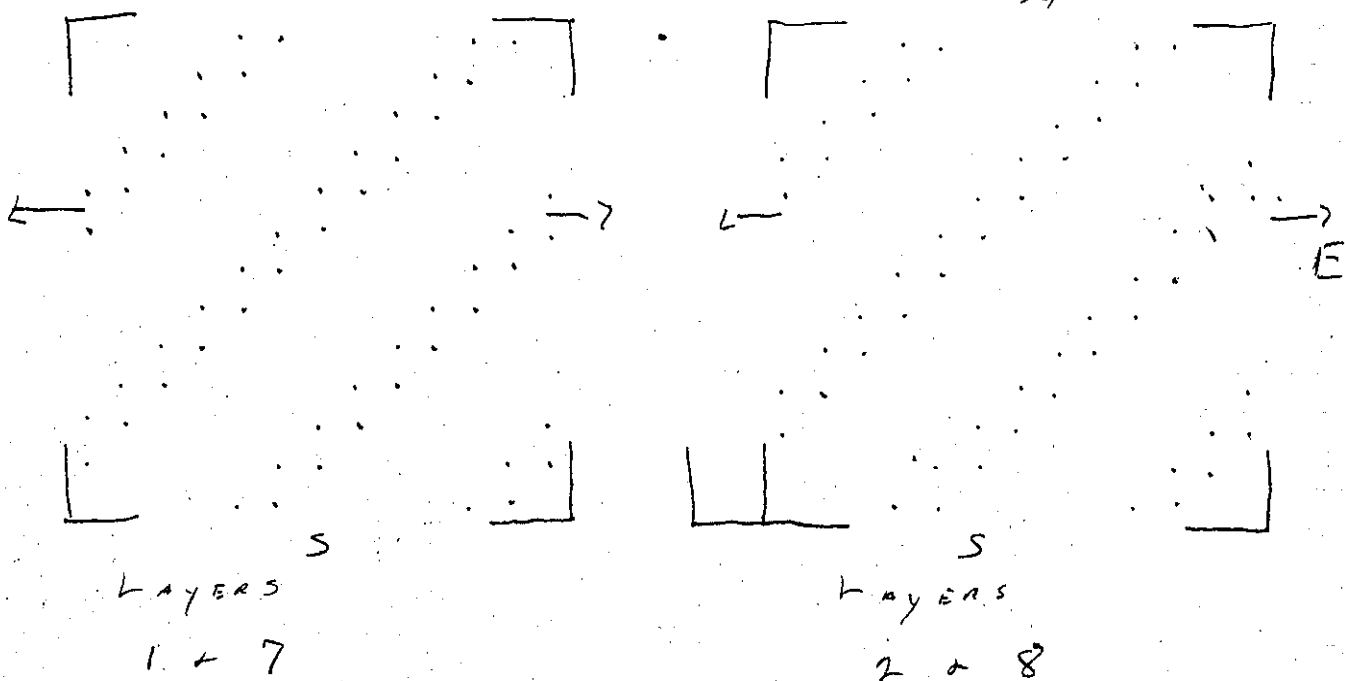
10/23/46

Test of inhomogeneity on tamped, moderated array

#17 cube = 7/4 initial array 13 N-S
13 E-W(Four green cubes + 2 white cubes in) 12 N-S
line in all three directionsPresent - Bush
Hull
Visner
Lisker
William

Instrument arrangement same as Exp 13 p. 60.

Construction of assembly:

□ = white cube
N

N

N

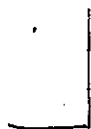


←
W

→
E

←

→



EWest

S
LAYERS 3 x 9

LAYERS 4 x 10

E



Dividing
Line ←

→

←

→



S
LAYERS 5 x 11

S
LAYERS 6 x 12

FIVE ROWS ON NORTH SIDE - MOVABLE TABLE
EIGHT ROWS ON SOUTH SIDE - STATIONARY TABLE

Exp. # 18

18/23/46

79

TIME	SEPARATION		Counter #1		Counter #3		REMARKS
	Inches	Dial	Counts	Accip	C/min	Accip	
11:20	0.16	104					Experiment 18 A Tubes = 1352 (+3?) N-S = 13 E-W = 13 Negt = 12. Instrument check. <u>Critical</u>
11:50	0.16	104					
13:00	90	46					Experiment 18 B Added two complete layers on top. (added 226 Tubes) New set-up contains 1578 Tubes. (+3?) Instrument check CRITICAL.
14:00	0.56	73					Experiment 18 C. took off - one top layer (113T) new assembly contains 1465T. CRITICAL Level allowed to increase to point where. Disassembly.
14:05							Counter 2 checked off.
14:15	0.53	75					Experiment 18 D. Removed. tamper from 1.5" X 6" = 9 in ² of assembly, equivalent to 0.9% of tampering Same cube or range as as in 18 C. Counter checked.
14:35	0.34	90					Exp 18 E. of assembly exposed with no tamper. Equivalent to 3.6 % of tampering. Inst. check.
							Argon chamber in control room read $35 \times 3.4 \times 10^{-5}$ while counter 2 read 70 dci (sensitivity = 1)

Experiment 18 F

Removed total of $9 \times 6 = 54 \text{ in}^2$ of tamping.
 equivalent to 5.3% of tamping removed.

14:55

Instrument Check
Critical.19 102.
Extra Experiment:

To determine the radiation level at various locations as measured by the Argon counter for the same multiplication as measured by counter no 2.

Exp. 18 G

Removed total of $12 \times 6 = 72 \text{ in}^2$ tamping.
 $\sim 7.1\%$

~0.11" 109.

critical

Exp. 18 H.

Covered exposed assembly. (72 in^2) with $\frac{1}{2}$ " white cubes. ~~Fluor~~ (covered ^{exposed} assembly) with $\frac{1}{2}$ " tamping.

Dial	Separation Inches	Time	
98	0.25	17.10	Critical.

Percent Temp. Missing	Critical Separation	C.M. for Fully tamped at this separat	% increase in C.M.	Δ C.M.	
0	0.56	1465			
0.9	0.53	1457	0.82	12	.83
3.6	0.34	1402	4.3	63	4.5
5.3	0.19	1358	7.3	107	7.9
7.1	.11	1335	8.9	130	9.7

Conclusions

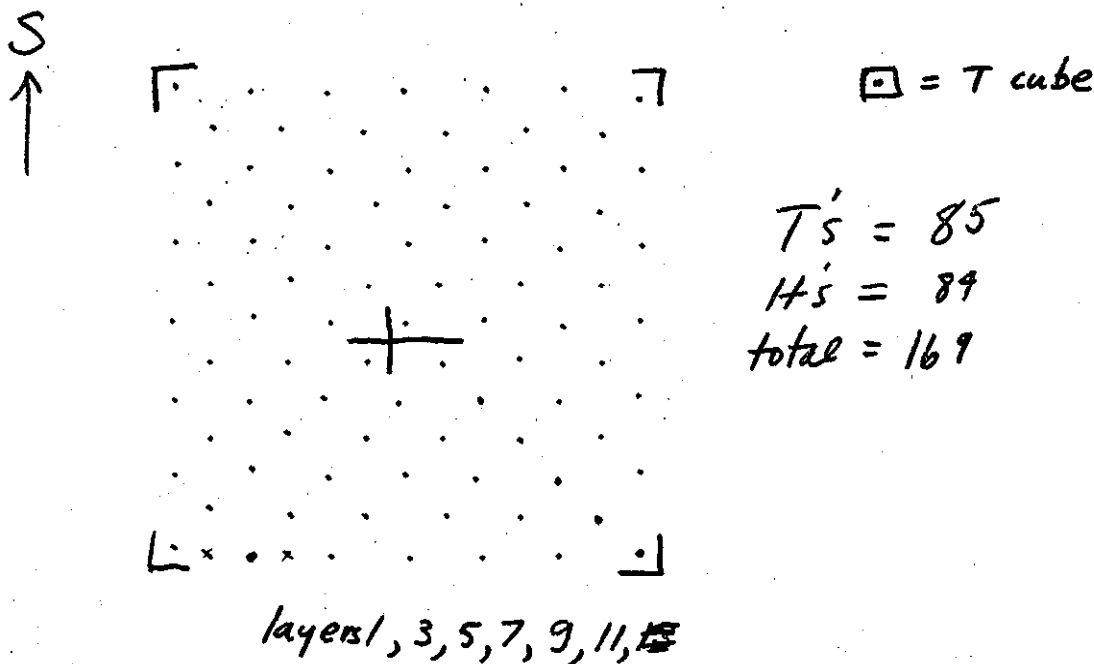
- ① For an extreme inhomogeneity of $2/4$, H/T ratio in all directions (x, y, z). The critical mass for the tamped assembly is 1306 T cubes (with $1/16$ " al.)
- ② Over a range of 0 to 7% in untamped surface, the ratio of % increase in C.M. to % surface of assembly that is completely untamped, (cubes visible), is 1.27

10/24/46

Conditions: Tamped, moderated, H/T cubes = $1/1$,
Cadmium shielded, by means of 0.020" sheets stacked
 between the pile and the tamper.

Basic array $13 \times 13 \times 13$

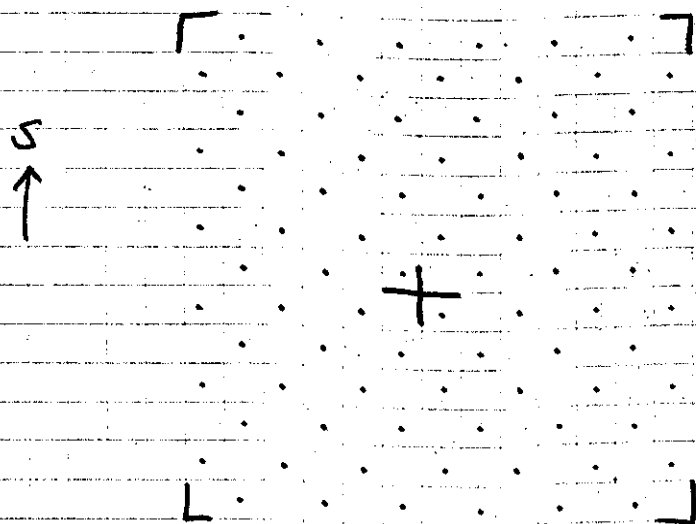
Present - Callihan Chief exp.
 Murray exp, records
 Visner
 Williams
 Macklin



other layers formed by shifting every thing one to the left.

Compare $1/1$ array, experiment 7, p 24.

T cubes there = 514. assuming a 1.8 effect of cd ,
 should go critical with present array at 925



$$\begin{aligned} T's &= 84 \\ H's &= 85 \\ \text{total} &= 169 \end{aligned}$$

Layers 2, 4, 6, 8, 10, 12

$$\begin{aligned} \text{total array contains } T's, & \quad 0 \times 85 = 595 \quad 510 \\ & + 6 \times 84 = \underline{504} \\ & \quad \quad \quad 1099 \quad 1014 \end{aligned}$$

$$\begin{aligned} H's & \quad 0 \times 84 = 588 \quad 504 \\ & \quad 6 \times 85 = \underline{510} \\ & \quad \quad \quad 1098 \quad 1014 \end{aligned}$$

$$\begin{aligned} \text{total} & = \underline{2197} = 13^3 \\ & \quad \quad \quad 2028 = 13 \times 13 \times 12 \end{aligned}$$

Experiment 19A - original conditions.

critical at 108 ie $1/8$ " separation

Experiment 19B

Removed 19 T's, ~~etc~~ from movable table, top layer, north 3 rows. Assembly now 995 T cubes.

critical at 113 ie $1/6$ " separation

Conclusion - Estimate of no. of T cubes that would be critical at $H/T = 1/1$, with Cd. shielding

$$= 975.$$

$$\frac{\text{Cd}}{\text{No Cd}} = \frac{975}{506} = 1.93$$

$$\begin{array}{r} 129 \\ 12 \\ \hline 332 \\ 167 \\ \hline 506 \end{array}$$

84 EXPERIMENT 20.

Conditions.

Tamped, moderated, $H/T = 4/1$

Cadmium Shielded by means of sheets of cadmium (0.1) between pile and tamper.

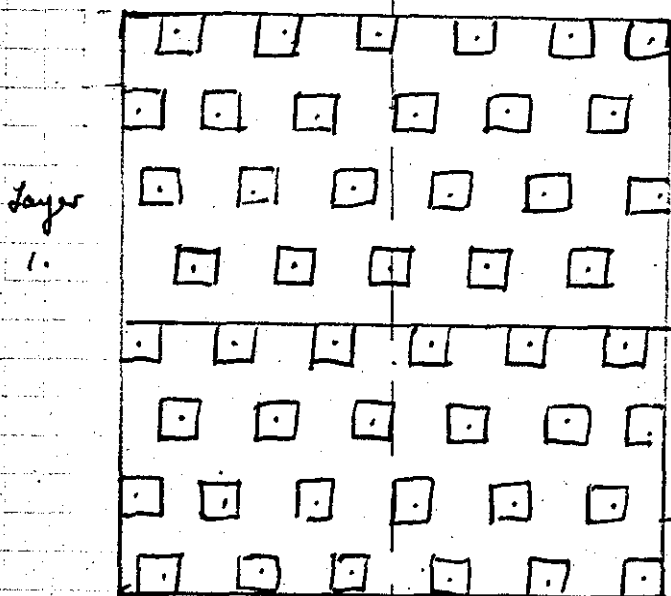
Initial array:

E-W = 14
N-S = 15
Height = 14.

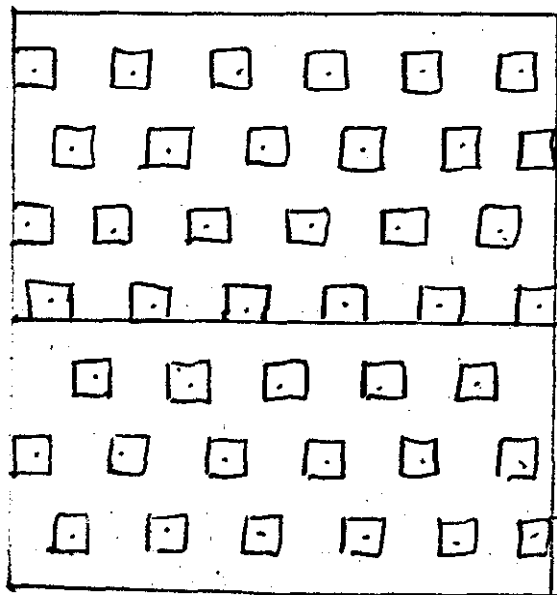
610 T's

Present: Callahan
Murray.
Visme
Williams.

□ = green, T.

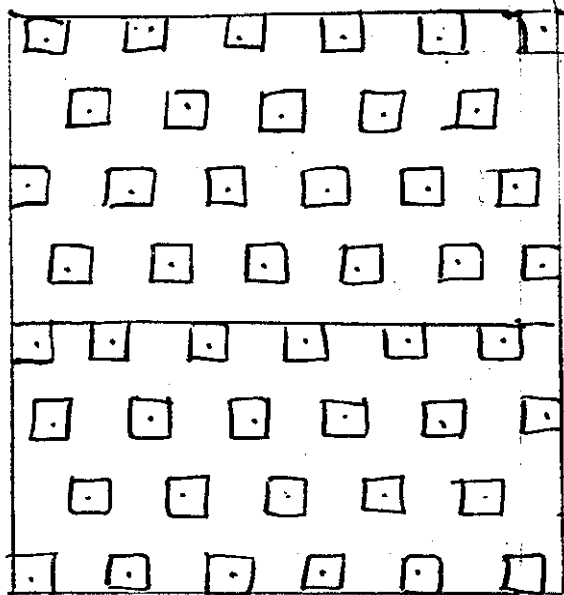


N T=47
H=163
Layer 1, 11

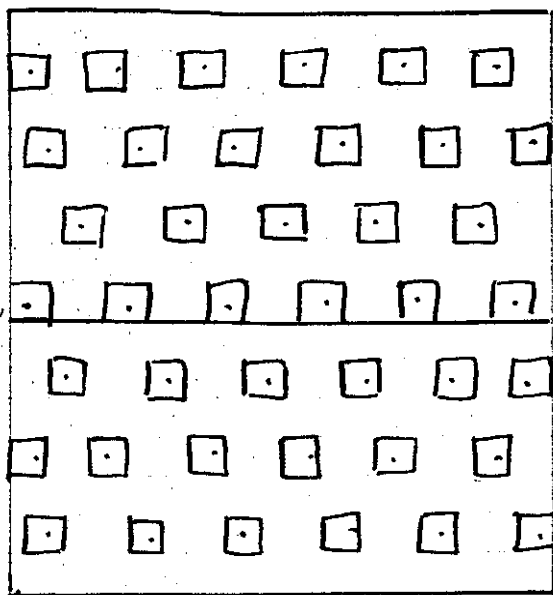


N T=41
H=169
Layer 2, 12

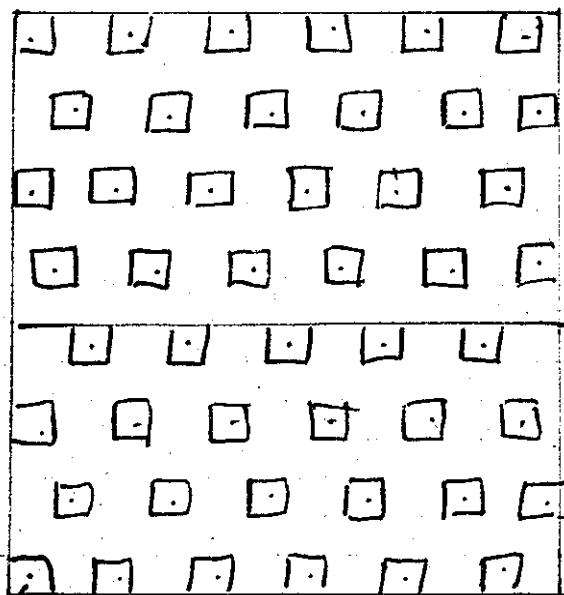
S.



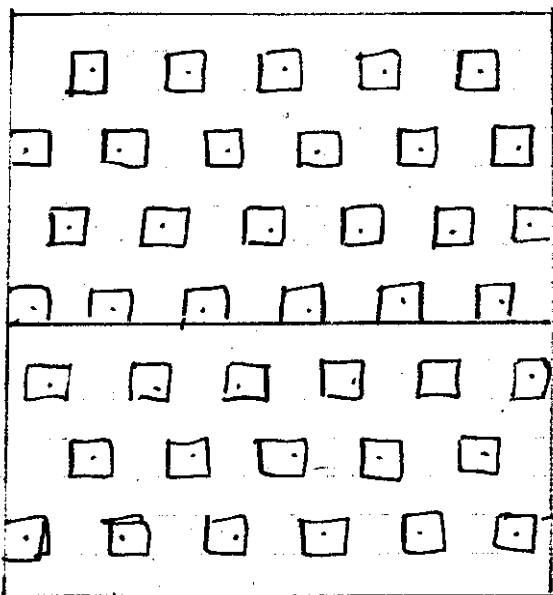
$N = 3, 13$
 Layer 3
 $T = 46$
 $H = 164$



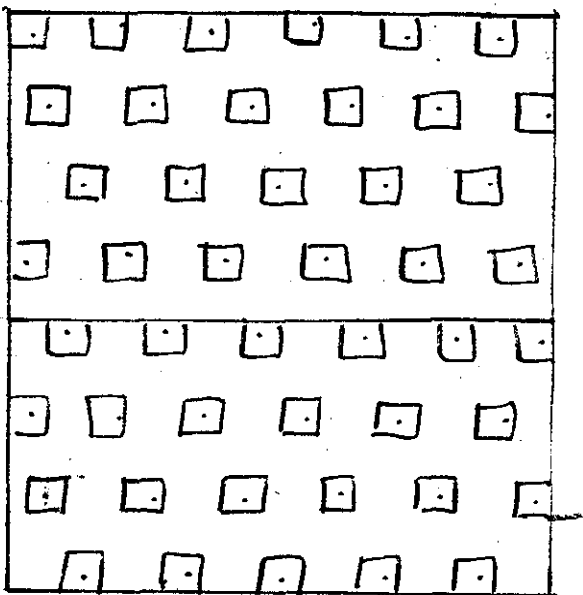
$N = 4, 14$
 Layer 4
 $T = 91$
 $H = 169$



$T = 47$
 $H = 163$
 Layer 5, 15



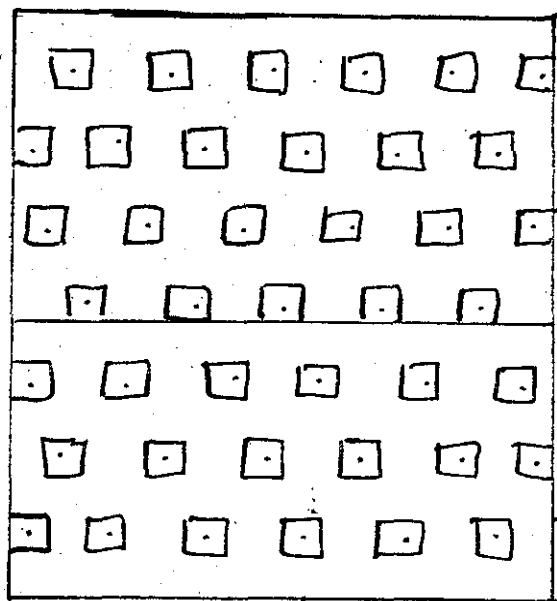
$T = 40$
 $H = 170$
 Layer 6.



Layer 7.

$$T=46$$

$$H=170$$

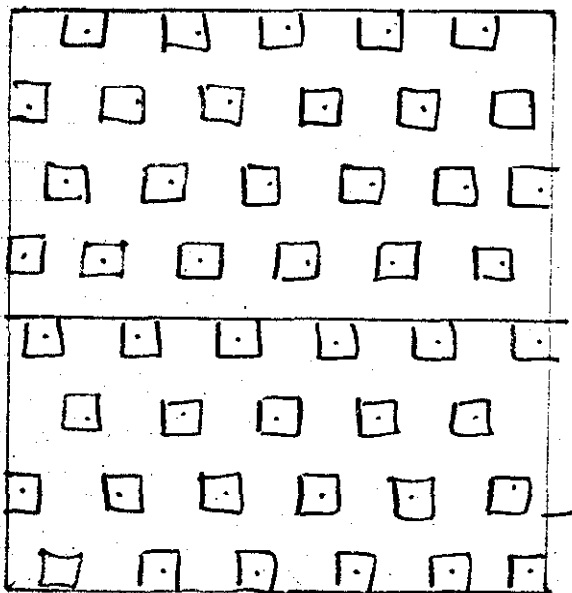


Layer 8.

$$T=41$$

$$H=169$$

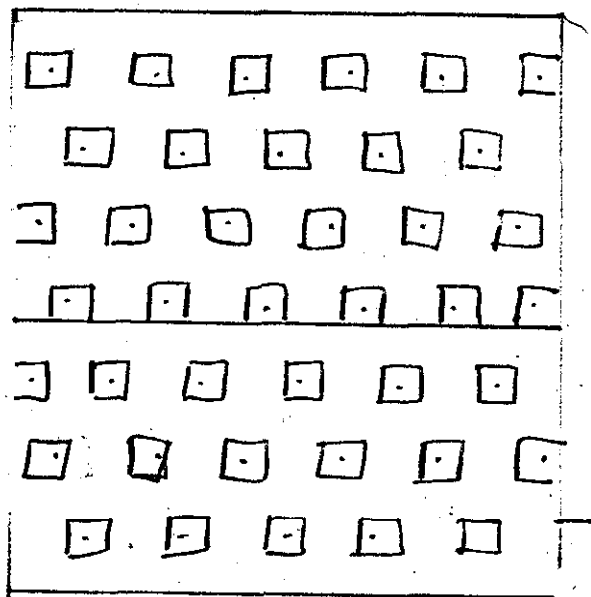
↓
N.



Layer 9.

$$T=46$$

$$H=164$$



Layer 10.

$$T=40$$

$$H=170$$

Monitoring of stacking

Count & 3. Time

51	<u>205</u>
52	<u>208</u>
56	<u>216</u>
61	<u>219</u>
58	<u>221</u>
61	<u>225</u>
61	<u>228</u>
60	<u>230</u>
60	<u>232</u>
60	<u>235</u>
?? 110	<u>237</u>
64	<u>239</u>
112	<u>241</u>
84	<u>243</u>
80	<u>246</u>
125	<u>253</u>
118	<u>256</u>
35	<u>259</u>
47	<u>305</u>
24	<u>308</u>

Composition of array

No. of layers	T's	H's	Tot T's	Tot H's
3	40	170	120	510
5	41	205	123	507
3	46	138	12	328
3	47	141	14	326
			<u>141</u>	<u>1671</u>
			total	2130
				= 14 x 15 x 14

Composition of array (2nd attempt)

no. of layers	T's	H's	Tot T's	Tot H's
2	40	170	80	340
5	41	169	205	845
4	46	164	184	656
3	47	163	141	487
			<u>610</u>	<u>2330</u>
			total	2940
				= 14 x 15 x 14

Experiment 20A

critical at dial setting 103 (that is 125 division from the near closure value of 103)

$$\frac{117}{103} = \frac{14}{14}$$

$$\frac{125}{139} = \frac{159}{80} = 1.74''$$

Experiment 20B

Removed north two faces, top on N, ~~at~~ movable table, 82 T's,
+12 total 94 cubes, 368 whites removed

Array now $13 \times 14 \times 13 \frac{8}{13}$

total T's = 516 ; H's, 1962 total 2478

critical at 0.9", ie 45.5 on dial.

Experiment 20C

Removed remaining part of top layer, on stationary table. 23T, 89 H's.
also one layer on West side, both tables, replacing all
protruding green cubes with $\frac{1}{2}$ white cubes.

this took out 51 T's, of which 17 were protruding, and thus
took with them an additional $\frac{1}{2}$ vacant space,

array now $13 \times 13 \times 13$

total T's = 442 ; H's = 1755 ; total 2197

critical at 0.34" ie 91 on dial.

Conclusions

Critical number of T cubes with $H/T = 4/1$,
(actually slightly less) with Cd shielding 0.020" thick,
is 405 ± 5 cubes (est.)

$$\frac{cd}{n_{ocd}} = \frac{405}{265} = 1.53$$

$$\begin{array}{r} 167 \\ 33 \overline{) 5511} \\ \underline{330} \\ 221 \\ \underline{165} \\ 561 \\ \underline{330} \\ 231 \\ \underline{165} \\ 661 \\ \underline{330} \\ 331 \\ \underline{165} \\ 1661 \\ \underline{1650} \\ 11 \end{array}$$

Experiment 21.

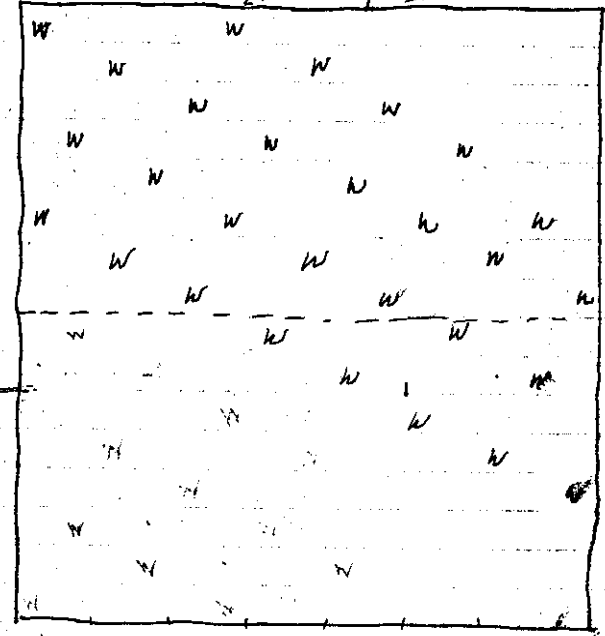
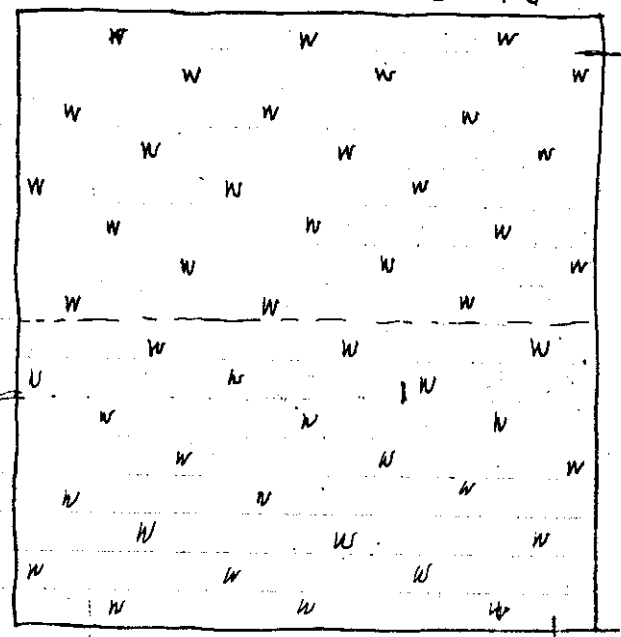
Oct 26, 1946 Saturday
Beck Schmidt
Hull *Sybilis* (3 hrs.)
chief

Conditions:

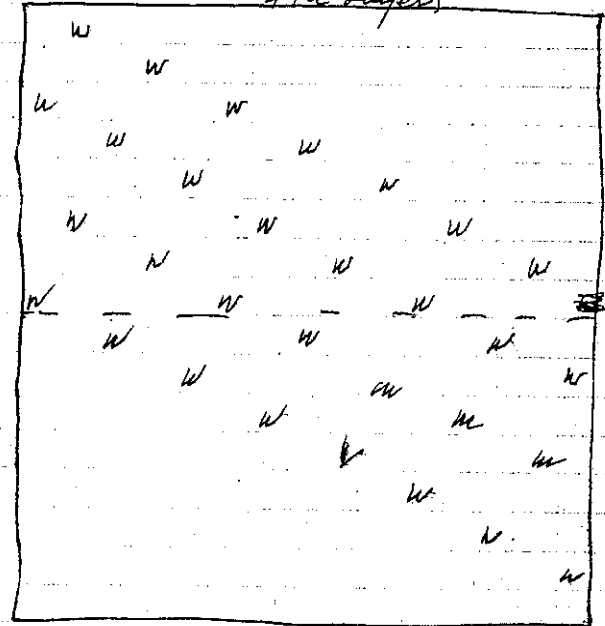
Sampled moderately, $\frac{4}{5} = \frac{1}{4}$ in all directions.

[2nd Layer]

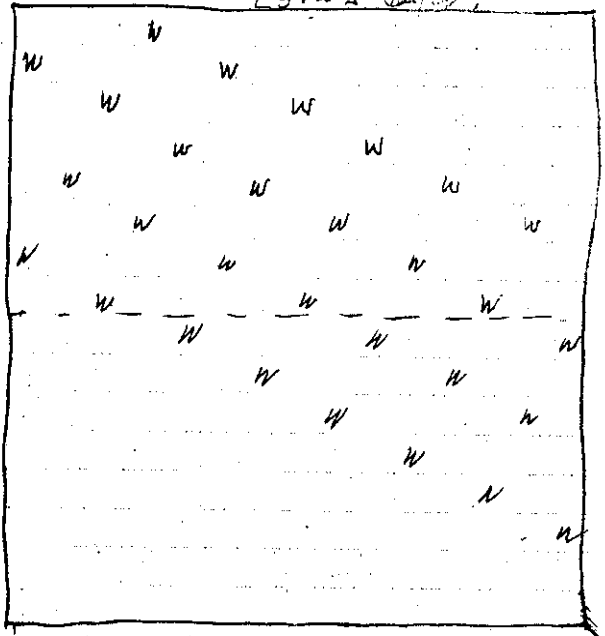
21.A. N-S = 16 culms } 2830 green
E-W = 15' } 700 White
U-D = 15' }
S [1st layer]



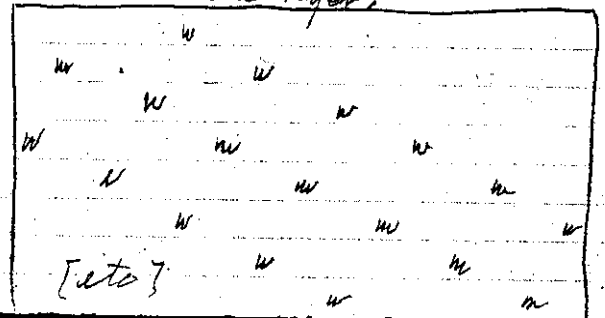
[4th Layer]



[3rd Layer]



[5th Layer]



6, 7, 8, 9, 10 repeats 1, 2, 3, 4, 5, respectively.

[etc.]

21A (continued).

Assembly: neutron level began to rise at $\approx 2"$. 2:31 PM.

Critical at 47 dial reading (last round).

$$\frac{117}{\frac{47}{70}} = \frac{70}{80} = \frac{7}{8}''$$

21B: 15 EW 15 \downarrow 14 NS 2520 cubics

2 layers taken off south end of 21A.

Level began to rise at $\approx 1"$

Critical at 102 = 0.19"

3:06 PM

$\frac{1}{16}''$ Al

Conclusion:

From these two points, the extrapolated Mc for $\frac{3}{16}''$ $\frac{3}{16}''$ separation is 2420 cubics for a stacking ratio of $\frac{1}{4}$.

Extrapolating to "zero" separation - no Al \rightarrow 2390 ^{green} Cubics
= 36.7 kv

DC 8/18/65

Experiment 22.

10/28/46 91

Purpose: To determine the effect of geometry
on C.M.

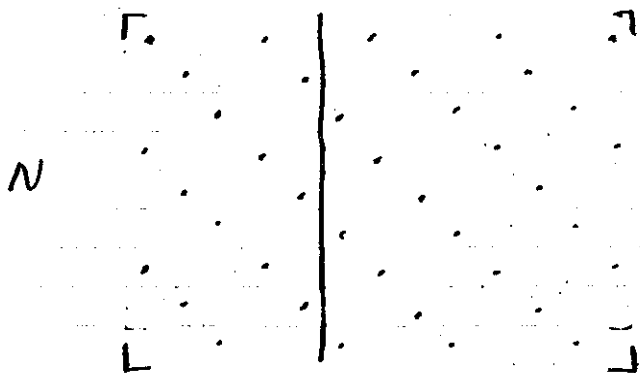
Conditions: Tamped, moderated H/T cube ratio = 2/1

Initial trial dimension: $L-W = 9$ High = 9.
 $N-S = 13$.

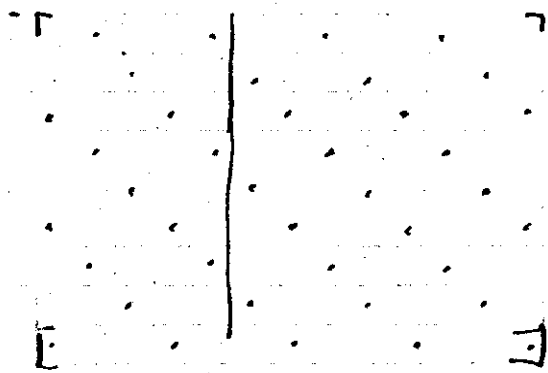
Persons Present:

5 rows on movable.

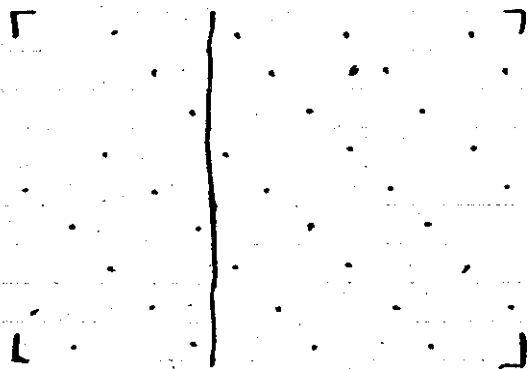
Beck. Chief Exp
Murray 2xp
Vesun
Williams



Layers 1, 4, 7



Layers 2, 5, 8



Layers 3, 6, 9.

39 T per layer.

First assembly
contains 351 T cubes

Stacking started at 09:00

Experiment 22 A

351 T cubes.

Initial array, $9 \times 9 \times 13$ - 351 T's.

Critical at 82, ie .42"

10:00 AM.

Experiment 22 B.

Removed South face. (27 T cubes)

New assembly contains 324 T cubes.

N-S : 12

E-W : 9

High : 9.

10:05 - Instrument Check.

Critical at $103\frac{1}{2}$: 0.162"

Time

10:20 AM.

Conclusion: C.M. estimated at 307 T cubes
by extrapolation.

Experiment 22 C.

N-S : 20

E-W : 8

High : 8.

Removed one face
from East.Assembly contains ~~474~~ T cubes.
426.Critical at 79 \approx 0.46"

Time

10:55

Experiment 22 D.

93

Removed two faces on South. (42 T cubes)
 New assembly: 384 T cubes.
 N-S = 18
 E-W = 8
 High = 8

Instrument checked at 11:08

Critical at 104. = 0.15.

Conclusion: C.M. estimated at 364 T cubes.

Exp. 22 E. 7x8 cross-section.

Removed 1 face from West.

N-S = 30 560 T cubes
 E-W = 7
 High = 8.

Instrument check at 12:20.

Critical at 94 = 0.40" at 12:30.

Experiment 22 F

Removed 3 faces from South. (56 T cubes)
 N-S = 27
 E-W = 7 504 T cubes.
 High = 8.

Instrument checked at 12:43.

CRITICAL. 112. = 0.05"

Experiment 22 G.

Removed 1 layer from height.

7x7

N-S = 55.
 E-W = 7
 High = 7.

897 T cubes.

Instrument checked at 14:10.

Scale → 115

Not Critical

Scale
119 1/2.

Removed
#1 counter.
8 in diam

Al. shield.
#3 counter.
326 in diam.

94

Experiment 22 H.

Added 4 faces to North (65 T cubes)
New Array.

N-S - 59

E-W - 7

High 7

962 T cubes.Deal
119 1/2.

#3 counter

345 in 2 min.

NOT CRITICAL

Al. shield removed.

Conclusions:

Tamped moderated $H_{eff} = 2/1$
The following arrays are critical.

9 x 10 x 10.1 = 303 T cubes.

9 x 9 x 11.37 = 307 T cubes.

8 x 8 x 17 = 364 T cubes.

8 x 7 x 26.45 = 496 T cubes

7 x 7 x 59 = 962. Not Critical; high multiplicity

Experiment 23.

10/29/46.

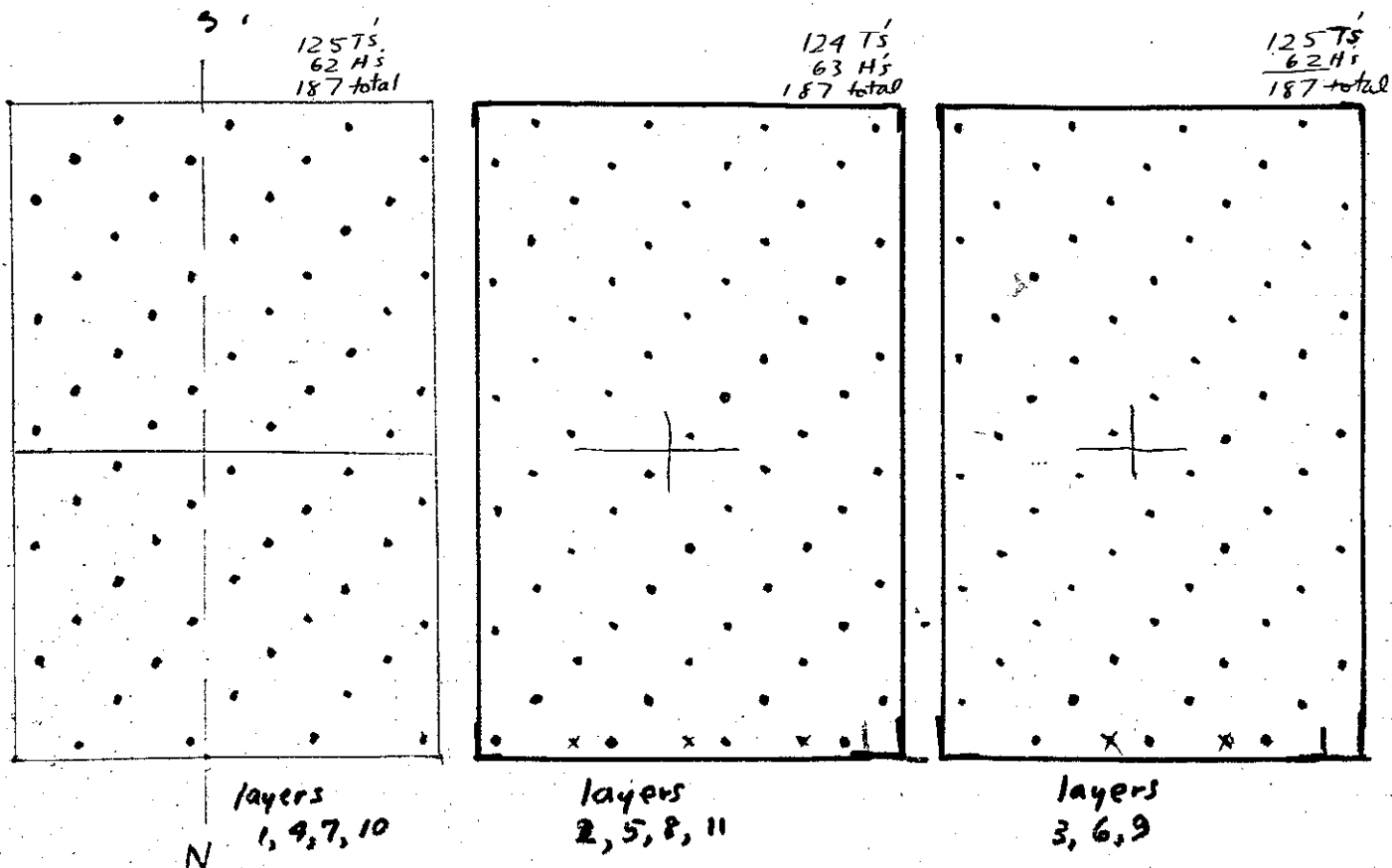
95

Tamped, H/T cubes = 1/2, parallelepiped.

Initial array 11 x 11 x 12. (9 on stationary table, 8 on movable)

Persons - Murray C.E.
 Callihan E.
 Williams
 Visner
 Smith

□ : white cube.



Experiment 23AInitial Array: $11 \times 11 \times 17$

30% material

1371 T's, 686 H's, 2057 total

Critical at 72 - .55"
on dialExperiment 23Btook off back layer and $\frac{1}{2}$ of layer (on stationary table) ie 121 T'sArray now $11 \times 11 \times 15 \frac{1}{2}$

1250 T's, 625 H's, 1875 total

Critical at 99 - .21"
on dialwith
washed
DCCritical mass estimated at 1175 Tubes for O separationExperiment 23C

Removed West side of both assemblies, extended length to 24 cubes, removed top. (12 on each in length)

Array now $10 \times 10 \times 24$

1600 T's, 800 H's, 2400 total

Critical at 71 - .56"
on dialExperiment 23DRemoved $2 \frac{2}{3}$ layers on N end of stationary table. (185 T's off)Array now $10 \times 10 \times 21 \frac{1}{3}$

1415 T's, 707 H's, 2122 total

Critical at 101 - .19"

Critical mass estimated at 1320 Tubes for O separation

Experiment 23 E

97

Removed top layer, west face on both tables.

Extended array to 37 in length: 18 on stationary, 19 on movable.

Array now $9 \times 9 \times 37$

(Each layer vertically,
now has 54 TS, 27 HS)

1998 TS's, 999 HS's, 2997 total

Not critical at 114 - ≈ 0 " is almost completely closed.

Experiment 23 F

added 14 vertical layers, 8 to stationary, 6 to movable

Array now $9 \times 9 \times 51$

2754 TS's, 1377 HS's, 4131 total

critical at 84.4"
on dial

Experiment 23 G

Removed 7 vertical layers from movable table, i.e.
378 TS's.

Array now $9 \times 9 \times 44$

2376 TS's, 1188 HS's, total, 3654

critical at 106 0.125"

Critical mass estimated at
2230 Tables for 0 separation.

Conclusions the following arrays of tamped parallelepipeds
at $H/T = 1/2$ were critical:

$12 \times 12 \times 12$ 1155 TS's

$11 \times 11 \times 14.6$ 1175 TS's

$10 \times 10 \times 19.8$ 1320 TS's

$9 \times 9 \times 41.3$ 2230 TS's

It is very unlikely that
 9×8 would go with any
extension.

Experiment 24.

95% Material.

Initial array 9 x 9 x 9.

Conditions Tamped. Moderated
H/T cube ratio = 1

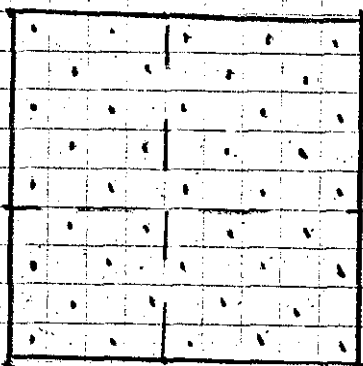
Purpose : To check the S.A. value of C.M. for these conditions.

People Present

- Bick C.E.
- Murray E.
- Vesin
- William
- Smith (30 minutes)

12
10
9
5
3
3.5

5 □ = green



25
16
9

N =

Layers 1, 3, 5, 7, 9

For. Layers 2, 4, 6, 8.

alternate green & white.

Experiment 24A.

365 T cubes. 364 H cubes.

N-S - 9
E-W - 9
Height - 9.

10:04 Instrument Check.

~~80.5~~
81. : .44

CRITICAL.

Experiment 24B.

Removed 18 T cubes. (replaced with H).
from Removed top layer of moving table.

New Assembly.

N-S - 9
E-W - 9
height = $8\frac{5}{9}$.

347 T cubes.

10:20. Instrument Check

~~92~~. 92 = 0.30.

Critical

Experiment 24C.

Removed balance of top layer. (23 T cubes)

New array.

N-S = 9
E-W = 9
height = 8.

324 T cubes.

10:37. Instrument Check.

113

8.04

CRITICAL.

Conclusion:

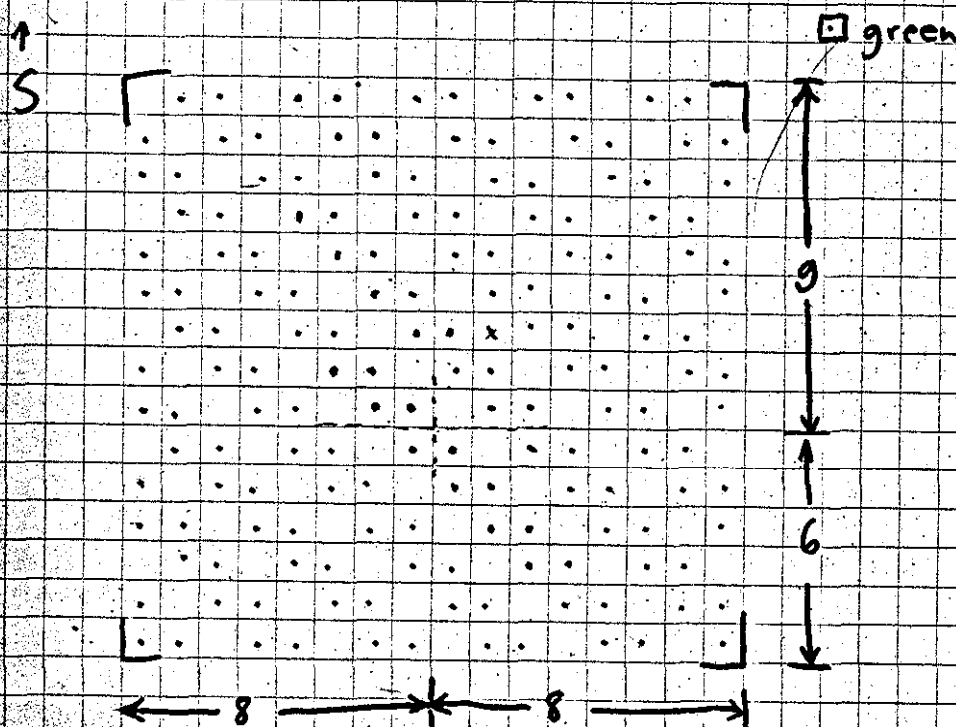
The critical mass for the assembly is estimated at 321 T cubes for 1/16 of separation. or 314 T cubes for zero separation. This agrees within 2.9% with the J.A. value.

10/31/46

Purpose: to find M_c with cadmium shielded, tamped

$H/T = 1/2$. Initial array
 16 E-W
 15 N-S
 15 height

Present - Murray AE.
 Beck CE.
 Williams AE
 Visner AE



Each layer has

$$10 \times 16 = 160 T's$$

$$15 \text{ layers} = 2400 T's$$

$$\text{total cubes} = 3600$$

$\frac{2265}{15} = 151$
 $\frac{151}{15} = 10.0667$
 $\frac{10.0667}{15} = 0.6711$

Exp 25A Critical at 95.26"

Exp. 25B Removed 90 cubes from SE. face, stationary table

Array 15x15x15 $\frac{1}{15}$, 2290 T's.

Critical at 112.05"

Conclusion: Critical no. of T cubes with Cd shielding

$$H/T = 1/2 = \boxed{2265}$$

Cd = 1.96
 no Cd

Purpose: To find M_c for an array consisting of 1 white, 1-30% cube units, simulating a H/T cube ratio of $1/2$ for 60% X.

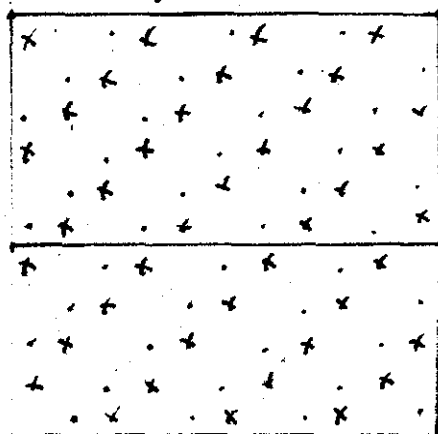
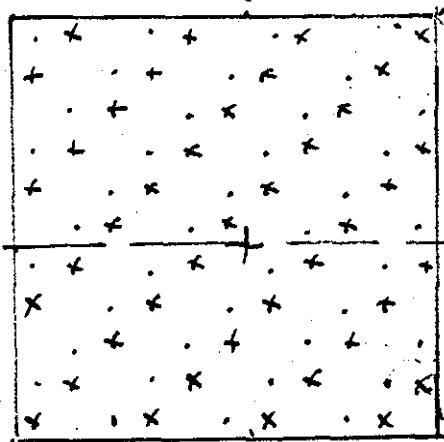
Conditions: Tamped, undrained H/T = $1/2$.

Present: Beck, Callahan, Vesner, Williams, Lykins, Smith

Initial Array

N-S = 11
E-W = 11
High = 12

- white
- 30%
- 95%

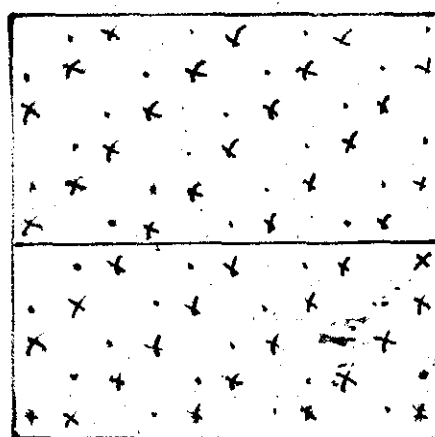


41
 40
 40

Layers: 2, 5, 8, 11.

↓
N
Layers: 1, 4, 7, 10.

= 40
 = 40
 = 41 } per layer.



= 40
 = 41
 = 40

Total: 484 (11) - 95%
484 (11) - 30%
484 whites.

Layers 3, 6, 9, 12.

Experiment 26 A.

10:03.

Instruments checked

483 -T95 N-S - 11

485 -T30 E-W - 11

484 White. High = 12.

968 T (total)

48 = 0.85"

CRITICAL

Experiment 26 B.

Removed complete top layer. (40 T(90) + 41 T(30))

New array: N-S - 11

E-W = 11

High = 11

887 T

10:28 AM.

Instruments checked

77 = 0.49"

CRITICAL.

Experiment 26 C.

Removed complete south face [41 T(90) + 40 T(30)]

New array N-S 10

E-W 11

High 11

806 T cubes.

10:48 AM.

Instruments checked

assembly - 109 did = 0.09"

CRITICAL

Conclusions: The CM. for simulated 60% X
 tamped assembly, moderated H/T cube ratio
 is $\frac{1}{2}$. is 786 T cubes.

24.4 Kg X

Purpose: To find H_c for an array consisting of $H/T(30) / T(95)$ cube ratio = 3/1/1 simulating a cube ratio of $H/T = 3/1$ for 60% X.

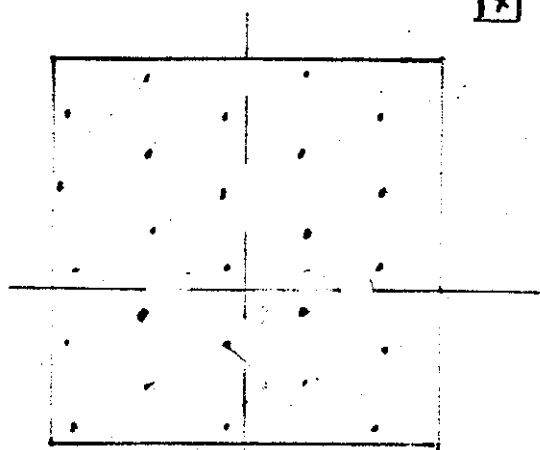
Conditions: Tamped, moderated $H/T = 3/1$.

Present:

Beck.
Callahan
Vespa.
Williams.

Lewis
Smith.

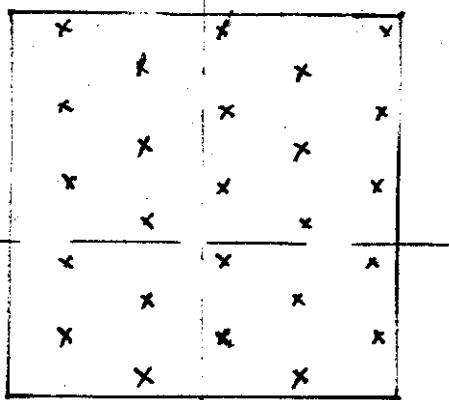
□ White.
○ T(30)
× T(90).



N

Layers 1, 3, 5, 7, 9.

25-T(30) per layer



N

Layers 2, 4, 6, 8, 10.

25-(T 95). per layer

Total { 125-12 T(30)
125-2 T(95).

104

Experiment 27A

N-S = 10	}	127	T(30)
E-W = 10		123	T(95)
High = 10		<u>250</u>	T

12:58

Instrument Check.

52 = 0.80"

CRITICAL

Experiment 27B.

Removed 20 T(95) and 15 T(30) from south faces (17 1/2 faces).
 New array: {

N-S = 10 8 3/5	}	105 - T(95)
E-W = 10		110 - T(30)
High = 10		<u>215</u> T(95+30)

13:16

Instrument Check.

101 = 0.19.

CRITICAL.

Conclusion:

The c.m. for simulated 60% X
 tamper assembly moderated H/T cube ratio
 = 3/1 is 204 T(95+30) cubes.
 6.6 Kg. X

469
 198

 667

268

17
 63

24

Purpose: To check the S.A. value of C.M.

Type of cube : 95%

Conditions: Tamped, moderate; H/T cube ratio: 1/2.

People Present:

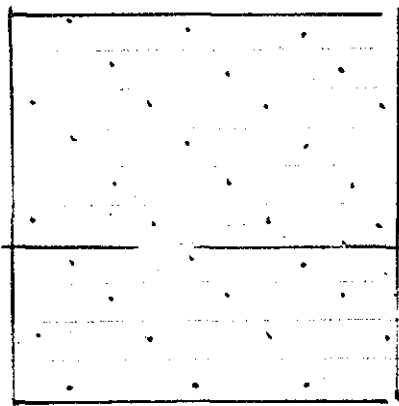
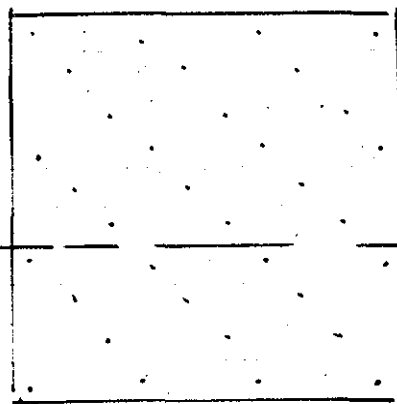
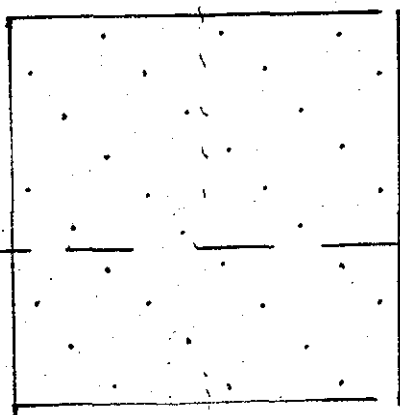
Beck.
Murray
Visni
Williams.

Likens.

Initial array:

N-S = 10
E-W = 10
Height = 10

} 667 T cube



Layers 1, 4, 7, 10

67 T per layer

Layers 2, 5, 8

↓
N

66 T / layer.

□ = White cube.

Layers 3, 6, 9.

67 T / layer.

Successive layers were made by shifting one row west

106

Experiment 28 A.

10:04.

Instrument Check

59 1/2, 61, 62 1/2, 64, 66

74 = 0.53"

CRITICAL

Experiment 28 B.

Removed West face from stationary table (40T).

New array.

N-S = 10

High = 10

E-W = 9 1/10

} 627 T cubes.

96 = 0.25"

Critical

Experiment 28 C.

Removed West face from movable table (27).

New array.

N-S = 10

E-W = 9

High = 10

} 600 T cubes.

10:26.

Instrument Check.

116 = 0.0"

CRITICAL

Conclusions - : For 95% X, tapered, moderate
 H/T = 1/2, the C.M. is 600 T cubes
 with 1/16" al. The Extrapolated CM with
 no al. separation is 594 T cubes.
 This value is only 1% lower than
 the S.A. value.

Experiment 29.

Nov?
Oct 4, 1946. 107

Purpose: To check the J.A. value of C.M.

Type of Cube: 95%.

Conditions: Tamped, moderated. $\frac{1}{2}$ T cube ratio = $\frac{1}{2}$ / 1

People Present:

Bech C.E. (left after stacking).
Murray C.E.
Vism
Williams

Initial Array.

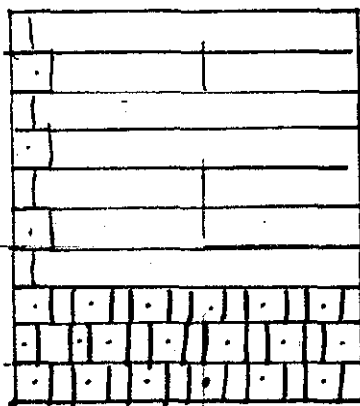
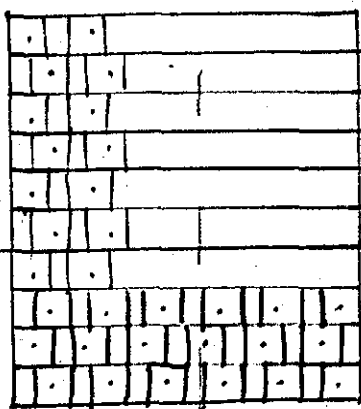
N-S - 10"

E-W - 9"

High - 10" $9\frac{4}{16}$

600 T cubes 540 564
600 $\frac{1}{2}$ white 564.

10 high.
9 high.



N

□ = T cube.

Layers 1, 3, 5, 7, 9

Layers 2, 4, 6, 8, 10

60 T per layer.

-108

Exp. 29A.

12:30.

Instrument check

115.

Not critical

Exp 29B

12:50 added 36 cubes to top of stationary array. Now 600 T's.

Array 10x10x9.

111 critical = 0.07"

Exp. 29 C.

Added 1 face to west on stationary table. (30)

array.

N-S = 10

E-W = 9%

High = 10

} 630 T's.

13:12

Instrument check.

83/2

= 0.41

CRITICAL.

Conclusion: For 95% X, lamped, moderated
H/T = 1/2/1 is 594 Tubes with 1/16" al.
or 588 T's. with no al.

This value is 12.5% higher than L.A. value.

Examination of assembly revealed that
assembly on stationary table was 1/2" off center.
i.e. 1/2" too far to east.

Exp. 29D.

109

Realigned assembly.

14:10 instrument check

85. Critical

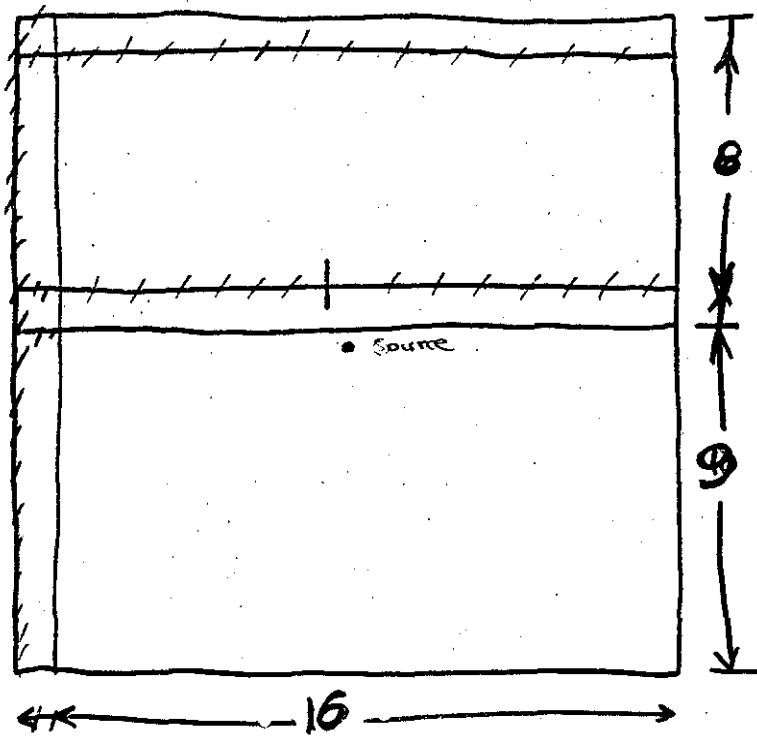
What to use
Conclude? chg
1/27/47

Previous conclusion p108
still valid S.V. 1/27/47.

Purpose: To find critical mass of X, tamped, unmoderated, of largest assembly possible, 30% + 90% cubes.

Present: Murray Callahan
 Visner
 Williams
 Lykins
 Smith

Array initial dimensions 17 x 16 x 16
 N-S height E-W



$$\begin{array}{r} 3248 \text{ of } 30\% \\ 1104 \text{ of } 95.3\% \\ \hline 4352 = 16 \times 16 \times 17 \end{array}$$

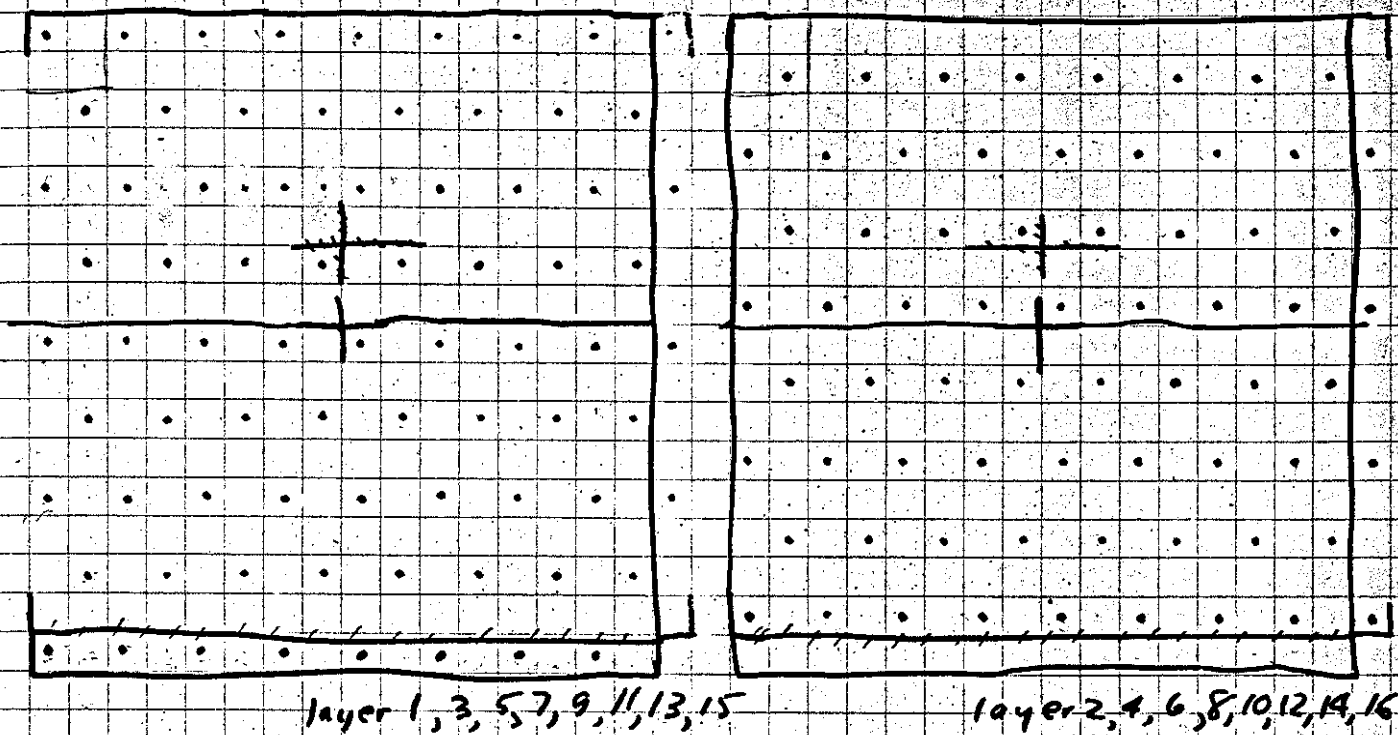
$$\begin{array}{r} \times 15.5 \approx 50 \text{ l.} \\ \times 48.8 \approx 54 \text{ kg} \\ \hline \approx 104 \text{ kg} \end{array}$$

N

□ 95% cubes

111

EW →



Used bad 30% cubes in layers 15, 16, last two rows (N) of 14th layer, ~~table~~ movable table.

Since $\frac{3248}{3} = 1083$, have 25 extra 95% cubes, which lie along the back row of the 16th layer, stationary table.

Actual array

$$\begin{array}{r} 95\% \cdot 1108 \\ \underline{-3} \\ 1105 \end{array} + \begin{array}{r} 30\% \cdot 3248 \\ \underline{-2} \\ 3246 \end{array} = 4351 + \text{one source space} = 4352.$$

$$\text{Kg X} = 53.88 \text{ Kg} + 49.89 = 103.77$$

$$49.92 = 103.80 \text{ Kg } 235-$$

112

Experiment 30 A

13:02.

Instrument Check

109 = 0.05"	Counter # 1		Counter # 3	
	c/5 min	Rec.	c/5 min	Rec.
	713	1.395	319	3.155
	722		315	

Experiment 30 B

Removed 512 green cubes - 146 of 95%, 366 of 30%, two north faces of movable table.

Actual array:

$$95\% = 959 + 30\% = 2880 = \text{total} = 3839$$

plus source space gives $3840 = 15 \times 16 \times 16$.

$$K_g X = 46.761^{95} + 44.266^{30} = 91.03$$

13:50

Instrument check

111 = 0.03"	Counter # 1		Counter # 3	
	c/5 min	Rec.	c/5 min	Rec.
	588	1.699	256	3.914
	589		255	

Experiment 30 C

Removed top of array (both sides), and west face both sides is 465 green cubes, 115 of 95%, 350 of 30%.

Actual array

$$95\% = 844 + 30\% = 2530 = 3374$$

plus source space gives $3375 = 15 \times 15 \times 15$

$$K_g X = 41.153^{95} + 38.886^{30} = 80.039$$

14:35

Instrument check

110 = 0.04"	Counter # 1		Counter # 3	
	c/5 min	Rec.	c/5 min	Rec.
	449	2.215	191	5.277
	454		188	

Experiment 30 D

Removed top array, both sides, and west face both sides,
 ie 435 green cubes, 108 of 95%, 327 of 30%.
 actual array.

$$95\% = 736 + 30\% = 2203 = 2939$$

plus source space given $2940 = 14 \times 14 \times 15$

kg X $35.887^{95} + 33.860^{30} = 69.747$
33.88

15:20 instrument check

110.5 = .04"	Counter #1		Counter #3	
	C/5min	rec.	C/5min	rec.
	357	2.805	148	6.826
	356		145	

Experiment 30 E

Because of curvature of $1/C/5min$ curve, decided to
 repeat exp. 30A. Restacked cubes as originally.

110.5 = .04"	counter #1		counter #3	
	C/5min	recip.	C/5min	recip.
	702	1.425	303	3.289
	701		306	

Conclusion: Tamped unmoderated mass of
 X (30+95) is > 125 kg, probably around 160 kg.
 see graph of multiplication extrapolation.

Purpose: To determine the effect of
density on CH.

ASSAY : 30% X.

Conditions: Tempered, moderated:

4 H : 1 T : 1 air

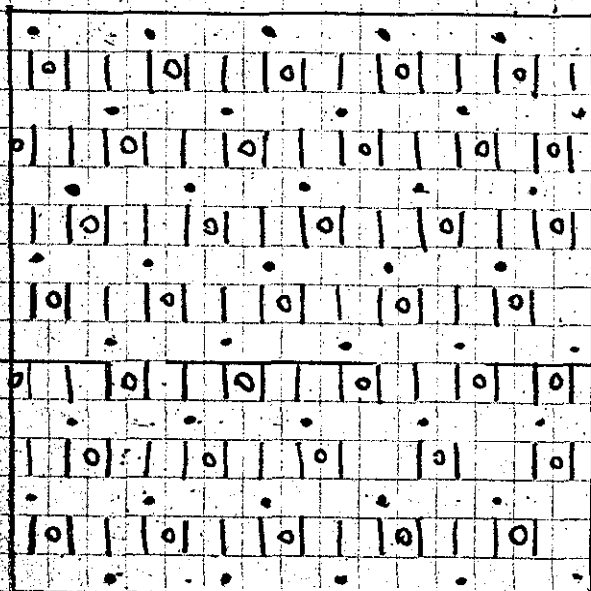
Personnel:

Beck
Held,
Vann
Williams.

Smith.

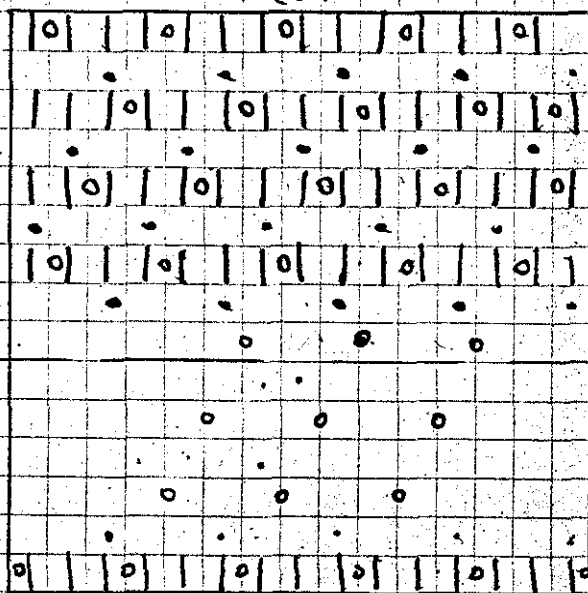
Initial Array: N-S = 15 } 565 T
E-W = 15. } 560 air
Hgt = 15. } 2250 (air)

Successive layers made by moving
one row to South { GREEN
20 AIR



Layers 1, 7, 13

N



Layers 2, 8, 14

N

Odd Layers.

40 T

35 air

150 H

Even Layers

35 T

40 air

150 H

115

Experiment 31 A.

13:26.

Instrument check.

93. = 1.77"

CRITICAL

35

Experiment 31 B.

Remove complete face from North. (40 T cubes)
New array: 35 air.

N-S = 14 } 525 T cubes.
E-W = 15 } 525 Air.
High = 15.

120. = 1.45"

CRITICAL

Experiment 31 C.

Removed 1 layer from top and 1 from West.
(68 T cubes). (40 air).

New assembly.

N-S = 14

E-W = 14

High = 14.

} 457 T cubes.
515 Air.

14:45

Instrument Check

43. = 0.875"

CRITICAL

Experiment 31 D.

Removed 1 layer from top and 1 from South. (65 T)

New assembly.

N-S = 13

E-W = 14

High = 13

} 392

15:26

Instrument Check.

101

0.13"

Critical

Conclusion:

Exp. 31.

The CM. for a tamped moderate
 assembly consisting of 4H : 1T : 1 air
 cube ratio is

381 Tubes (with $\frac{1}{16}$ " al)

378 Tubes for 0 sep.) 5.81 Kg.

CM (4:1) to 1 air

CM (4:1)

= 1.47.

Purpose: To find CM for a tamped assembly.
 moderated H/T cube ratio = 1/7.
 (repetition of Exp. 13)

Present:
 Callahan
 Schmidt.
 Vixen
 Williams

Location of counters: same as p. 60.

Initial Array.

N-S = 16
 E-W = 15
 H. = 15.

Same array as in Exp. 13 p. 61

Source buried in pile.

Location of source

Layers 8 from bottom.
 Row 9 from North.
 Cube 8 from East. } removed one green cube.

Layers: 1, 3, 5, 7, 9, 11, 13, 15. contain $16 \times 15 = 240$ T.
 Layers: 2, 4, 6, 8, 10, 12, 14. 60 H + 180 T

8×240

- 1920

7×180

1260

3180 - 1 = 3179

398

2782

48.9 net

118

Experiment 32A.

13:50.

109

Instrument		Check	
Counter #1	Counter #3	Counter #1	Counter #3
#/5min	Recip. X1000	#/5min	Recip. X1000
285	3.53	175	5.76
282		172	

Experiment 32B

Removed 2 faces from North (~~398 T~~) cubes
398.

109. - New assembly { 15 - E-W
14 - N-S
15 - High. } ~~3281 T cubes~~
2781
= 42.7 Kg.

1500

Instrument Check

Counter #1		Counter #3	
#/5min	Recip. X1000	#/5min	Recip. X1000
215	4.62	126	7.88
218		128	

108.

Experiment 32C

Replaced 1 face to North (added 225 T)

New assembly { 15 - N-S
15 - E-W
15 - High. } 3006 T cubes
46.3 Kg.

16:10

Instrument check

Counter #1		Counter #3	
#/5min	Recip. X1000	#/5min	Recip. X1000
248	4.03	142	6.95
246		146	

Removed 2 faces from N. }
 1 face from W. } 606 Tubes
 1 layer from Top }

New array: N-S-14 }
 E-W-14 } 2400 Tubes
 High-14. } 36.9 Kg X

108.

Counts #1		Counts #3	
#/5 min	Recip- X/1000	#/5 min	Recip X/1000
155		92	
159.	6.37	93.	10.8.

Conclusion:

The extrapolated value of CM.
 by multiplication experiment is 64 Kg X.
 for a tamped assembly, moderated $1/T = 1/7$.
 30% enrichment.

120

Experiment 33

11/8/46

Purpose: To further determine the effect
of density on C.M. (Compare with Exp 31 p 116)

Assay - 30% X.

Condition - Tamped, moderated.
4H : 1T : 1/2 air.

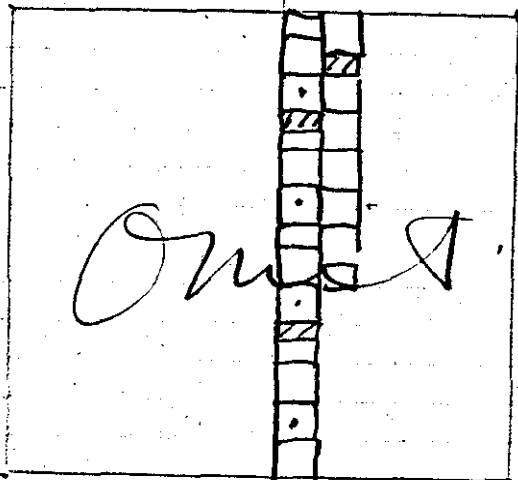
Personnel:

Callahan E. Smith
Hull C.E.
Vinson
Williams

Initial Assay

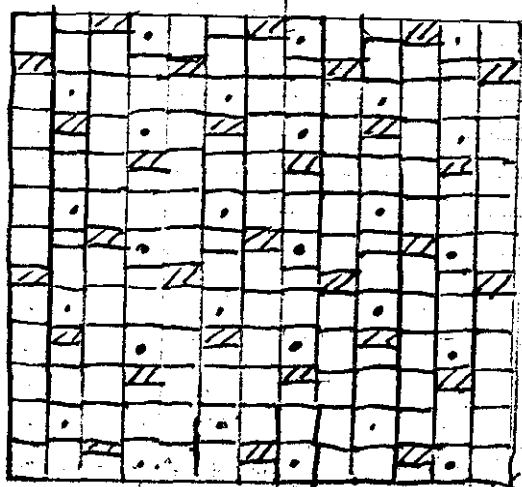
□ = 1/2" air
□ = white
□ = green.

Top



Bottom

Top



Bottom

Face 7 from North.
(first on N on stationary)
table

Successive faces toward south are
made by shifting previous face
~~two~~ ^{one} vertical rows to East.

$$\left. \begin{array}{l} N-S = 13 \\ E-W = 13 \\ \text{Height} = 12. \end{array} \right\} 378 \text{ T cubes.}$$

Exp. 33A.

12:45 Instrument check,

78 1/2 = 0.39" CRITICAL.

Repeat to check reproducibility.78 1/2 ~~±~~

Experiment 33B.

Removed one face from north (27 T
30 1/2 air space)

$$\left. \begin{array}{l} \text{New Array } N-S = 12 \\ E-W = 13 \\ \text{Height} = 12 \end{array} \right\} 351 \text{ T Cubes.}$$

1:45 Instrument check.

105 0.06, CRITICAL

Conclusion: The CM for a tapered moderated
assembly, consisting of 4H:1T:1/2 air.

cub ratio is $\frac{346 \text{ T cubes (with } 1/16" \text{ al)}}{341 \text{ no al.}} = 5.24 \text{ kgx}$

$$\frac{\text{CM (4:1) to } 1/2 \text{ air}}{\text{CM (4:1)}} = \frac{5.24}{3.97} = 1.32.$$

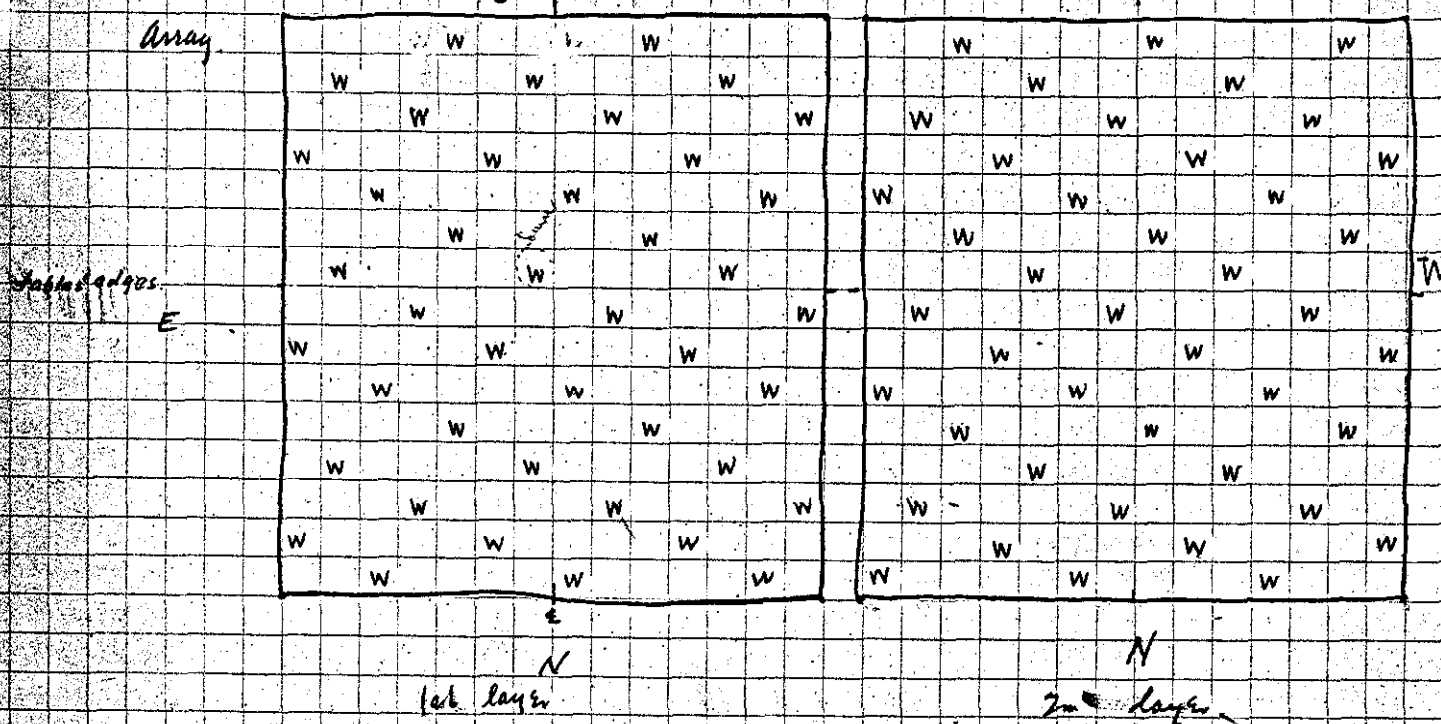
11/9/46

Experiment 34

To compare the value of M_c obtained directly with that obtained by extrapolation of the multiplication curve.

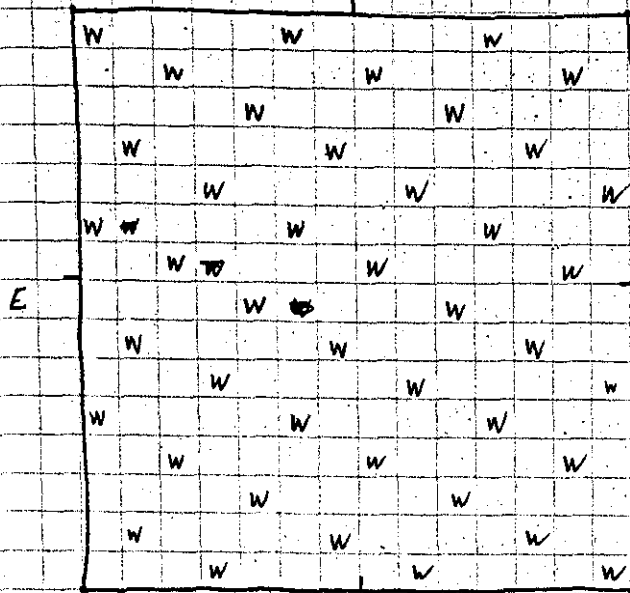
Method: A tapered IH-4T array has been found to be critical (Exp. 21, pg 89, 10/26/46). Multiplication measurements was to be taken on a similar and slightly subcritical assemblies: $2420T + 605H = 3025$ total cubes were found to be critical previously. First construct a $15 \times 14 \times 14 = 2940$ assembly:

Personnel: Beck,
Callahan
Schmidt
Williams
Smith.

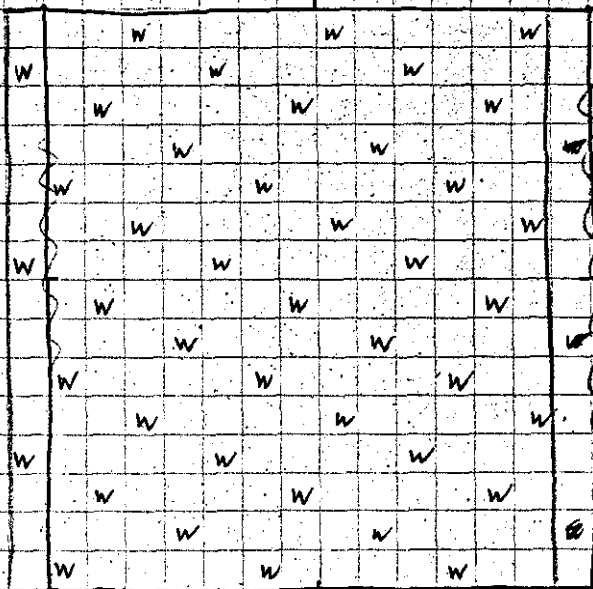


14 - E-W
14 - V-D (15th layer of white cubes added)
15 - N-S { 8 on movable table
7 " stationary }

Source placed in 6th layer (= 1st layer away) in 7th row from east +
in plane of an H cube.

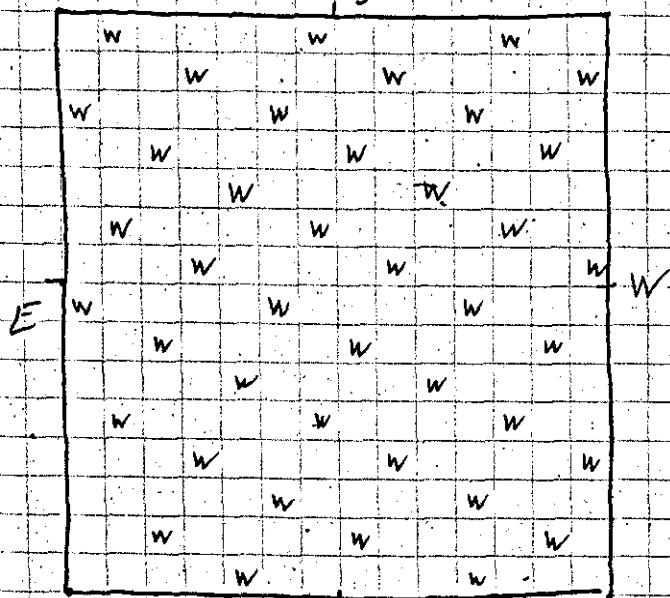


N
3rd Layer



N
4th Layer

(Red dot) ←



N
5th Layer

- 6" Layer = 1st
- 7" " = 2
- 8" " = 3
- 9" " = 4
- 10" " = 5
- 11" " = 1
- 12 " = 2
- 13 " = 3
- 14 " = 4

Each layer contains $168T + 42H = 210$ cubes
 14x14x15 array }
 { 2352 T cubes
 { 587 H cubes.

Experiment 34A.

~~Tables~~ Tables together at $\frac{108}{107.5}$ div.

#1 Counter	Counts/min	Recip.	#3 Counter	Counts/min	Recip. = 1000/count
2352 Tcubes	1859		1099		
= 36.2 Kg 25.	1879	= 0.530	1120	ave 1207	0.829
	1902		1217		
	1881		1283		

Experiment 34B.

Removed north face of assembly leaving 14 U-D
14 E-W
14 N-S.

156 Tcubes removed - replaced with white.

2196 Tcubes
= 33.8 Kg 25

Replaced #2 scaler pan in counter #3.

Instrument ^{check} (11:30 A).

Table position \rightarrow 107.5 divisions

991		501	
989	= 1.01	502	2.00
ave 990		ave 501.5	

Experiment 34C

Removed north face of assembly and replaced with white cubes -

157 Tcubes removed - Now 14 U-D; 14 E-W, 13 N-S.

Instrument check (11:50 A).

Table position 108 divisions

664		335	
673	= 1.50	339	= 2.97
ave 668.5		ave 337	

Experiment 34D

Removed west face of assembly, did not replace with white -

146 Tcubes removed - Now 14 U-D, 13 E-W, 13 N-S.

Table position 108 divisions

483		249	
492	= 2.05	249	= 4.02
487.5		249	
(492)		(251)	

1893 Tcubes
= 29.1 Kg 25

~~1939 Tcubes~~
~~= 29.8 Kg 25~~
2039 Tcubes
= 31.3 Kg.

Removed top (14th) layer - replaced with white cubes
 Removed 135 T cubes. Now 13x13x13

1758 T cubes
 = 27.0K925

Table position → 108" dia.

#1	mc.
380	
399	
<u>389.5</u>	= 2.57

#3	mc.
201	
204	
<u>202.5</u>	= 4.94

Experiment 34F

Removed top, west and north faces - no solid white layers now -
 Removed 375 T cubes - Now 12x12x12
 Instrument check - 1:45 P.

1383 T cubes
 = 21.3K925

Table position - 108" diameter -

240	$\frac{\text{counts}}{64} / 5 \text{ min}$
241	
<u>240.5</u>	= 4.16

131	$\text{counts}/64 / 5 \text{ min} -$
126	
<u>128.5</u>	= 7.78

Counts taken with source, cubes, paraffin, etc as in 34F
 except with tables 30" apart:

116	$\frac{\text{counts}}{64} / 5 \text{ min}$
-----	--

86

Conclusion:

- ① Extrapolation of multiplication data from masses ~~of~~ ^{between} 55% to 95% of M_c gives M_c to within $\pm 4\%$ of the mass estimated from critical arrays having H/T cube ratio = $\frac{1}{4}$, tamped.
- ② Indications are that above 75% criticality the multiplication curve is linear - over a wider range of masses, the curvature is such as to give, upon extrapolation from low mass, a value of M_c which is too small. -

Purpose: To further determine the effect of density on C.M.

Assay: 30% X.

Conditions: Tamped. moderated.

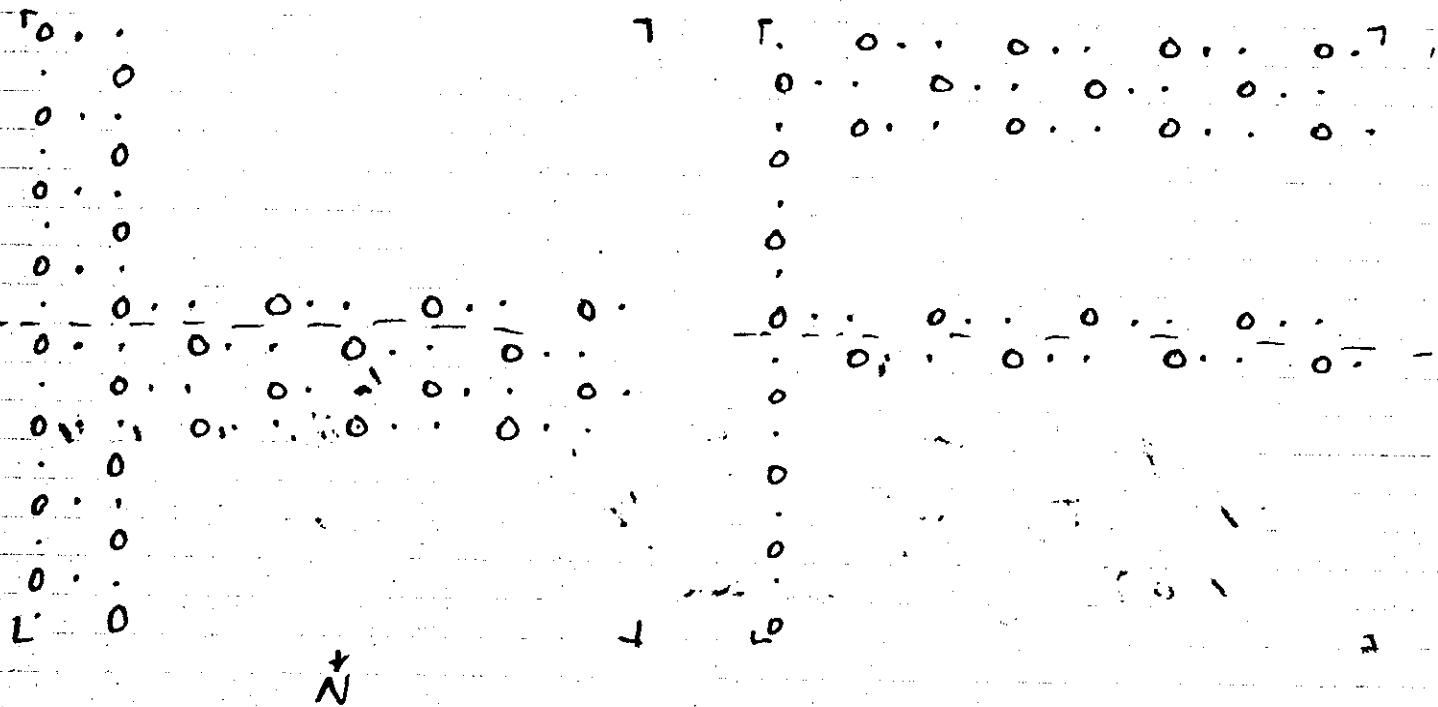
~~2T : 1H : 1 Air~~ cube ratio
1H : 2T : 1 Air.

Personnel.

Beck. L. Auer
Vossin
Wilhelm.

Initial Assay.

E-W = 16
N-S = 16
Height = 16.



Odd Layers.

For Even Layers, let us change E-W rows.

128 T cubes per layer

127

Assembly contains

}	2048 T cubes
	1024 Air spaces
	1024 μ cubes

9.6

Exp. 35 A.

11:15 Instrument check

62 ~ 0.61

CRITICAL

256
~~4136~~
~~1024~~
~~256~~
~~4096~~

Exp. 35 B

Removed complete face from Mott.
also top layer on movable table.

Removed 184 T cubes
 New array. E-W = 16
 N-S = 15
 Height = $15 \frac{2}{15}$ } 7864 T

11:40 Instrument check

103 0.1

CRITICAL

Conclusion:

The CM for a tapered, moderated assembly with a cube ratio of 1H:2T:1Air is 1828 T cubes for $\frac{1}{16}$ " al sep or 1807 for no al (27.28 Kg X)

$$\frac{CM(1:2) + 1 \text{ air}}{CM(1:2)} = \frac{1807}{1140} = 1.59$$

Purpose: To further determine the effect of density on C.M.

Assay: 30% X.

Conditions: Tamped, moderated
1H : 2T : 1/2 Air.

People Present

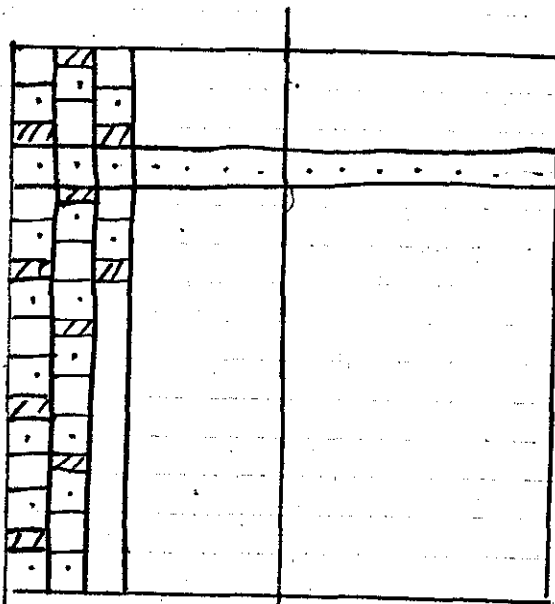
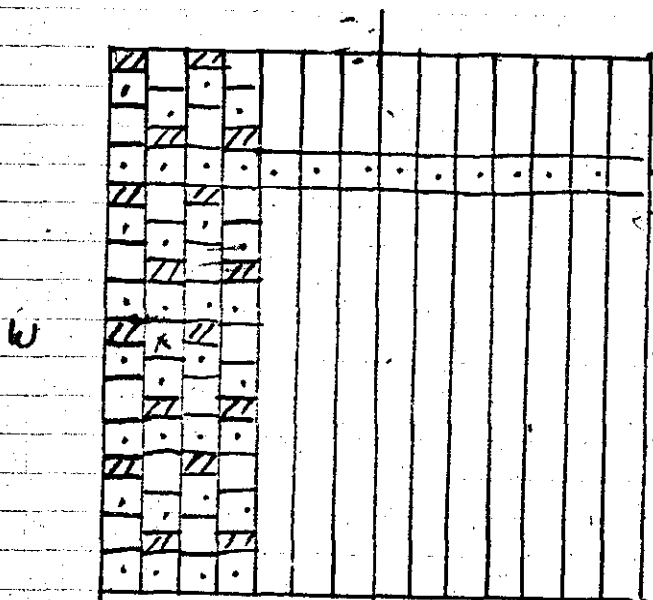
Boch.
Voss
Williams

Callahan
Felbeck } Visitors
Recher }

Initial Assembly.

Top.

Top.



Bottom.

Sections 1, 3, 5, 7, 9, 11, 13
from North.

Bottom.

Sections 2, 4, 6, 8, 10, 12, 14
from N.

8x4 = 112 T cubes } per E-W face.
56 H } per N-S face.
56 1/2 Air

129

N-S = 14. } 1568 T cubes
E-W = 14. } 784 H cubes.
Top Part = 14. } 784 1/2 air cells.

Experiment 36 A.

10:45. Instrument Check.

99. ~ 0.15" CRITICAL.

Exp. 36 B.

Added one complete face on South.
(112 T cubes, 56 H, 56 1/2 air)

14:10 Instrument check.

New array.

N-S - 15 } 1680
E-W - 14 }
High - 14 }

68. ~ 0.54" - CRITICAL.

Exp. 36 C.

Inserted. 1/8" al between tables

63 1/2. ~ 0.59.

Exp 36 D.

Repeat Exp 36 B. (Removed al.

68.

Conclusions:

- ①. The CM for a tamped, moderated assembly with a cube ratio of 1H:2T; 1/2 air is 1525 T cubes with 1/16" al. or -
1510 T cubes without al. (23.22 kg x)
- ②. The effect of introducing an aluminum sheet between the two assemblies is to lower the CM by 3/4% for 1/8" al sheet.
- ③
$$\frac{\text{CM (1:2) to 1 air}}{\text{CM (1:2)}} = \frac{1510}{1140} = 1.32$$

Experiment 37.

131

Purpose: To determine the CM of an untamped assembly.

Assay: 30% X.

Conditions: Untamped, moderated.
cube ratio $H/T = 4/1$.

People Present:

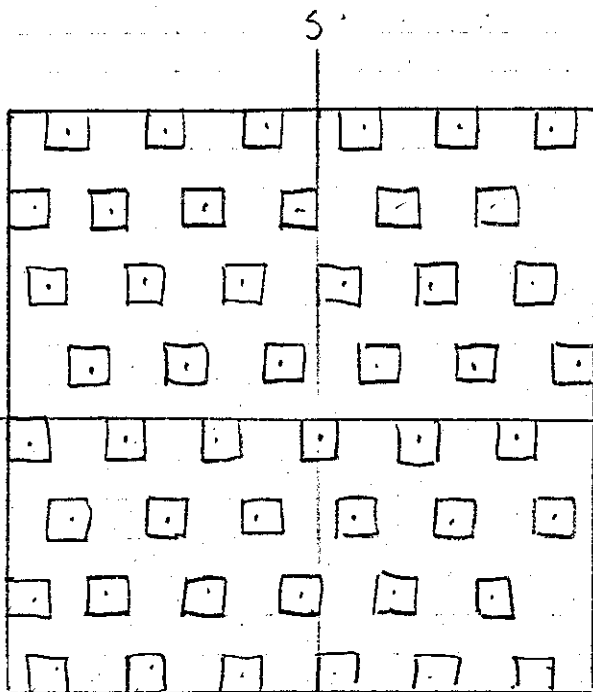
Bech.
Hull
Visser
Williams

Smith

Initial Array.

N-S = 15
E-W = 15
Height = 15

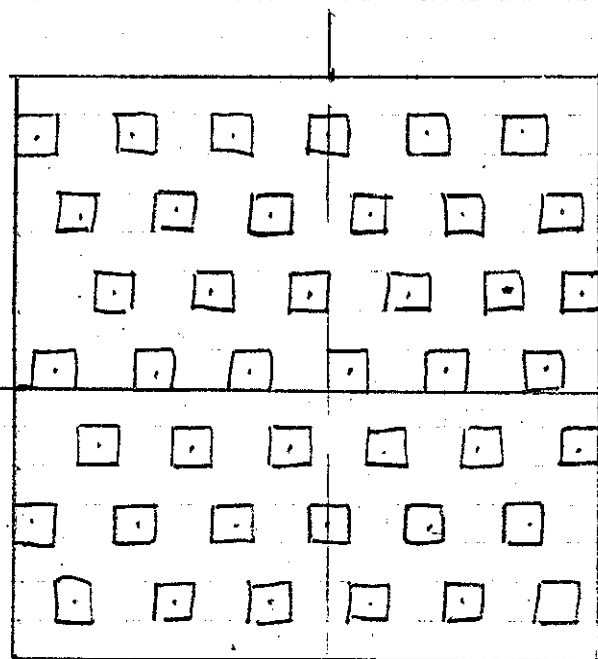
□ = T cube.



64 T₁ = 48

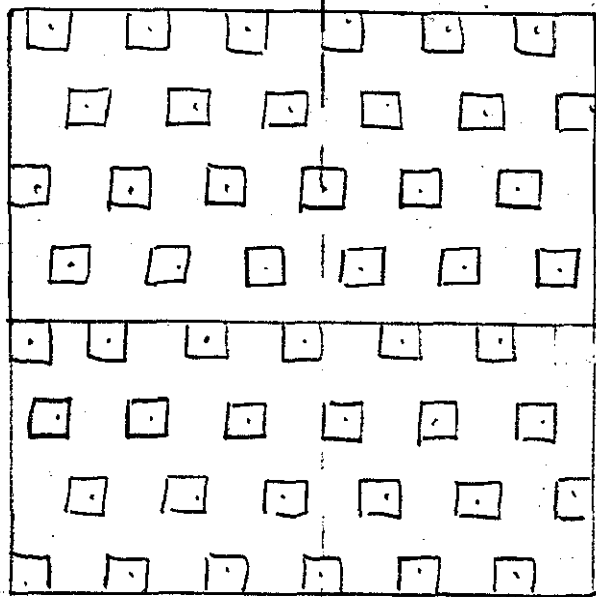
N

Layer 1, 10

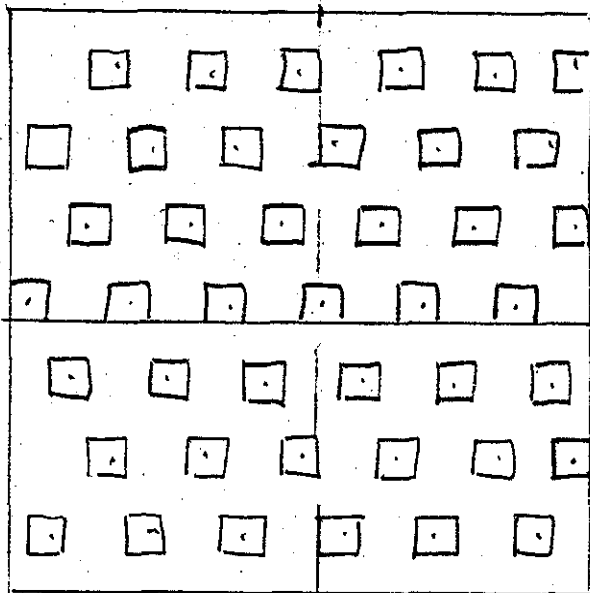


42 T₂

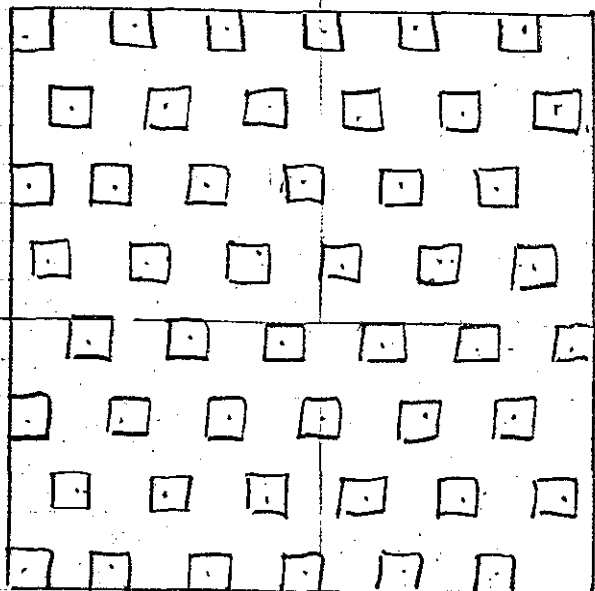
Layer 2, 12.



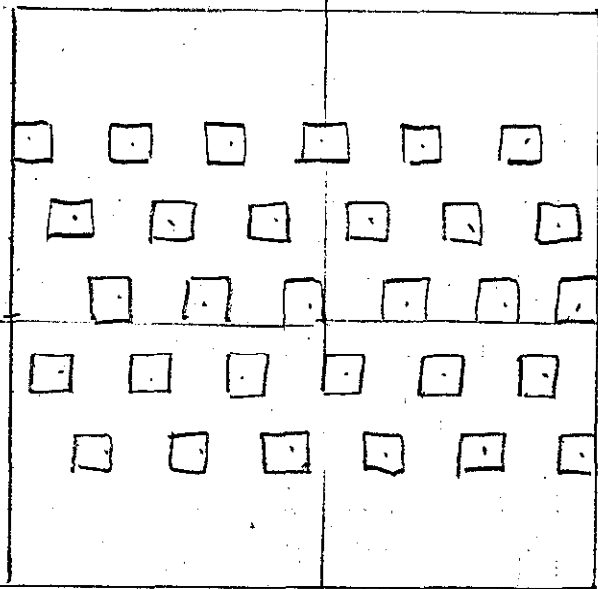
Layer 3.



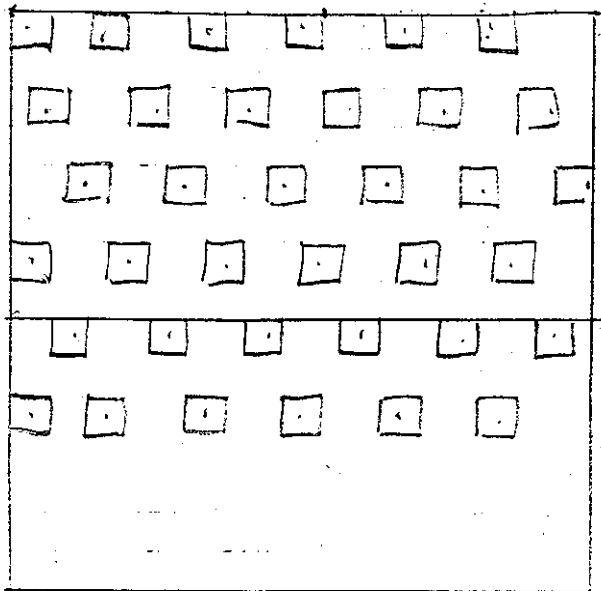
Layer 4.



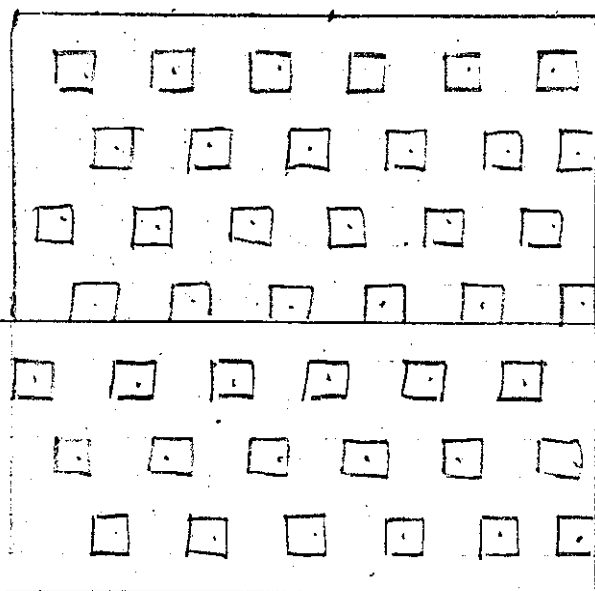
Layer 5.



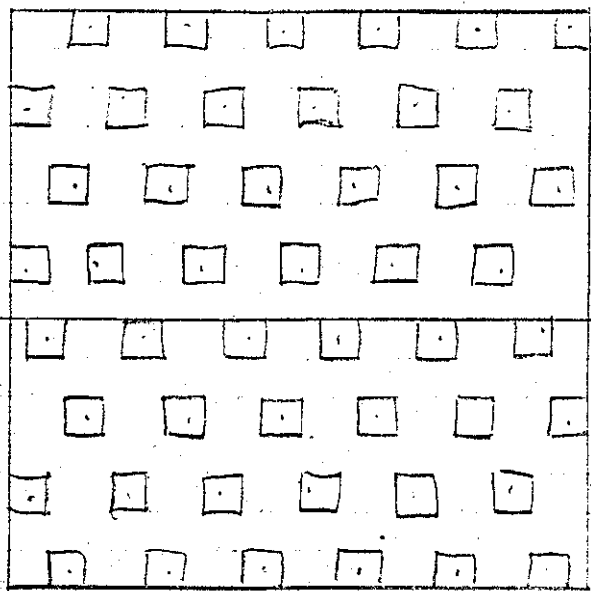
Layer 6.



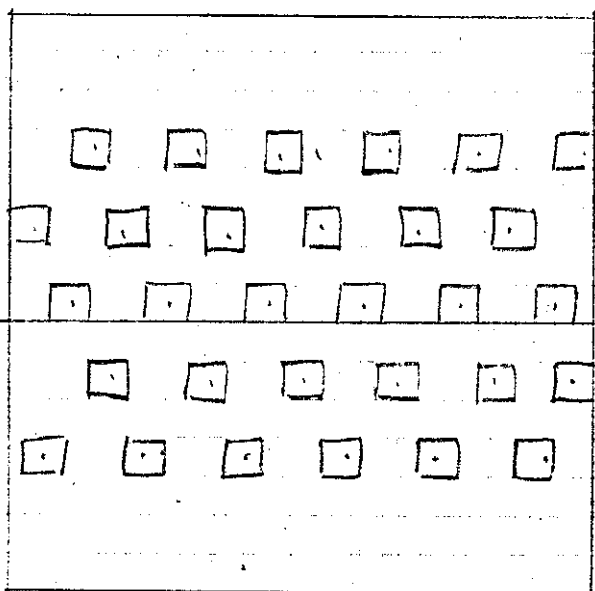
Layer 7.



Layer 8.



Layer 9.



Layer 10.

8 x 48	+ 7 x 42.	
544	294	900
<u>294</u>	<u>387</u>	<u>222</u>
838	T cubes: 678	678

Experiment 37A.

10:55. Instrument Check.

113. ~ 1.54"

CRITICAL

Exp. 37B.

Removed complete face from South. (48 T cubes)

New Assembly:

N-S - 14	}	630
E-W - 15.		
High - 15.		

11:33 Instrument check.

24. ~ 1.09.

CRITICAL.

Removed top layer - 42 T cubes. Exp. 37C.

11:50
44 ~ .84"

Critical

N-S - 14	588
E-W - 15	
High 14	

Removed complete ^{Experiment 37D} W side face [40 T cubes]

1:05

N-S - 14

E-W - 14

65 ~ 0.58" High - 14.

548.

Repeated 37D, but with ^{Experiment 37E} the table under the pile covered with Cd.

67 ~ 0.55"

548

Experiment 37 F.

135

Removed complete face from South (39 Tubes)
New array.

N-S - 13
E-W - 14
Hgt - 14. } 509

13:35 Instrument Check.

Cdq min removed

88. $\sim 0.29''$ CRITICAL.

Experiment 37 G

Removed 8p layer from stationary table.
(17 Tubes).

N-S - 13
E-W - 14 $\frac{6}{13}$ } 492 Tubes
Hgt: 13 $\frac{6}{13}$.

98. ~ 0.16 CRITICAL.

Exp. 37 H.

Put layer of 1" white cubes on top only.

Same no of T cubes as 37 G.

83 $\sim .35$

Exp. 37 I

Covered South face with 1" white cubes,
(in addition)

66 $\sim 0.56''$ Critical

Exp. 37 J

Covered all of 5 faces with 1" white cubes.

10 $\sim 1.26''$ Critical

Conclusion:

① The CM for an untamped assembly moderated at a cube ratio $H/T = 4/1$

is, $\begin{cases} 470 & T \text{ cubes for } 1/16" \text{ at} \\ 464 & T \text{ cubes for } 0 \text{ sep.} \end{cases} = 7.13 \text{ Kg}$

Ratio of $\frac{\text{Untamped}}{\text{Tamped}} = \frac{464}{258} = 1.80$

② The wooden table has negligible tamping effect.

Purpose: To determine the effect of
Baron shielding on CM.

Conditions: Tamped, moderated
cube ratio of H/T = 1/1

Assay - 30%.

People Present

Calhoun
Vine
Williams.

Initial Assay

Negh - 13 } 1183 Tubes
N-S - 14 }
E-W - 13 }

Experiment 38 A.

1302 Instrument checks.

93. 0.20" CRITICAL

Repeat.

92.5. Infinite doubling period

93.3 20 ^{sec} ~~min~~ doubling time.

94.5 22 sec doubling time.

169
14
59
59
2366

Removed 6/7 of South face. (39 Tubes).

New array.

$$\left. \begin{array}{l} N-S = 13 \frac{6}{7} \\ E-W = 13 \\ \text{Height} = 13. \end{array} \right\} 1144$$

14:12. Instrument Checks.

106 D.04" 34 sec doubling time. CRITICAL

105. 47 sec doubling time

103 1/2. Infinite doubling time.

Conclusion:

The CM for a tamper assembly, moderated at a cube root of $H/T = 1/1$.

with boron shielding is 1134 Tubes for 1/104

1117 Tubes for mod.
17.2 Kg X

$$\frac{CM (1/1) \text{ Boron}}{CM (1/1) \text{ no boron}} = 2.25.$$

CM (1/1) no boron

Purpose: To determine CM for an untamped assembly

Assay: 30% X.

Condition: Untamped, H/T cube ratio = 1/2

Personnel.

Callahan
Hull
Vivari
Williams

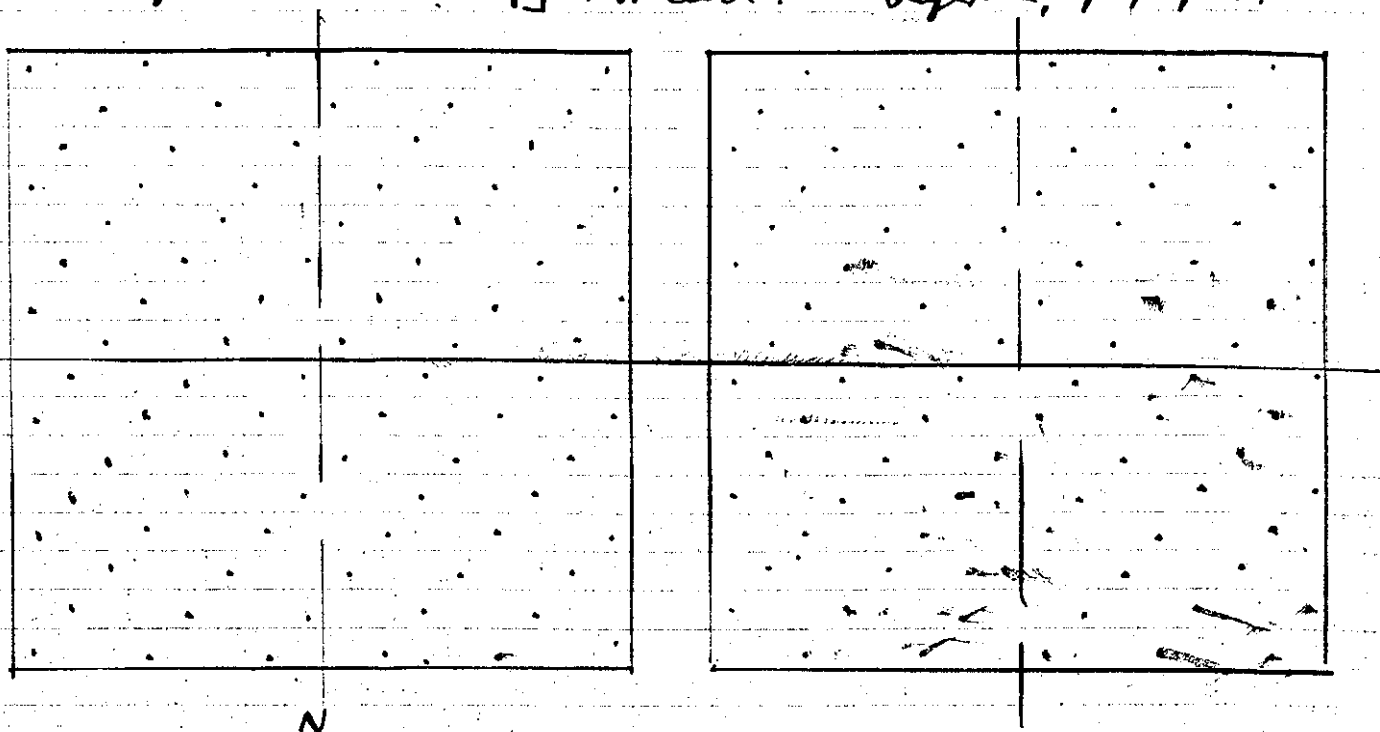
Successive layers are made by shifting one to East.

Initial Assay.

N-S = 16 } 2730 T.
E-W = 16 }
High = 16 }

Layers 1, 4, 7, 10, 13, 16 \square = H cube.

Layers 2, 5, 8, 11, 14.



140

Experiment 39 A.

9:55

Instrument check.

NOTCRITICAL

Exp. 39 B.

Add complete top layer (171 T cubes).

New array

N-S = 16

E-W = 16

Height = 17.

} 2901 T cubes

44.6Kg

10:24

Instrument check.

10:3

0.08"

CRITICAL

Exp. 39 C.

Partly covered assembly with Boron pancake
35% of surface area covered.

92

= 0.21"

CRITICAL

Exp. 39 D.

Covered 73% of surface area covered
with Boron pancake.

81

= 0.35"

CRITICAL

Exp. 39 E.

Removed Boron but covered 76%
of surface area with cadmium.

102.

CRITICAL

Removed cadmium, added 1 complete face & South
and 1 face & West on stationary
table only. added 283

3184 T cubes.

New array.

N-S = 17

E-W = 16 $\frac{9}{17}$

High = 17

48.9 Kg 25

645 dw = 0.53"

CRITICAL.

Period measurements on this assembly:

Scale	Doubling Time	Exponential Rise Time	$\frac{\Delta C}{C}$	ΔY
64	∞	∞		0
66	ca 150			2
67	47	68	0.13	3
67	36	52	0.16	3
68	18	26	0.24	4

Conclusion:

① For an untamped assembly, moderated
at a cube ratio of $H/T = 1/2$, the
CM is $\left\{ \begin{array}{l} 2850 \text{ T cubes for } \frac{1}{16}'' \text{ of sep.} \\ 2810 \text{ T cubes of 0 sep (43.2 Kg X)} \end{array} \right.$

② Tamping Ratio = $\frac{\text{CM untamped}}{\text{CM tamped}} = 2.45$

③ "Boron" shielding of the untamped
assembly decreased the CM.
(5.5% decrease in CM for 73% shielding
of surface area).

④ Cadmium shielding of the untamped
assembly did not change the CM.

Experiment 40

11/16/46

To measure CM of a modified (14:16) unstepped assembly of 30% material.

Personnel: Beck
Callahan
Williams -

Initial assembly: 16:1 W cube retro in usual array

14x14x14 containing 1372 G cubes 21.6%
 Asymmetric with respect to three axes and \neq } $\frac{1372 \text{ W Cubes}}{2742}$

Critical at 66 scale division = 0.55"

Exp 40B-

Removed 98 G cubes from south face
 assembly now 14x14x13 = 2548 : $\frac{1274 \text{ G} - 19.6\% \times}{1274 \text{ W}} = 2548$

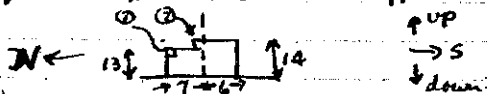
Critical at 90 scale division = 0.25"

Exp 40C.

Removed top of North assembly - 49 Green cubes -
 now 14x13x13^{1/2} containing 1225 G cubes
 = 2450

Not quite critical at 108 div $\&$ (Removal of 7 green cubes, as shown did not affect criticality: $\frac{1225 \text{ W}}{1225}$)

Exp 40D.



Add 14 G cubes ^{2 rows} to top of north assembly, these added ^{at} new south face.
 now 14x13x13^{2/3} = 2478 containing 1239 G cubes -
 1239 W

Critical at 109 division = 1/80" = 0.01"

Experiment 40E

$x + 14 = 1239$
 $\frac{11}{55}$ 11/16/16 143

Since mass vs critical distance curve is not linear a point is to be taken at $d = 0.5$

~~Added two faces to S side of assembly, making it a 5-sided face.~~
 Returned top face to north side and South face, then added another face to South.

Assembly $14 \times 14 \times 15 = 2940$ containing 1470 G 27.6 kg
 1470 W cubes
 2940

Critical at 50 div = $0.75''$

Experiment 40F

To examine further the interaction of parallelepiped assemblies having

14×14 cross-section -

added two addition faces - one on north - one on south -

now $14 \times 14 \times 17 = 3332$: $1666 \text{ G} = 25.6 \text{ kg}$ 235
 $\begin{matrix} 14 \times 14 \times 9 \\ 14 \times 14 \times 8 \end{matrix}$ $\frac{1666 \text{ W}}{3332}$

Critical at 121 div = $\frac{114}{80} = 1.43''$

Experiment 40G

Added 1 face each - N + S, now $14 \times 14 \times 19 = 3724$: 1862 W

$1862 \text{ G} = 28.6 \text{ kg}$

Critical at $6 \frac{9}{32}''$ or threaded rod (closure at $3 \frac{4}{16}$)

Critical distance = $2 \frac{13}{32} = 2.41''$ (also critical at $6 \frac{1}{2}$ turns

before engaging dial indicator; dial at 77 at extreme separation

\therefore distance = $\frac{48+100}{80} + \frac{6 \frac{9}{32}}{16} = 2 \frac{13}{32}''$

Experiment 40H

Added 1 face each - N + S, now $14 \times 14 \times 21$ (ie 2 assemblies $14 \times 14 \times 11 + 14 \times 14 \times 10$)
 $= 4116 = 2058 \text{ G} + 2058 \text{ W}$

Critical at $4.09''$ (ie max travel of scale + $2 \frac{13}{32}''$) = 31.7 kg

Experiment 40I

Same as 40H, except Cd sheet placed between two good assemblies -

\rightarrow Critical at $3.63''$ (i.e. $7 \frac{1}{2} - 3 \frac{14}{16}$) $\rightarrow 2058 \text{ G}$ cubes.

$\rightarrow 31.7 \text{ kg}$

Experiment 40J

Added face to north, now 2 - $14 \times 14 \times 11$ assemblies containing total of 2156 green cubes

\rightarrow Cd still between assemblies.

Critical at $(8 \frac{12}{16} - 3 \frac{14}{16}) = 4 \frac{7}{8} = 4.88''$

$= 33.2 \text{ kg}$

Experiment 40K

Same as 40J but with Cd sheet removed - 2156 green cubes
 Critical at $(9\frac{3}{16} - 3\frac{14}{16}) = 5\frac{5}{16} = 5.31"$ 33.2 % X

Experiment 40L

Added face to south assembly - now assemblies are
 $14 \times 14 \times 12 + 12 \times 14 \times 11$ total of 2254 T cubes -
 → Cd sheet placed between assemblies. 34.7 % X
 Critical at $(11\frac{11}{16} - 3\frac{14}{16}) = 7\frac{13}{16} = 7.81"$

Experiment 40M

Same as 40L except without Cd - 2254 T cubes.
 Critical at $(12\frac{7}{16} - 3\frac{14}{16}) = 8\frac{4}{16} = 8.25$ 34.7 % X

Experiment 40N

To examine interaction of cubical array -

Rearranged the above arrays into two cubes each $13 \times 13 \times 13$
 and ~~each~~ containing 1098 + 1099 green cubes, respectively, total
 2197 green cubes - 33.8 % X

Critical at $(9\frac{9}{16} - 3\frac{14}{16}) = 5.5"$

Experiment 40-O

→ Same as 40N except Cd placed between assemblies. 2197 green cubes
33.8 % X
 Critical at $(8\frac{14}{16} - 3\frac{14}{16}) = 5.0"$

Experiment 40-P

Removed ~~two~~ ^{one} layer from each face of each cubical assembly
 making two $12 \times 12 \times 12$ cubes, each containing 864 green
 cubes - total 1728 green cubes. = 26.6 % X

→ Cd sheet between two assemblies -

Critical at 87 div (2nd revolution of disc) = $\frac{125 + (110 - 87)}{10} = \frac{148}{10} = 14.8$
= 0.29

Experiment 40-Q

Same as 40-P except with Cd removed
 Critical at 46 div = $\frac{(110 - 46)}{10} = \frac{64}{10} = 6.4$
= 0.8

Experiment 40-R-

Reduced each assembly to $11 \times 11 \times 12$ containing 720 & 732
green cubes respectively, total ~~was~~ 1452 green cubes -
22.3 kg.

Not critical at 108 — needed several more divisions approx.

Conclusions: ① The critical mass of a cubical, moderated
(1H:1T), untamped array of 30% material is
1239 Tcubes = 140 kg at $1/16$ " separation -
1232 Tcubes = 18.9 kg at zero ~~cube~~ separation.

$$\text{Ratio, at this reduction, } \frac{\text{untamped}}{\text{tamped}} = \frac{1232}{498} = 2.48$$

② Examination of the interaction of two subcritical
assemblies as they were brought together until criticality was
reached, showed that the "safe distance" of separation increases
more rapidly than the "safe mass" increased. When the mass in
each assembly varied from 55% CM to 90% CM the relation
is approximately "safe mass" \propto log (safe separation).

③ Interposition of Cd between the two subcritical
assemblies decreases the separation, at criticality, by only
about 7% at separations > 3 ".

④ As the ^{adjacent} "area" of the two assemblies is
decreased, the "safe distance" decreases. -

19/12	10/17	10/17	10/18	10/19	10/22	10/23	10/24	10/26	10/29	10/30
1000	900	900			900	900	900	900	930	
1000	804				848	848	9	900	900	
484	900				-		900	900	600	
547.	360				-			328	598.	818
217.	220				-			220	-220	
<u>3248</u>	<u>3248</u>							<u>3248</u>	<u>3248</u>	

TABLE

	$\frac{10}{30}$	30%	$\frac{1}{1}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{1}{6}$	$\frac{1}{7}$	$\frac{1}{9}$	$\frac{1}{11}$	$\frac{1}{12}$	$\frac{1}{13}$
1	930	600	600		900		852	728	900	900	900
2	900	} 900 - 930			898	898	690	818	900	900	
3	600				639		900	900	646		
4	818				812		802				
Total	3248				3248		3248				
5	468				478	592		592			
6	$\frac{640}{1108}$		640	630	$\frac{515}{1107}$			$\frac{516}{1108}$			

95%

Note: one 95 can be
in a 30% table.

TABLE

	$\frac{1}{15}$	$\frac{1}{16}$	$\frac{1}{20}$
1	646	900	
2	900	900	
3	900	646	50 cut 7596 + 646 = 3090
4	802		
5	9090		
5		200	
6		858	

30% cubes contain $\frac{15.38}{15.37} \text{ g} \times / \text{cuba.} \leftarrow$
 $H/T = 32.0$ for $\frac{1 \text{ white}}{1 \text{ green (30%)}}$

Cadmium Sheet .017" thick
density = $8.67 \text{ g/cc} \times 0.017 \times 2.54 = 0.38 \text{ g/cm}^2$

Boron Powder
density = $0.29 \text{ g/cc} \times \frac{5}{8} \text{ " } \times 2.54 = 0.46 \text{ g/cm}^2$

Boron Carbide Powder
density = $0.77 \text{ g/cc} \quad \frac{3}{4} \text{ " thick}$
 $= 0.77 \times \frac{3}{4} \text{ " } \times 2.54 =$

48 x 70 - 3

96

480 - 3
600
+ 77.

123

640
513

127.

27
13

81
27

351
27

286

276

558

48

598

1108
1083
3/3248
25

Classification Change to Decl.

Authority of E.J. M. Date 5/27/60