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ENGINEERING OPERATIONS REPORT

COMMON RADIATION ANALYSIS MODEL

FOR 75,000 LB THRUST NERVA ENGINE (1137400E)

DRA

Project 110, Para. 01

April 1972

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(NASA-CR-132228) COMMON RADIATION ANALYSIS MODEL FOR 75,000 POUND THRUST NERVA ENGINE (1137400E) (Westinghouse Astronuclear Lab., Pittsburgh) 174 p HC $10.75 CSCL 21F G3/22

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I. INTRODUCTION AND SUMMARY

This report documents the mathematical model and sources of radiation used for the radiation analysis and shielding activities in support of the design of the 1137400E version of the 75,000 lbs thrust NERVA engine. It supersedes and replaces the last published Common Radiation Analysis Model (CRAM) document (ANSC Report - RN-S-0551, 6 March 1970).

The nuclear subsystem (NSS) and non-nuclear components are treated in two separate sections. The NSS section is as submitted by WANL for the R1 reactor with composite fuel. From the standpoint of neutron leakage which determines non-nuclear component secondary gamma sources, there is no essential difference between the graphite and composite core NSS configurations. In the forward direction the pressure vessel neutron leakage magnitudes were adjusted to be equal to the specification extreme leakages legislated in the engine specification. This then resulted in non-nuclear component sources which would not be exceeded with either candidate NSS design.

The geometrical model for the NSS is two dimensional as would be required for the DOT discrete ordinates computer code or for an azimuthally symetrical three dimensional Point Kernel or Monte Carlo code.

The geometrical model for the non-nuclear components is three dimensional in the FASTER geometry format. This geometry routine is inherent in the ANSC versions of the QAD and GGG Point Kernel programs and the COHORT Monte Carlo program.

The nuclear subsystem section also includes data pertaining to a pressure vessel surface radiation source data tape which has been used as the basis for starting ANSC analyses with the DASH code to bridge into the COHORT Monte Carlo code using the WANL supplied DOT angular flux leakage data.

In addition to the model descriptions and sources of radiation, the methods of analyses are briefly described in each section.

II. TECHNICAL DISCUSSION

A. Non-Nuclear Components

1. Geometrical Models

Figures 1 and 2 show two views of the 1137400E engine configuration components forward of the reactor including the upper portion of the pressure vessel assembly. Some of the major zones in the mathematical model description of these components are superimposed in these two figures. The basic mathematical model is essentially mass equivalent to the actual engine in that the mass of the engine between two engine station planes, which are a foot or more apart, is closely approximated by the mathematical model between these planes. The total math model description represents the actual engine mass within 1%. The mass distribution is approximated as closely as was possible within reasonable computer running times.

A total of 172 zones and boundaries were used to describe the components forward of the pressure vessel. The nozzle and nozzle extension were represented by zones and boundaries. The cylindrical portion of the pressure vessel was represented exactly as a single annular zone.

The non-nuclear components were originally described for the 1137400C engine configuration and only the engine station locations were changed in remodeling for the E engine design. It was decided that the model was sufficiently complicated and the analysis much too expensive to repeat for the changes in some of the components from the C to E engine designs.

Figure 3 depicts the model representing a conglomerate of small engine parts and the lower thrust structure (LTS). The gimbal actuator models are shown in Figure 4 and the gimbal regions in Figure 5. The upper thrust structure (UTS) region is shown in Figure 6. The few zone model of the turbopump assembly (TPA) is depicted in Figures 7 and 8. A much more detailed model of the TPA was used to compute radiation heating levels internal to the TPA, as reported in Engineering Operations Report N8140R:71-0005.

The pump inlet line, pump shutoff valve, turbine inlet line, turbine bypass line, turbine exhaust line, pump discharge line, and structural support cooldown line are depicted in Figures 9 through 14. These regions are based on the C engine configuration but present a fair representation of the mass distribution and secondary source magnitudes for the E engine.

Figures 15 through 24 depict the zones in the CRAM which are required to describe the void regions in the engine forward of the pressure vessel. These are extremely important from a radiation transport viewpoint and are required to complete the mathematical model without resorting to slab configurations.

Figures 25 and 26 depict the nozzle and nozzle extension models. The extension model shown here is for the Columbium alloy backup configuration. A simple model was required for the primary configuration employing a graphite material, as it was assumed that secondary gamma and inelastic scatter gamma sources would be minimal for such a design.

Appendix A is a computer listing of the FASTER geometry CRAM including zone and boundary descriptions in cm units with the origin of the model at 220 and R=0 on the engine axis at the mating plane between the pressure vessel and nozzle flange. This corresponds to an engine station of 206.93 inches. The dimensions of all the figures in this report are keyed to this model zero location.

View of Forward Portion of 1137400E Engine
Configuration - Showing Twin Turbopumps

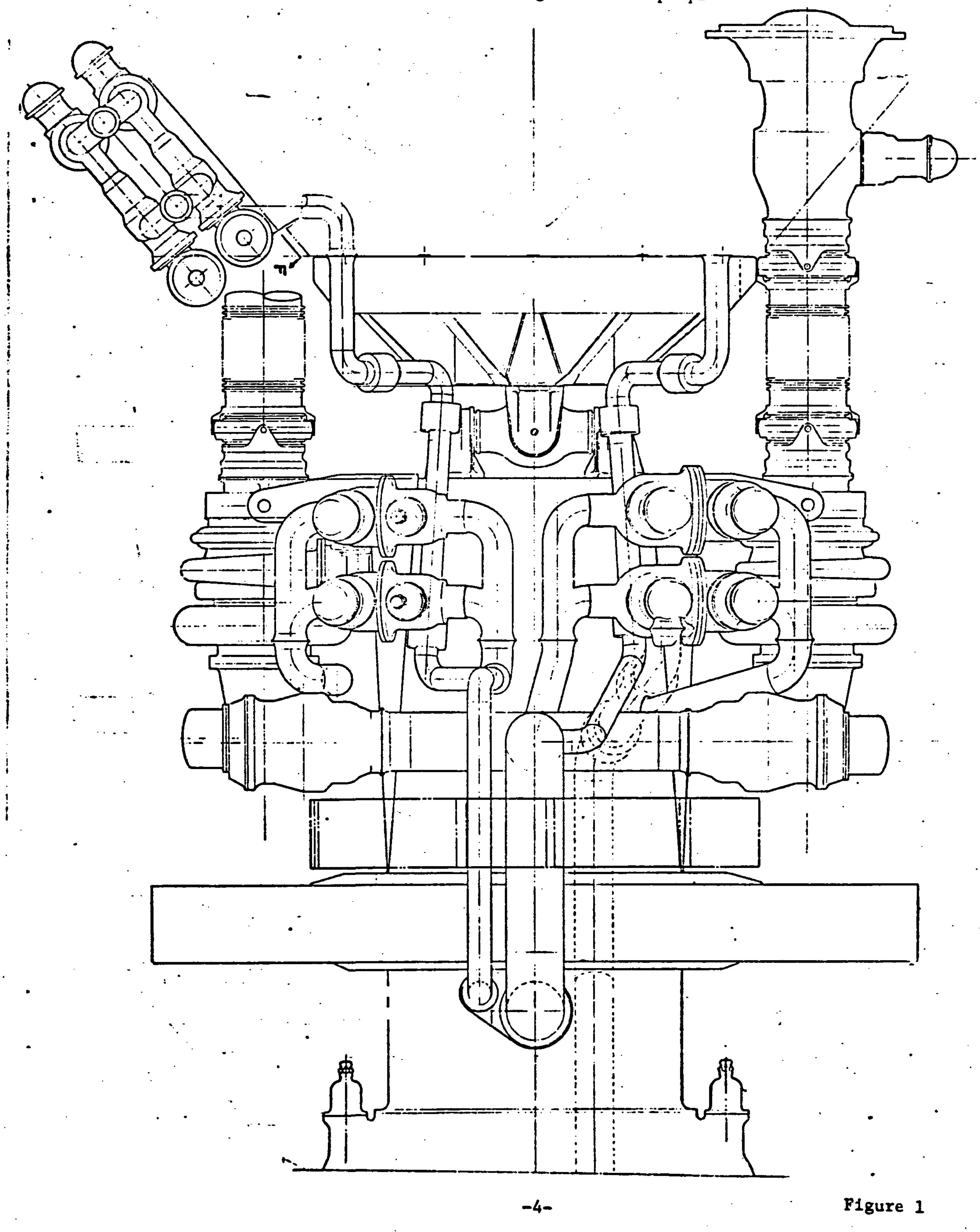


Figure 1

View of Forward Portion of 1137400E Engine
Configuration - Showing Line Routing ARound Disk Shield

NOTE: Sources in forward components are based on case with the disk shield removed.

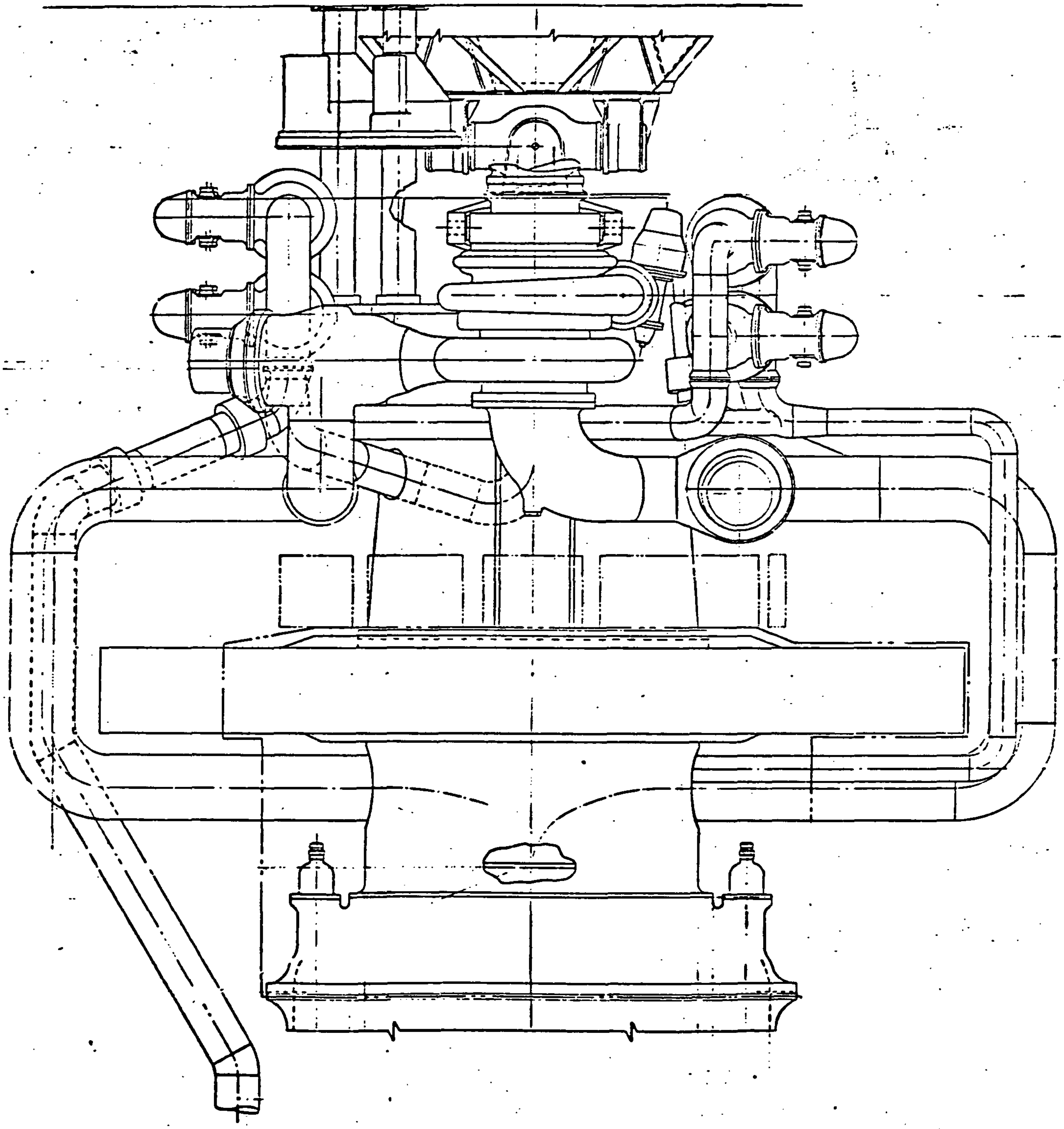
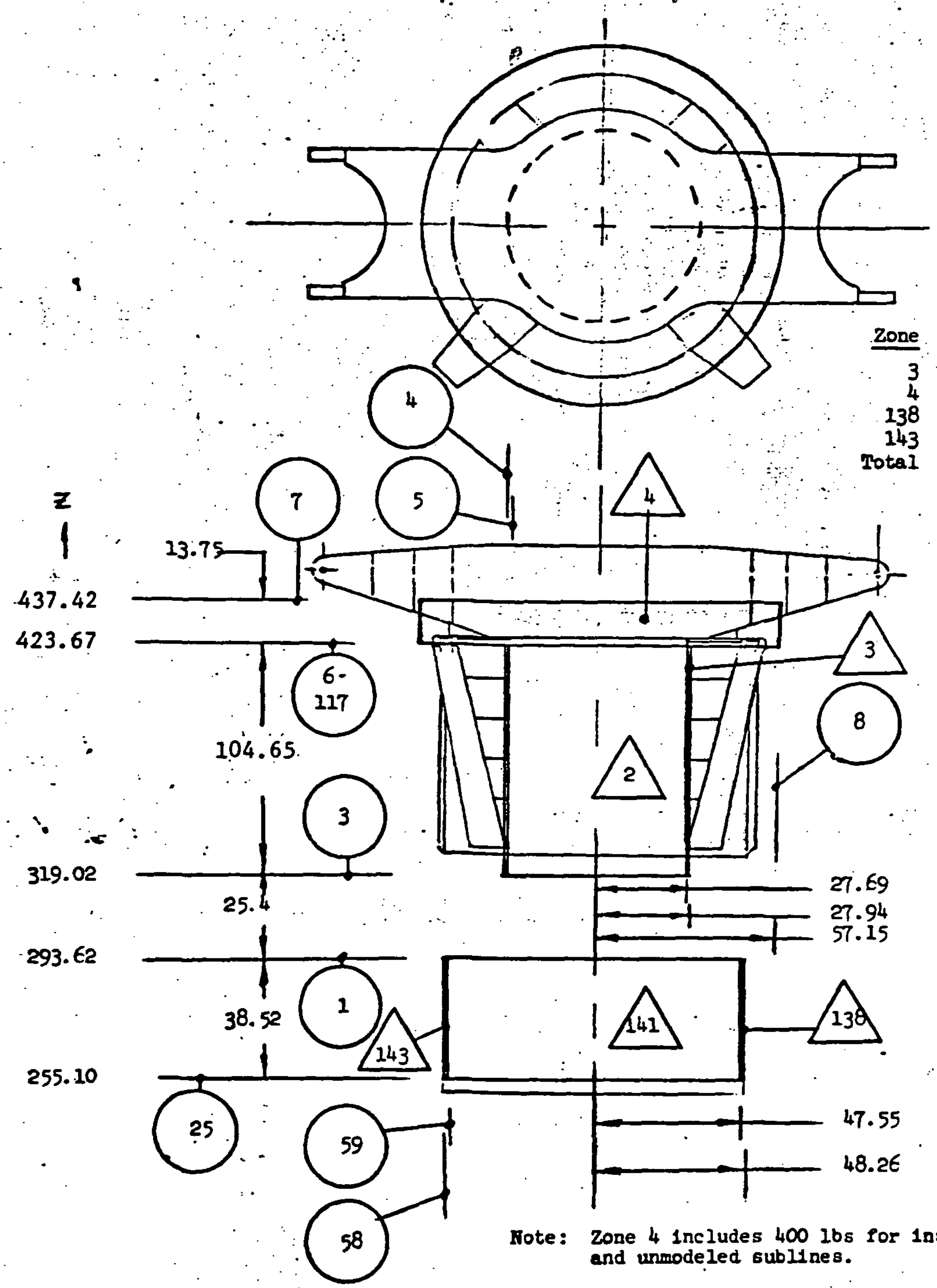


Figure 2

LTS & Conglomerate

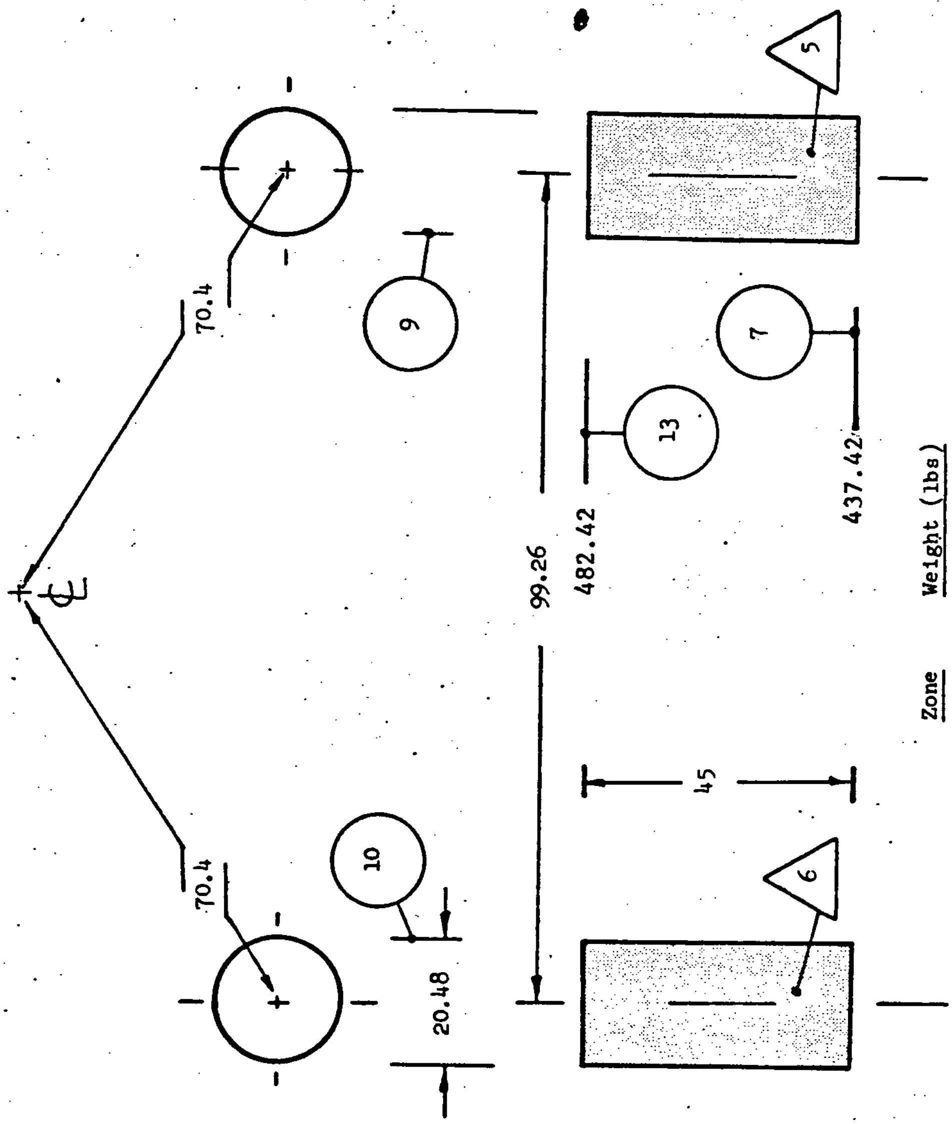


Zone	Weight (lbs)
3	69.34
4	880.72
138	25.17
143	25.17
Total	1000.4

Note: Zone 4 includes 400 lbs for instrumentation and unmodeled sublines.

Figure 3

Gimbal Actuators

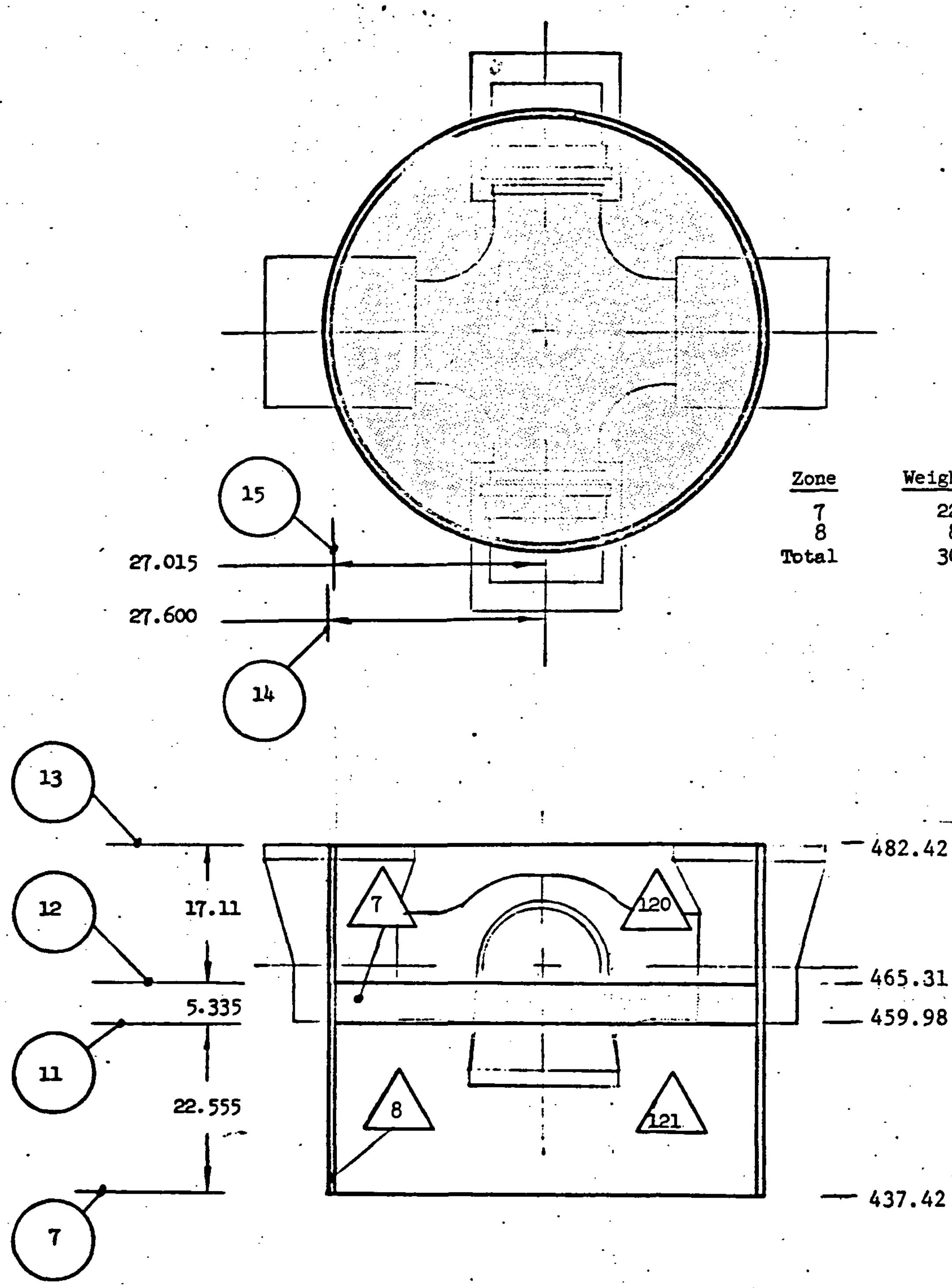


Zone	Weight (lbs)
5	396.10
6	396.10
Total	792.2

GA's

Figure 4

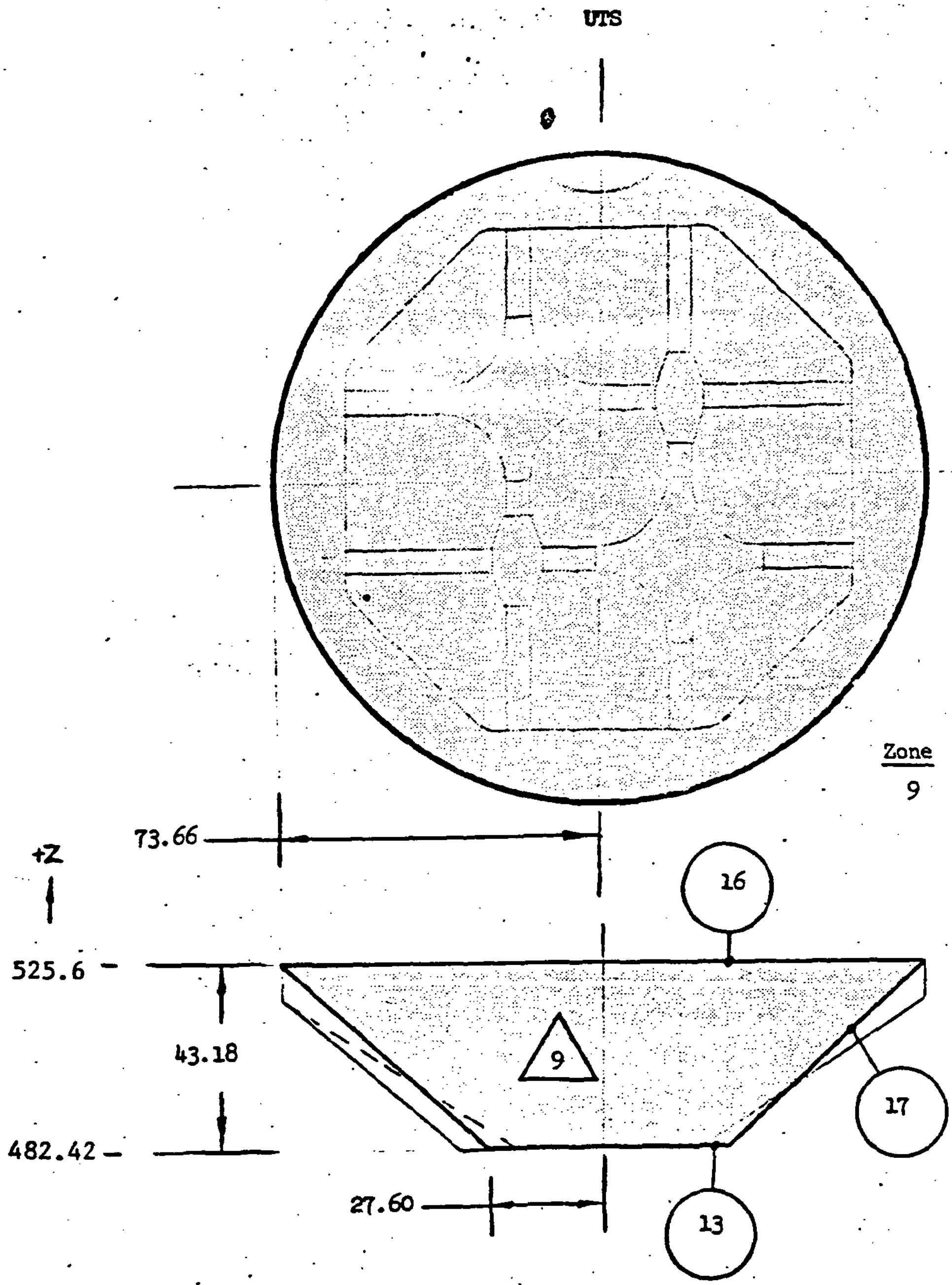
Gimbal



Zone	Weight (lbs)
7	221.05
8	81.6
Total	302.65

GIMB.

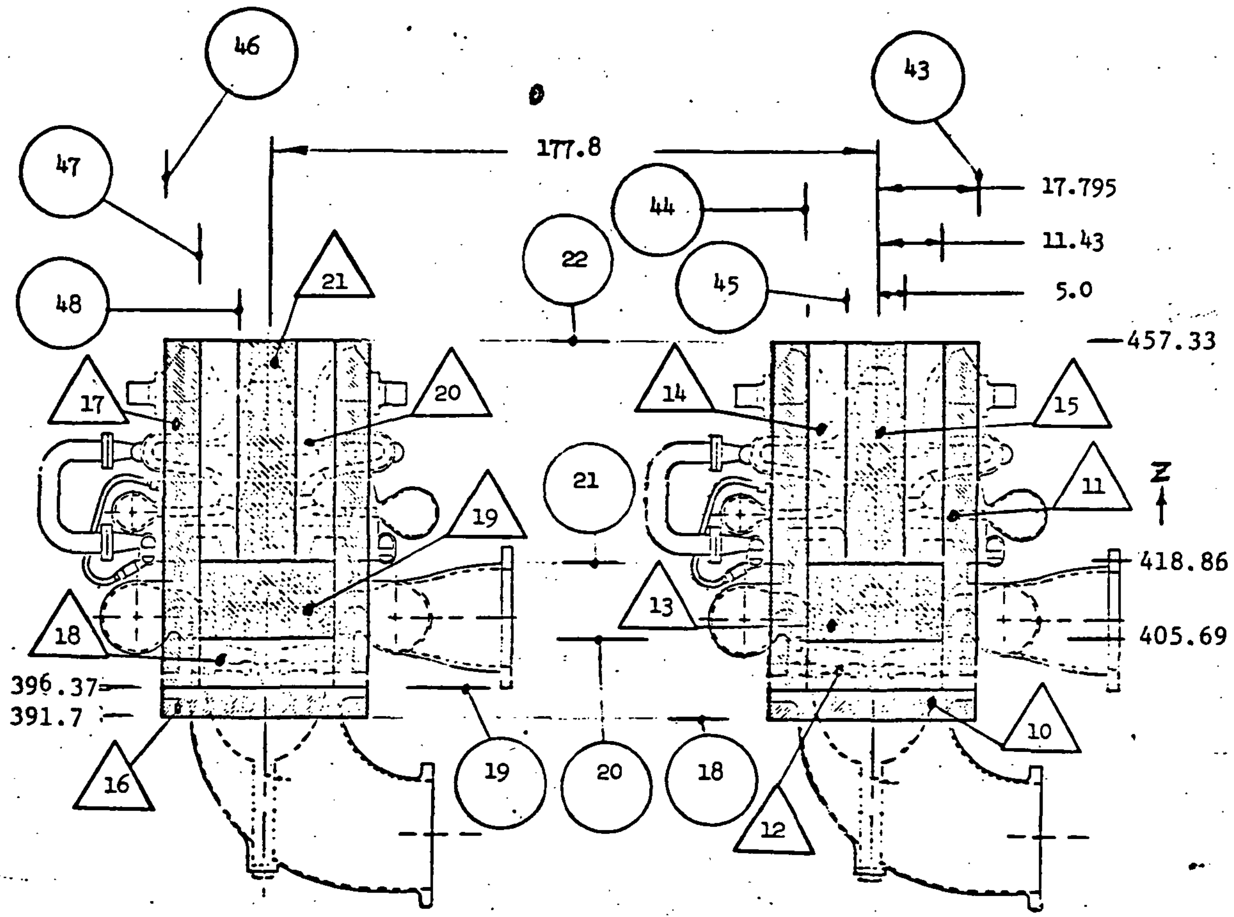
Figure 5



Zone	Weight (lbs)
9	193.85

Figure 6

Turbopump Assembly



Zone	Weight (lbs)
10	81.89
11	627.97
12	0.07
13	48.10
14	1.97
15	26.9
Subtotal	786.9
16	81.89
17	627.97
18	0.07
19	48.10
20	1.97
21	26.9
Total	1573.80

Figure 7

Turbopump Assembly

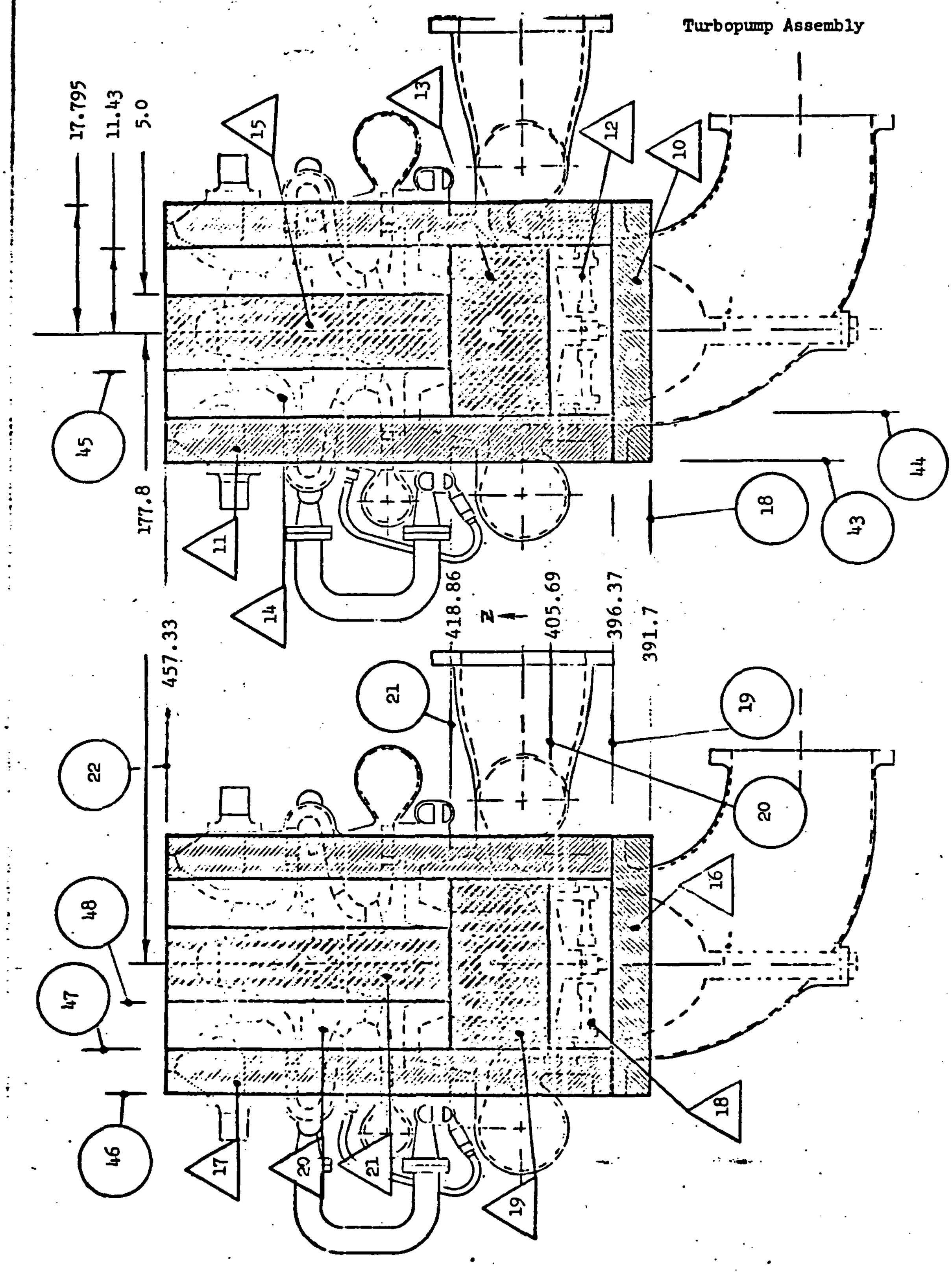
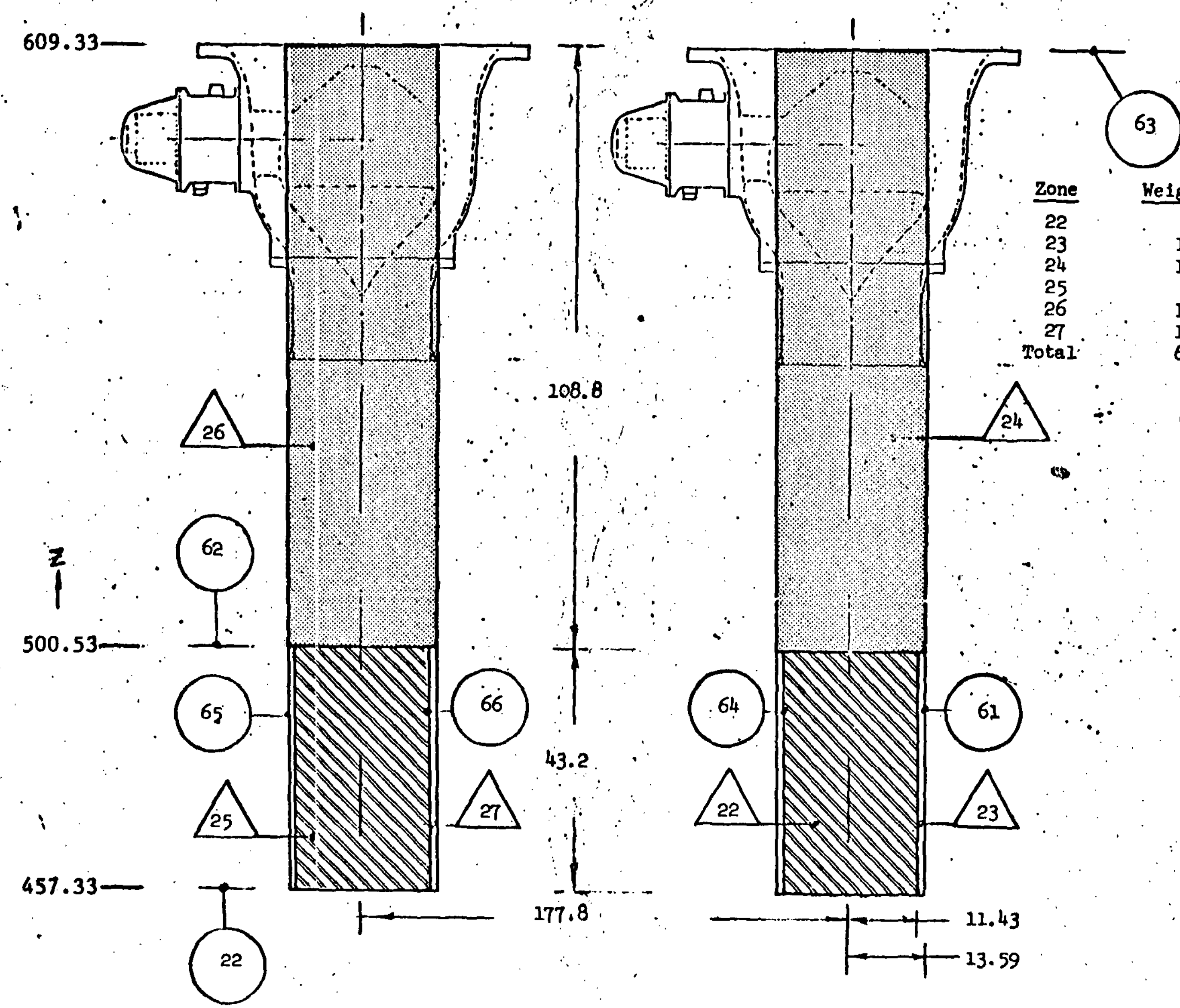


Figure 8



Zone	Weight (lbs)
22	2.73
23	132.53
24	182.21
25	2.73
26	182.21
27	132.53
Total	634.94

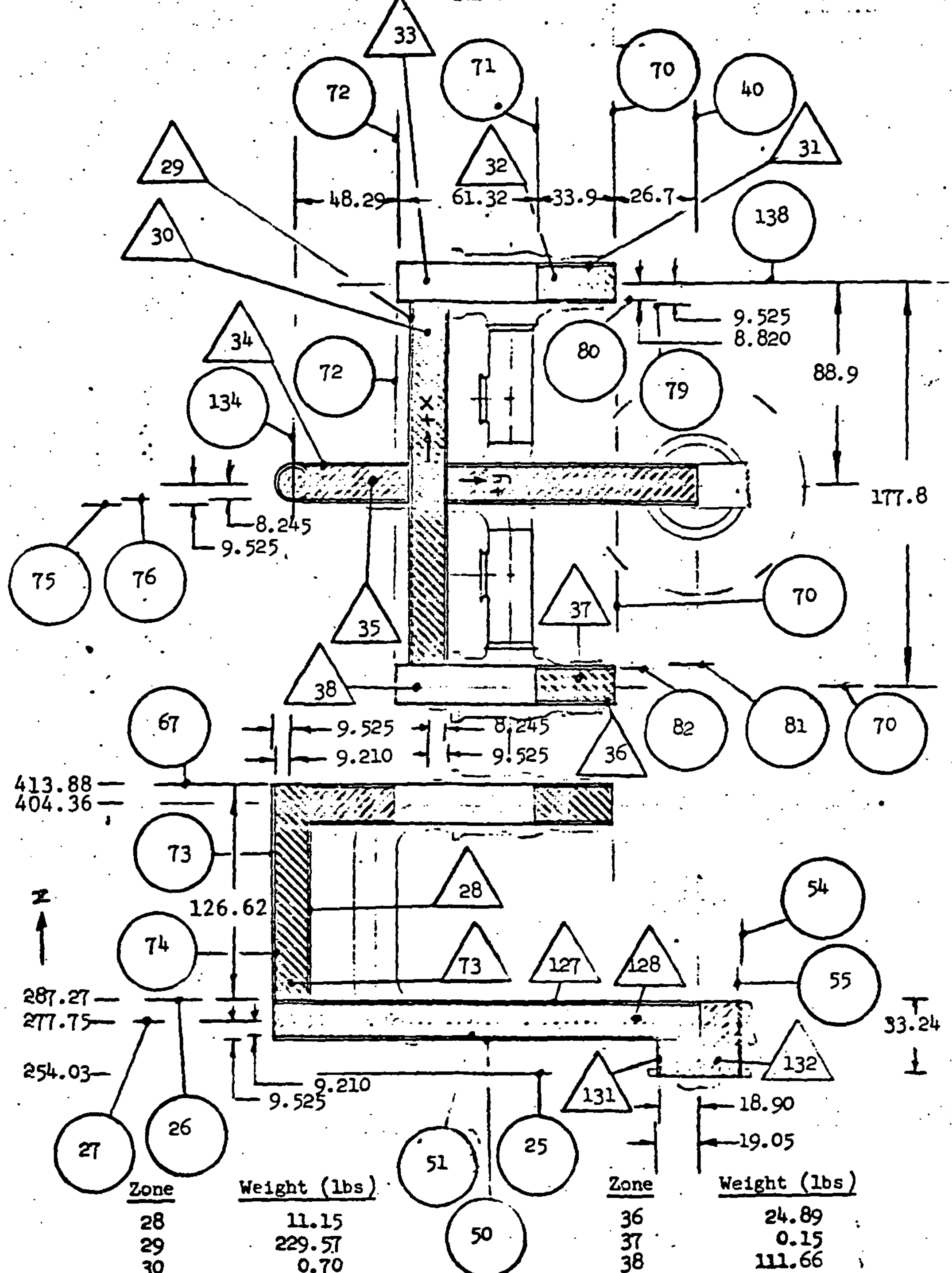
Propellant Inlet Line

PIL & PSOV

Figure 9

B

Turbine Inlet Line

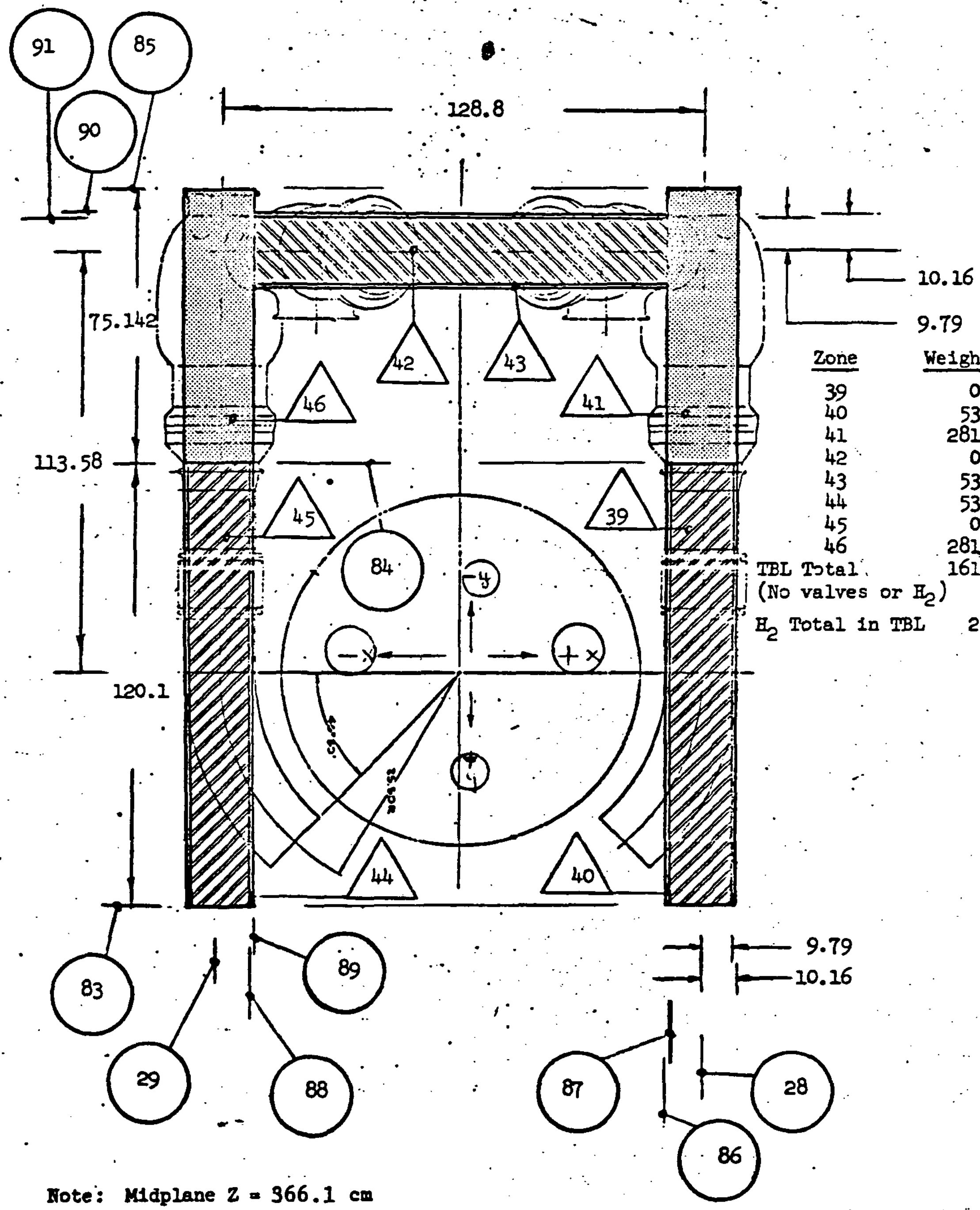


Zone	Weight (lbs)
28	11.15
29	229.57
30	0.70
31	24.89
32	0.15
33	111.66
34	25.92
35	0.24

Zone	Weight (lbs)
36	24.89
37	0.15
38	111.66
73	0.52
127	19.83
128	0.89
131	11.91
132	0.49
Total TIL	348.16 (No H_2 or valves) (in TIL only) TIL
Total H2	2.9

Figure 10

Turbine Bypass Line

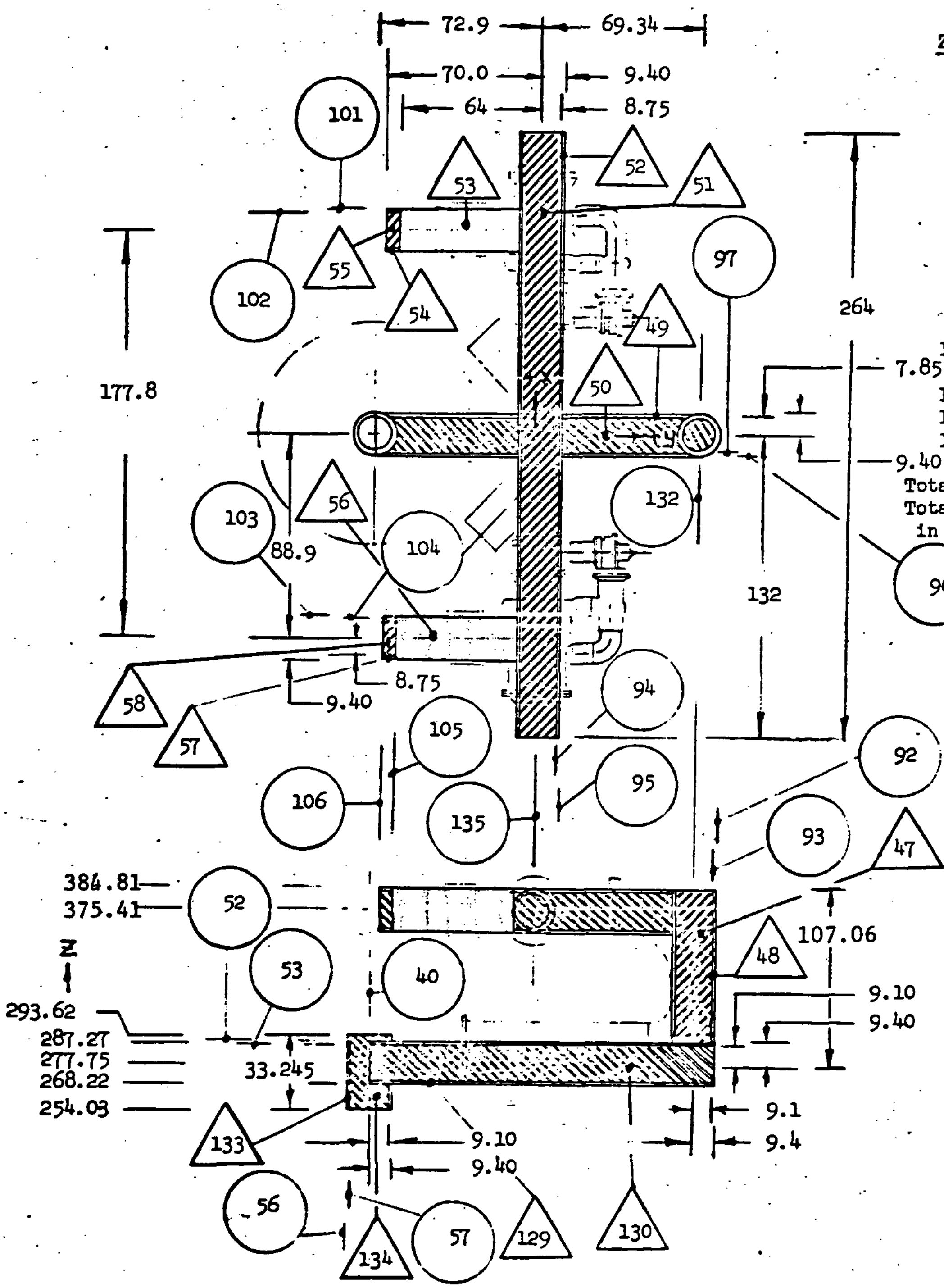


Zone	Weight (lbs)
39	0.67
40	53.65
41	281.63
42	0.72
43	53.96
44	53.65
45	0.67
46	281.63
TBL Total (No valves or H_2)	161.26
H_2 Total in TBL	2.06

Note: Midplane Z = 366.1 cm

Figure 11

Turbine Exhaust Line

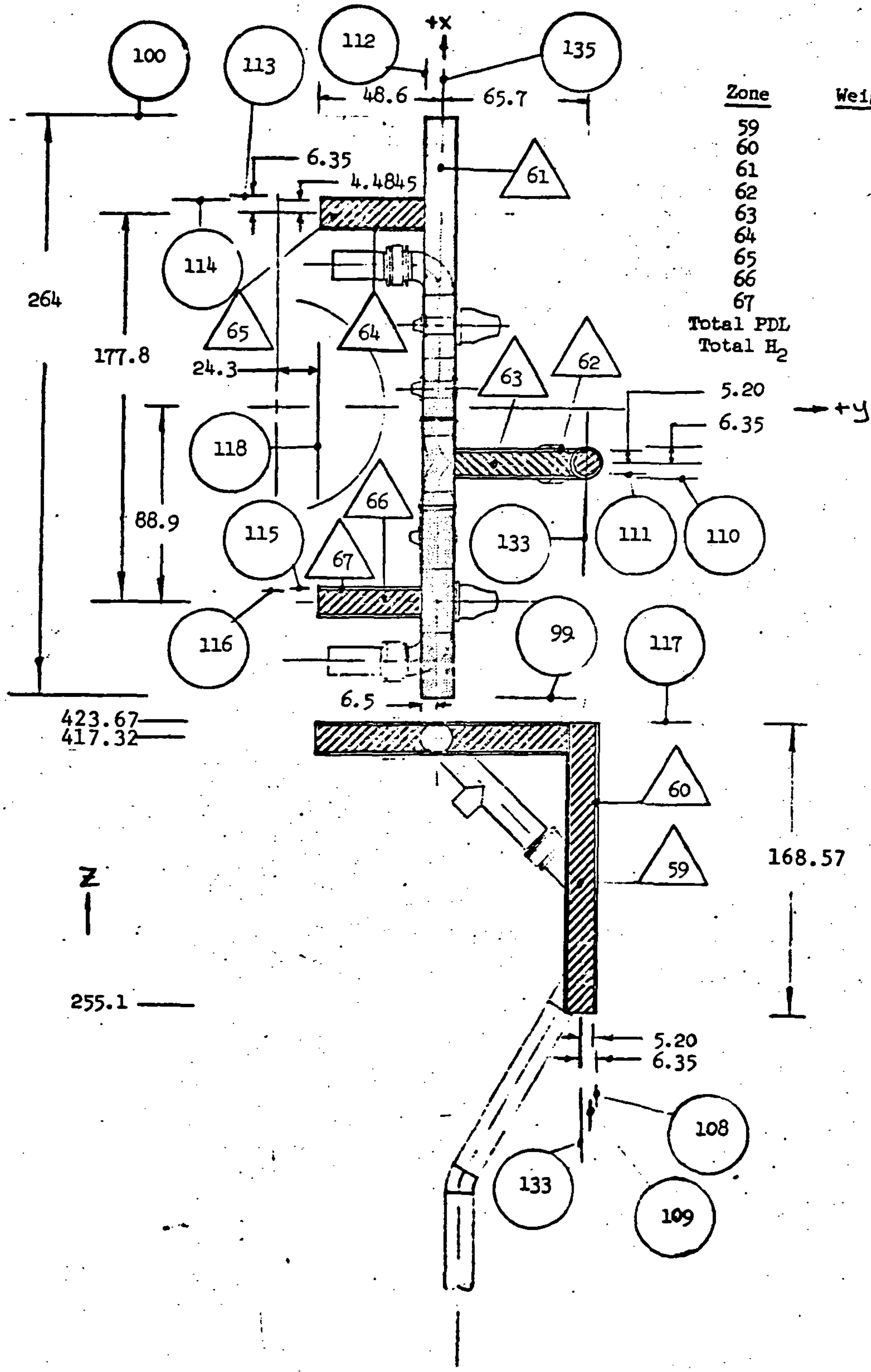


Zone	Weight (lbs)
47	0.37
48	7.99
49	34.65
50	.25
51	1.17
52	176.8
53	205.32
54	4.01
55	0.03
56	205.32
57	4.01
58	0.03
129	10.54
130	0.75
133	3.45
134	0.16
Total TIL	241.45
Total H_2 in TIL	2.76

TLL

Figure 12

Pump Discharge Line



Zone	Weight (lbs)
59	2.8
60	24.76
61	252.18
62	16.31
63	0.86
64	46.48
65	0.55
66	0.55
67	46.48
Total PDL	134.03
Total H_2	4.76

Figure 13

Structural Support Cooldown Line

Zone	Weight (lbs)
68	2.49
69	88.92
70	569.77
71	0.55
72	26.39
123	32.59
126	0.11
Total Line	147.90
Total H_2	3.15

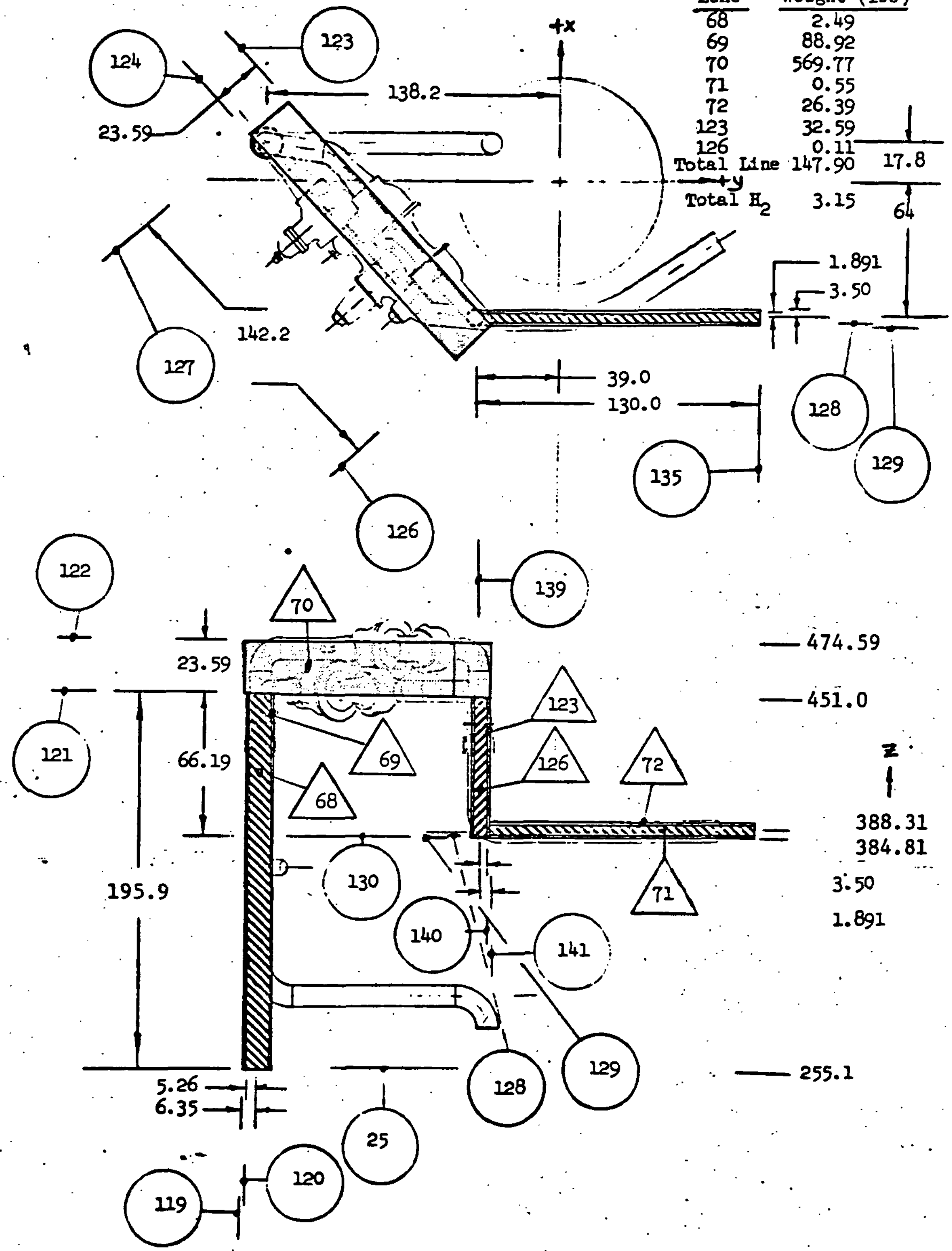


Figure 14

Void Regions

Z = 254.03 to Z = 355.5

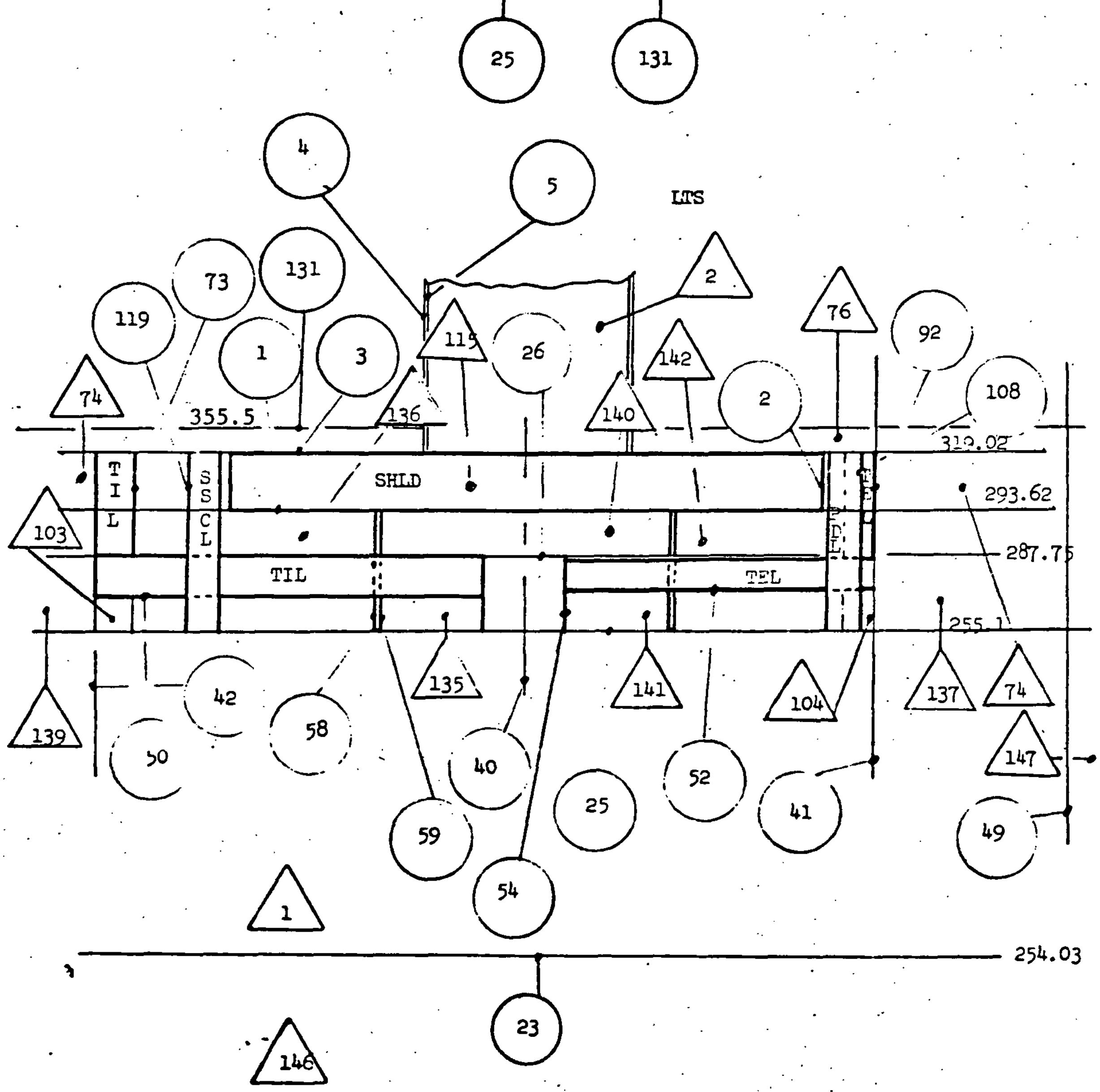


Figure 15

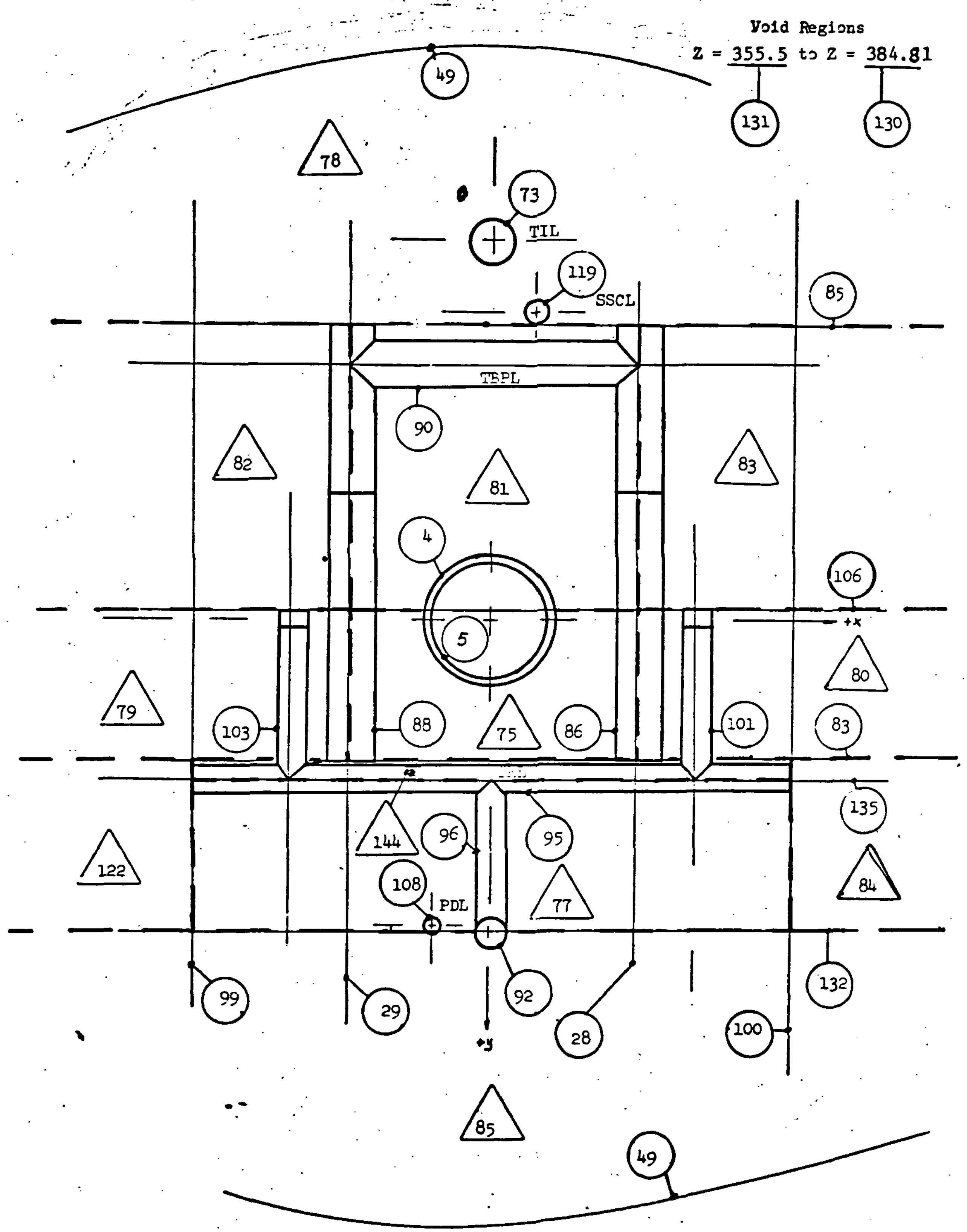

Void Regions
Z = 355.5 to Z = 384.81
131
130
49
78
73
TIL
119
SSCL
85
TBPL
90
82
81
83
4
106
+x
5
80
79
103
88
75
86
101
83
135
144
96
95
122
108
PDL
77
84
99
29
92
28
100
132
+y
85
49

Figure 16

Void Regions

Z = 384.81 to Z = 391.7

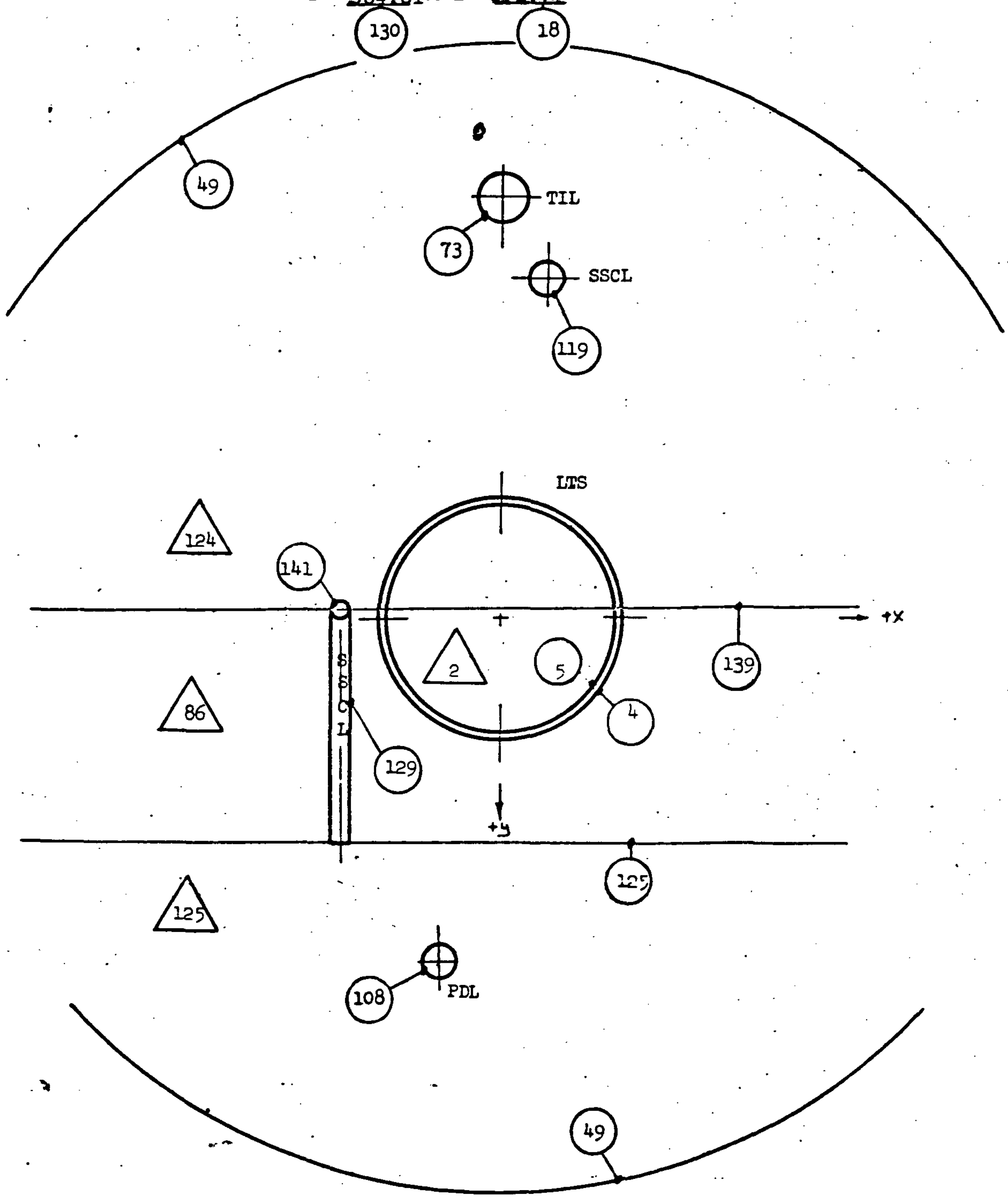


Figure 17

Void Regions

Z = 391.7 to Z = 423.67

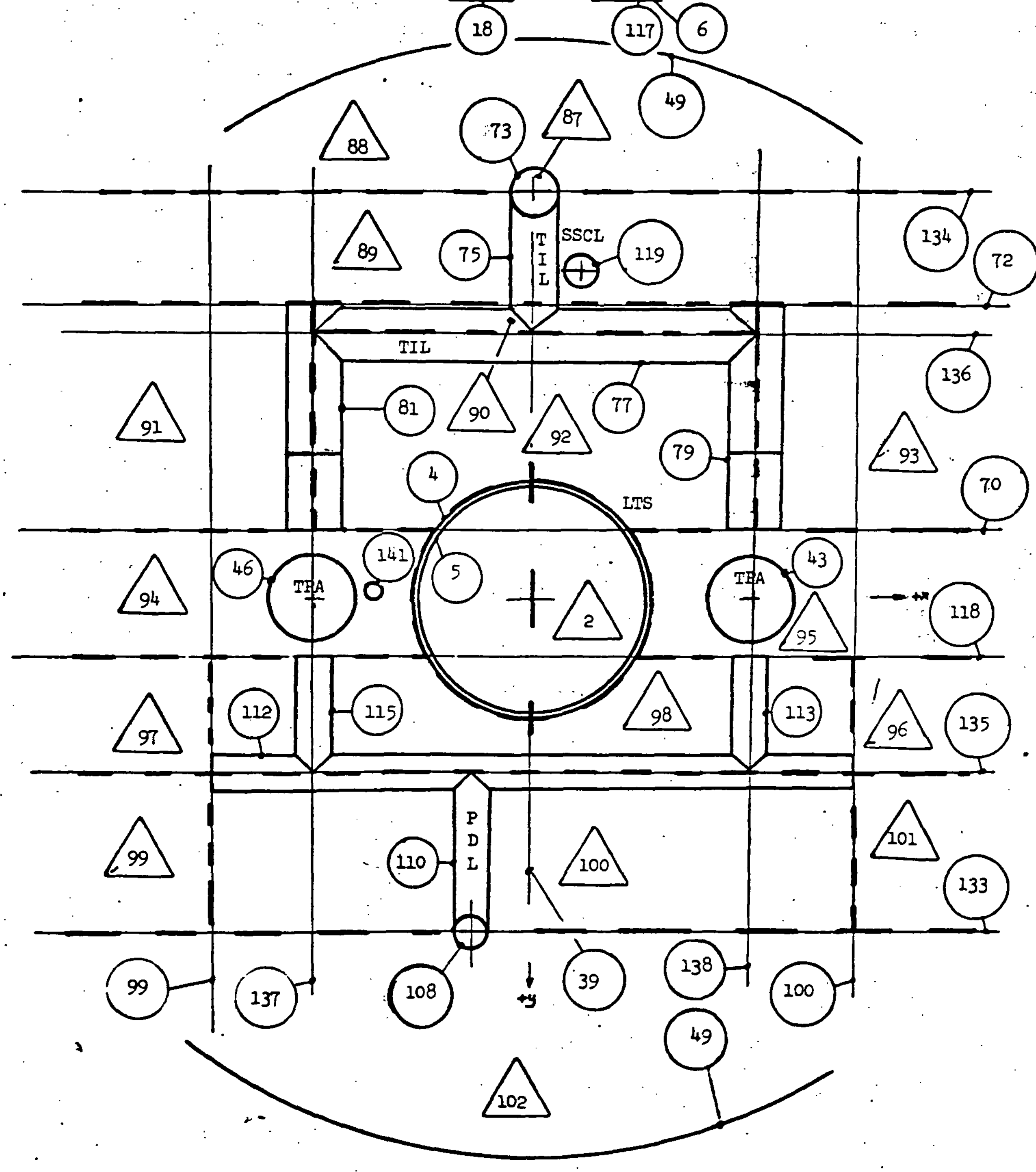
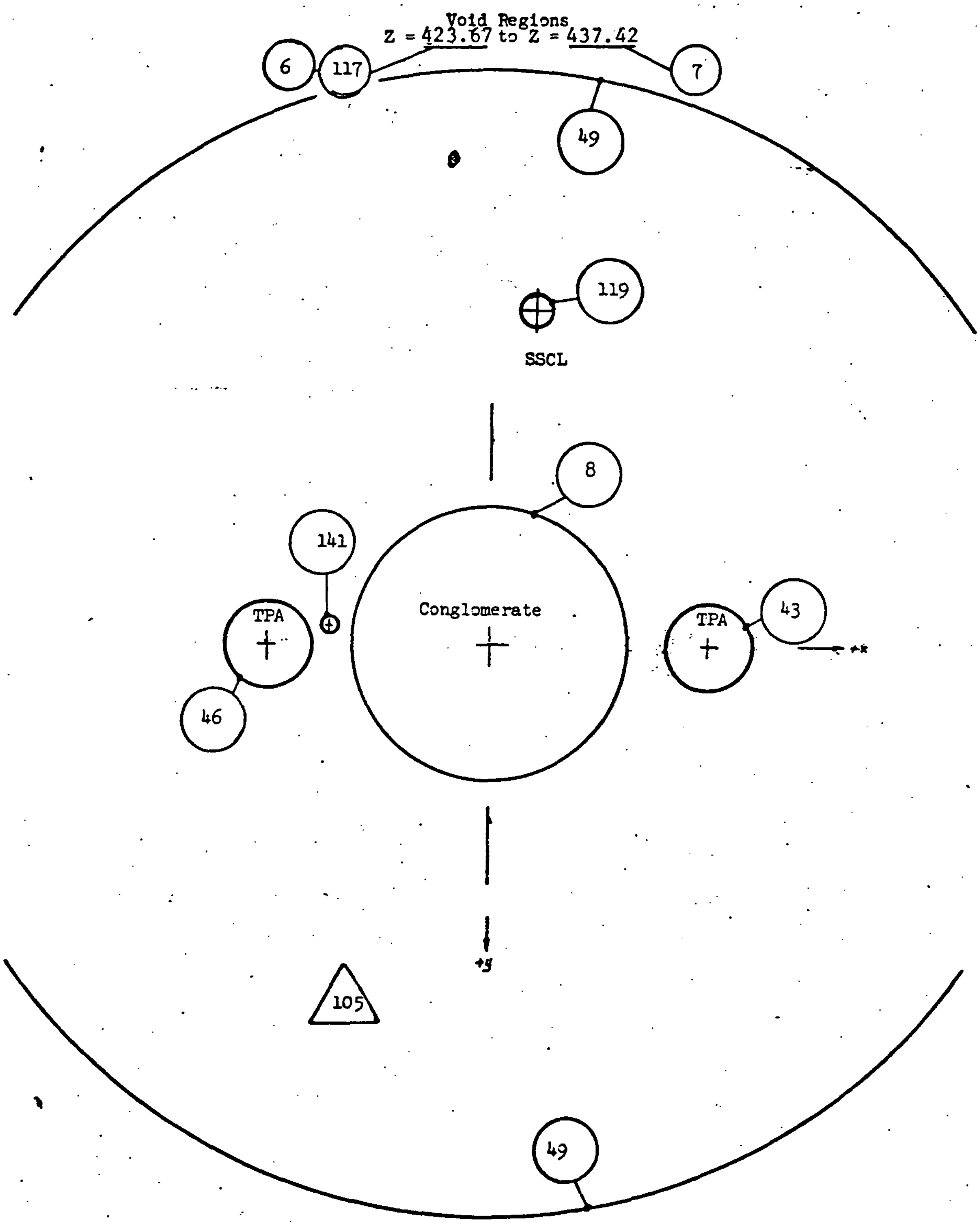


Figure 18



Void Regions
Z = 423.67 to Z = 437.42
6
117
7
49
119
SSCL
8
141
Conglomerate
TPA
TPA
43
46
+x
+y
105
49

Figure 19

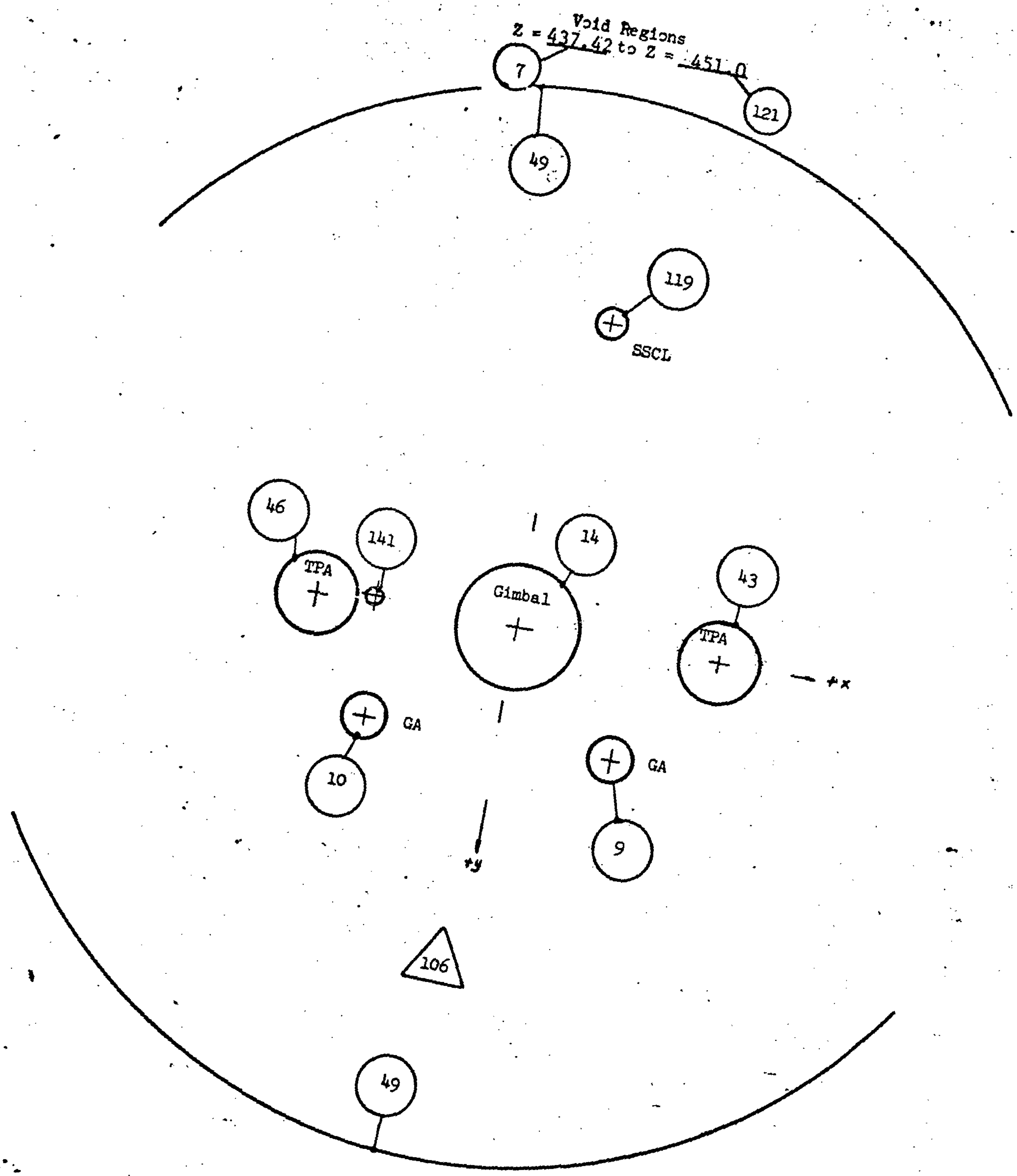
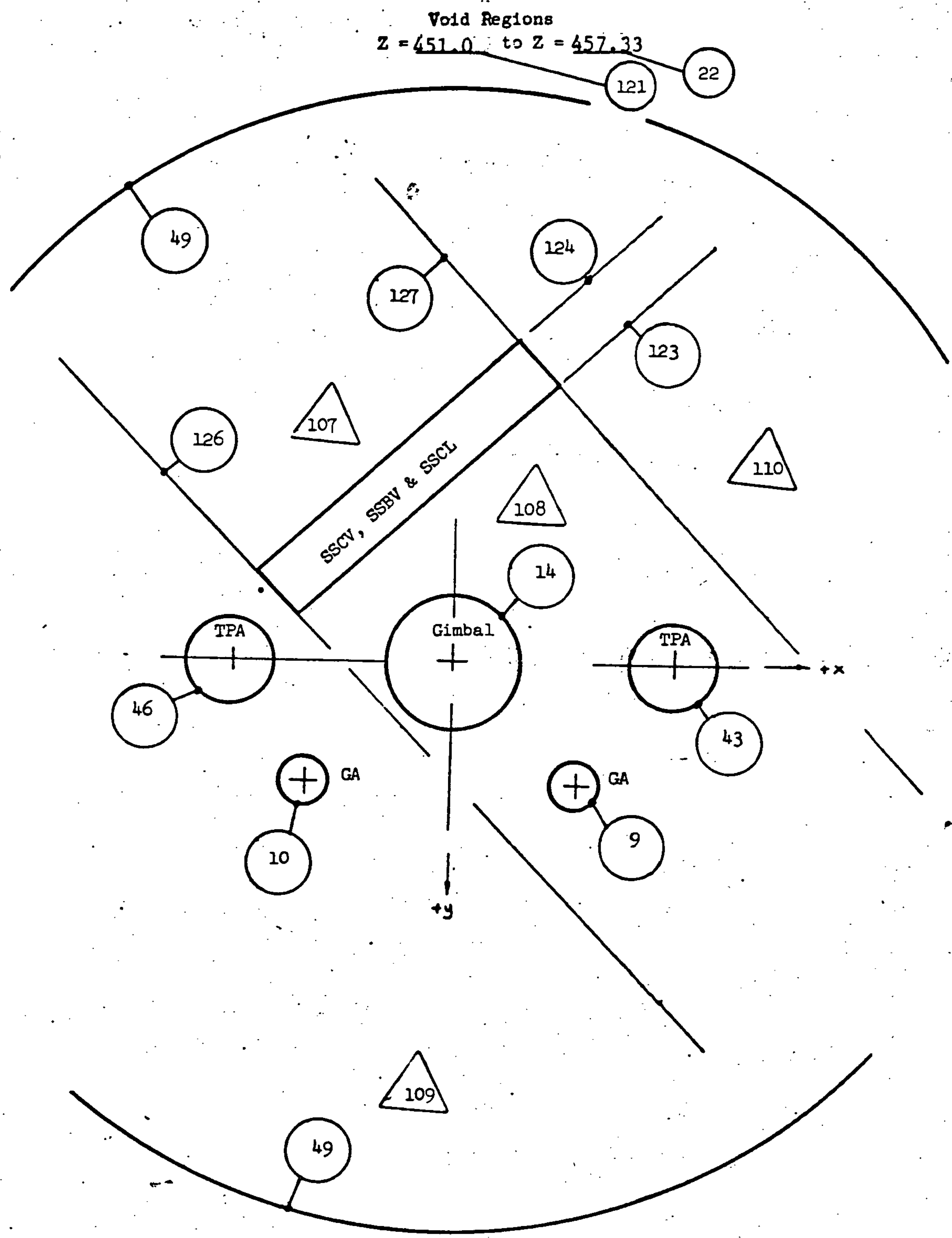

Void Regions
Z = 437.42 to Z = 451.0
7
121
49
119
SSCL
46
141
TPA
14
Gimbal
43
TPA
+x
GA
10
GA
+y
9
106
49

Figure 20



Void Regions
Z = 451.0 to Z = 457.33
121
22
49
127
124
123
126
107
110
SSCV, SSBV & SSCL
108
14
TPA
Gimbal
TPA
+x
46
43
GA
GA
10
9
+y
109
49

Figure 21

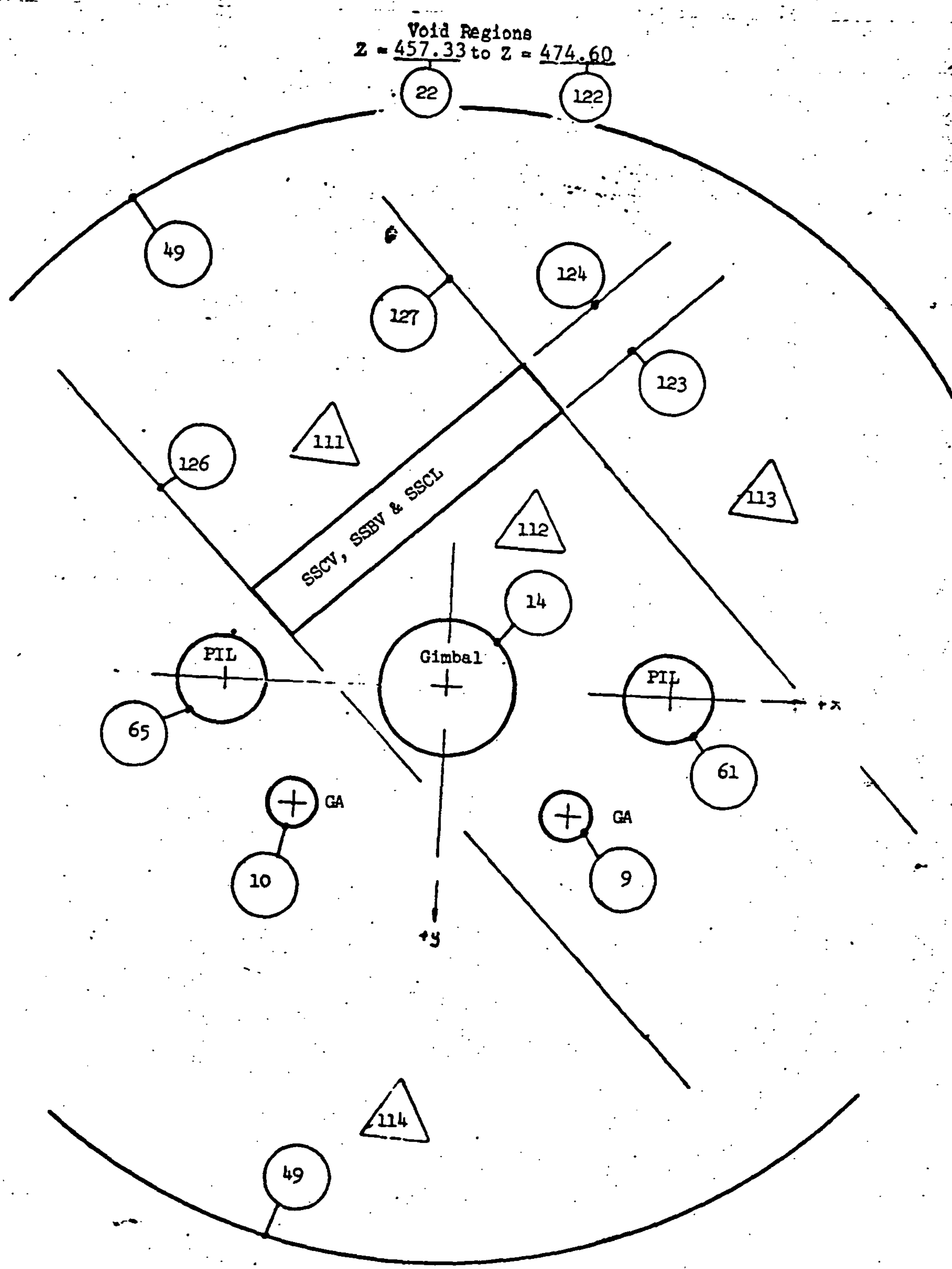

Void Regions
Z = 457.33 to Z = 474.60
22
122
49
127
124
123
126
111
113
SSCV, SSBV & SSCL
112
14
PIL
Gimbal
PIL
+x
65
61
GA
GA
10
9
+y
114
49

Figure 22

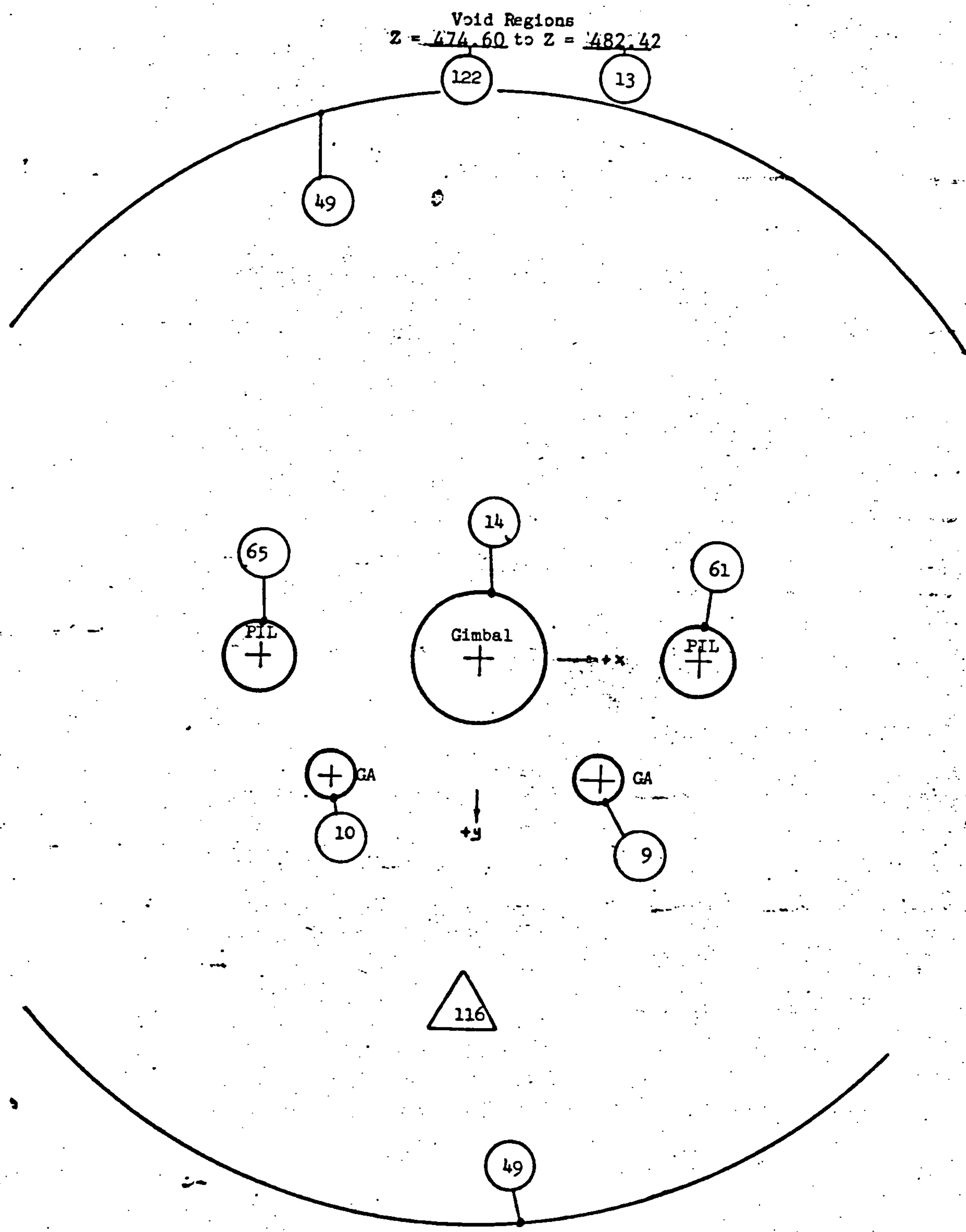

Void Regions
Z = 474.60 to Z = 482.42
122
13
49
14
65
61
PIL
Gimbal
+x
PIL
GA
GA
10
+y
9
116
49

Figure 23

C

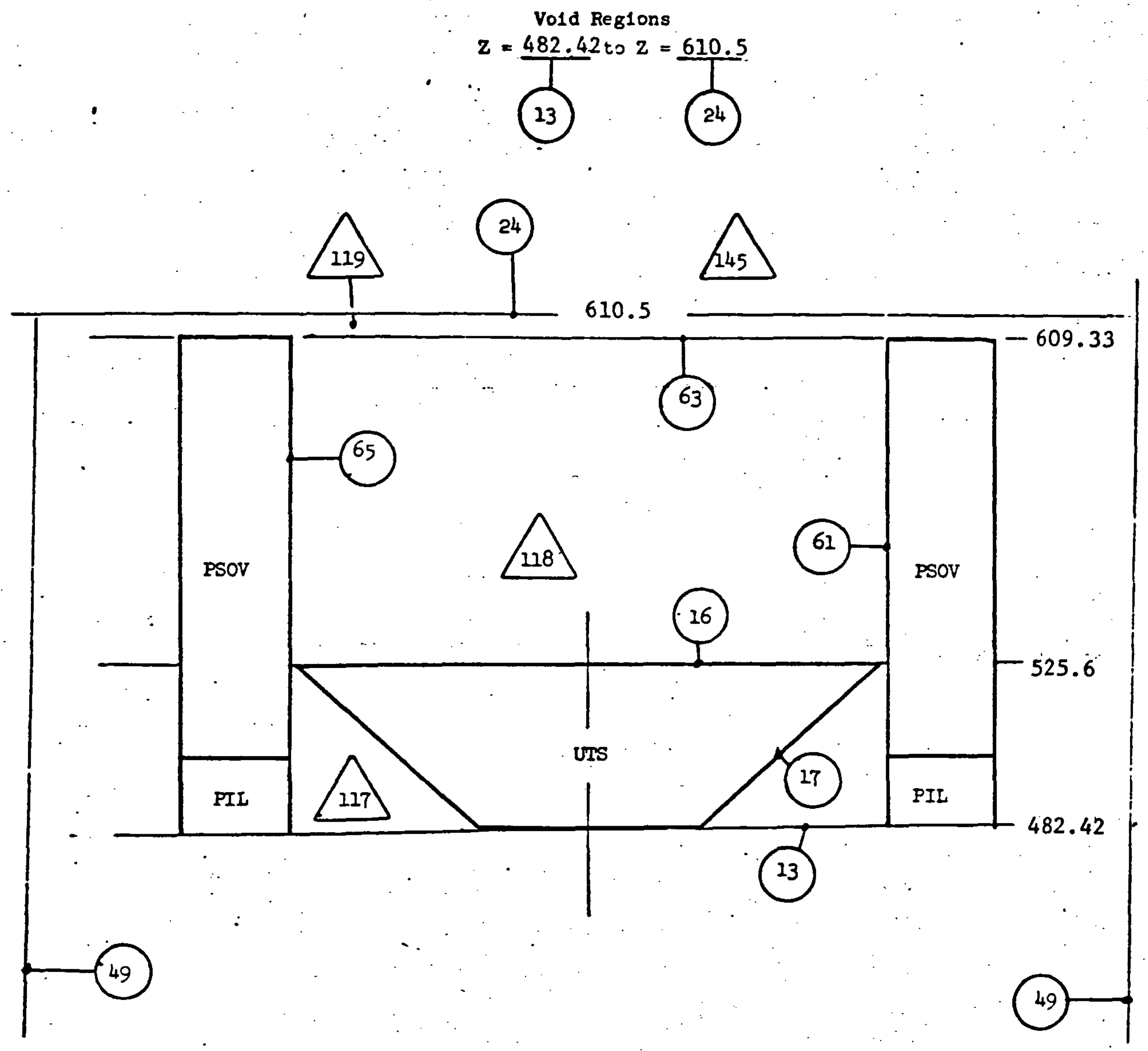

Void Regions
Z = 482.42 to Z = 610.5
13
24
119
24
145
610.5
609.33
63
65
118
61
PSOV
PSOV
16
525.6
UTS
17
PIL
117
PIL
482.42
13
49
49

Figure 24

2. Materials of Composition

Tables 1 and 2 presents the materials of composition for each of the regions of the non-nuclear component portions forward of and including the pressure vessel. Two identification numbering systems are used, one for the QAD Point Kernel model and another for the COHORT Monte Carlo model. The zones are as described in the appropriate figures and Appendix A.

Tables 3 and 4 present similar materials of composition information for the ARMCO nozzle and Columbium alloy backup nozzle extension models. The prime candidate graphite nozzle extension is represented by a single material composition of carbon.

TABLE 1

MATERIALS

ID NO. COHORT	ID NO. QAD	COMPOSITION BY WEIGHT (%w)	PARTIAL DENSITIES (gm/cm^3)	TOTAL DENSITIES	DESCRIPTION
5	10	97.47% Al, 0.15% Ti, .35% Cr, .7% Fe, .48% Ni, .4% Si, .45% Cu	Al 2.6317, Ti .0041, Cr .0095, Fe .0189, Ni .013, Cu .011	2.7	Al 6066
6	16	19.5% Cr, 2.0% Mn, 63.5% Fe, 14% Ni, .5% Mo, .5% Cu	Cr 1.60, Nm .16, Fe 5.208, Ni 1.15, Mo .041, Cu .041	8.2	347 SST
7	22	.58% Al, 96.07% Ti, .1% Mn, .25% Fe, 3.0% Sn	Al .234, Ti 3.6709, Nm .0040, Fe .0101, Sn .121	4.04	Titanium
8	31	0.4% Al, .9% Ti, 20% Cr, .35% Mn, 14.25% Fe, 55.9% Ni, 5% Nb, 3% Mo, .1% Cu, 1.0% Co	Al .0328, Ti .0739, Cr 1.642, Mn .0287, Fe 1.170, Ni 4.5058, Nb .4105, Mo .246, Cu .0082, Co .0821	8.2	INC 718
9	32	22.71% 347 SST + 77.29% Al	SST 0.6436, Al 2.1894	2.833	Al + SST 347
10	33	19.73% Cu, 78.91% INC, 1.36% LH_2	INC 2.5773, Cu 0.6444, LH_2 0.0443	3.266	LH_2 valves
11	34	14.86% Cu, 85.149% INC, .001% GH_2	INC 4.4656, Cu 0.7789, GH_2 0.0005	5.245	GH_2 valves
12	35	.03% C, .1% Si, .1% Mn, .01% S, .01% P, 19% Ni, 8.5% Co, 5.1% Mo, .15% Al, .5% Ti, .003% B, .02% Zr, 66.577% Fe	C .0025, Si .0082, Mn .0082, P .0008, Ni 1.5580, Co .6970, Mo .4182, Al .0123, Ti .041, B .0002, Zr .0016, Fe 5.452	8.2	Vescomax 250
13	36	9.37% Al, rest void	Al .2477, Ti .0005, Cr .0009, Fe .0018, Ni .0012, Cu .0010	0.253	6066 Al in UTS
14	37	Same as 16 but reduced	Cr 1.561, Mn .1561, Fe 5.081, Ni 1.1220, Mo 0.04, Cu 0.04	8.0	347 SST
3	38	100% H_2	0.07 H_2	0.07	LH_2
4	39	100% H_2	0.0084 H_2	0.0084	GH_2
15	40	50% H_2 + 50% Al	H_2 .0027, Al 1.2799, Ti .0020, Cr .0046, Fe .0092, Ni .0063, Cu .0053	1.31	PSOV
0	41	Void at the present	Void	--	Shield

TABLE 1

MATERIALS

ID NO. COHORT	ID NO. QAD	COMPOSITION BY WEIGHT (%w)	PARTIAL DENSITIES (gm/cm^3)	TOTAL DENSITIES	DESCRIPTION
16	42	59.27% SST + 40.73% Cu	Cu 4.9395, 347 SST 7.1874	12.1269	GA
17	43	20% Ti, 80% LH_2	Al .0468, Ti .7342, Mn .0008, Fe .002, Sn .0242, H_2 .056	0.864	Ti + LH_2
18	44	20% SST, 80% LH_2	Cr .3122, Mn .0312, Fe 1.0162, Ni .2244, Mo .008, H_2 .056, Cu 0.008	1.656	SST + LH_2

TABLE 2

ZONE ID	MATERIAL NUMBER (COHORT)	QAD	DESCRIPTION	VOLUME cm^3	DENSITY (gm/cm^3)	WEIGHT lbs	ZONE DESCRIPTION
3	5	10	Aluminum	11,650	2.7	69.34	LTS Barrel Section Above Shield
4	9	32	Aluminum + SST	141,015	2.833	880.72	LTS + Bleed Line - Conglomerate
5	16	42	SST + Cu	14,816	12.1269	396.10	Gimbal Actuator (Right)
6	16	42	SST + Cu	14,816	12.1269	396.10	Gimbal Actuator (Left)
7	12	35	Vescomax 250	12,228	8.2	221.05	Gimbal Inner Surface
8	12	35	Vescomax 250	4,514	8.2	81.60	Gimbal Outer Ring Shell
9	13	36	Low Density Al	347,559	0.253	193.85	UTS
10	14	37	SST - 347	4,643	8.0	81.89	Right TPA Lower Closure Plate
11	14	37	SST - 347	35,606	8.0	627.97	Right TPA Outer Shell
12	4	39	GH_2	3,823	0.0084	0.07	Right TPA - Hot Gas Volume
13	7	22	Titanium	5,401	4.04	48.10	Right TPA - Impellers
14	3	38	LH_2	12,763	0.07	1.97	Right TPA - LH_2 Volume
15	7	22	Titanium	3,020	4.04	26.90	Right TPA - Shafting
16	14	37	SST+ρ = 8.0	4,643	8.0	81.89	Left TPA - Lower Closure Plate
17	14	37	SST-ρ = 8.0	35,606	8.0	627.97	Left TPA - Outer Shell
18	4	39	GH_2	3,823	0.0084	0.07	Left TPA - Hot Gas Volume
19	7	22	Titanium	5,401	4.04	48.10	Left TPA - Impellers
20	3	38	LH_2	12,763	0.07	1.97	Left TPA - LH_2 Volume
21	7	22	Titanium	3,020	4.04	26.90	Left TPA - Shafting
22	3	38	LH_2	17,722	0.07	2.73	Inside of Right Propellant Inlet Line and Bellows

TABLE 2

ZONE ID	MATERIAL NUMBER (COHORT)	QAD	DESCRIPTION	VOLUME cm^3	DENSITY (gm/cm^3)	WEIGHT lbs	ZONE DESCRIPTION
23	6	16	SST-ρ = 8.2	7,331	8.2	132.53	Right Propellant Inlet Line and Bellows
24	15	40	Al + LH_2	63,095	1.31	182.21	Right PSOV
25	3	38	LH_2	17,722	0.07	2.73	Inside of Left Propellant Inlet Line and Bellows
26	15	40	Al + LH_2	63,095	1.31	182.21	Left PSOV
27	6	16	SST-ρ = 8.2	7,331	8.20	132.53	Left Propellant Inlet Line and Bellows
28	5	10	Al-ρ = 2.7	1,874	2.70	11.15	Vertical Portion of TIL - Shell
29	8	31	INC - 718	12,699	8.2	229.57	TIL (Portion - Shell)
30	4	39	GH_2	37,953	0.0084	0.70	TIL (Inside - Above)
31	8	31	INC - 718	1,377	8.2	24.89	TIL (Right - Shell)
32	4	39	GH_2	8,281	0.0084	0.15	TIL (Inside - Above)
33	11	34	GH_2 Valve	9,657	5.245	111.66	Right BBB + TTV
34	5	10	Al-ρ = 2.7	4,354	2.7	25.92	TIL - Center Horizontal Section - Shell
35	4	39	GH_2	13,012	0.0084	0.24	TIL - Inside Above
36	8	31	INC - 718	1,377	8.2	24.89	TIL (Left Shell - See 31)
37	4	39	GH_2	8,281	0.0084	0.15	TIL - Inside Above
38	11	34	GH_2 Valve	9,657	5.245	111.66	Left BBV + TTV
39	4	39	GH_2	35,960	0.0084	0.67	Inside Right Section of TBPL
40	8	31	INC - 718	2,968	8.2	53.65	Right Section of TBPL - Shell
41	11	34	GH_2 Valve	24,356	5.245	281.63	Right TBV + TCV
42	4	39	GH_2	38,762	0.0084	0.72	Inside Middle Section of TBPL

TABLE 2

ZONE ID	MATERIAL NUMBER (COHORT)	QAD	DESCRIPTION	VOLUME cm^3	DENSITY (gm/cm^3)	WEIGHT lbs	ZONE DESCRIPTION
43	8	31	INC - 718	2,985	8.2	53.96	Shell of Middle Section TBPL
44	8	31	INC - 718	2,968	8.2	53.65	Left Section of TBPL - Shell
45	4	39	GH_2	35,960	0.0084	0.67	Inside Left Section of TBPL
46	11	34	GH_2 Valve	24,356	5.245	28[illegible].63	Left TBV + TCV
47	4	39	GH_2	20,043	0.0084	0.37	Inside Vertical Portion of TEL
48	5	10	Al-ρ = 2.7	1,343	2.7	7.99	•Vertical Portion of TEL - Shell
49	5	10	Al-ρ = 2.7	5,821	2.7	34.65	Center Horizontal Section - Shell
50	4	39	GH_2	13,417	0.0084	0.25	Inside Above
51	4	39	GH_2	63,467	0.0084	1.17	Inside TEL Horizontal Connecting Section
52	8	31	INC - 718	9,780	8.2	176.80	Shell for Above - TEL
53	11	34	GH_2 Valve	17,757	5.245	205.32	Right TDBV
54	8	31	INC - 718	222	8.2	4.01	Right TEL Section - Shell
55	4	39	GH_2	1,442	0.0084	0.03	Inside Above
56	11	34	GH_2 Valve	17,757	5.245	205.32	Left TDBV
57	8	31	INC - 718	222	8.2	4.01	Left TEL Section - Shell
58	4	39	GH_2	1,442	0.0084	0.03	Inside Above
59	3	38	LH_2	13,459	0.07	2.08	Inside the Vertical Portion of PDL
60	5	10	Al-ρ = 2.7	4,160	2.7	24.76	Vertical Portion of PDL
61	10	33	LH_2 Valves	35,024	3.266	252.18	All LH_2 Valves Homogenized with Line
62	5	10	Al-ρ = 2.7	2,740	2.7	16.31	Center Horizontal Section of PDL - Shell

TABLE 2

ZONE ID	MATERIAL NUMBER (COHORT)	QAD	DESCRIPTION	VOLUME cm^3	DENSITY (gm/cm^3)	WEIGHT lbs	ZONE DESCRIPTION
63	3	38	LH_2	5,578	0.07	0.86	Inside Above
64	8	31	INC - 718	2,571	8.2	46.48	Right Side Horizontal PDL Section - Shell
65	3	38	LH_2	3,582	0.07	0.55	Inside Above - PDL
66	3	38	LH_2	3,582	0.07	0.55	Inside Left Horizontal PDL Section
67	8	31	INC - 718	2,571	8.2	46.48	Left Horizontal PDL Section - Shell
68	3	38	LH_2	16,161	0.07	2.49	Inside the External Vertical Section of SSCL
69	8	31	INC - 718	4,919	8.2	88.92	External Vertical Section of SSCL - Shell
70	10	33	LH_2 Valves	79,133	3.266	569.77	Diagonal Section of SSCL and Four Valves (SSCV, SSBV two each) Homogenized Together
72	8	31	INC - 718	1,460	8.2	26.39	Horizontal Section SSCL
71	3	38	LH_2	3,541	0.07	0.55	Inside Above
73	4	39	GH_2	28,141	0.0084	0.52	Inside Vertical Portion of TIL (Zone 28)
123	8	31	INC - 718	1,803	8.2	32.59	Internal Vertical Section of SSCL
126	3	38	LH_2	743	0.07	0.11	Inside Internal Vertical Section SSCL (Zone 123)
127	5	10	Al-ρ = 2.7	3,331	2.7	19.83	TIL - Below the Shield (Horizontal Section)
128	4	39	GH_2	47,872	0.0084	0.89	Inside Above
129	5	10	Al-ρ = 2.7	1,771	2.7	10.54	TEL - Horizontal Section Below the Shield
130	4	39	GH_2	40,301	0.0084	0.75	Inside Above
131	5	10	Al-ρ = 2.7	2,001	2.7	11.91	TIL Vertical Section Below Shield
132	4	39	GH_2	26,658	0.0084	0.49	Inside Above
133	5	10	Al-ρ - 2.7	579	2.7	3.45	TEL Vertical Section Below the Shield
134	4	39	GH_2	8,644	0.0084	0.16	Inside Above
138	5	10	Al-ρ - 2.7	4,228	2.7	25.17	TEL Side Half of LTS Below Shield
143	5	10	Al-ρ = 2.7	4,228	2.7	25.17	TIL Side Half of LTS Below Shield

TABLE 3

MATERIALS OF COMPOSITION FOR AFT PRESSURE VESSEL FLANGE AND ARMCO NOZZLE

MAT NO.	PARTIAL DENSITIES (gm/cm^3)	TOTAL	DESCRIPTION
1	Al 2.7	2.7	Aluminum
2	Cv 1.750, Fe 4.496, Ni .985, C .030, Mn .395, Nb .016, Mo .175	7.896	ARMCO
3	H.01	.01	Hydrogen
4	H.07	.07	Hydrogen
5	Nb 7.459, W 1.947, Zr .057, Ti .001, C .002, 0.003, Ni .029	9.498	Columbium WC-129Y
6	H 1.51-6	151-6	Hydrogen
7	H 2.59-6	2.59-6	Hydrogen
8	H 5.86-6	5.86-6	Hydrogen
9	H 1.67-5	1.67-5	Hydrogen
10	H 1.673-4	1.673-4	Hydrogen
11	H 3.01-4	3.012-4	Hydrogen
12	H .018, Cr .254, Fe .652, Ni .201, C .004, Mn .057, Nb .002, Au .196, Mo .043	1.428	ARMCO No. 2 Coolant
13	H .029, Cr .254, Fe .652, Ni .201, C .004, Mn .057, Nb .002, Au .196, Mo .043	1.438	ARMCO No. 2 Coolant
14	H .037, Cr .254, Fe .652, Ni .201, C .004, Mn .057, Nb .002, Au .196, Mo .043	1.446	ARMCO No. 2 Coolant
15	H .047, Cr .254, Fe .652, Ni .201, C .004, Mn .057, Nb .002, Au .196, Mo .043	1.456	ARMCO No. 2 Coolant
16	H .064, Cr .254, Fe .652, Ni .201, C .004, Mn .057, Nb .002, Au .196, Mo .043	1.473	ARMCO No. 2 Coolant

TABLE 4

MATERIALS OF COMPOSITION - ARMCO NOZZLE AND COLUMBIUM EXTENSION

NO. Z ZONE	MAT. NO.	MATERIAL	VOLUME (cm^3)	DENSITY (gm/cm^3)	DESCRIPTION
2	11	Hydrogen	1.603 +5	1.8-4	Propellant
3	10	Hydrogen	9.458 +3	1.0-4	Propellant
4	9	Hydrogen	-	1.0-5	Propellant
5	8	Hydrogen	-	3.5-6	Propellant
6	12		5.769 +3		Core support coolant
7	13		1.156 +4		Convergent nozzle coolant
8	14		1.199 +3		Throat coolant
9	15		5.968 +3		Divergent nozzle coolant
10	16		8.609 +3		Divergent nozzle coolant
11	2	ARMCO	1.668 +4	7.896	Core support
12	2	ARMCO	1.903 +4	7.896	Convergent nozzle
13	2	ARMCO	1.054 +3	7.896	Throat
14	2	ARMCO	4.386 +3	7.896	Divergent nozzle
15	2	ARMCO	1.746 +4	7.896	Divergent nozzle
16	3	Hydrogen	4.631 +4	6.0-3	LH_2 plenum
17	3	Hydrogen	2.857 +4	6.0-3	LH_2 plenum
18	1	Aluminum	1.908 +4		Pressure vessel
19	1	Aluminum	1.313 +4		Pressure vessel aft flange
20	2	ARMCO	2.227 +4	7.896	Nozzle
21	2	ARMCO	2.579 +3	7.896	Torus
22	2	ARMCO	2.658 +3	7.896	Torus
23	4	Hydrogen	1.239 +4	4.18-2	Torus
24	2	ARMCO	1.878 +3	7.896	Torus
25	5	Columbium	2.040 +2	9.498	Nozzle extension
26	6	Columbium	2.226 +2	9.498	Nozzle extension
27	5	Columbium	2.570 +2	9.498	Nozzle extension
28	5	Columbium	2.944 +2	9.498	Nozzle extension
29	5	Columbium	3.156 +2	9.498	Nozzle extension
30	5	Columbium	3.356 +2	9.498	Nozzle extension
31	5	Columbium	3.442 +2	9.498	Nozzle extension
32	5	Columbium	5.271 +2	9.498	Nozzle extension
33	5	Columbium	1.483 +3	9.498	Nozzle extension
34	5	Columbium	2.607 +3	9.498	Fore flange
35	5	Columbium	2.067 +3	9.498	Fore flange

3. Sources of Radiation

The computer printout listed in Table 5 presents the secondary gamma sources for the combinations of regions grouped into thirteen equivalent sources. The $ and Z locations of these effective sources are the second and third vertical columns for lines 000004, 10, 17, 24, 31, 38, 52, 59, 66, 73, 80 and 87. The sources are given in units of mev/in per energy group in descending order. The energy group structure is listed on the second page of this table.

Table 6 is a computer listing of the capture gamma, inelastic scatter gamma and total gamma sources in the 45 regions used to describe the ARMCO nozzle and Columbium nozzle extension. As was discussed earlier, sources are not available for the graphite nozzle extension, as these are considered to be negligibly small.

TABLE 5

LISTINGS OF FASTRAND FILE PTCOMP/DATA

W ELT COMPON/COMPLX,1,710811, 56360

NON-NUCLEAR COMPONENTS - FORWARD OF PRESSURE VESSEL
GAMMA RAY SOURCE STRENGTH - Mev/Sec
IN DESCENDING ENERGY - 13 GROUPS

```
000001    01 LTS    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000002       1  0  0 24  36  68  13  52   1  32   3 210            31 0101  *NEW   Lower Thrust Structure
000003                                                              1 0102  **-1
000004    0.0     0.0    306.    1.0                                  1LTS
000005            2.887 +144.346 +131.682 +132.150 +149.706 +133.091 +141.045 +14 1LTS  1
000006    1.078 +136.880 +137.736 +131.582 +143.357 +12    SUM1.393 +15    1LTS  2
000007    02 LTSCG  POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000008       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Lower Thrust Structure
000009                                                                0102         and Conglomerate
000010    0.0     0.0    400.    1.0                                  2LTSCG
000011            1.149 +152.673 +143.145 +143.764 +142.758 +141.518 +144.239 +14 2LTSCG1
000012    3.426 +132.900 +143.330 +143.895 +143.133 +13    SUM4.040 +15    2LTSCG2
000013                                      0                            9999
000014    03 GMBLAC POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000015       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Gimbal Actuators
000016                                                                0102
000017    0.0     50.    429.    1.0                                  3GMBLAC
000018            8.469 +141.254 +147.538 +138.604 +131.180 +141.092 +136.568 +13 3GMBAC1
000019    4.302 +131.218 +145.036 +139.645 +131.851 +13    SUM1.658 +15    3GMBAC2
000020                                      0                            9999
000021    04 GMBL   POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000022       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Gimbal
000023                                                                0102
000024    0.0     0.0    432.    1.0                                  4GMBL
000025            1.529 +142.463 +141.846 +141.356 +141.282 +141.988 +134.191 +13 4GMBL 1
000026    1.268 +108.035 +132.764 +129.692 +137.431 +12    SUM1.116 +15    4GMBL 2
000027                                      0                            9999
000028    05 UTS    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000029       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Upper Thrust Structure
000030                                                                0102
000031    0.0     0.0    474.    1.0                                  5UTS
000032            3.336 +122.520 +121.076 +131.393 +141.590 +132.410 +111.581 +13 5UTS  1
000033            6.334 +121.040 +132.163 +135.560 +11     SUM2.268 +14    5UTS  2
000034                                      0                            9999
000035    06 TPA    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP                 Turbopump Assembly
000036       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101
000037                                                                0102
000038    89.9    0.0    383.    1.0                                  6TPA
000039            2.044 +153.425 +144.965 +142.950 +141.876 +141.434 +141.111 +14 6TPA  1
000040    3.658 +132.949 +141.493 +143.535 +143.176 +13    SUM4.487 +15    6TPA  2
000041                                      0                            9999
000042    07 TPA    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000043       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Turbopump Assembly
000044                                                                0102
000045    -50.9   0.0    383.    1.0                                  7TPA
000046            1.030 +152.665 +141.032 +142.769 +141.738 +141.529 +131.142 +14 7TPA  1
000047    6.899 +131.582 +148.762 +132.413 +141.755 +13    SUM2.554 +15    7TPA  2
000048                                      0                            9999
000049    08 PIL    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000050       1  0  0 24  36 -68  13  52  11  32   3 210             3 0101         Pump Inlet Line
000051                                                                0102
000052    0.0     0.0    503.    1.0                                  8PIL
000053            3.530 +142.865 +133.611 +131.807 +133.907 +121.011 +131.519 +13 8PIL  1
000054    2.708 +137.203 +126.543 +122.511 +134.440 +12    SUM5.374 +14    8PIL  2
000055                                      0                            9999
000056    09 TIL    POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP                 Turbine Inlet Line
```

TABLE 5 (CONTINUED)

```
                LISTING OF FASTRAND FILE PTCOMP/DATA
000057           1  0   0  24   36 -68   13  52   11  32    3 210            3  0101
000058                                                                          0102
000059        0.0      -66.     374.     1.0                                    9TIL
000060                 1.347 +163.964 +152.095 +152.147 +152.609 +154.365 +143.446 +14 9TIL  1
000061        4.518 +141.007 +154.913 +141.429 +153.334 +14      SUM2.878 +16      9TIL  2
000062                                       9                                     9999
000063        10 TBL      POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000064           1  0   0  24   36 -68   13  52   11  32    3 210            3  0101    Turbine Block Valve
000065                                                                          0102
000066        0.0      -85.     336.     1.0                                   10TBL
000067                 2.850 +169.216 +155.810 +153.157 +153.250 +151.057 +151.305 +15110TBL  1
000068        9.158 +141. 3 +151.290 +153.383 +154. 12 +14       SUM5.998 +1      10TBL  2
000069                                       9                                     9999
000070        11 TEL      POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000071           1  0   0  24   36 -68   13  52   11  32    3 210            3  0101    Turbine Exhaust Line
000072                                                                          0102
000073        0.0       41.     345.     1.0                                   11TEL
000074                 1.746 +165.302 +152.422 +152.740 +151.906 +153.948 +147.707 +14111TEL  1
000075        5.608 +141.484 +159.562 +141.918 +153.331 +14      SUM3.627 +16      11TEL  2
000076                                       9                                     9999
000077        12 PDL      POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000078           1  0   0  24   36 -68   13  52   11  32    3 210            3  0101    Pump Discharge Line
000079                                                                          0102
000080        0.0       73.     387.     1.0                                   12PDL
000081                 3.700 +156.260 +141.486 +155.284 +147.457 +141.021 +141.617 +14112PDL  1
000082        4.605 +152.501 +141.463 +142.684 +146.751 +13      SUM1.269 +16      12PDL  2
000083                                       9                                     9999
000084        13 SSCL     POINT SOURCE    JULY70 PVARA WITH COMPLEX PUMP
000085           1  0   0  24   36 -68   13  52   11  32    3 210            3  0101    Structural Support
000086                                                                          0102    Coolant Line
000087         -41.    -89.     177.     1.0                                   13SSCL
000088                 8.203 +153.220 +152.035 +155.751 +145.606 +148.929 +131.488 +14113SSCL 1
000089        2.172 +154.253 +143.153 +147.634 +141.038 +14      SUM1.861 ++16     13SSCL 2
000090                                       9                                     9999

    3. ERS                                                                  16:07:08

       END CUR

  QP HOG     LISTING OF FASTRAND FILE ENGINE/POINTS                25 AUG 71   16:07:08.772
```

PHOTON ENERGY GROUP STRUCTURE

Group	Energy Bounds (MeV)
1	7.5 - 10
2	7.0 - 7.5
3	6.0 - 7.0
4	5.0 - 6.0
5	4.0 - 5.0
6	3.0 - 4.0
7	2.6 - 3.0
8	2.2 - 2.6
9	1.8 - 2.2
10	1.35 - 1.8
11	0.9 - 1.35
12	0.4 - 0.9

TABLE 6

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 59

			CAPTURE SOURCE					
MEV	1	2	3	4	5	6	7	8
.400+00	.0000	.0000	.0000	.0000	.0000	.8060+16	.1715+17	.6304+15
.900+00	.0000	.0000	.0000	.0000	.0000	.9358+16	.2013+17	.7304+15
.135+01	.0000	.0000	.0000	.0000	.0000	.1420+17	.3038+17	.1110+16
.180+01	.0000	.0000	.0000	.0000	.0000	.1745+17	.3715+17	.1364+16
.220+01	.0000	.0000	.0000	.0000	.0000	.1533+17	.3260+17	.1199+16
.260+01	.0000	.8607+15	.6855+13	.1974+13	.4713+12	.1652+17	.3613+17	.1355+16
.300+01	.0000	.0000	.0000	.0000	.0000	.1672+17	.3556+17	.1308+16
.400+01	.0000	.0000	.0000	.0000	.0000	.4641+17	.9908+17	.3630+16
.500+01	.0000	.0000	.0000	.0000	.0000	.7217+17	.1536+18	.5647+16
.600+01	.0000	.0000	.0000	.0000	.0000	.4425+17	.9431+17	.3460+16
.700+01	.0000	.0000	.0000	.0000	.0000	.5698+17	.1213+18	.4456+16
.750+01	.0000	.0000	.0000	.0000	.0000	.3330+16	.7244+16	.2579+15
.100+02	.0000	.0000	.0000	.0000	.0000	.2237+17	.4847+17	.1728+16
TOTAL	.0000	.8607+15	.6855+13	.1974+13	.4713+12	.3432+18	.7331+18	.2680+17

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 60

INELASTIC SOURCE

MEV	1	2	3	4	5	6	7	8
.400+00	.0000	.0000	.0000	.0000	.0000	.7208+15	.1431+16	.8114+14
.900+00	.0000	.0000	.0000	.0000	.0000	.1300+17	.2538+17	.1238+16
.135+01	.0000	.0000	.0000	.0000	.0000	.2755+16	.5205+16	.3756+15
.180+01	.0000	.0000	.0000	.0000	.0000	.4327+16	.8379+16	.6235+15
.220+01	.0000	.0000	.0000	.0000	.0000	.3399+15	.6894+15	.5341+14
.260+01	.0000	.0000	.0000	.0000	.0000	.2296+16	.4600+16	.3527+15
.300+01	.0000	.0000	.0000	.0000	.0000	.2862+15	.5831+15	.4535+14
.400+01	.0000	.0000	.0000	.0000	.0000	.1312+16	.2674+16	.2080+15
.500+01	.0000	.0000	.0000	.0000	.0000	.4262+15	.8683+15	.6753+14
.600+01	.0000	.0000	.0000	.0000	.0000	.2436+15	.4963+15	.3860+14
.700+01	.0000	.0000	.0000	.0000	.0000	.3277+14	.6676+14	.5192+13
.750+01	.0000	.0000	.0000	.0000	.0000	.1487+14	.3022+14	.2356+13
.100+02	.0000	.0000	.0000	.0000	.0000	.2123+14	.4326+14	.3364+13
TOTAL	.0000	.0000	.0000	.0000	.0000	.2577+17	.5045+17	.3095+16

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72   PAGE 61

TOTAL SOURCE

MEV	1	2	3	4	5	6	7	8
.400+00	.0000	.0000	.0000	.0000	.0000	.8781+16	.1858+17	.7115+15
.900+00	.0000	.0000	.0000	.0000	.0000	.2235+17	.4551+17	.1968+16
.135+01	.0000	.0000	.0000	.0000	.0000	.1704+17	.3559+17	.1493+16
.180+01	.0000	.0000	.0000	.0000	.0000	.2178+17	.4553+17	.1988+16
.220+01	.0000	.0000	.0000	.0000	.0000	.1567+17	.3329+17	.1252+16
.260+01	.0000	.2607+15	.6855+13	.1974+13	.4713+12	.1882+17	.4073+17	.1708+16
.300+01	.0000	.0000	.0000	.0000	.0000	.1701+17	.3615+17	.1353+16
.400+01	.0000	.0000	.0000	.0000	.0000	.4772+17	.1018+18	.3839+16
.500+01	.0000	.0000	.0000	.0000	.0000	.7260+17	.1544+18	.5714+16
.600+01	.0000	.0000	.0000	.0000	.0000	.4449+17	.9481+17	.3498+16
.700+01	.0000	.0000	.0000	.0000	.0000	.5701+17	.1213+18	.4461+16
.750+01	.0000	.0000	.0000	.0000	.0000	.3353+16	.7274+16	.2603+15
.100+02	.0000	.0000	.0000	.0000	.0000	.2239+17	.4852+17	.1731+16
TOTAL	.0000	.2607+15	.6855+13	.1974+13	.4713+12	.3690+18	.7835+18	.2998+17

TABLE 6 (CONTINUED)

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72   PAGE 62

	CAPTURE SOURCE							
MEV	9	10	11	12	13	14	15	16
.400+00	.2442+15	.2040+15	.9017+16	.7784+16	.1823+15	.2895+15	.1182+15	.0000
.900+00	.3136+15	.2184+15	.3689+17	.3307+17	.7614+15	.1213+16	.4587+15	.0000
.135+01	.4300+15	.3632+15	.1347+17	.1156+17	.2711+15	.4303+15	.1774+15	.0000
.180+01	.5421+15	.4399+15	.2807+17	.2349+17	.5595+15	.8887+15	.3844+15	.0000
.220+01	.4627+15	.3890+15	.1587+17	.1363+17	.3197+15	.5070+15	.2088+15	.0000
.260+01	.6039+15	.4658+15	.2145+17	.1819+17	.4282+15	.6772+15	.2859+15	.6076+16
.300+01	.5057+15	.4243+15	.1791+17	.1524+17	.3590+15	.5700+15	.2368+15	.0000
.400+01	.1390+16	.1154+16	.5702+17	.5383+17	.1205+16	.1896+16	.6418+15	.0000
.500+01	.2151+16	.1831+16	.5950+17	.5297+17	.1222+16	.1932+16	.7435+15	.0000
.600+01	.1361+16	.1106+16	.6880+17	.6046+17	.1405+16	.2234+16	.8804+15	.0000
.700+01	.1749+16	.1436+16	.7598+17	.6537+17	.1539+16	.2462+16	.1009+16	.0000
.750+01	.1586+15	.6775+14	.4433+17	.3686+17	.8826+15	.1408+16	.6155+15	.0000
.100+02	.1117+16	.4419+15	.3123+18	.2634+18	.6291+16	.1017+17	.4320+16	.0000
TOTAL	.1103+17	.8541+16	.7605+18	.6558+18	.1542+17	.2468+17	.1008+17	.6076+16

TABLE 6 (CONTINUED)

INELASTIC SOURCE

MEV	9	10	11	12	13	14	15	16
.400+00	.5023+14	.1148+14	.7669+16	.9232+16	.2265+15	.8289+15	.1812+15	.0000
.900+00	.9336+15	.2069+15	.1972+18	.2494+18	.5321+16	.2156+17	.4652+16	.0000
.135+01	.1239+15	.3747+14	.3263+17	.4269+17	.1229+16	.3721+16	.7798+15	.0000
.180+01	.2986+15	.6098+14	.5285+17	.7009+17	.1709+16	.6103+16	.1338+16	.0000
.220+01	.2566+14	.5135+13	.2693+16	.3625+16	.7108+14	.3153+15	.7240+14	.0000
.260+01	.1664+15	.3406+14	.3297+17	.4424+17	.9114+15	.3848+16	.8754+15	.0000
.300+01	.2124+14	.4354+13	.2860+16	.3862+16	.7173+14	.3358+15	.7789+14	.0000
.400+01	.9739+14	.1996+14	.1829+17	.2470+17	.4583+15	.2149+16	.4981+15	.0000
.500+01	.3163+14	.6483+13	.6065+16	.8191+16	.1521+15	.7121+15	.1652+15	.0000
.600+01	.1808+14	.3706+13	.3581+16	.4972+16	.9233+14	.4323+15	.1003+15	.0000
.700+01	.2432+13	.4925+12	.4900+15	.6617+15	.1229+14	.5753+14	.1334+14	.0000
.750+01	.1103+13	.2262+12	.2243+15	.3029+15	.5626+13	.2634+14	.6108+13	.0000
.100+02	.1575+13	.3230+12	.3265+15	.4409+15	.8188+13	.3833+14	.8891+13	.0000
TOTAL	.1381+16	.3916+15	.3590+18	.4621+18	.1027+17	.4913+17	.8769+16	.0000

TOTAL SOURCE

MEV	9	10	11	12	13	14	15	16
.400+00	.2944+15	.2154+15	.1569+17	.1772+17	.4088+15	.1118+16	.2994+15	.0000
.900+00	.1297+16	.4253+15	.2341+19	.2814+19	.6083+16	.2277+17	.5111+16	.0000
.135+01	.6139+15	.4007+15	.4510+17	.5425+17	.1500+16	.4152+16	.9571+15	.0000
.180+01	.8409+15	.5009+15	.8092+17	.9358+17	.2268+16	.6992+16	.1723+16	.0000
.220+01	.4978+15	.3942+15	.1856+17	.1726+17	.3903+15	.8222+15	.2812+15	.0000
.263+01	.7703+15	.4999+15	.5442+17	.6242+17	.1340+16	.4526+16	.1161+16	.6076+16
.300+01	.5269+15	.4286+15	.2067+17	.1911+17	.4307+15	.9058+15	.3147+15	.0000
.400+01	.1487+16	.1174+16	.7531+17	.7853+17	.1663+16	.4043+16	.1140+16	.0000
.500+01	.2183+16	.1837+16	.6557+17	.6116+17	.1374+16	.2644+16	.9087+15	.0000
.600+01	.1380+16	.1110+16	.7248+17	.6543+17	.1497+16	.2666+16	.9806+15	.0000
.700+01	.1752+16	.1437+16	.7647+17	.6603+17	.1551+16	.2519+16	.1022+16	.0000
.750+01	.1597+15	.6798+14	.4455+17	.3717+17	.8862+15	.1434+16	.6216+15	.0000
.100+02	.1119+16	.4421+15	.3126+18	.2639+18	.6299+16	.1021+17	.4329+16	.0000
TOTAL	.1291+17	.8932+16	.1118+19	.1118+19	.2569+17	.6481+17	.1885+17	.6076+16

TABLE 6 (CONTINUED)

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 65

MEV	17	18	19	20	21	22	23	24
		CAPTURE SOURCE						
.400+00	.0000	.0000	.0000	.3049+16	.2675+14	.3197+14	.0000	.1129+13
.900+00	.0000	.0000	.0000	.1292+17	.1053+15	.1199+15	.0000	.4295+13
.135+01	.0000	.0000	.0000	.4550+16	.3997+14	.4811+14	.0000	.1704+13
.180+01	.0000	.0000	.0000	.9146+16	.8664+14	.1070+15	.0000	.3765+13
.220+01	.0000	.0000	.0000	.5329+16	.4722+14	.5684+14	.0000	.2010+13
.260+01	.3308+16	.0000	.0000	.7189+16	.6395+14	.7838+14	.1041+16	.2764+13
.300+01	.0000	.0000	.0000	.5896+16	.5380+14	.6513+14	.0000	.2290+13
.400+01	.0000	.0000	.0000	.2144+17	.1472+15	.1515+15	.0000	.5514+13
.500+01	.0000	.0000	.0000	.2094+17	.1686+15	.1934+15	.0000	.6851+13
.600+01	.0000	.0000	.0000	.2353+17	.2011+15	.2343+15	.0000	.8357+13
.700+01	.0000	.0000	.0000	.2537+17	.2301+15	.2750+15	.0000	.9794+13
.750+01	.0000	.0000	.0000	.1828+17	.1390+15	.1737+15	.0000	.6071+13
.100+02	.0000	.0000	.0000	.9490+17	.9993+15	.1218+16	.0000	.4340+14
TOTAL	.3308+16	.0000	.0000	.2525+18	.2309+16	.2753+16	.1041+16	.9794+14

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72   PAGE 65

INELASTIC SOURCE

MEV	17	18	19	20	21	22	23	24
.400+00	.0000	.0000	.0000	.3900+16	.6949+14	.4413+14	.0000	.1049+14
.900+00	.0000	.0000	.0000	.1143+18	.1713+16	.9462+15	.0000	.2252+15
.135+01	.0000	.0000	.0000	.1644+17	.3171+15	.2359+15	.0000	.5859+14
.180+01	.0000	.0000	.0000	.2521+17	.5665+15	.4712+15	.0000	.1259+15
.220+01	.0000	.0000	.0000	.1205+16	.3185+14	.2907+14	.0000	.8161+13
.260+01	.0000	.0000	.0000	.1196+17	.3922+15	.3424+15	.0000	.9540+14
.300+01	.0000	.0000	.0000	.1261+16	.3452+14	.3201+14	.0000	.9077+13
.400+01	.0000	.0000	.0000	.8064+16	.2208+15	.2047+15	.0000	.5806+14
.500+01	.0000	.0000	.0000	.2674+16	.7321+14	.6788+14	.0000	.1925+14
.600+01	.0000	.0000	.0000	.1623+16	.4444+14	.4120+14	.0000	.1168+14
.700+01	.0000	.0000	.0000	.2160+15	.5915+13	.5484+13	.0000	.1555+13
.750+01	.0000	.0000	.0000	.9889+14	.2707+13	.2510+13	.0000	.7119+12
.100+02	.0000	.0000	.0000	.1439+15	.3941+13	.3654+13	.0000	.1036+13
TOTAL	.0000	.0000	.0000	.1991+18	.3465+16	.2426+16	.0000	.6251+15

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 67

TOTAL SOURCE

MEV	17	18	19	20	21	22	23	24
.400+00	.0000	.0000	.0000	.6949+16	.9624+14	.7610+14	.0000	.1162+14
.900+00	.0000	.0000	.0000	.1273+18	.1318+16	.1065+16	.0000	.2294+15
.135+01	.0000	.0000	.0000	.2199+17	.3571+15	.2840+15	.0000	.6030+14
.180+01	.0000	.0000	.0000	.3436+17	.6532+15	.5782+15	.0000	.1297+15
.220+01	.0000	.0000	.0000	.6533+16	.7907+14	.8587+14	.0000	.1017+14
.260+01	.3308+16	.0000	.0000	.2215+17	.4962+15	.4208+15	.1041+16	.9816+14
.300+01	.0000	.0000	.0000	.7157+16	.8833+14	.9714+14	.0000	.1137+14
.400+01	.0000	.0000	.0000	.2950+17	.3690+15	.3562+15	.0000	.6357+14
.500+01	.0000	.0000	.0000	.2361+17	.2418+15	.2613+15	.0000	.2610+14
.600+01	.0000	.0000	.0000	.2515+17	.2455+15	.2755+15	.0000	.2004+14
.700+01	.0000	.0000	.0000	.2559+17	.2360+15	.2805+15	.0000	.1135+14
.750+01	.0000	.0000	.0000	.1439+17	.1417+15	.1762+15	.0000	.6793+13
.100+02	.0000	.0000	.0000	.9204+17	.1003+16	.1222+16	.0000	.4443+14
TOTAL	.3308+16	.0000	.0000	.4427+18	.5774+16	.5180+16	.1041+16	.7230+15

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 68

MEV	25	26	27	28	29	30	31	32
	CAPTURE SOURCE							
.400+00	.6831+13	.5101+13	.7044+13	.5858+13	.6930+13	.5506+13	.4880+13	.6585+13
.900+00	.5381+13	.3108+13	.4292+13	.3570+13	.4223+13	.3355+13	.2974+13	.4013+13
.135+01	.4719+13	.2726+13	.3764+13	.3131+13	.3703+13	.2942+13	.2608+13	.3519+13
.180+01	.4086+13	.2360+13	.3259+13	.2710+13	.3206+13	.2547+13	.2258+13	.3047+13
.220+01	.2980+13	.1721+13	.2377+13	.1977+13	.2339+13	.1858+13	.1647+13	.2222+13
.260+01	.2053+13	.1186+13	.1638+13	.1362+13	.1611+13	.1280+13	.1135+13	.1531+13
.300+01	.2782+13	.1607+13	.2219+13	.1845+13	.2183+13	.1734+13	.1537+13	.2074+13
.400+01	.7341+14	.4240+14	.5855+14	.4870+14	.5761+14	.4577+14	.4057+14	.5474+14
.500+01	.3974+14	.2295+14	.3170+14	.2636+14	.3118+14	.2478+14	.2196+14	.2963+14
.600+01	.3339+14	.1929+14	.2664+14	.2215+14	.2620+14	.2082+14	.1845+14	.2490+14
.700+01	.1076+14	.6216+13	.8585+13	.7140+13	.8446+13	.6711+13	.5948+13	.8025+13
.750+01	.1601+13	.9245+12	.1277+13	.1062+13	.1256+13	.9980+12	.8846+12	.1194+13
.100+02	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
TOTAL	.1897+15	.1096+15	.1513+15	.1259+15	.1489+15	.1183+15	.1049+15	.1415+15

TABLE 6 (CONTINUED)

TABLE 6 (CONTINUED)

EXECUTE UOAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 69

INELASTIC SOURCE

MEV	25	26	27	28	29	30	31	32
.400+00	.9750+12	.4299+12	.7460+12	.5097+12	.1656+13	.3283+12	.2619+12	.9961+12
.900+00	.1765+14	.1881+14	.1714+14	.1273+14	.3153+14	.1821+14	.1595+14	.1858+14
.135+01	.3621+14	.4559+14	.3396+14	.1366+14	.5962+14	.3977+14	.4449+14	.2971+14
.180+01	.1616+14	.6010+13	.1206+14	.8180+13	.2749+14	.4213+13	.3181+13	.1657+14
.220+01	.1556+14	.5793+13	.1163+14	.7385+13	.2649+14	.4062+13	.3066+13	.1598+14
.260+01	.1029+14	.3628+13	.7683+13	.5211+13	.1750+14	.2684+13	.2026+13	.1056+14
.300+01	.9382+13	.3490+13	.7004+13	.4750+13	.1595+14	.2446+13	.1847+13	.9623+13
.400+01	.1292+14	.4471+13	.8975+13	.6096+13	.2044+14	.3135+13	.2366+13	.1233+14
.500+01	.3169+13	.1179+13	.2366+13	.1604+13	.5389+13	.8264+12	.6239+12	.3250+13
.600+01	.1403+13	.5218+12	.1047+13	.7102+12	.2386+13	.3658+12	.2762+12	.1439+13
.700+01	.8648+12	.3217+12	.6456+12	.4378+12	.1471+13	.2255+12	.1702+12	.8870+12
.750+01	.3602+12	.1340+12	.2689+12	.1824+12	.6126+12	.9390+11	.7092+11	.3695+12
.100+02	.2086+12	.7758+11	.1557+12	.1056+12	.3547+12	.5439+11	.4106+11	.2139+12
TOTAL	.1253+15	.9365+14	.1936+15	.6706+14	.2109+15	.7642+14	.7429+14	.1205+15

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72   PAGE 70

TOTAL SOURCE

MEV	25	26	27	28	29	30	31	32
.400+00	.9806+13	.5530+13	.7790+13	.6368+13	.8586+13	.5835+13	.5142+13	.7581+13
.900+00	.2403+14	.2192+14	.2143+14	.1630+14	.3575+14	.2156+14	.1893+14	.2259+14
.135+01	.4093+14	.5131+14	.3763+14	.2179+14	.6332+14	.4272+14	.4700+14	.3323+14
.180+01	.2924+14	.8370+13	.1532+14	.1099+14	.3068+14	.6761+13	.5439+13	.1962+14
.220+01	.1856+14	.7515+13	.1401+14	.9863+13	.2882+14	.5920+13	.4713+13	.1820+14
.260+01	.1234+14	.5014+13	.9321+13	.6573+13	.1911+14	.3964+13	.3161+13	.1209+14
.300+01	.1216+14	.5096+13	.9223+13	.6595+13	.1814+14	.4181+13	.3384+13	.1170+14
.400+01	.6543+14	.4687+14	.6753+14	.5479+14	.7805+14	.4891+14	.4294+14	.6707+14
.500+01	.4291+14	.2413+14	.3406+14	.2727+14	.3657+14	.2560+14	.2259+14	.3288+14
.600+01	.3479+14	.1981+14	.2768+14	.2286+14	.2859+14	.2119+14	.1873+14	.2634+14
.700+01	.1163+14	.6539+13	.9231+13	.7578+13	.9916+13	.6936+13	.6118+13	.8913+13
.750+01	.1961+13	.1058+13	.1546+13	.1244+13	.1869+13	.1092+13	.9555+12	.1563+13
.100+02	.2086+12	.7758+11	.1557+12	.1056+12	.3547+12	.5439+11	.4106+11	.2139+12
TOTAL	.3159+15	.2032+15	.2549+15	.1929+15	.3598+15	.1947+15	.1791+15	.2620+15

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 71

MEV	CAPTURE SOURCE 33	34	35	36	37	38	39	40
.400+00	.1932+14	.3521+14	.1785+13	.0000	.0000	.0000	.0000	.0000
.900+00	.8728+13	.2146+14	.1989+13	.0000	.0000	.0000	.0000	.0000
.135+01	.7654+13	.1682+14	.9537+12	.0000	.0000	.0000	.0000	.0000
.180+01	.6627+13	.1629+14	.8257+12	.0000	.0000	.0000	.0000	.0000
.220+01	.4834+13	.1188+14	.6723+12	.0000	.0000	.0000	.0000	.0000
.260+01	.3330+13	.6187+13	.4149+12	.0000	.0000	.0000	.0000	.0000
.300+01	.4512+13	.1109+14	.5622+12	.0000	.0000	.0000	.0000	.0000
.400+01	.1191+15	.2927+15	.1484+14	.0000	.0000	.0000	.0000	.0000
.500+01	.6445+14	.1585+15	.8031+13	.0000	.0000	.0000	.0000	.0000
.600+01	.5416+14	.1332+15	.6748+13	.0000	.0000	.0000	.0000	.0000
.700+01	.1746+14	.4292+14	.2175+13	.0000	.0000	.0000	.0000	.0000
.750+01	.2596+13	.6382+13	.3235+12	.0000	.0000	.0000	.0000	.0000
.100+02	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
TOTAL	.3077+15	.7566+15	.3835+14	.0000	.0000	.0000	.0000	.0000

INELASTIC SOURCE

MEV	33	34	35	36	37	38	39	40
.400+00	.1462+13	.4735+13	.5631+13	.0000	.0000	.0000	.0000	.0000
.900+00	.4824+14	.1080+15	.1039+15	.0000	.0000	.0000	.0000	.0000
.135+01	.1049+15	.2020+15	.1919+15	.0000	.0000	.0000	.0000	.0000
.180+01	.2216+14	.7684+14	.9380+14	.0000	.0000	.0000	.0000	.0000
.220+01	.2136+14	.7407+14	.9043+14	.0000	.0000	.0000	.0000	.0000
.260+01	.1412+14	.4994+14	.5975+14	.0000	.0000	.0000	.0000	.0000
.300+01	.1287+14	.4462+14	.5447+14	.0000	.0000	.0000	.0000	.0000
.400+01	.1649+14	.5717+14	.6979+14	.0000	.0000	.0000	.0000	.0000
.500+01	.4347+13	.1507+14	.1840+14	.0000	.0000	.0000	.0000	.0000
.600+01	.1924+13	.6671+13	.8145+13	.0000	.0000	.0000	.0000	.0000
.700+01	.1186+13	.4113+13	.5021+13	.0000	.0000	.0000	.0000	.0000
.750+01	.4941+12	.1713+13	.2091+13	.0000	.0000	.0000	.0000	.0000
.100+02	.2861+12	.9918+12	.1211+13	.0000	.0000	.0000	.0000	.0000
TOTAL	.2499+15	.6450+15	.7045+15	.0000	.0000	.0000	.0000	.0000

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 73

		TOTAL SOURCE						
MEV	33	34	35	36	37	38	39	40
.400+00	.1579+14	.3995+14	.7416+13	.0000	.0000	.0000	.0000	.0000
.900+00	.5697+14	.1295+15	.1050+15	.0000	.0000	.0000	.0000	.0000
.135+01	.1126+15	.2208+15	.1020+15	.0000	.0000	.0000	.0000	.0000
.180+01	.2079+14	.9313+14	.9463+14	.0000	.0000	.0000	.0000	.0000
.220+01	.2620+14	.8595+14	.9103+14	.0000	.0000	.0000	.0000	.0000
.260+01	.1745+14	.5713+14	.6017+14	.0000	.0000	.0000	.0000	.0000
.300+01	.1738+14	.5571+14	.5503+14	.0000	.0000	.0000	.0000	.0000
.400+01	.1355+15	.3499+15	.8463+14	.0000	.0000	.0000	.0000	.0000
.500+01	.6880+14	.1735+15	.2643+14	.0000	.0000	.0000	.0000	.0000
.600+01	.5608+14	.1398+15	.1489+14	.0000	.0000	.0000	.0000	.0000
.700+01	.1064+14	.4703+14	.7196+13	.0000	.0000	.0000	.0000	.0000
.750+01	.3690+13	.8096+13	.2415+13	.0000	.0000	.0000	.0000	.0000
.100+02	.2861+12	.9918+12	.1211+13	.0000	.0000	.0000	.0000	.0000
TOTAL	.5576+15	.1402+16	.7429+15	.0000	.0000	.0000	.0000	.0000

TABLE 6 (CONTINUED

E

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72 PAGE 74

	CAPTURE SOURCE				
MEV	41	42	43	44	45
.400+00	.0000	.0000	.0000	.0000	.0000
.500+00	.0000	.0000	.0000	.0000	.0000
.135+01	.0000	.0000	.0000	.0000	.0000
.180+01	.0000	.0000	.0000	.0000	.0000
.220+01	.0000	.0000	.0000	.0000	.0000
.260+01	.0000	.0000	.0000	.0000	.0000
.300+01	.0000	.0000	.0000	.0000	.0000
.400+01	.0000	.0000	.0000	.0000	.0000
.500+01	.0000	.0000	.0000	.0000	.0000
.600+01	.0000	.0000	.0000	.0000	.0000
.700+01	.0000	.0000	.0000	.0000	.0000
.750+01	.0000	.0000	.0000	.0000	.0000
.100+02	.0000	.0000	.0000	.0000	.0000
TOTAL	.0000	.0000	.0000	.0000	.0000

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION   DATE 09 MAR 72   PAGE   75

INELASTIC SOURCE

MEV	41	42	43	44	45
.400+00	.0000	.0000	.0000	.0000	.0000
.900+00	.0000	.0000	.0000	.0000	.0000
.135+01	.0000	.0000	.0000	.0000	.0000
.180+01	.0000	.0000	.0000	.0000	.0000
.220+01	.0000	.0000	.0000	.0000	.0000
.260+01	.0000	.0000	.0000	.0000	.0000
.300+01	.0000	.0000	.0000	.0000	.0000
.400+01	.0000	.0000	.0000	.0000	.0000
.500+01	.0000	.0000	.0000	.0000	.0000
.600+01	.0000	.0000	.0000	.0000	.0000
.700+01	.0000	.0000	.0000	.0000	.0000
.750+01	.0000	.0000	.0000	.0000	.0000
.100+02	.0000	.0000	.0000	.0000	.0000
TOTAL	.0000	.0000	.0000	.0000	.0000

TABLE 6 (CONTINUED)

EXECUTE UDAP FOR SECONDARY SOURCE IN COLUMBIUM EXTENSION DATE 09 MAR 72 PAGE 76

TOTAL SOURCE

MEV	41	42	43	44	45
.400+00	.0000	.0000	.0000	.0000	.0000
.900+00	.0000	.0000	.0000	.0000	.0000
.135+01	.0000	.0000	.0000	.0000	.0000
.180+01	.0000	.0000	.0000	.0000	.0000
.220+01	.0000	.0000	.0000	.0000	.0000
.260+01	.0000	.0000	.0000	.0000	.0000
.300+01	.0000	.0000	.0000	.0000	.0000
.400+01	.0000	.0000	.0000	.0000	.0000
.500+01	.0000	.0000	.0000	.0000	.0000
.600+01	.0000	.0000	.0000	.0000	.0000
.700+01	.0000	.0000	.0000	.0000	.0000
.750+01	.0000	.0000	.0000	.0000	.0000
.100+02	.0000	.0000	.0000	.0000	.0000
TOTAL	.0000	.0000	.0000	.0000	.0000

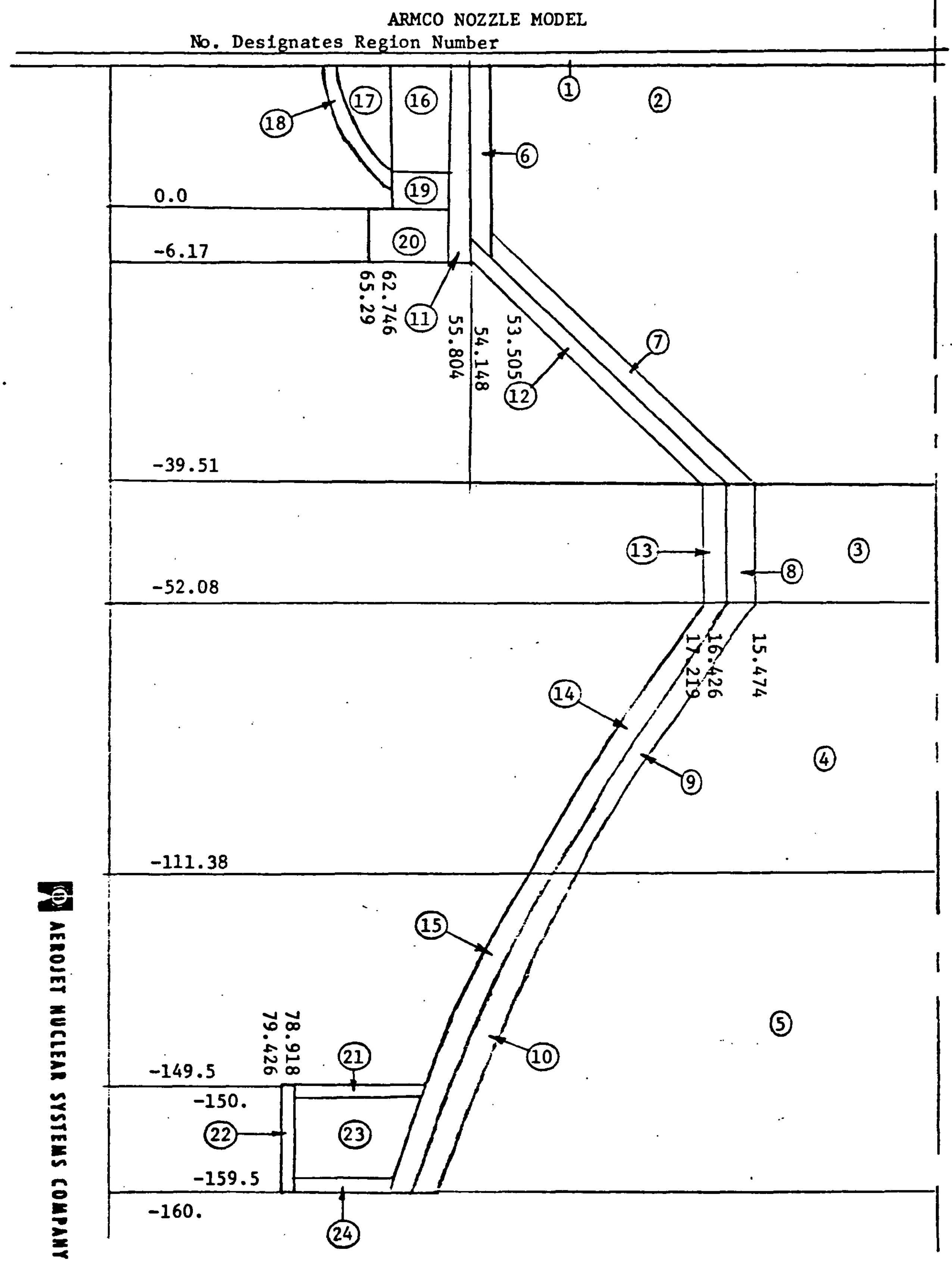


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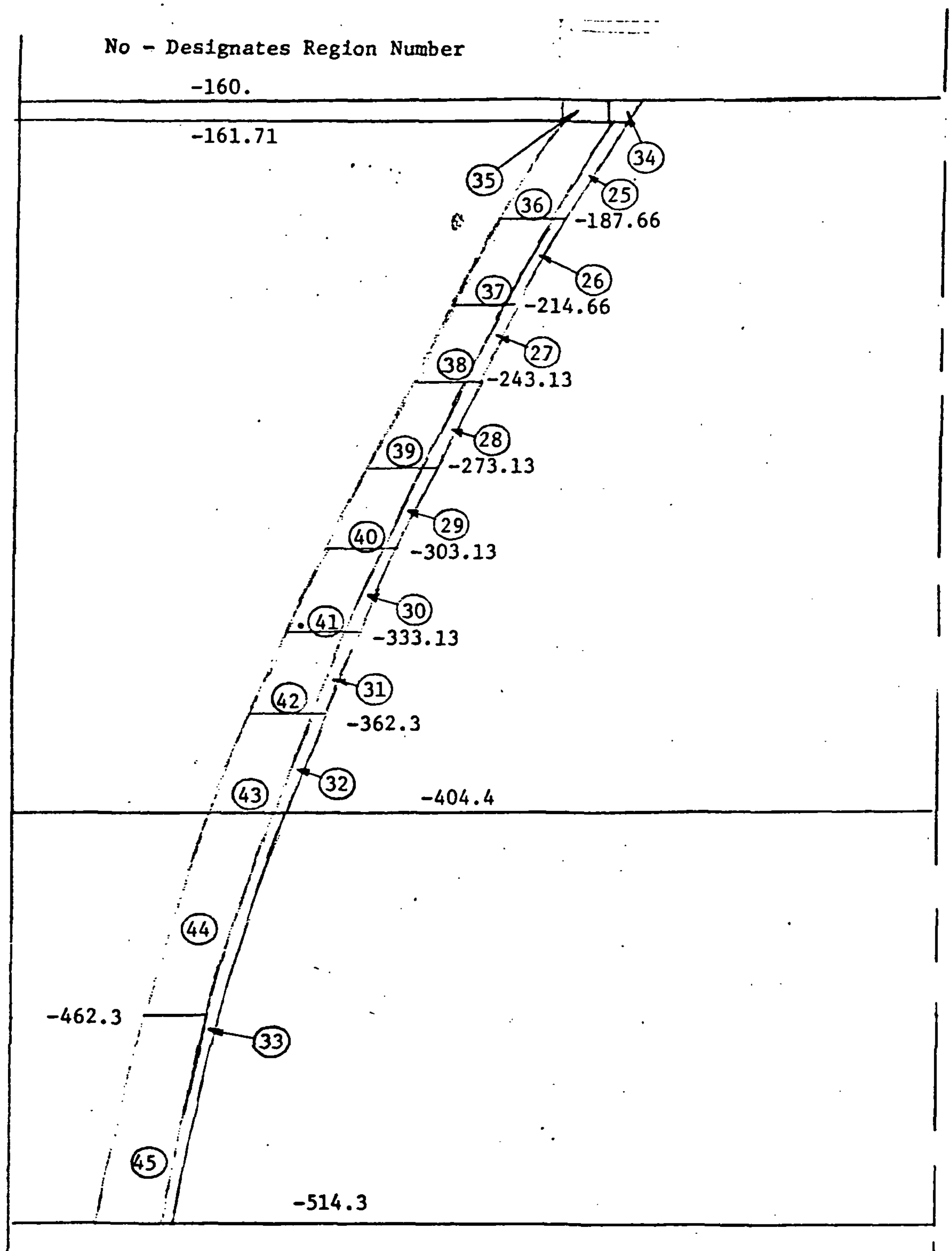
Figure 25

COLUMBIUM NOZZLE EXTENSION MODEL



NOTE: Prime candidate graphite nozzle extension model not shown as sources are negligible in graphite.

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Figure 26

4. Methods of Analysis

The non-nuclear components are described in three dimensional terms in the FASTER geometry routine suitable for direct use with the ANSC versions of the QAD and GGG Point Kernel codes or the COHORT Monte Carlo code.

The secondary gamma source strengths in the forward direction were computed for the model of the 1137400C engine configuration. It was not deemed economically feasible to repeat the analysis for the 1137400E configuration. The neutron angular and energy leakage data from WANL was inputed into the DASH code and normalized in magnitude to be equal to the specification extreme levels, as reported in the engine specification. The COHORT model of the components and propellant tank bottom was used to compute the neutron transport and subsequent secondary gamma sources. The UDAP code was used to categorize the secondary sources by groups of regions, reducing the number of sources to 13.

A similar DOT/DASH/COHORT/UDAP coupling was used to compute the sources in the nozzle and nozzle extension. The cylindrical portion of the pressure vessel source was taken from the WANL-DOT model. The curved portions of the pressure vessel were estimated from DASH and Point Kernel data. These data were used to back extrapolate to the pressure vessel closure dome and curved bottom near the nozzle flange.

The neutron flux was treated as follows: The sixteen group structure from the DOT leakage tape was used as input to the COHORT Monte Carlo analysis through the DASH code by reformating into sixteen source energy groups. Particle histories were generated in the H01 procedure in COHORT and neutrons were followed in twenty two groups. These twenty two group fluxes were then analyzed with the A02 and A03 analysis routines. Since these are Monte Carlo procedures, based on particle history information, the identification with the original energy group structure is only indirect.

Table 7 lists the neutron and photon energy group structures used in these analysis.

The neutron sources for any other analyses can be obtained from the WANL-DOT analyses reported in this document.

Each of the computer codes used in the ANSC analyses is described in Engineering Operations Report N8140:R-72-0015. Users Manuals and sample problems are included in that report along with description material on each method of analysis.

TABLE 7

NEUTRON AND PHOTON ENERGY GROUPS STRUCTURE

Neutron DOT/DASH		Neutron Monte Carlo		Photon Secondary Sources	
GROUP	ENERGY, Mev	GROUP	ENERGY, Mev	GROUP	ENERGY, Mev
1	3.0 - 10.0	1	9.0 - 10.	1	7.5 - 10.0
2	1.4 - 3.0	2	8.0 - 9.0	2	7.0 - 7.5
3	0.9 - 1.4	3	7.0 - 8.0	3	6.0 - 7.0
4	0.4 - 0.9	4	6.0 - 7.0	4	5.0 - 6.0
5	0.1 - 0.4	5	5.0 - 6.0	5	4.0 - 5.0
6	1.7(-2) - 1.0(-1)	6	4.0 - 5.0	6	3.0 - 4.0
7	3.0(-3) - 1.7(-2)	7	3.0 - 4.0	7	2.6 - 3.0
8	5.5(-4) - 3.0(-3)	8	1.4 - 3.0	8	2.2 - 2.6
9	1.0(-4) - 5.5(-4)	9	0.9 - 1.4	9	1.8 - 2.2
10	3.0(-5) - 1.0(-4)	10	0.4 - 0.9	10	1.35 - 1.8
11	1.0(-5) - 3.0(-5)	11	0.1 - 0.4	11	0.9 - 1.35
12	3.0(-6) - 1.0(-5)	12	1.7(-2) - 1.0(-1)	12	0.4 - 0.9
13	1.0(-6) - 3.0(-6)	13	3.0(-3) - 1.7(-2)	13	0 - 0.4
14	4.0(-7) - 1.0(-6)	14	5.5(-4) - 3.0(-3)		
15	1.0(-7) - 4.0(-7)	15	1.0(-4) - 5.5(-4)		
16	0 - 1.0(-7)	16	3.0(-5) - 1.0(-4)		
		17	1.0(-5) - 3.0(-5)		
		18	3.0(-6) - 1.0(-5)		
		19	1.0(-6) - 3.0(-6)		
		20	4.0(-7) - 1.0(-6)		
		21	2.5(-8) - 4.0(-7)		
		22	0 - 2.5(-8)		

B. Nuclear Subsystem

WANL-DRM-54255

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OF 1954

Westinghouse Electric Corporation
Industry & Defense Products
Astronuclear Laboratory Box 10864, Pittsburgh, Pa. 15236
Telephone: 892-5600

NA-71-90

SEP 30 1971

Mr. J. L. Dooling
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~~(INSERT PROPER~~ CLASSIFICATION)

Attention: Mr. E. A. Warman

Subject: Transmittal of the September, 1971 Common Radiation Analysis Model (U)

Gentlemen:

Transmitted herewith are copies of the following document: DRM No. 54266, "Common Radiation Analysis Model (CRAM) for the R-1 Reactor Design Employing Composite Fuel and a Shaped Internal Shield". Transmittal of this document completes IED No. 016. The September, 1971 CRAM was updated under Project 712, Work Statement f.52.

This document contains: (1) a geometric model and material description of the Nuclear Subsystem for use in radiation analysis, (2) radiation source strengths and distributions in each geometric region of the Nuclear Subsystem, and (3) a description of the neutron and photon angular leakage fluxes at the surface of the Nuclear Subsystem.

The physical data tapes, containing the angular surface leakage data will be transmitted under separate cover.

Respectfully,

ORIGINAL SIGNED BY
R. F. ~~Dickson, Manager~~
Program Management
NERVA Nuclear Subsystem

WPK/tak

Enclosures

cc: Mr. R. W. Schroeder, SNSO-C, w/o encl.
Mr. M. R. Fleishman, SNSO-C, w/encl.
Mr. H. H. Hoffman, SNSO-C Resident at WANL, w/o encl.

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~~CONFIDENTIAL~~ ~~RESTRICTED DATA~~ ATOMIC ENERGY ACT OF 1954 Cp-1	Westinghouse Astronuclear Laboratory CODE IDENT NO. 14683 SHEET 1 OF 100	54266	
		DRM TYPE (13) Analysis	
		DEPARTMENT (13) Nuclear Analysis	

SUBJECT (120)
COMMON RADIATION ANALYSIS MODEL (CRAM) FOR THE R-1 REACTOR DESIGN EMPLOYING COMPOSITE FUEL AND A SHAPED INTERNAL SHIELD U

DATE (6)	REACTOR
092771	R-1

PARA NO	CEI	PARA NO	CEI	PARA NO	CEI	TEST SCOPE NO	DATA ITEM	
1.	55						1.	2.
2.							3.	4.
3.							5.	6.

DOCUMENT REFERENCES
(DWG NO/PART NO/COMPUTER CODES/DRMS/MTLS SPECS/CORRESPONDENCE)

1. DRM 54313	2. TME-2774	3. DRM 53360	4. DRM 54264	5. DRM 54133
6.	7.	8.	9.	10.

1. PURPOSE 2. ASSUMPTIONS/METHODS 3. CONCLUSIONS (USE CONTINUATION SHEET IF NECESSARY)

1. PURPOSE

To document the CRAM for the R-1 reactor employing composite fuel and a shaped internal shield. This document contains: (1) a geometric and material description of the NSS suitable for use in radiation analysis, (2) radiation source strengths and distributions in each geometric region of the NSS, and (3) a description of the radiation leakage flux data contained on the CRAM data tapes. (This work was accomplished under Project 712, Work Statement f.52.)

2. ASSUMPTIONS/METHODS

The following were employed to develop the CRAM:

(a) The composite core weights, dimensions, and atom densities were obtained from Reference 1.

(b) The PDR recommended design (Reference 2) for all ECC's, except the internal shield were employed in this CRAM.

(c) The "shaped" internal shield geometry is based on WANL Drawing 940J511.

GROUP 1
Excluded From Automatic Downgrading
and Declassification

APPROVALS

F. S. Frantz R. K. Disney R. V. Rittenberger M.A. Capo M a Capo 9/27/71	INFORMATION CATEGORY CONFIDENTIAL - RD CLASSIFICATION
PREPARED BY DATE W. P. Kovacik W P Kovacik 9/29/71 APPROVED BY DATE	W P Kovacik 9/29/71 AUTHORIZED CLASSIFIER DATE

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TC 1190

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A detailed discussion of the method of analysis is given in the body of this DRM.

3. CONCLUSIONS

The geometric model of the R-1 Nuclear Subsystem is shown in Figure 1 as a cross-sectional view of the reactor taken in the R-Z plane. The model shown in Figure 1 is referenced to the intersection of the reactor axis with the pressure vessel-nozzle mating plane and all dimensions are given in centimeters. The material composition of each of the 36 geometric regions shown in Figure 1 is given in Table 1.

The gamma ray source strengths for each of the zones depicted in Figure 1 are given in Table 2; and are presented in the standard WISDM 13 energy group structure. These data represent the total gamma ray energy release rate (Mev/Sec) in each region for maximum gamma activity during operation. This condition occurs at the end of an assumed 60 minute reactor burn at a power level of 1515 megawatts (Thermal).

The spatial variation of the source strength in each geometric region is presented in Figures 2 through 73. These are two figures for each region. The first figure depicts the radial distribution of source strength within the region, whereas the second figure gives the axial variation.

The envelope which defines the leakage surface of the NSS is the external surface of the NSS analytical model employed in the DOT-IIW calculations.

This leakage surface is subdivided according to the dimensions shown in Table 3 and 4. The CRAM data tapes contain the leakage fluxes from each interval defined on the surface and for each discrete direction.

The angular quadrature data corresponding to the discrete direction fluxes are listed in Tables 5 and 6. The contents of the CRAM data tapes are described in Tables 7 and 8.

METHOD OF ANALYSIS

The development of the CRAM NSS radiation sources involves the use of the DOT-IIW[3] and NAGS[5] codes to produce the NSS internal radiation source description and the NSS surface radiation source description. Development of each type of data is described below.

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Two coupled neutron DOT-IIW calculations were performed to compute 16 group neutron fluxes throughout a reactor model[4] similar to that shown in Figure 1. The first was a neutron fixed source calculations on that part of the reactor which extends from Z = 23.04 to an axial plane located a short distance into the BATH central shield. From this fixed source problem, the neutron flux distributions throughout the aft portion of the analytical model were obtained. In addition, an angular and energy dependent boundary source, based on the angular flux distributions near the forward face of the core support plate, was generated. Using this boundary source as a coupling mechanism, a second DOT-IIW calculation was employed to obtain neutron flux distributions throughout the forward portions of the analytical model.

The neutron problem on the aft portion of the reactor utilized 4160 spatial mesh cells arranged in an array of 52 radial by 80 axial mesh cells. The boundary source calculation contained 5420 spatial mesh cells in a 52 radial by 85 axial array. Both calculations employed 16 group, P_0-transport corrected neutron cross sections and an S_8 order of angular quadrature.

The neutron fluxes obtained from the two DOT-IIW calculations were input to the NAGS[5] data processing code which combines neutron flux data together with neutron reaction cross sections (i.e., neutron radiative capture, fission, and inelastic scatter) and photon production data to produce a spatial and energy dependent photon source in each spatial mesh cell of the analytical model.

This NAGS photon source data by mesh cell is used in photon DOT-IIW calculations to compute 13 group photon flux distributions through the reactor model[4] similar to that shown in Figure 1. The photon DOT-IIW problems are: (1) a coupled calculation of two DOT-IIW problems to analyze the photon transport due to the photon sources in the first neutron problem (i.e., the portion of the NSS extending from Z = 23.04 to an axial position located a short distance into the BATH shield), and (2) a DOT-IIW calculation to analyze the photon transport due to the photon sources in the second neutron problem (i.e., the portion of the NSS from the forward face of the support plate to the pressure vessel). The coupled calculation involves the use of the NAGS calculated fixed photon source distribution in the first portion of the reactor to obtain the flux distribution and an energy and angular dependent boundary source as a coupling mechanism to obtain the photon flux distribution throughout the forward portion of the analytical model.

The photon problem on the aft portion of the reactor utilized 2808 spatial mesh cells arranged in an array of 52 radial by 54 axial mesh intervals. The boundary source and fixed source calculations in the forward portion of the reactor utilized 52 radial by 46 axial mesh intervals. All three calculations employed 13 group P_1 photon cross sections and an asymmetric angular quadrature containing 124 angles.

The use of the DOT-IIW and NAGS output in developing the CRAM radiative sources is described in following sections.

NSS INTERNAL RADIATION SOURCE

The photon source data by spatial mesh cell is used in NAGS to provide the internal radiation source description. These data are integrated by NAGS to provide the radial, axial, and energy distribution of photon source in each geometric zone of the analytical model depicted in Figure 1. The data for each geometric zone are summarized in Table 2 and Figures 2 through 73. The data in Table 2 and Figures 2 through 73 assume that the radial, axial, and energy distribution of the radiation source in each zone is separable into three distributions. Data in Table 2 are the total gamma ray energy release (Mev/Sec) in each zone. The radial source distributions in Figures 2 through 73 are plotted such that:

$$\frac{\int R\, f\,(R)\, dR}{\int R\, d\, R} = 1.0$$

and, the axial source distributions are plotted such that:

$$\frac{\int f\,(Z)\, dZ}{\int d\, Z} = 1.0$$

These data comprise the NSS internal radiation source description.

NSS SURFACE RADIATION SOURCE

The NSS surface angular fluxes which define the NSS surface radiation source on the CRAM data tapes are obtained from DOT-IIW calculations of the neutron transport and photon transport in the NSS.

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The neutron leakage flux data are obtained from the DOT-IIW calculations as described previously. The DOT-IIW output data tapes are linked using the CAFT[6] code to produce a single data tape describing the leakage angular fluxes from the NSS surface envelope. The merging of the DOT-IIW output tapes for neutrons results in a single data tape for an analytical model with a total of 6188 spatial mesh cells arranged in an array of 52 radial by 119 axial mesh cells. The 119 axial mesh intervals result from data for the 85 axial mesh for the boundary source DOT-IIW calculation and 34 of 80 axial mesh for the fixed source (aft portion) DOT-IIW calculation. The radial and axial mesh lines describing the 52 radial and 119 axial mesh intervals are listed in Table 3.

The neutron leakage angular flux tape contains sixteen group data with a total of 48 angular flux values for each surface mesh interval. The 48 angular directions are defined by the quadrature data given in Table 5. The contents of the magnetic tape for the CRAM NSS surface radiation source for neutrons is described in Table 7. The neutron group structure is given in Table 9.

The photon leakage flux data are obtained from the DOT-IIW calculations as described previously. DOT-IIW data tapes are added and linked using the CAFT code to produce a single data tape describing the leakage angular fluxes from the NSS surface envelope. This merging of the DOT-IIW output tapes for photons results in a single data tape for an analytical model with a total of 4160 spatial mesh cells arranged in an array of 52 radial by 80 axial mesh cells. The 80 axial mesh intervals result from data for the 47 axial mesh intervals of the boundary source DOT-IIW calculation and 33 of 54 axial mesh intervals from the fixed source (aft portion) DOT-IIW calculation. The radial and axial mesh lines describing the 52 radial and 80 axial mesh intervals are listed in Table 4.

The photon leakage angular flux tape contains thirteen group data with a total of 124 angular flux values for each surface mesh interval. The 124 angular directions are defined by the quadrature data given in Table 6. The contents of the magnetic tape for the CRAM NSS surface radiation source for photons is described in Table 8.

A computer code to assist in conversion of CRAM data tapes at the users computer facility is listed in Table 10. The CRAM data tapes are written at 800 bpi density on 7 track tape with a maximum of 3960 BCD characters per record. Each set of 3960 characters contain 240 data words written with the FORTRAN format (30 (8E15.8, 12X)) such that each line of 132 characters contains 8 data words each represented as fifteen characters. The neutron and photon tape contents are described in Tables 7 and 8.

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TABLE 2

PRESSURE VESSEL AND REACTOR ASSEMBLY SOURCE STRENGTHS

Photon Energy Group (Mev)	Gamma Source Strength (Mev/Sec)								
	Region 1 Hot End Hardware	Region 2 Reactor Core	Region 3 Core Periphery	Region 4 Lateral Support	Region 5 Structure	Region 6 Reflector	Region 7 Pressure Vessel - Side A	Region 8 Nozzle Chamber	Region 9 Aft Reflector and Plenum
7.5-10.0	5.39(16)	2.68(18)	1.15(17)	0.0	2.56(18)	7.60(18)	4.07(17)	0.0	3.86(16)
7.0-7.5	3.46(16)	1.50(18)	5.19(16)	0.0	3.12(17)	1.04(18)	5.03(16)	0.0	1.58(16)
6.0-7.0	1.81(17)	1.13(19)	6.16(17)	0.0	7.24(17)	2.66(17)	1.14(17)	0.0	1.29(16)
5.0-6.0	2.18(17)	1.52(19)	5.53(17)	0.0	5.00(17)	1.30(18)	7.50(16)	0.0	1.35(16)
4.0-5.0	2.62(17)	4.17(19)	1.05(18)	2.66(17)	1.14(18)	1.20(18)	2.37(17)	0.0	1.25(16)
3.0-4.0	3.65(17)	8.11(19)	1.09(18)	9.25(15)	8.57(17)	1.20(18)	1.66(17)	0.0	9.71(15)
2.6-3.0	1.94(17)	4.90(19)	5.43(17)	0.0	4.37(17)	3.94(17)	7.83(16)	0.0	3.99(15)
2.2-2.6	2.27(17)	6.75(19)	5.71(17)	1.92(16)	5.29(17)	7.04(17)	7.92(16)	2.99(13)	7.95(15)
1.8-2.2	2.41(17)	8.68(19)	6.49(17)	0.0	4.19(17)	3.43(17)	5.46(16)	0.0	4.57(15)
1.35-1.8	2.00(17)	1.15(20)	5.11(17)	0.0	5.38(17)	5.05(17)	5.70(16)	0.0	5.40(15)
0.9-1.35	2.31(17)	1.50(20)	3.28(17)	2.91(15)	6.20(17)	2.77(17)	6.16(16)	0.0	4.75(15)
0.4-0.9	1.95(17)	2.00(20)	3.16(17)	0.0	2.19(17)	3.46(17)	2.29(16)	0.0	2.57(15)
0-0.4	6.71(16)	9.19(19)	3.83(16)	0.0	6.83(16)	8.76(16)	1.09(16)	0.0	9.31(14)
TOTAL	2.47(18)	9.14(20)	6.44(18)	2.98(17)	8.95(18)	1.77(19)	1.41(18)	2.99(13)	1.33(17)

NOTE: Numbers in parentheses refer to powers of ten.

TABLE 2 (Cont)

Photon Energy Group (Mev)	Gamma Source Strength (Mev/Sec)							
	Region 10 Core Plenum	Region 11 Lateral Support Forward	Region 12 Support Plate	Region 13 Forward Reflector Hardware I	Region 14 Support Plate Plenum	Region 15 Aft Central Shield Plate	Region 16 Instrumentation Ring	Region 17 Forward Reflector Hardware II
7.5-10.0	1.14(18)	3.77(17)	3.06(18)	6.25(17)	3.74(17)	5.81(16)	6.28(16)	6.24(16)
7.0-7.5	3.43(17)	5.62(16)	5.69(17)	1.37(17)	7.61(16)	5.49(15)	7.01(15)	9.13(15)
6.0-7.0	7.57(17)	1.04(17)	7.31(17)	1.63(17)	8.53(16)	1.62(16)	1.68(16)	1.56(16)
5.0-6.0	8.50(17)	6.73(16)	6.07(17)	1.33(17)	7.43(16)	1.13(16)	1.08(16)	1.03(16)
4.0-5.0	1.03(18)	5.03(16)	6.22(17)	9.26(16)	4.32(16)	3.95(16)	2.52(16)	6.16(15)
3.0-4.0	1.29(18)	4.84(16)	4.99(17)	7.72(16)	3.96(16)	2.70(16)	1.66(16)	5.62(15)
2.6-3.0	6.69(17)	2.00(16)	2.03(17)	2.68(16)	1.28(16)	1.35(16)	7.63(15)	1.89(15)
2.2-2.6	6.54(17)	2.77(16)	3.41(17)	8.41(16)	2.72(16)	1.53(16)	9.50(15)	1.27(15)
1.8-2.2	6.59(17)	2.04(16)	1.83(17)	2.56(16)	1.19(16)	1.14(16)	5.42(15)	1.75(15)
1.35-1.8	6.51(17)	3.83(16)	2.57(17)	3.57(16)	1.91(16)	1.36(16)	6.28(15)	2.99(15)
0.9-1.35	3.03(17)	2.27(16)	2.21(17)	1.77(16)	9.69(15)	1.74(16)	5.99(15)	1.12(15)
0.4-0.9	8.69(17)	2.24(16)	1.67(17)	2.51(16)	1.68(16)	5.22(15)	2.91(15)	2.26(15)
0-0.4	4.76(16)	5.78(15)	4.96(16)	7.77(15)	4.66(15)	1.86(15)	1.08(15)	6.13(14)
TOTAL	9.27(18)	8.61(17)	7.51(18)	1.45(18)	7.94(17)	2.36(17)	1.78(17)	1.32(17)

NOTE: Numbers in parentheses refer to powers of ten.

TABLE 2 (Cont)

Photon Energy Group (Mev)	Gamma Source Strength (Mev/Sec)								
	Region 18 BATH Central Shield	Region 19 Flow Baffle I	Region 20 Forward Reflector Plenum I	Region 21 Forward Reflector Plenum II	Region 22 Forward Reflector Plenum III	Region 23 Forward Reflector Plenum IV	Region 24 Peripheral Shield I	Region 25 Peripheral Shield II	Region 26 Peripheral Shield III
7.5-10.0	1.37(16)	1.70(16)	1.42(15)	1.36(14)	5.57(16)	2.11(14)	4.03(14)	4.69(14)	1.97(15)
7.0-7.5	1.87(16)	1.94(15)	1.33(14)	2.48(13)	8.19(15)	1.96(13)	5.40(13)	6.37(13)	4.31(14)
6.0-7.0	1.40(17)	4.61(15)	3.87(14)	3.06(13)	1.39(16)	5.69(13)	3.98(15)	4.69(15)	4.91(15)
5.0-6.0	7.63(15)	3.00(15)	2.62(14)	2.55(13)	9.22(15)	3.89(13)	2.08(14)	2.62(14)	6.40(14)
4.0-5.0	2.66(16)	6.78(15)	9.40(14)	1.87(13)	5.52(15)	1.41(14)	7.34(14)	9.08(14)	1.16(15)
3.0-4.0	2.12(16)	4.60(15)	6.04(14)	1.55(13)	5.06(15)	8.78(13)	5.86(14)	7.32(14)	1.03(15)
2.6-3.0	8.07(15)	2.17(15)	2.86(14)	5.33(12)	1.71(15)	4.28(13)	2.17(14)	2.85(14)	4.26(14)
2.2-2.6	1.84(16)	2.27(15)	4.28(15)	3.34(15)	5.34(15)	2.52(15)	5.13(14)	6.41(14)	8.11(14)
1.8-2.2	1.18(16)	1.74(15)	1.81(14)	4.33(12)	1.58(15)	3.10(13)	2.94(14)	4.14(14)	5.79(14)
1.35-1.8	4.32(16)	2.08(15)	1.75(14)	6.36(12)	2.69(15)	3.33(13)	1.13(15)	1.44(15)	1.75(15)
0.9-1.35	4.21(16)	2.09(15)	1.78(14)	3.07(12)	1.04(15)	3.87(13)	8.55(14)	1.31(15)	1.68(15)
0.4-0.9	7.84(17)	9.26(14)	6.56(13)	5.17(12)	2.05(15)	1.23(13)	2.33(16)	2.71(16)	2.58(16)
0-0.4	3.51(15)	3.21(14)	3.03(13)	1.48(12)	5.54(14)	5.17(12)	9.21(13)	1.15(14)	1.65(14)
TOTAL	1.12(18)	4.96(16)	8.94(15)	3.62(15)	1.13(17)	3.24(15)	3.24(16)	3.84(16)	4.13(16)

NOTE: Numbers in parentheses refer to powers of ten.

TABLE 2 (Cont)

Photon Energy Group (Mev)	Gamma Source Strength (Mev/Sec)									
	Region 27 Peripheral Shield IV	Region 28 Pressure Vessel - Side B	Region 29 Lead Central Shield	Region 30 Shield Plenum	Region 31 Flow Baffle II	Region 32 Central Dome Plenum	Region 33 Peripheral Dome Plenum I	Region 34 Peripheral Shield Plate	Region 35 Peripheral Dome Plenum II	Region 36 Pressure Vessel Dome
7.5-10.0	7.51(14)	1.56(16)	2.19(12)	1.61(14)	1.81(15)	0.0	2.35(14)	4.18(14)	8.51(14)	7.16(14)
7.0-7.5	1.19(14)	1.93(15)	1.08(14)	1.66(13)	1.09(14)	0.0	2.19(13)	5.63(13)	1.49(14)	8.74(13)
6.0-7.0	3.56(15)	4.39(15)	9.89(12)	4.31(13)	3.17(14)	0.0	6.35(13)	1.21(14)	1.99(14)	1.99(14)
5.0-6.0	3.08(14)	2.98(15)	3.56(12)	3.09(13)	2.18(14)	0.0	4.27(13)	9.74(13)	1.58(14)	1.38(14)
4.0-5.0	8.39(14)	9.38(15)	2.34(13)	1.01(14)	7.92(14)	0.0	1.55(14)	2.17(14)	1.11(14)	4.38(14)
3.0-4.0	7.22(14)	6.64(15)	2.71(13)	6.52(13)	4.88(14)	0.0	9.67(13)	1.88(14)	1.02(14)	3.00(14)
2.6-3.0	3.19(14)	3.32(15)	6.19(13)	3.32(13)	2.41(14)	0.0	4.57(13)	1.12(14)	3.89(13)	1.57(14)
2.2-2.6	6.88(14)	3.95(15)	1.92(13)	4.25(14)	2.37(14)	1.87(14)	1.61(15)	1.97(14)	1.10(15)	1.81(14)
1.8-2.2	4.86(14)	2.83(15)	1.41(13)	2.88(13)	1.77(14)	0.0	2.71(13)	1.58(14)	3.61(13)	1.46(14)
1.35-1.8	1.38(15)	3.15(15)	2.12(13)	3.09(13)	1.77(14)	0.0	2.39(13)	2.10(14)	5.73(13)	1.56(14)
0.9-1.35	1.58(15)	3.53(15)	3.21(13)	3.49(13)	1.89(14)	0.0	2.11(13)	2.58(14)	3.54(13)	1.66(14)
0.4-0.9	1.97(16)	1.17(15)	6.27(13)	1.10(13)	6.19(13)	0.0	8.59(12)	7.74(14)	4.25(13)	5.22(13)
0-0.4	1.16(14)	4.89(14)	4.07(11)	4.19(12)	2.72(13)	0.0	4.49(12)	2.16(13)	1.18(13)	2.21(13)
TOTAL	3.06(16)	5.94(16)	3.86(14)	9.86(14)	4.21(15)	1.87(14)	2.35(15)	2.13(15)	2.89(15)	2.76(15)

NOTE: Numbers in parentheses refer to powers of ten.

TABLE 3. MESH DESCRIPTION FOR THE NEUTRON CRAM NSS SURFACE RADIATION SOURCE

Mesh Line No.	Radius* (cm)	Height** (cm)
1	.0000	23.0400
2	3.0000	23.5300
3	6.0000	26.6550
4	8.0330	28.4530
5	11.0000	29.3950
6	14.0580	31.0050
7	16.0000	33.0050
8	17.8500	37.0050
9	19.0000	45.6350
10	20.0840	54.2450
11	21.5000	62.8650
12	22.6330	71.4750
13	24.0000	80.0950
14	25.3440	88.7050
15	26.3000	97.3250
16	27.5190	105.6650
17	27.7370	114.5550
18	29.4310	123.1650
19	31.0000	131.7850
20	32.3680	140.3950
21	34.0000	149.0050
22	36.4000	153.0050
23	38.0000	157.0050
24	39.9030	159.0050
25	40.5000	160.5330
26	41.3180	163.4950
27	42.0000	166.4650
28	42.7570	169.4230
29	44.0000	171.6050
30	45.0320	173.7850
31	46.0000	175.9550
32	47.3880	178.1350
33	48.4560	180.3150
34	49.4690	182.4850
35	49.7840	184.6630
36	52.0830	186.3550
37	53.6320	188.0410
38	56.1470	190.0400
39	56.4260	191.9780
40	57.5000	192.3570
41	59.0000	192.7350
42	59.4640	193.1140
43	59.5000	193.4920
44	59.6000	193.8710

TABLE 3 (Cont)

Mesh Line No.	Radius (cm)	Height** (cm)
45	59.7290	194.2500
46	60.0080	194.6280
47	61.0000	195.0070
48	63.0000	195.3860
49	64.4650	195.7640
50	67.0000	196.1430
51	68.5800	196.5210
52	70.0000	196.9000
53	70.8410	197.2780
54		197.6570
55		198.0360
56		198.4140
57		198.7930
58		199.1720
59		199.5500
60		199.9290
61		200.3070
62		200.6860
63		201.0650
64		201.4430
65		201.8220
66		202.2010
67		202.5790
68		202.9580
69		203.3360
70		203.7150
71		204.0940
72		204.4720
73		204.8510
74		205.2290
75		205.6080
76		205.9870
77		206.3650
78		206.7440
79		207.1230
80		207.5250
81		207.9060
82		208.2870
83		208.6680
84		209.0490
85		209.4300
86		209.8110
87		210.1920
88		210.5730

TABLE 3 (Cont)

Mesh Line No.	Height** (cm)
89	211.3350
90	212.0970
91	212.8590
92	213.6210
93	214.3630
94	215.0180
95	215.6530
96	216.2880
97	217.0250
98	217.7610
99	218.4970
100	219.2340
101	219.6020
102	219.9700
103	220.3380
104	220.7060
105	221.0740
106	221.4420
107	221.8420
108	222.0770
109	225.5060
110	228.9350
111	232.3640
112	235.7930
113	237.2160
114	238.6500
115	241.9970
116	245.3560
117	248.7150
118	252.0740
119	253.2940
120	254.5130

*Radial mesh lines define the surface mesh intervals at the top (H = 254.513) and bottom (H = 23.04) surfaces.

**Axial mesh lines define the surface mesh intervals at the right (R = 70.84) surface.

TABLE 4. MESH DESCRIPTION FOR THE PHOTON CRAM NSS SURFACE RADIATION SOURCE

Mesh Line No.	Radius* (cm)	Height** (cm)
1	.0000	23.0400
2	3.0000	23.5300
3	6.0000	26.6550
4	8.0330	28.4530
5	11.0000	29.3950
6	14.0580	31.0050
7	16.0000	33.0050
8	17.8500	37.0050
9	19.0000	45.6350
10	20.0840	54.2450
11	21.5000	62.8650
12	22.6330	71.4750
13	24.0000	80.0950
14	25.3440	88.7050
15	26.3000	97.3250
16	27.5190	105.6650
17	27.7370	114.5550
18	29.4310	123.1650
19	31.0000	131.7850
20	32.3680	140.3950
21	34.0000	149.0050
22	36.4000	153.0050
23	38.0000	157.0050
24	39.9030	159.0050
25	40.5000	160.5330
26	41.3180	163.4950
27	42.0000	166.4650
28	42.7570	169.4230
29	44.0000	171.6050
30	45.0320	173.7850
31	46.0000	175.9550
32	47.3880	178.1350
33	48.4560	180.3150
34	49.4690	182.4850
35	49.7840	184.6630
36	52.0830	186.3550
37	53.6320	188.0410
38	56.1470	190.0400
39	56.4260	191.9780
40	57.5000	192.3570
41	59.0000	193.4920
42	59.4640	194.6280
43	59.5000	195.7640
44	59.6000	197.2780

TABLE 4 (Cont)

Mesh Line No.	Radius* (cm)	Height** (cm)
45	59.7290	198.4140
46	60.0080	199.9290
47	61.0000	201.0650
48	63.0000	202.2010
49	64.4650	203.3360
50	67.0000	203.7150
51	68.5800	204.0940
52	70.0000	205.2290
53	70.8410	206.3650
54		207.1230
55		208.2870
56		209.8110
57		211.3350
58		213.6210
59		214.3830
60		215.0180
61		215.6530
62		216.2880
63		217.7610
64		219.2340
65		219.9700
66		220.7060
67		221.4420
68		221.8420
69		222.0770
70		225.5060
71		228.9350
72		232.3640
73		235.7930
74		237.2160
75		238.6500
76		241.9970
77		245.3560
78		248.7150
79		252.0740
80		253.2940
81		254.5130

TABLE 5. ANGULAR QUADRATURE DESCRIPTION FOR THE NEUTRON CRAM NSS SURFACE RADIATION SOURCE

Discrete Direction No.	μ	η	W
1	-.308606714	-.951189727	.000000000
2	-.218217900	-.951189727	.030246915
3	.218217900	-.951189727	.030246915
4	-.617213403	-.786795790	.000000000
5	-.577350269	-.786795790	.022685185
6	-.218217900	-.786795790	.022685185
7	.218217900	-.786795790	.022685185
8	.577350269	-.786795790	.022685185
9	-.816496581	-.577350269	.000000000
10	-.786795790	-.577350269	.022685185
11	-.577350269	-.577350269	.023148144
12	-.218217900	-.577350269	.022685185
13	.218217900	-.577350269	.022685185
14	.577350269	-.577350269	.023148144
15	.786795790	-.577350269	.022685185
16	-.975900071	-.218217900	.000000000
17	-.951189727	-.218217900	.030246915
18	-.786795790	-.218217900	.022685185
19	-.577350269	-.218217900	.022685185
20	-.218217900	-.218217900	.030246915
21	.218217900	-.218217900	.030246915
22	.577350269	-.218217900	.022685185
23	.786795790	-.218217900	.022685185
24	.951189727	-.218217900	.030246915
25	-.308606714	.951189727	.000000000
26	-.218217900	.951189727	.030246915
27	.218217900	.951189727	.030246915
28	-.617213403	.786795790	.000000000
29	-.577350269	.786795790	.022685185
30	-.218217900	.786795790	.022685185
31	.218217900	.786795790	.022685185
32	.577350269	.786795790	.022685185
33	-.816496581	.577350269	.000000000
34	-.786795790	.577350269	.022685185
35	-.577350269	.577350269	.023148144
36	-.218217900	.577350269	.022685185
37	.218217900	.577350269	.022685185
38	.577350269	.577350269	.023148144
39	.786795790	.577350269	.022685185
40	-.975900071	.218217900	.000000000
41	-.951189727	.218217900	.030246915
42	-.786795790	.218217900	.022685185
43	-.577350269	.218217900	.022685185
44	-.218217900	.218217900	.030246915

TABLE 5 (Cont)

Discrete Direction No.	μ	η	W
45	.218217900	.218217900	.030246915
46	.577350269	.218217900	.022685185
47	.786795790	.218217900	.022685185
48	.951189727	.218217900	.030246915

TABLE 6. ANGULAR QUADRATURE DESCRIPTION FOR THE PHOTON CRAM NSS SURFACE RADIATION SOURCE

Discrete Direction No.	μ	η	W
1	-.361249000	-.932470000	.000000000
2	-.238619000	-.932470000	.042831100
3	.238619000	-.932470000	.042831100
4	-.750201000	-.661209000	.000000000
5	-.661209000	-.661209000	.055238700
6	-.238619000	-.661209000	.034951700
7	.238619000	-.661209000	.034951700
8	.661209000	-.661209000	.055238700
9	-.971113000	-.238619000	.000000000
10	-.932470000	-.238619000	.042831100
11	-.661209000	-.238619000	.034951700
12	-.238619000	-.238619000	.039195600
13	.238619000	-.238619000	.039195600
14	.661209000	-.238619000	.034951700
15	.932470000	-.238619000	.042831100
16	-.024917777	.999689504	.000000000
17	-.024913982	.999689504	.000004427
18	-.023764506	.999689504	.000061973
19	-.012458888	.999689504	.000132799
20	.012458888	.999689504	.000132799
21	.023764506	.999689504	.000061973
22	.024913982	.999689504	.000004427
23	-.057171433	.998364376	.000000000
24	-.057162725	.998364376	.000010300
25	-.054525365	.998364376	.000144197
26	-.028585716	.998364376	.000308994
27	.028585716	.998364376	.000308994
28	.054525365	.998364376	.000144197
29	.057162725	.998364376	.000010300
30	-.089555393	.995981843	.000000000
31	-.089541753	.995981843	.000016171
32	-.085410496	.995981843	.000226390
33	-.044777696	.995981843	.000485122
34	.044777696	.995981843	.000485122
35	.085410496	.995981843	.000226390
36	.089541753	.995981843	.000016171
37	-.121887680	.992543900	.000000000
38	-.121869116	.992543900	.000022025
39	-.116246347	.992543900	.000308354
40	-.060943840	.992543900	.000660759
41	.060943840	.992543900	.000660759
42	.116246347	.992543900	.000308354
43	.121869116	.992543900	.000022025

TABLE 6 (Cont)

Discrete Direction No.	μ	η	W
45	-.154083777	.988054126	.000027857
46	-.146974695	.988054126	.000389994
47	-.077053624	.988054126	.000835700
48	.077053624	.988054126	.000835700
49	.146974695	.988054126	.000389994
50	.154083777	.988054126	.000027857
51	-.186171501	.982517263	.000000000
52	-.186143147	.982517263	.000033659
53	-.177554917	.982517263	.000471220
54	-.093085751	.982517263	.001009758
55	.093085751	.982517263	.001009758
56	.177554917	.982517263	.000471220
57	.186143147	.982517263	.000033659
58	-.218042951	.975939174	.000000000
59	-.218009742	.975939174	.000039425
60	-.207951259	.975939174	.000551948
61	-.109021476	.975939174	.001182745
62	.109021476	.975939174	.001182745
63	.207951259	.975939174	.000551948
64	.218009742	.975939174	.000039425
65	-.249686111	.968326828	.000000000
66	-.249648083	.968326828	.000045149
67	-.238129877	.968326828	.000632090
68	-.124843056	.968326828	.001354479
69	.124843056	.968326828	.001354479
70	.238129877	.968326828	.000632090
71	.249648083	.968326828	.000045149
72	-.281066512	.959688291	.000000000
73	-.281023704	.959688291	.000050826
74	-.268057897	.959688291	.000711563
75	-.140533256	.959688291	.001524778
76	.140533256	.959688291	.001524778
77	.268057897	.959688291	.000711563
78	.281023704	.959688291	.000050826
79	-.312150340	.950032718	.000000000
80	-.312102798	.950032718	.000056449
81	-.297703070	.950032718	.000790282
82	-.156075170	.950032718	.001693462
83	.156075170	.950032718	.001693462
84	.297703070	.950032718	.000790282
85	.312102798	.950032718	.000056449
86	-.342904308	.939370340	.000000000
87	-.342852082	.939370340	.000064109
88	-.327033651	.939370340	.000897526

G

TABLE 6 (Cont)

Discrete Direction No.	μ	η	W
89	-.171452154	.939370340	.001923271
90	.171452154	.939370340	.001923271
91	.327033651	.939370340	.000897526
92	.342852082	.939370340	.000064109
93	-.501663000	.865063000	.000000000
94	-.433395000	.865063000	.024441900
95	-.148874000	.865063000	.012920900
96	.148874000	.865063000	.012920900
97	.433395000	.865063000	.024441900
98	-.733759000	.679410000	.000000000
99	-.679410000	.679410000	.027011100
100	-.433395000	.679410000	.008549830
101	-.148874000	.679410000	.019210600
102	.148874000	.679410000	.019210600
103	.433395000	.679410000	.008549830
104	.679410000	.679410000	.027011100
105	-.901204000	.433395000	.000000000
106	-.865063000	.433395000	.024441900
107	-.679410000	.433395000	.008549830
108	-.433395000	.433395000	.027468300
109	-.148874000	.433395000	.006856610
110	.148874000	.433395000	.006856610
111	.433395000	.433395000	.027468300
112	.679410000	.433395000	.008549830
113	.865063000	.433395000	.024441900
114	-.988856000	.148874000	.000000000
115	-.973907000	.148874000	.016667800
116	-.865063000	.148874000	.012920900
117	-.679410000	.148874000	.019210600
118	-.433395000	.148874000	.006856610
119	-.148874000	.148874000	.018225100
120	.148874000	.148874000	.018225100
121	.433395000	.148874000	.006856610
122	.679410000	.148874000	.019210600
123	.865063000	.148874000	.012920900
124	.973907000	.148874000	.016667800

TABLE 7

CONTENTS OF THE CRAM NSS SURFACE RADIATION SOURCE DATA TAPE

The CRAM neutron data tape contains:

1. A total of 560 physical records of BCD information written at a density of 800 bpi on 7 tracks.

2. Each physical record contains a maximum of 3960 characters with a total of 240 data words per record. The 3960 characters were placed on tape with the FORTRAN format (30(8E15.8, 12X)). This results in thirty (30) lines of data with 120 (8 x 15) characters of BCD character information to represent 8 words. Twelve (12) blank characters fill out each line to a total of 132 characters.

3. The 560 physical records result from a total of 16 sets of 35 records, one set for each group of the neutron flux solution. The first 34 records of each 35 records are complete records and the 35th of each set contains 792 BCD characters.

4. Data on the CRAM neutron tape are the left-right boundary surface angular fluxes and top-bottom surface angular fluxes for each of 16 groups. These data are in the following order:

$$((\phi_{mj}, m = 1,48), j = 1,119), ((\phi_{mi}, m = 1,48), i = 1,52)$$

where;

ϕ_{mj} is the angular flux for angle number m and left or right surface mesh interval j,

ϕ_{mi} is the angular flux for angle m and top or bottom surface mesh interval i.

5. The right boundary surface fluxes are those flux values with a positive direction cosine μ in Table 5. The top boundary surface fluxes are those flux values with a positive direction cosine η in Table 5 and the bottom boundary surface fluxes are those flux values with a negative direction cosine η in Table 5.

TABLE 8

CONTENTS OF THE CRAM NSS SURFACE RADIATION SOURCE DATA TAPE

The CRAM photon data tape contains:

1. A total of 897 physical records of BCD information written at a density of 800 bpi on 7 tracks.

2. Each physical record contains a maximum of 3960 characters with a total of 240 data words per record. The 3960 characters were placed on tape with the FORTRAN format (30 (8E15.8, 12X)). This results in thirty (30) lines of data with 120 (8 x 15) characters of BCD character information to represent 8 words. Twelve (12) blank characters fill out each line to a total of 132 characters.

3. The 897 physical records result from a total of 13 sets of 69 records, one set for each group of the photon flux solution. The first 68 records of each 69 records are complete records and the 69th of each set contains 792 BCD characters.

4. Data on the CRAM photon tape are the left-right boundary surface angular fluxes and top-bottom surface angular fluxes for each of 13 groups. These data are in the following order:

$$((\phi_{mj}, m = 1,124), j = 1,80), ((\phi_{mi}, , = 1,124), j = 1,52)$$

where;

ϕ_{mj} is the angular flux for angle number m and left or right surface mesh interval j,

ϕ_{mi} is the angular flux for angle m and top or bottom surface mesh interval i.

5. The right boundary surface fluxes are those flux values with a positive direction cosine μ in Table 6. The top boundary surface fluxes are those flux values with a positive direction cosine η in Table 6 and the bottom boundary surface fluxes are those flux values with a negative direction cosine η in Table 6.

TABLE 9

NEUTRON ENERGY GROUP STRUCTURE FOR THE NSS CRAM

Group Number	Energy Bounds (ev)
1	2.87(6) to 1.0(7)*
2	1.35(6) to 2.87(6)
3	8.21(5) to 1.35(6)
4	3.88(5) to 8.21(5)
5	1.11(5) to 3.88(5)
6	1.50(4) to 1.11(5)
7	5.53(3) to 1.50(4)
8	5.83(2) to 5.53(3)
9	7.89(1) to 5.83(2)
10	1.068(1) to 7.89(1)
11	1.86(0) to 1.068(1)
12	3.0(-1) to 1.86(0)
13	1.2(-1) to 3.0(-1)
14	6.0(-2) to 1.2(-1)
15	2.0(-2) to 6.0(-2)
16	0.0 to 2.0 (-2)

*Numbers in parentheses refer to powers of ten.

TABLE 10. FORTRAN LISTING OF COMPUTER CODE TO CONVERT CRAM BCD TRANSMITTAL TAPE

```
      PROGRAM DOTMAP(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE1,TAPE2,
     1TAPE3)
      COMMON DUM,N6,
     1       IM,JM,NGP,MM,NPL,MMIM,MMJM,IMJM,NOMA,
     2       A(30000)
C     INPUT DATA DESCRIPTION
C      IM - NO. OF RADIAL MESH INTERVALS IN DOT PROBLEM
C      JM - NO. OF OF AXIAL MESH INTERVALS IN DOT PROBLEM
C      NO. OF GROUPS IN DOT PROBLEM
C     .NO. OF DISCRETE DIRECTIONS(ANGLES) IN DOT PROBLEM
C      P(L) SCATTERING APPROXIMATION IN DOT PROBLEM
C      KEY - OUTPUT TAPE OPTION - 0/GENERATE A BCD TAPE FOR TRANSMITTAL
C                                 1/GENERATE MAP INPUT TAPE FROM BCD
C                                   TRANSMITTAL TAPE
C                                 2/GENERATE A DASH INPUT TAPE FROM
C                                   BCD TRANSMITTAL TAPE
C
C     TAPE MOUNTING INSTRUCTIONS ARE AS FOLLOWS
C     TAPE 1 IS THE DOT-IIW PRODUCED BINARY TAPE
C     TAPE 2 IS THE CRAM BCD TRANSMITTAL TAPE
C     TAPE 3 IS THE MAP OR DASH INPUT TAPE
C
      N6=6
      READ(5,100) IM,JM,NGP,MM,NPL,KEY
  100 FORMAT(6I12)
      REWIND 1
      REWIND 2
      REWIND 3
      IMJM=IM*JM
      MMIM=MM*IM
      MMJM=MM*JM
      NOMA=NPL*(NPL+3)*IMJM/2
      IF(NPL.EQ.0) NOMA=1
      LN2=1
      LB2=LN2+MAX0(IMJM,NOMA)
      LB2=LN2+IMJM
      LB4=LB2+MMJM
      LST=LB4+MMIM
      IF(LST.LE.30000) GO TO 5
      STOP 1
    5 CALL FLUX(A(LN2),A(LB2),A(LB4),KEY)
      STOP 7
      END
```

TABLE 10 (Cont)

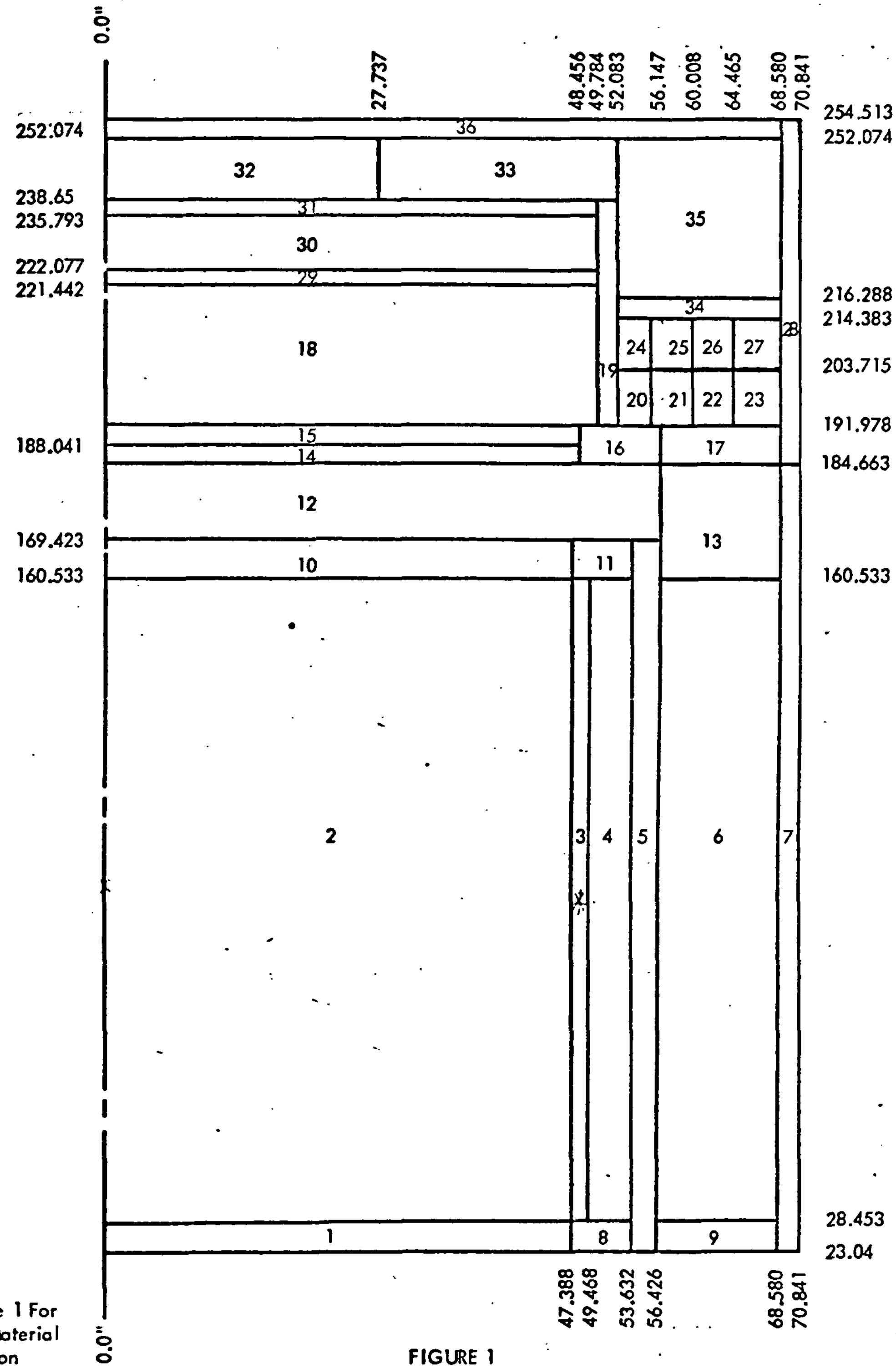
```
      SUBROUTINE FLUX(N2,B2,B4,KEY)
      COMMON DUM,No,
     1        IM,JM,NGP,MM,NPL,MMIM,MMJM,IMJM,NOMA
      DIMENSION N2(1),B2(1),B4(1)
      DO 10 K=1,NGP
      IF(KEY.GE.1) GO TO 15
C
C     GENERATE A BCD TRANSMITTAL TAPE
C     FORMAT 200 REQUIRES THAT THE COMPUTER BE CAPABLE OF PRODUCING
C     BCD RECORDS CONTAINING 3960 CHARACTERS
C
      READ(1) (N2(I),I=1,IMJM),(N2(I),I=1,NOMA),(B2(I),I=1,MMJM),(B4(I),
     1I=1,MMIM)
      WRITE(2,200) (B2(I),I=1,MMJM),(B4(I),I=1,MMIM)
  200 FORMAT(30(8E15.5,12X))
      GO TO 30
   15 CONTINUE
C
C     GENERATE A MAP OR DASH INPUT TAPE
C     THE FOLLOWING READ STATEMENT REQUIRES THAT THE COMPUTER BE CAPABLE
C     OF READING BCD RECORDS CONTAING 3960 CHARACTERS
C     ON SOME MACHINES THIS MAY HAVE TO BE REPLACED BY A SPECIAL SUBROUTINE
C     CALL
C
      READ (2,200) (B2(I),I=1,MMJM),(B4(I),I=1,MMIM)
      IF(KEY.EQ.1)
     1WRITE(3)(N2(I),I=1,IMJM),(N2(I),I=1,NOMA),(B2(I),I=1,MMJM),(B4(I),
     2I=1,MMIM)
      IF(KEY.EQ.2)
     1WRITE(3)(B2(I),I=1,MMJM),(B4(I),I=1,MMIM)
   30 CONTINUE
      WRITE(6,300) K
  300 FORMAT(35H1 SURFACE ANGULAR FLUXES FOR GROUP ,I3/)
      CALL WOT(B2,JM,MM,1,4HANG.,4HMNO.,4H    )
      WRITE(6,300) K
      CALL WOT(B4,IM,MM,1,4HANG.,4HMNO.,4H    )
   10 CONTINUE
      IF(KEY.EQ.0) ENDFILE 2
      IF(KEY.EQ.1) ENDFILE 3
      RETURN
      END
```

TABLE 10 (Cont)

```
      SUBROUTINE WOT(X,NCOL,LTBL,LG,TOP1,TOP2,TOP3)
C
      COMMON DUM,N6
C
      DIMENSION X(LTBL,NCOL,1 )
C
C    *** OUTPUT WRITES 1,2, OR 3-D ARRAYS
C
      DO 45 L=1,LG
      I02=0
      I03=(NCOL+7)/8
      IF(LG.GT.1)WRITE(N6, 5) TOP3,L
    5 FORMAT(/1H0,2X,A6,I5)
      DO 40 I=1,I03
      I01=I02+1
      I02=MINO(I01+7,NCOL)
      WRITE (N6, 50) TOP1,(TOP2,J,J=101,I02)
      DO 35 K=1,LTBL
      IF(K.EQ.1)GO TO 30
      DO 10 J=I01,I02
      IF(X(K,J,L).NE.X(K-1,J,L))GO TO 25
   10 CONTINUE
      IF(KE.EQ.KS)GO TO 15
      KE=K
      IF(K.EQ.LTBL)GO TO 25
      GO TO 35
   15 IF(K.EQ.LTBL)GO TO 30
      DO 20 J=I01,I02
      IF(X(K,J,L).NE.X(K+1,J,L)) GO TO 30
   20 CONTINUE
      KE=KE+1
      GO TO 35
   25 IF(KE.EQ.KS)GO TO 30
      WRITE(N6, 60) TOP1,KS,TOP1,KE
      IF(K.EQ.LTBL.AND.KE.EQ.K)GO TO 35
   30 WRITE(N6, 55) K,(X(K,J,L),J=I01,I02)
      KS=K+1
      KE=KS
   35 CONTINUE
   40 CONTINUE
   45 CONTINUE
   50 FORMAT(1H0,A6,1X,A6,I3,7(4X,A6,I3))
   55 FORMAT(I6,  8E13.5)
   60 FORMAT(8X,A6,I5,6H THRU ,A6,I5,14H SAME AS ABOVE)
```

TABLE 10 (Cont)

```
      RETURN                                                            WOT 0450
      END                                                               WOT 0460
```



NOTE: See Table 1 For Region Material Description

FIGURE 1

REGION DESCRIPTION OF THE R1 REFERENCE DESIGN EMPLOYING COMPOSITE FUEL

FIGURE 2

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 1
CHESH

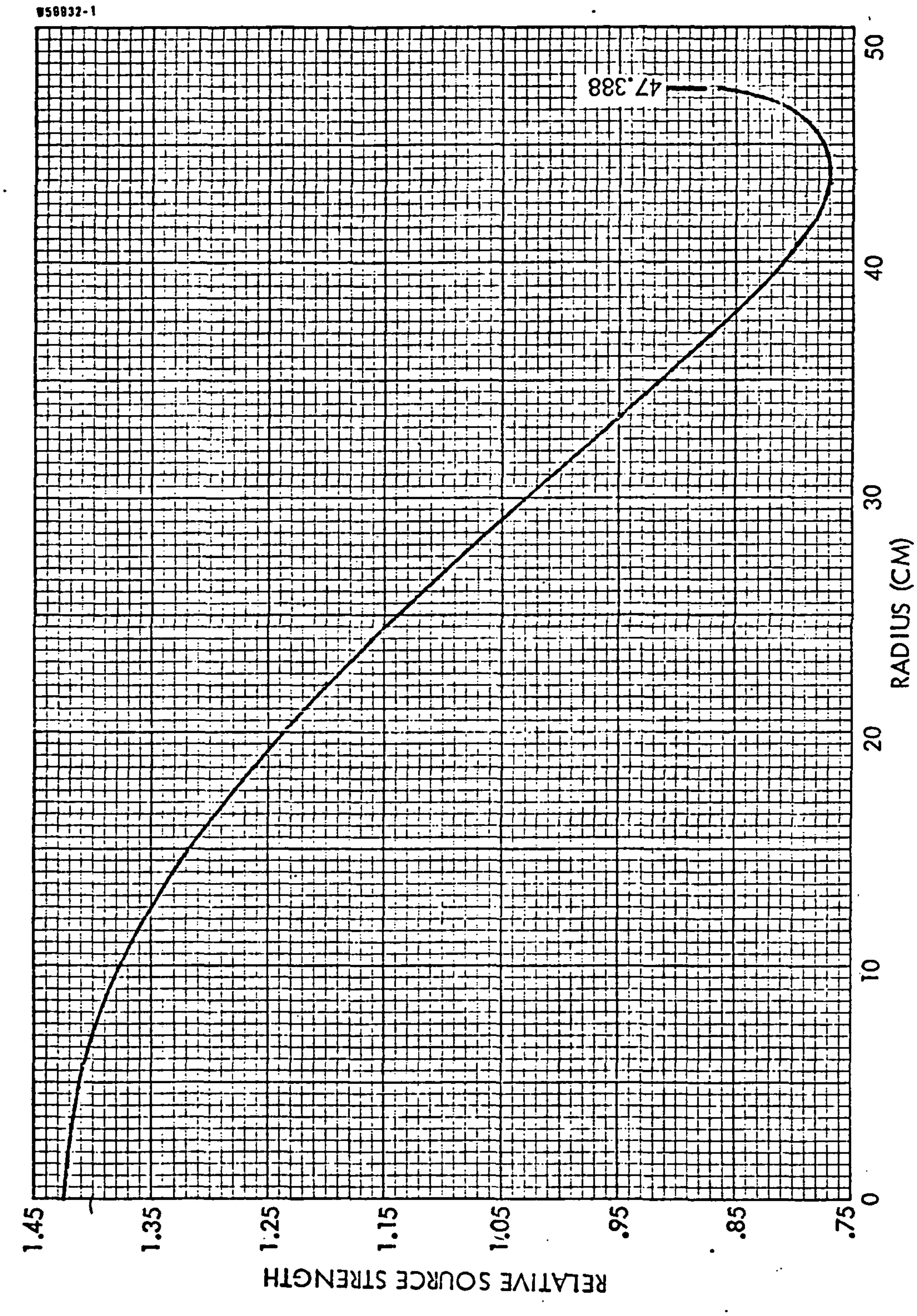
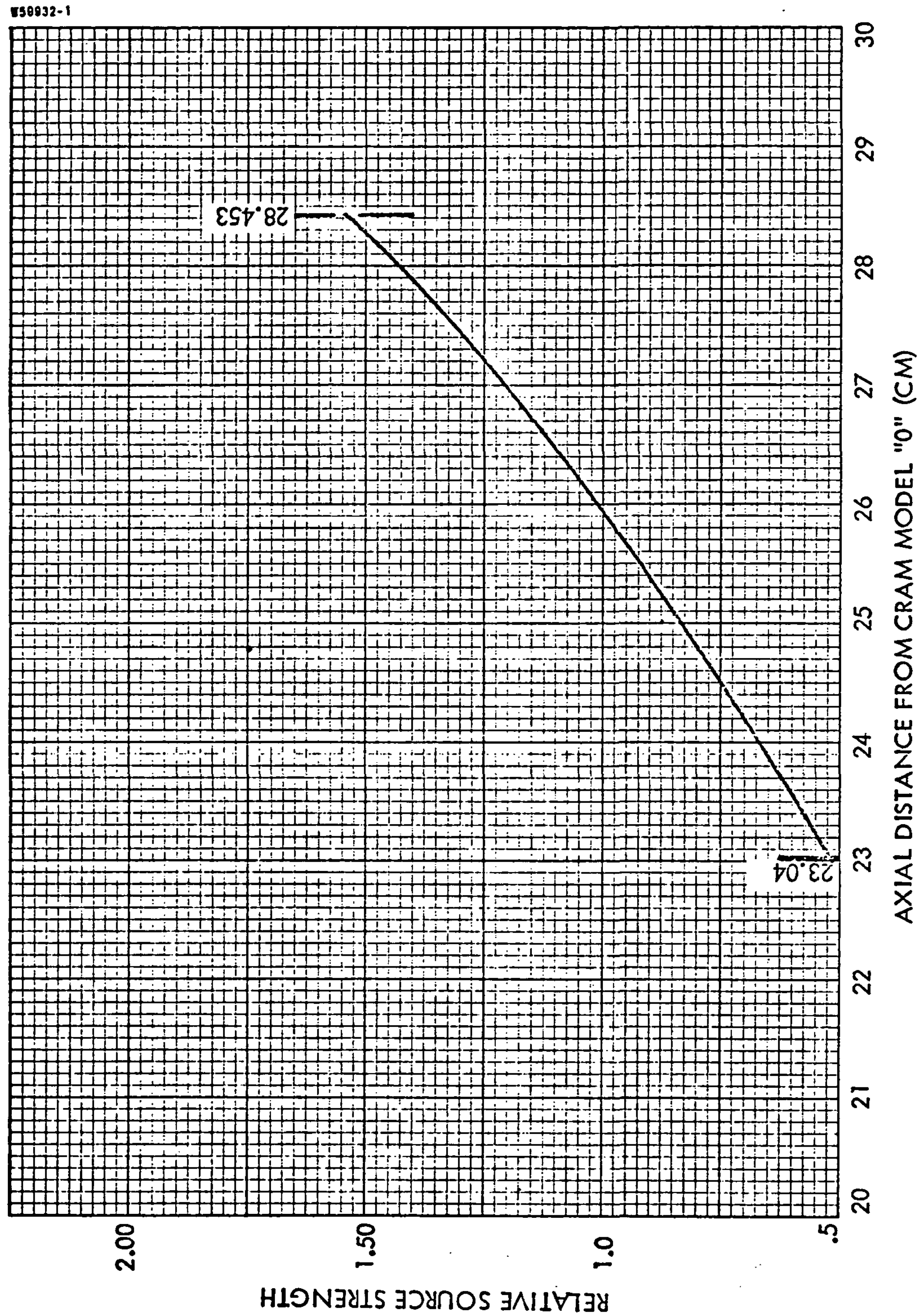


FIGURE 3

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 1
CHESH



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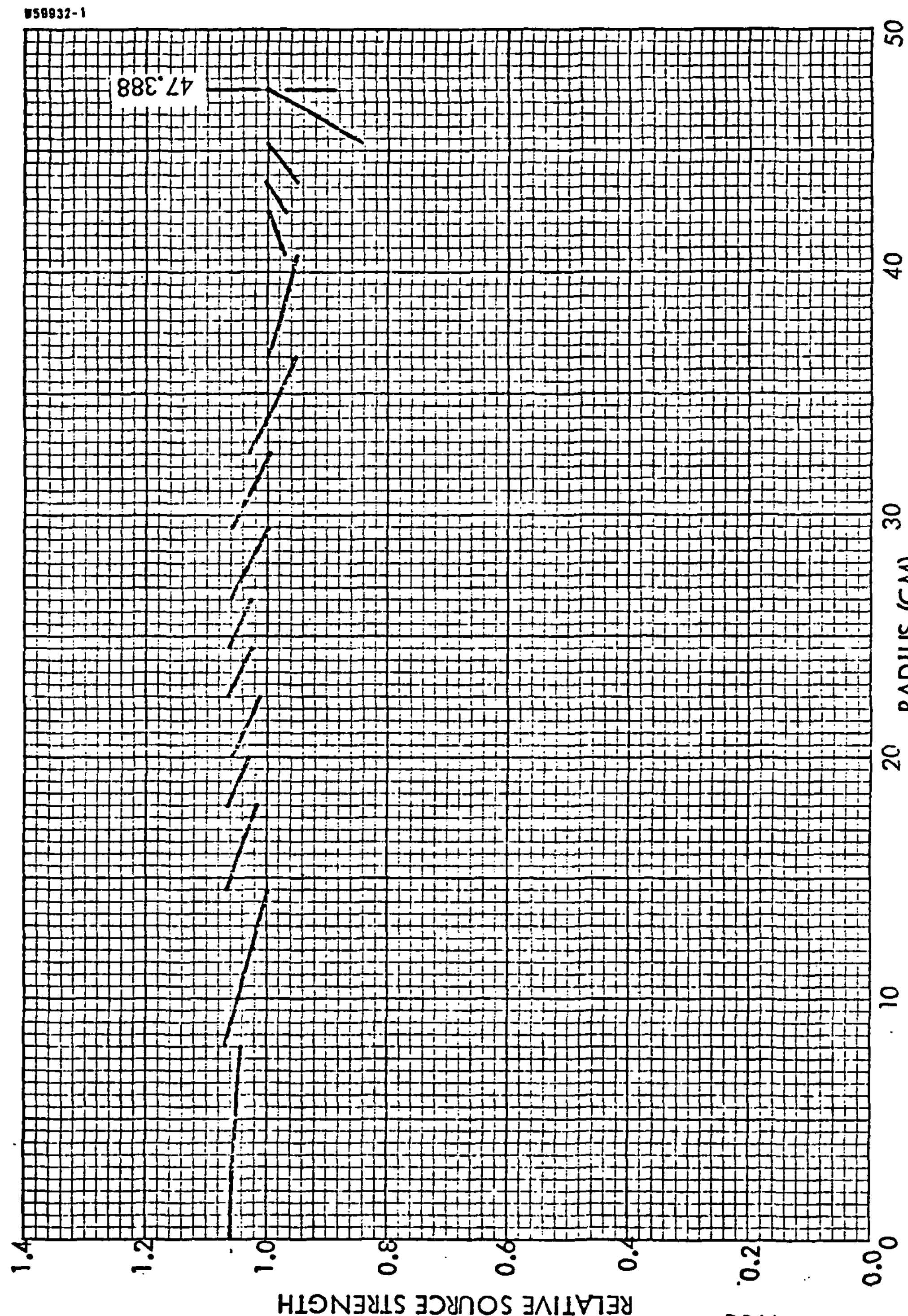

FIGURE 4
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 2
CORE-COMPOSITE

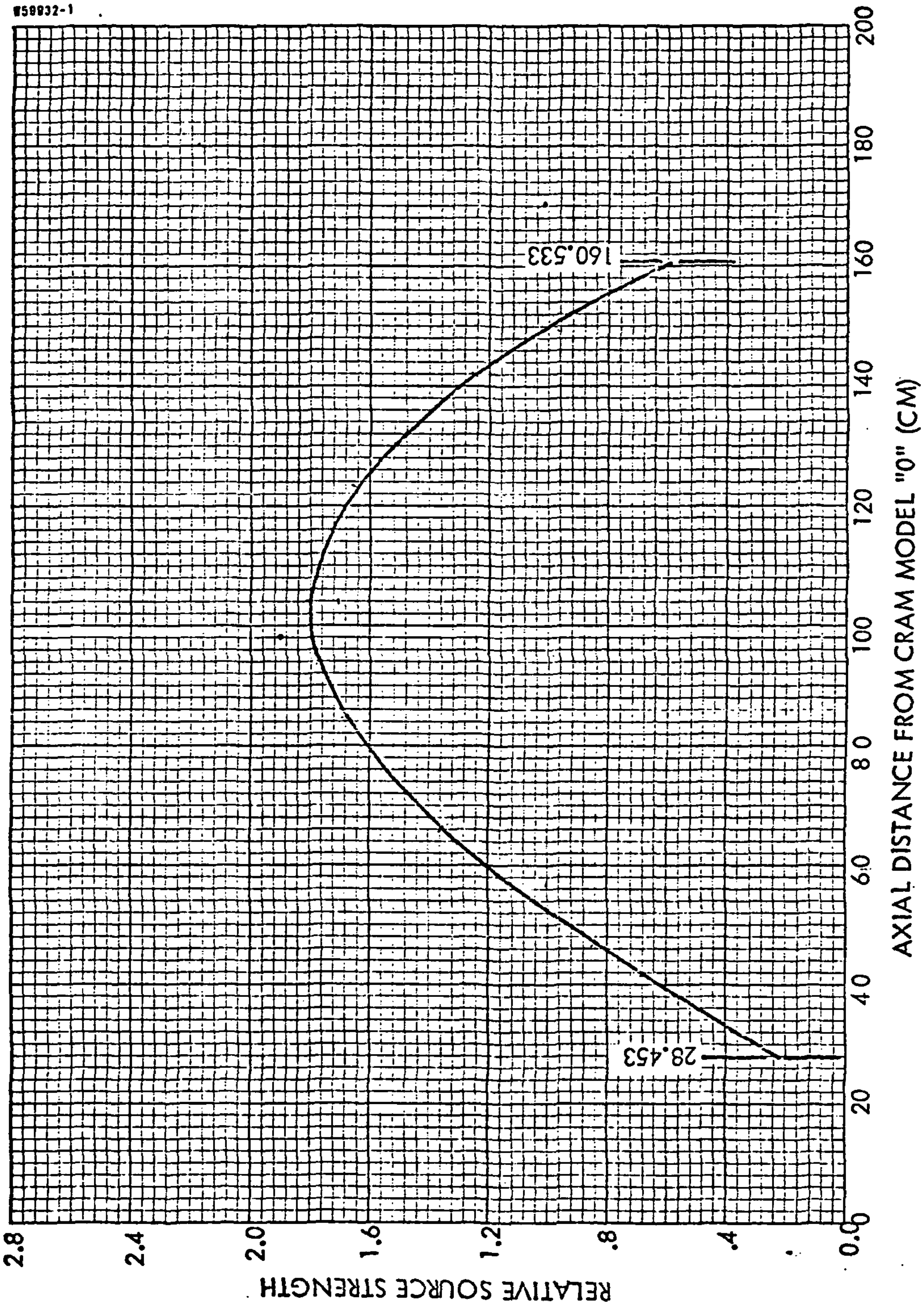

FIGURE 5

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 2
CORE-COMPOSITE

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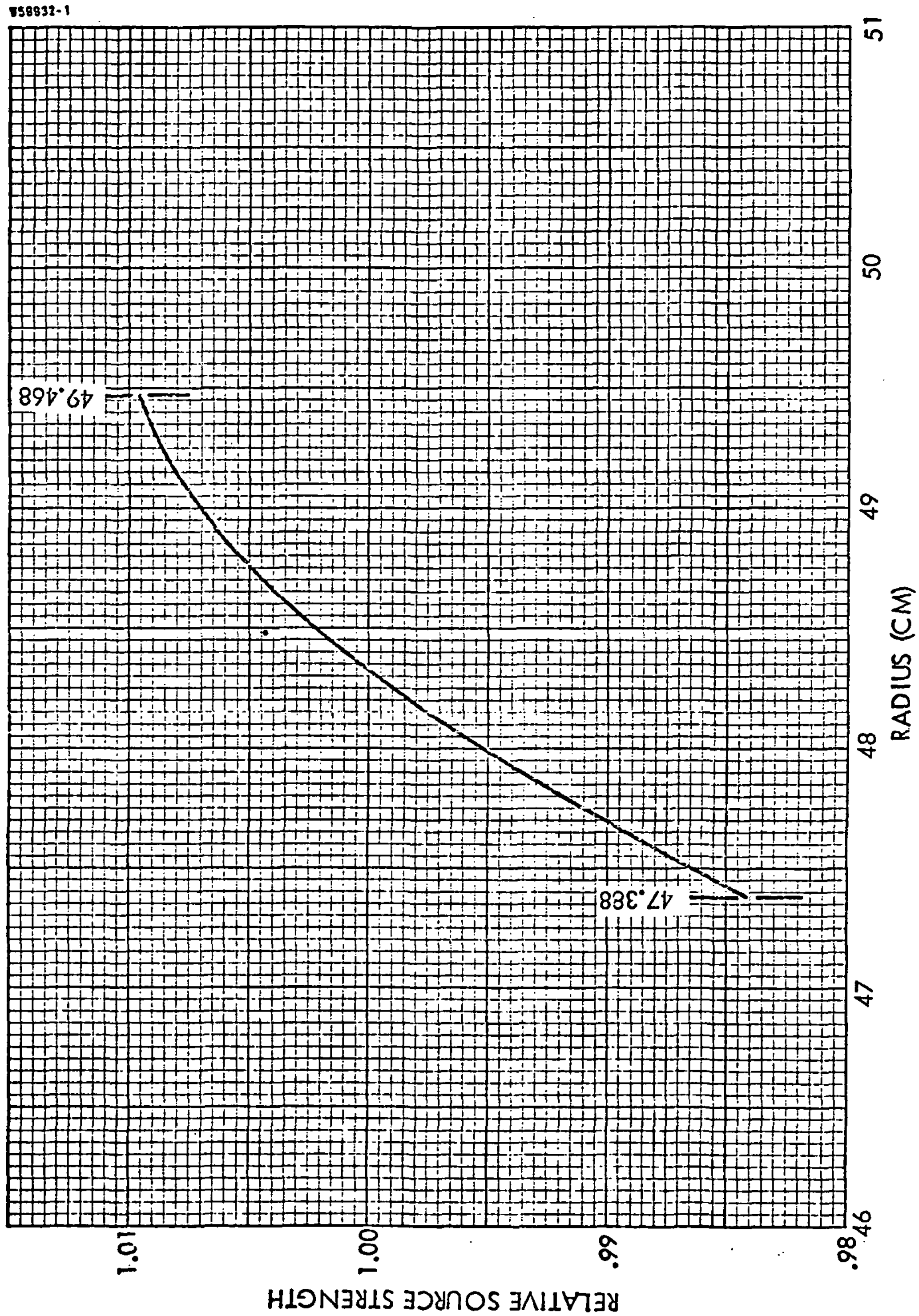
FIGURE 6
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 3
CORE PERIPHERY



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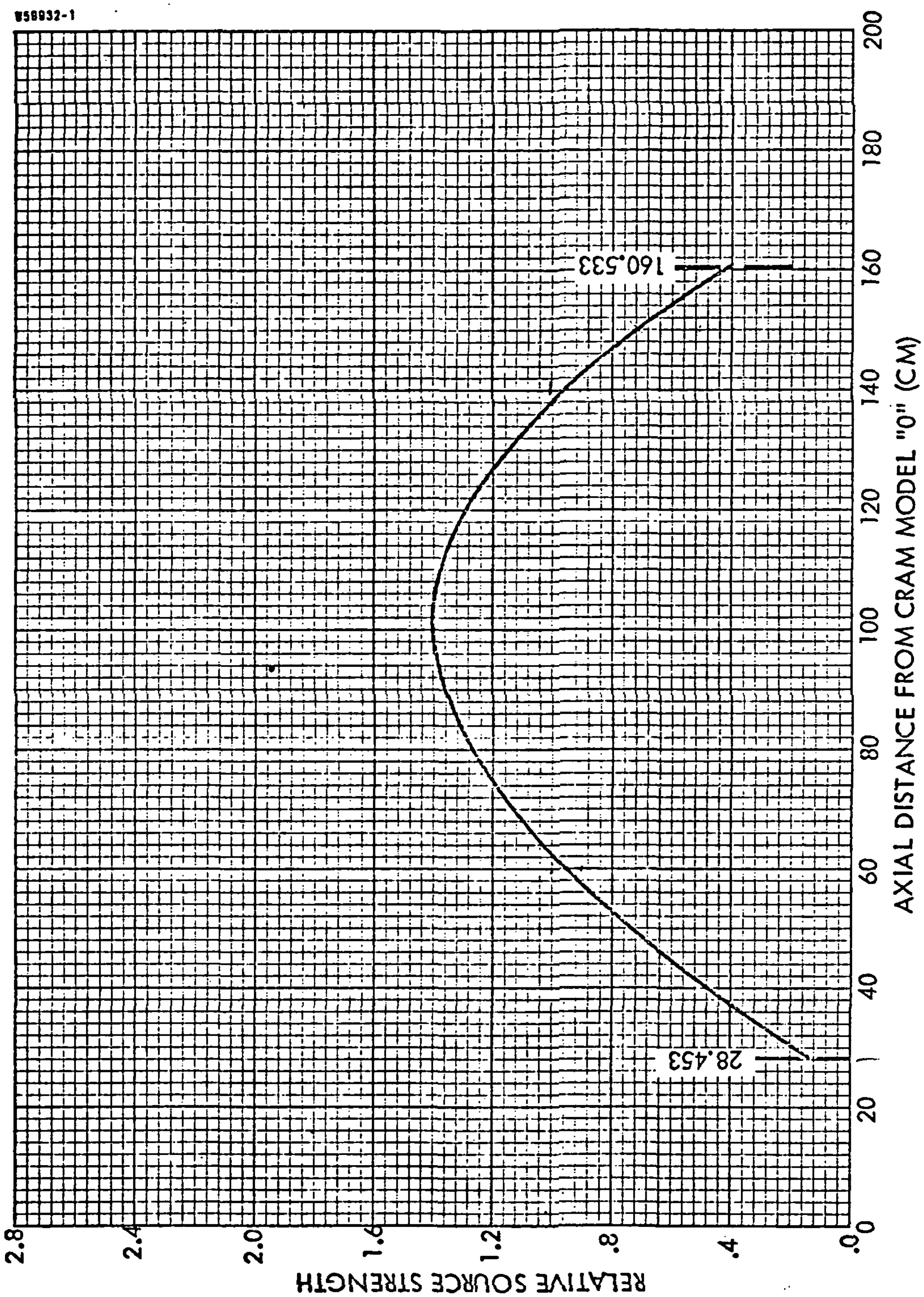

FIGURE 7
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 3
CORE PERIPHERY

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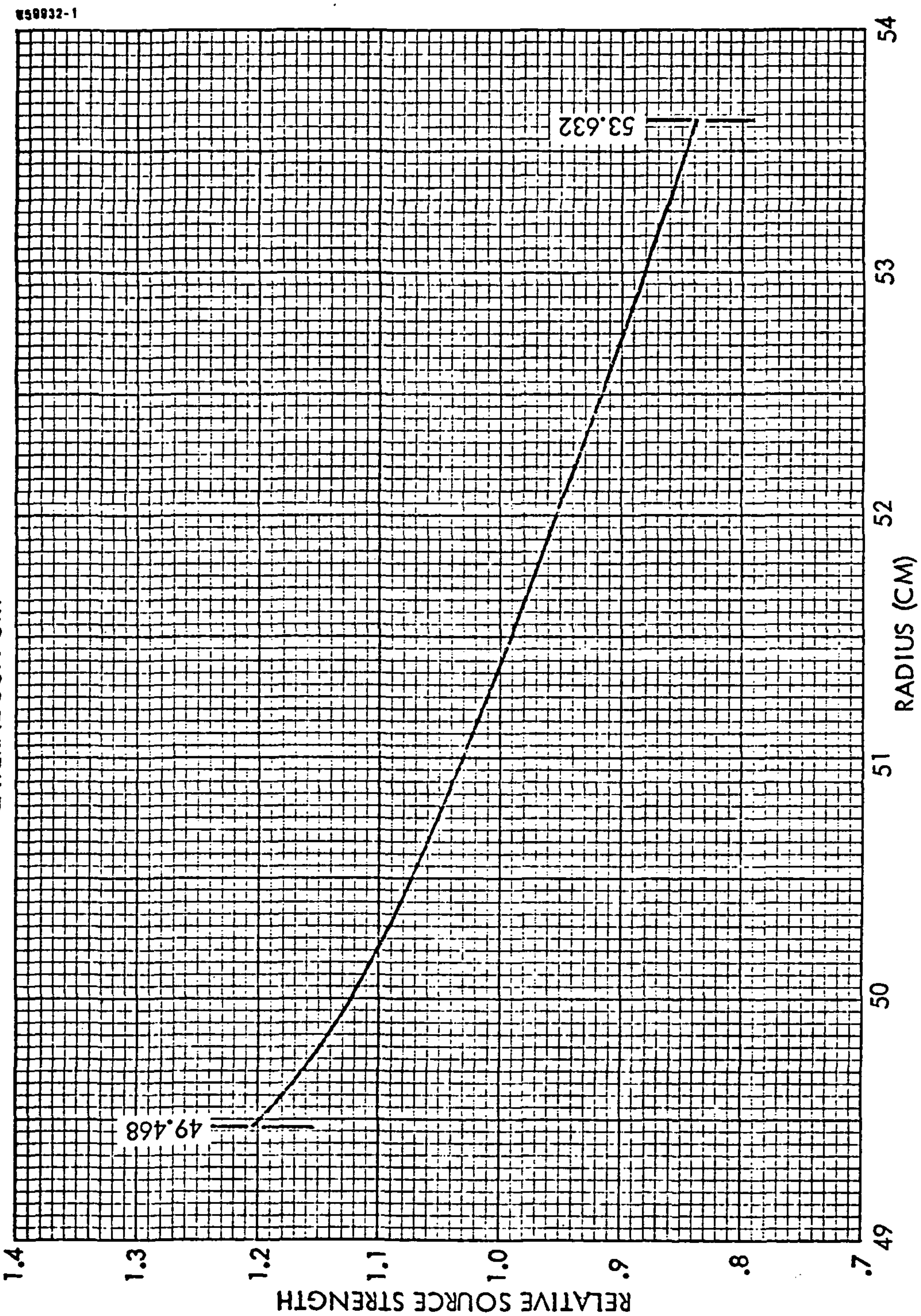


FIGURE 8
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 4
LATERAL SUPPORT

FIGURE 9
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 4
LATERAL SUPPORT

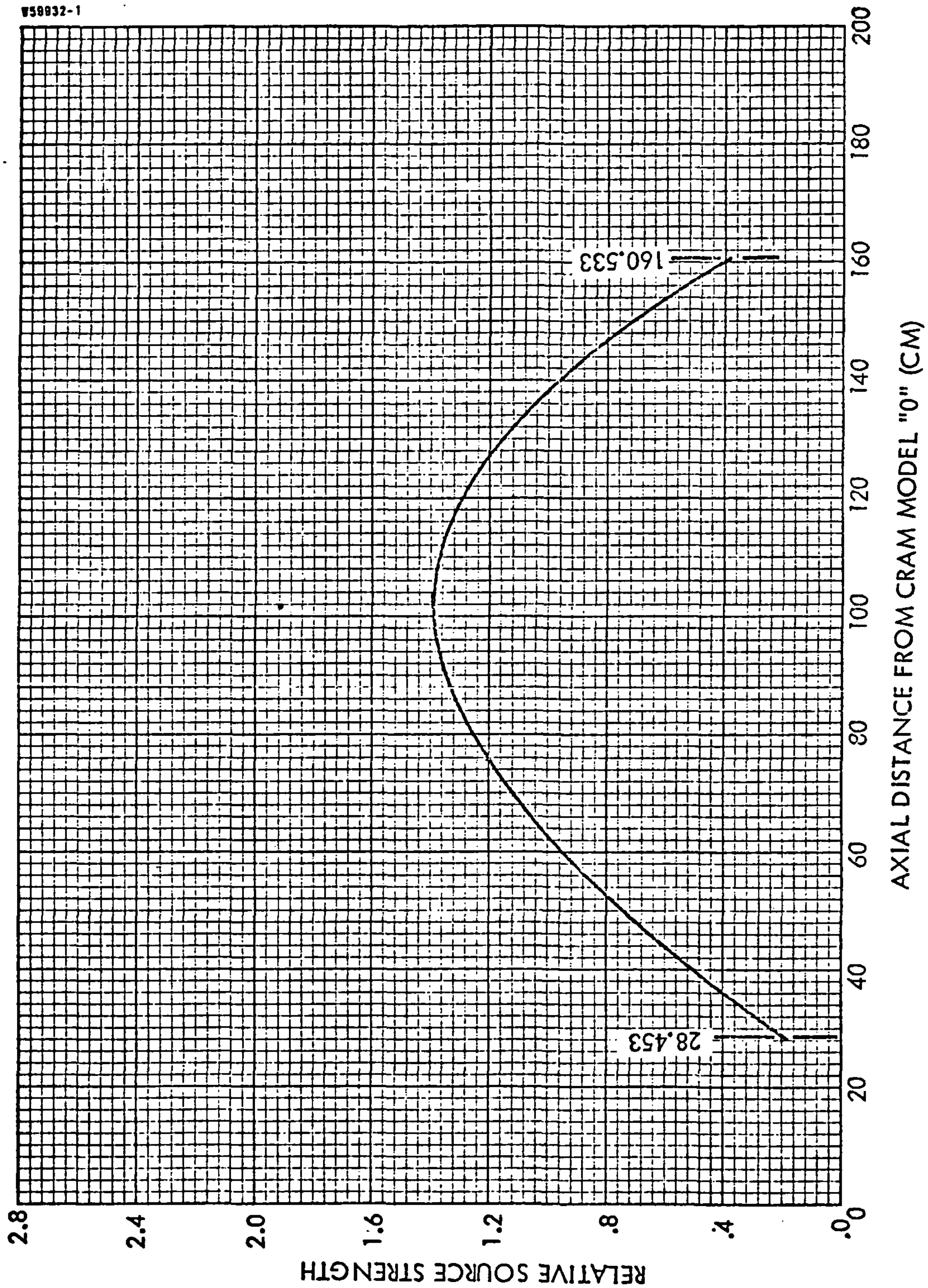
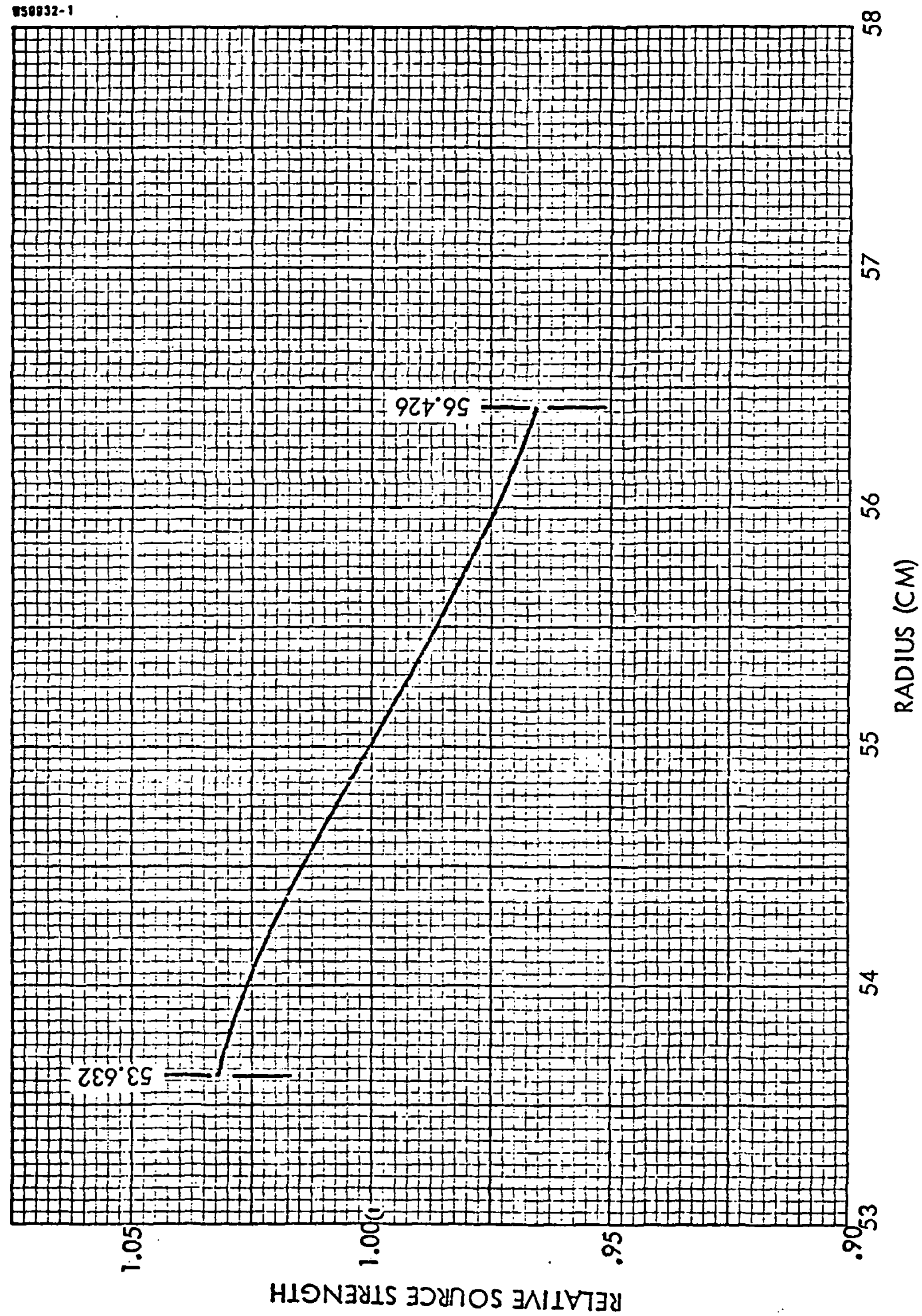


FIGURE 10
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 5
STRUCTURE



X

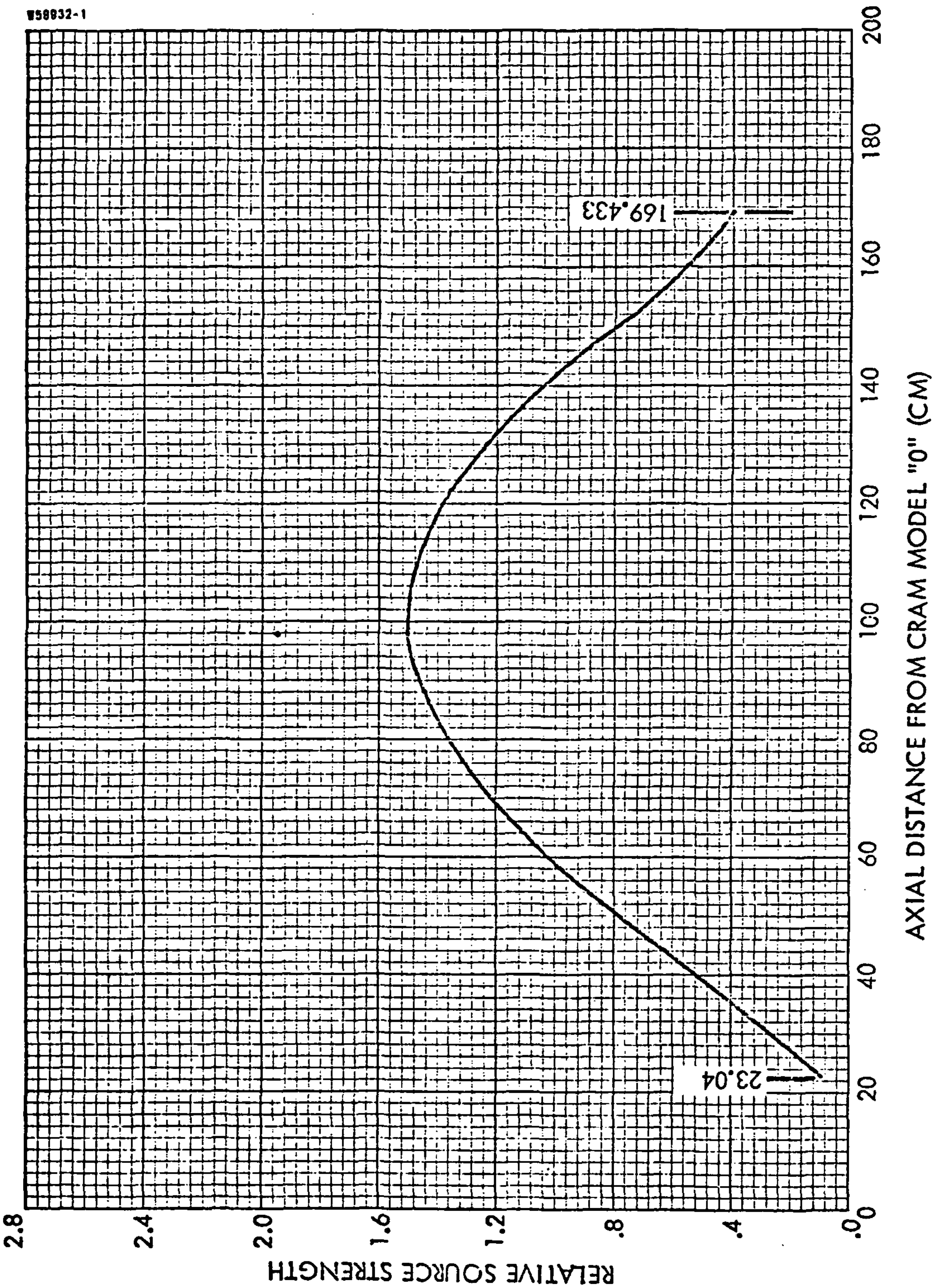


FIGURE 11

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 5 STRUCTURE

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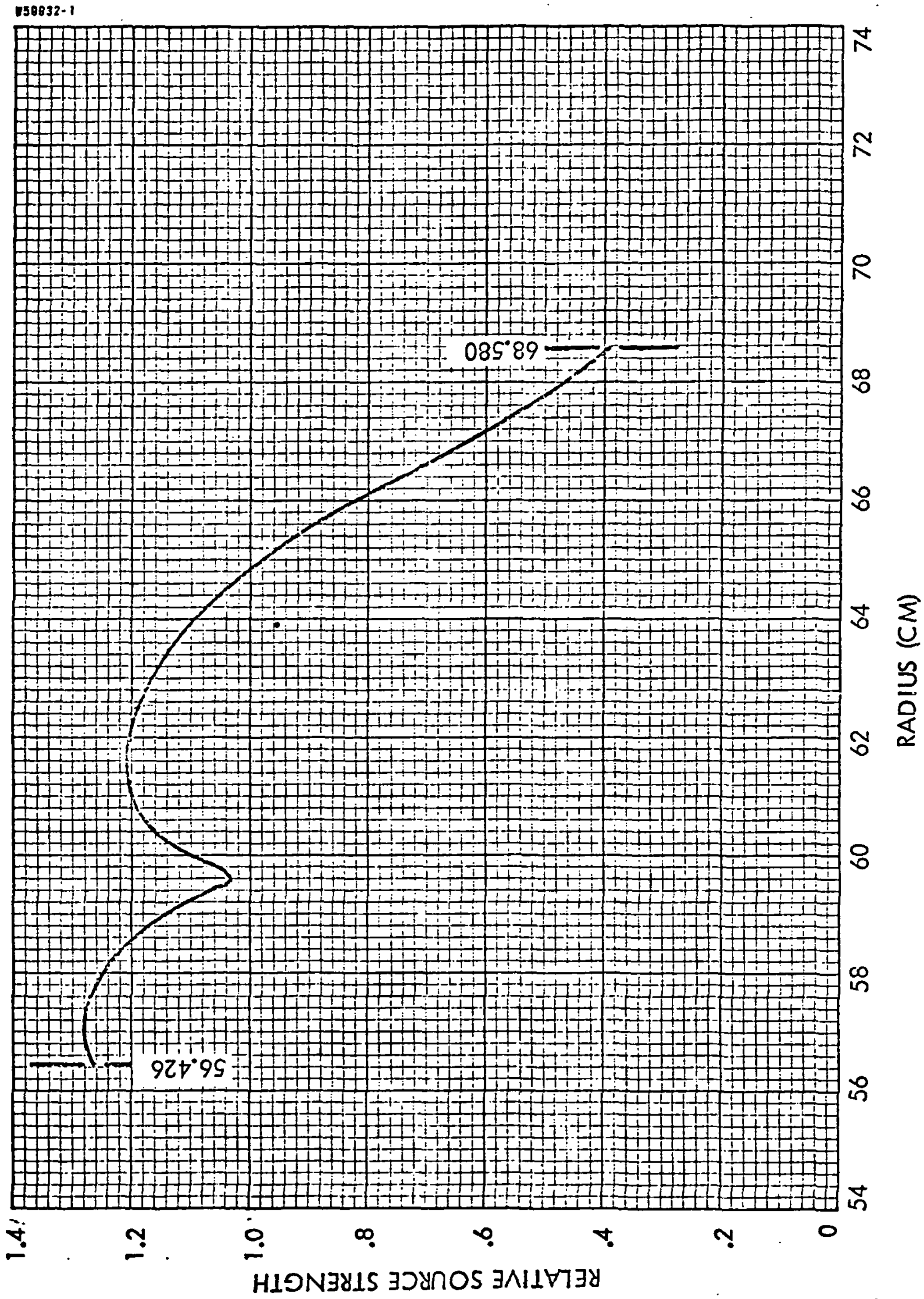

FIGURE 12
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 6
REFLECTOR

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FIGURE 13
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 6
REFLECTOR

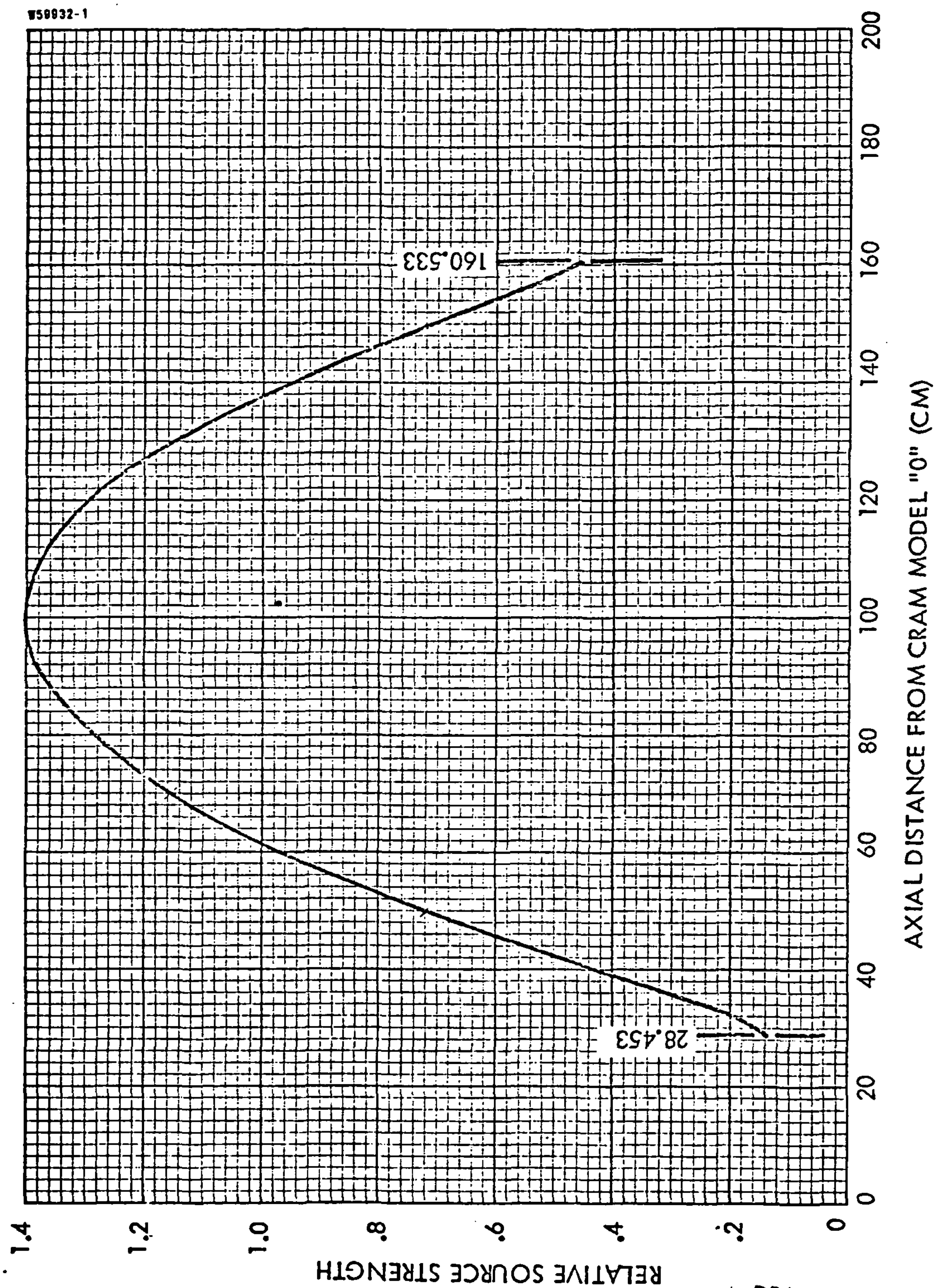

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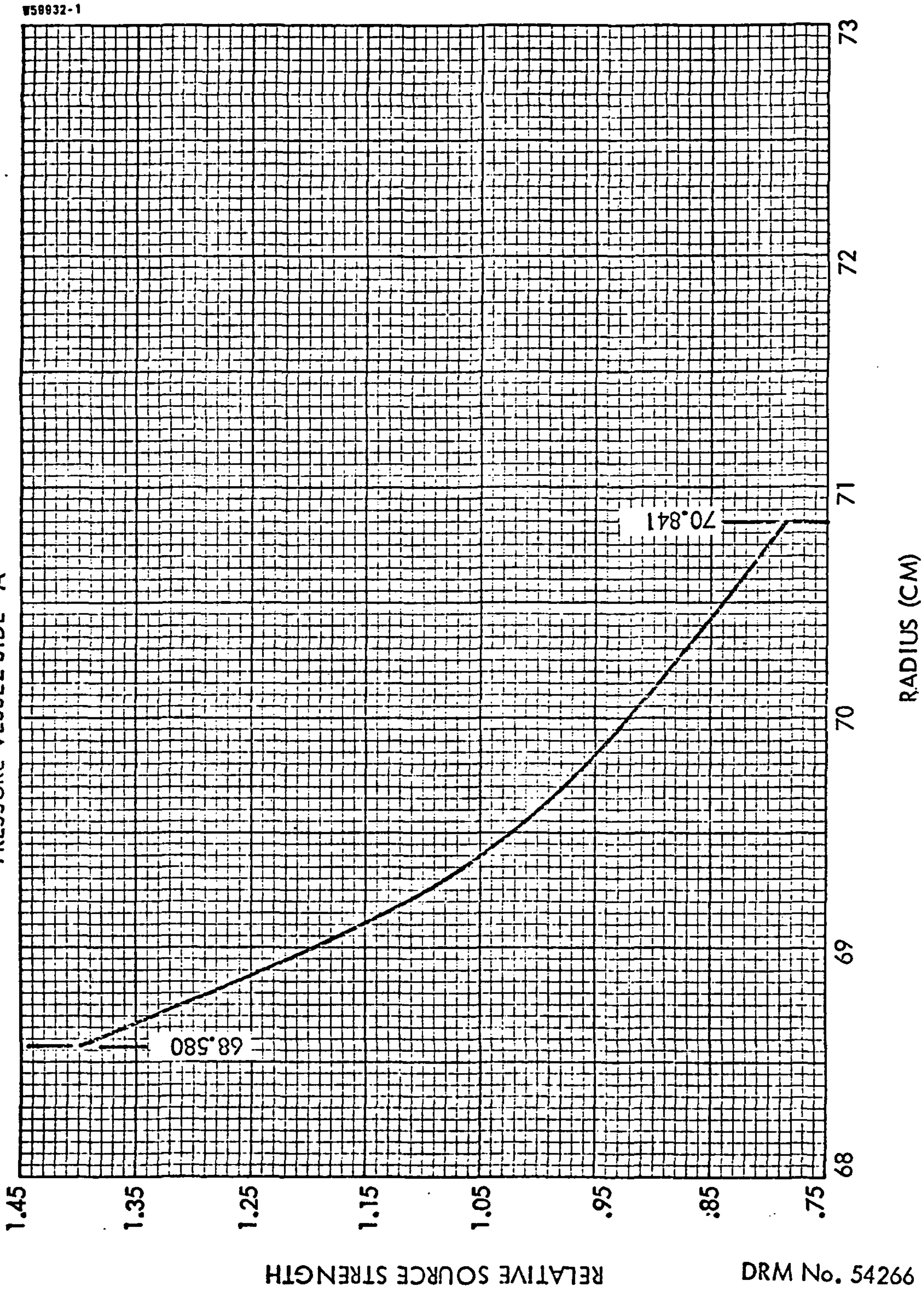
FIGURE 14
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 7
PRESSURE VESSEL SIDE- A



X

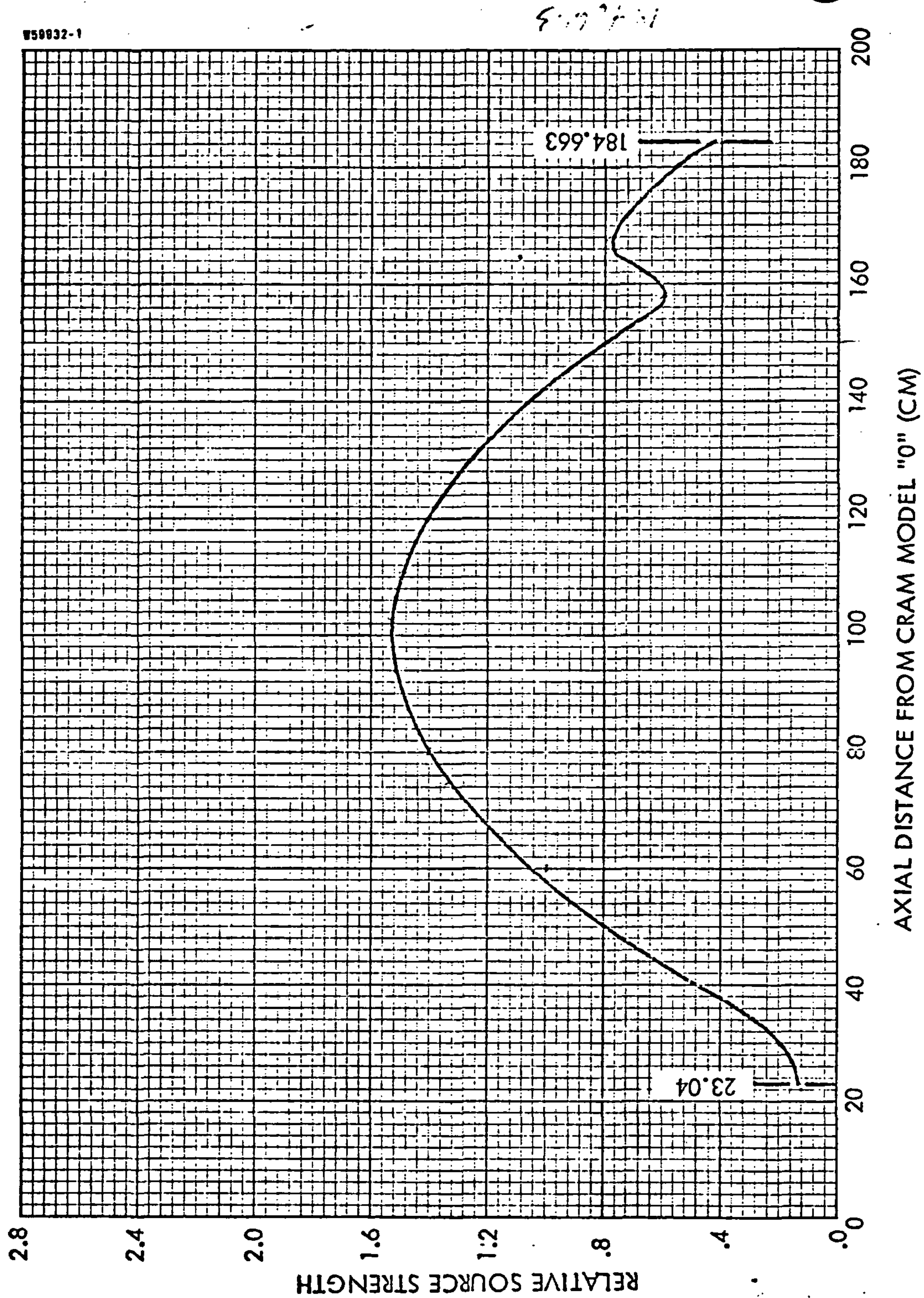
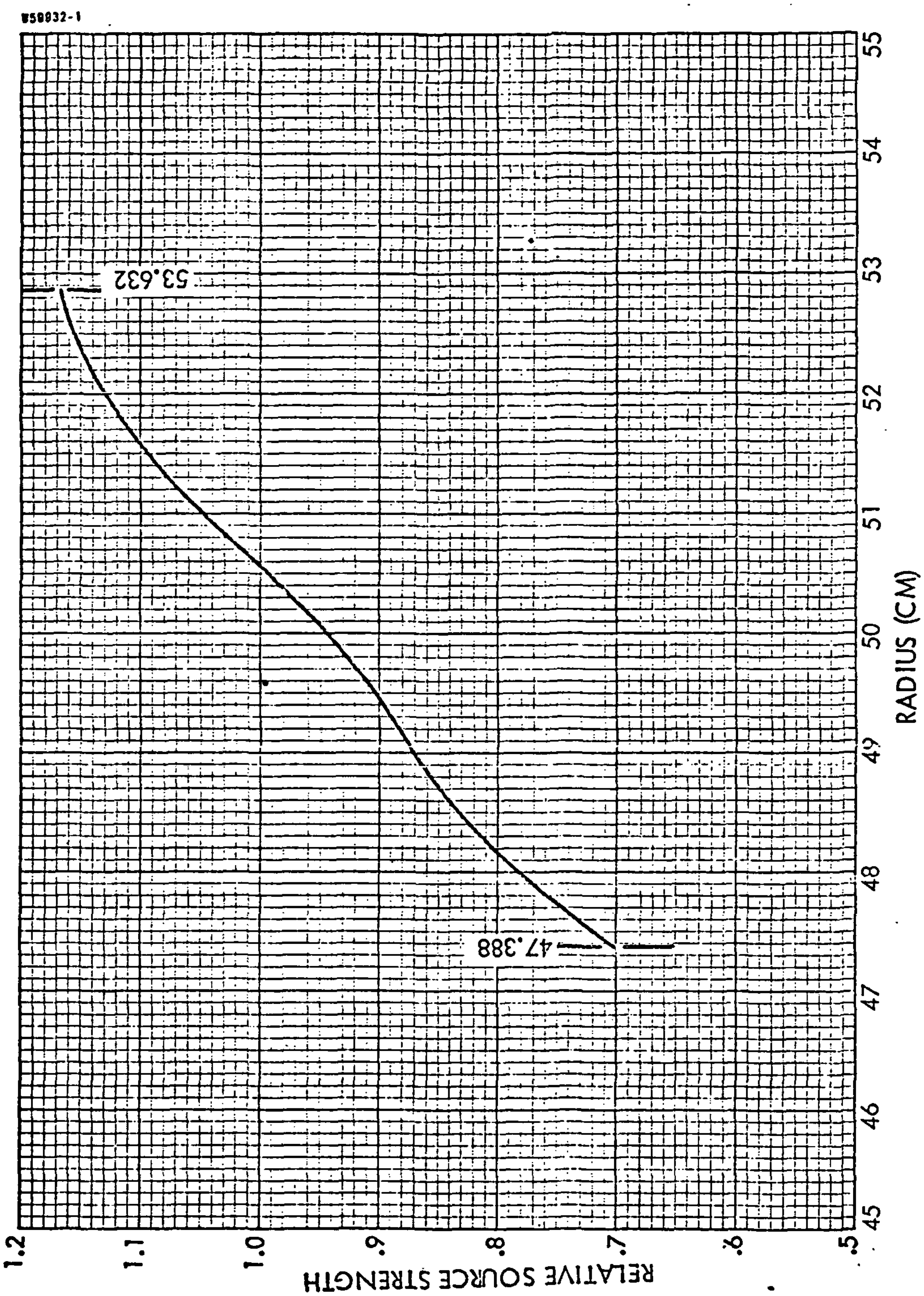


FIGURE 15

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 7
PRESSURE VESSEL SIDE-A

FIGURE 16
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 8
NOZZLE CHAMBER



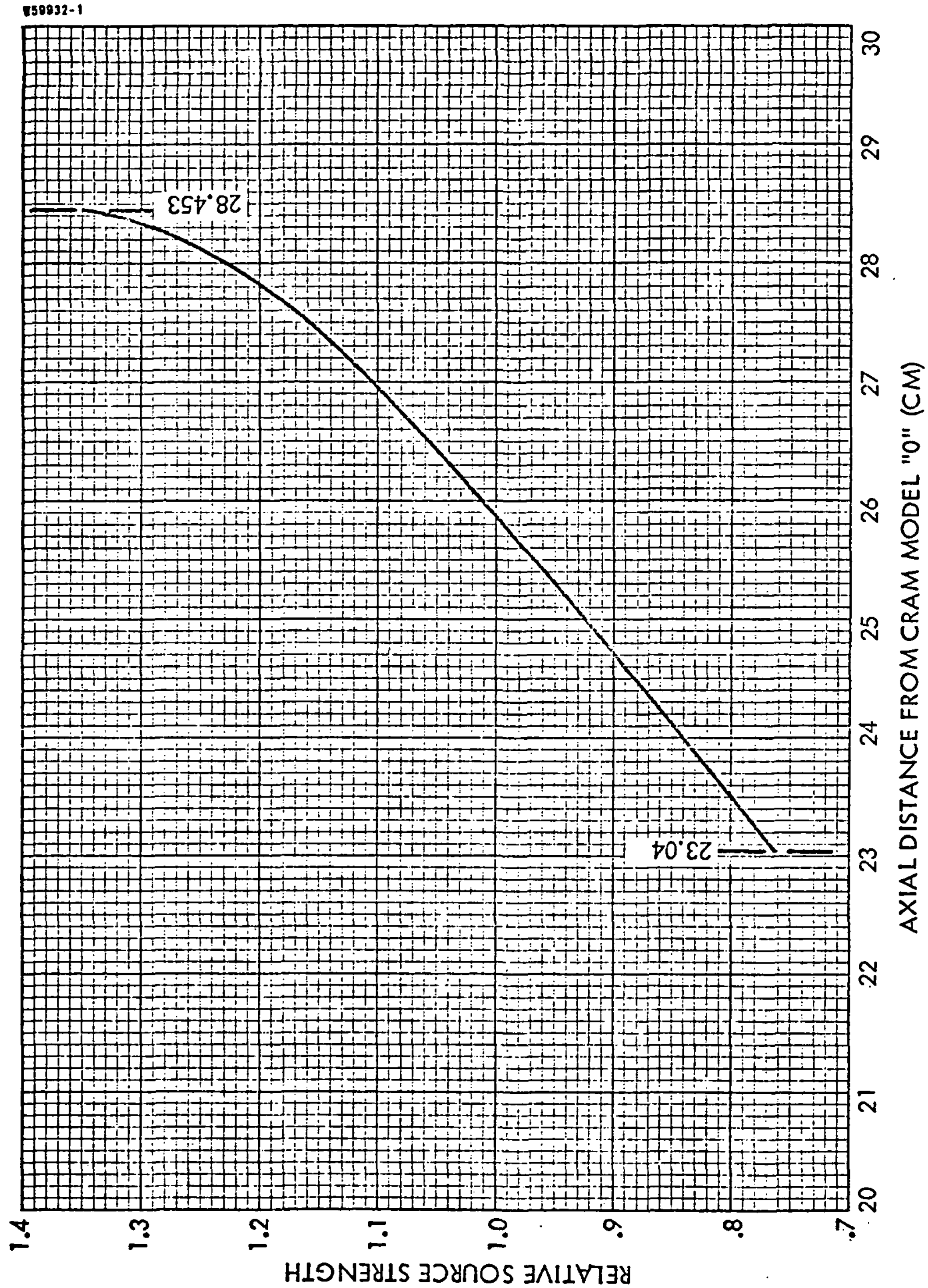


FIGURE 17

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURVE IN REGION 8
NOZZLE CHAMBER

FIGURE 18
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 9
AFT REFLECTOR AND PLENUM

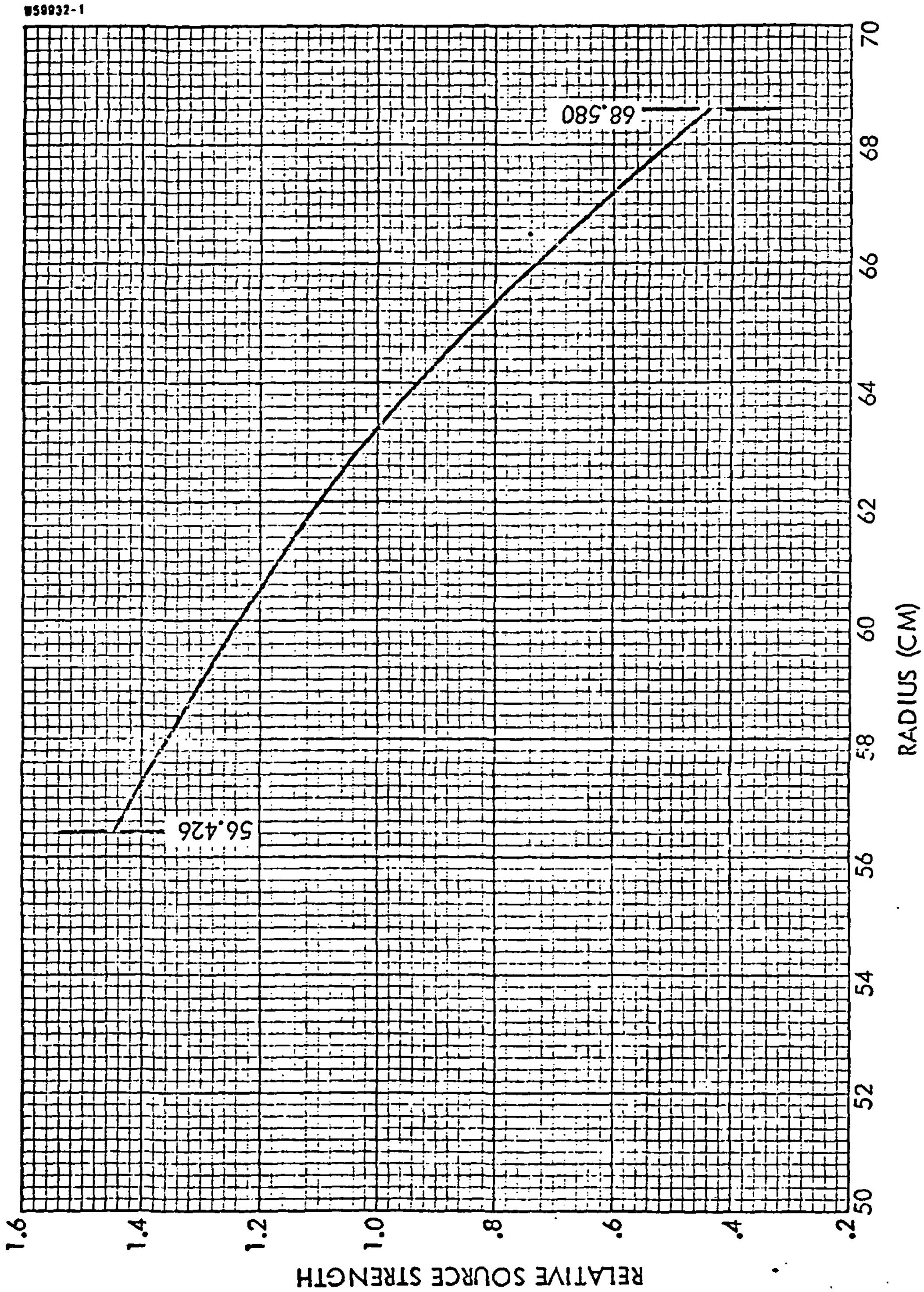


FIGURE 19
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 9
AFT REFLECTOR AND PLENUM

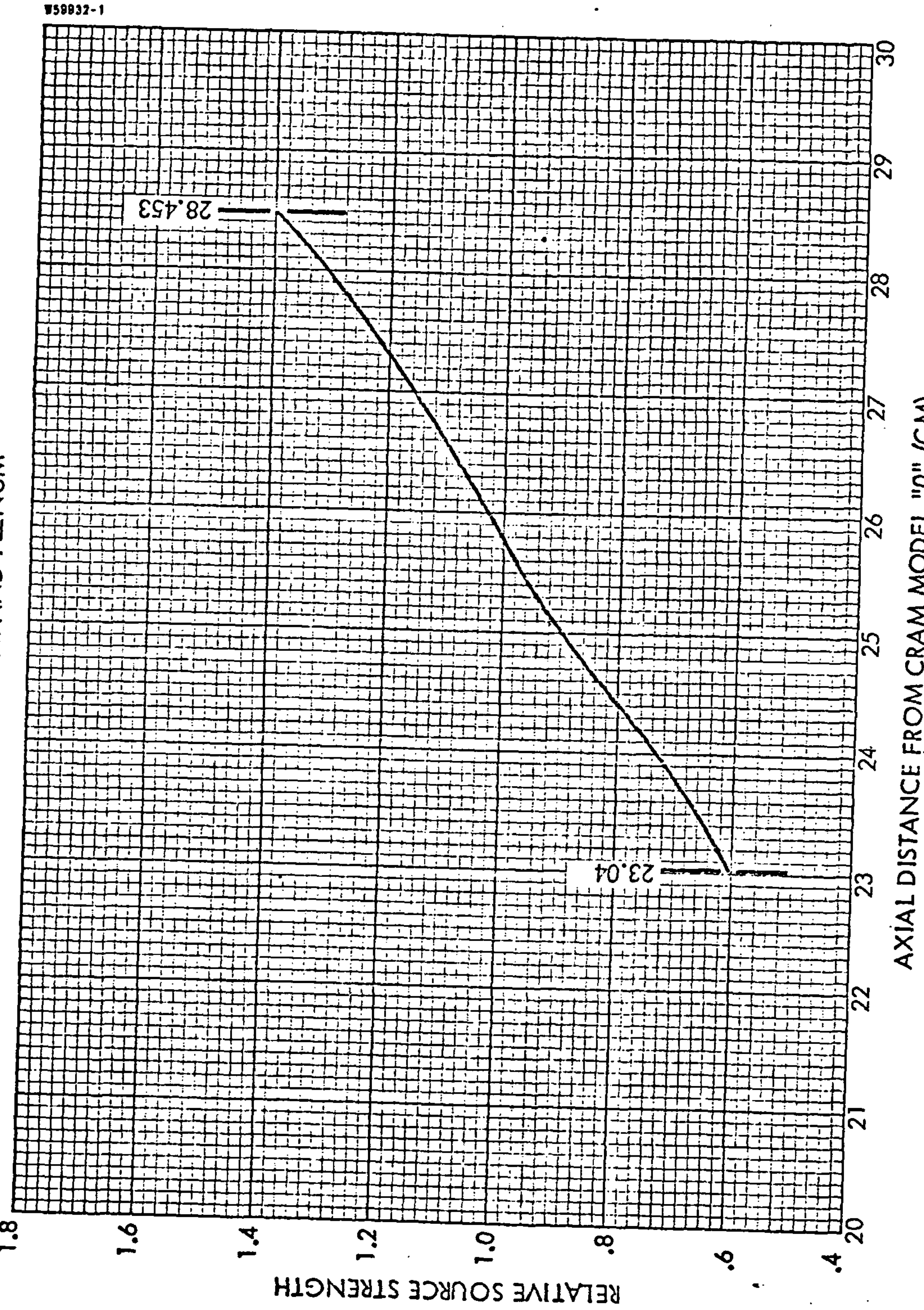


FIGURE 20

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 10
CORE PLENUM

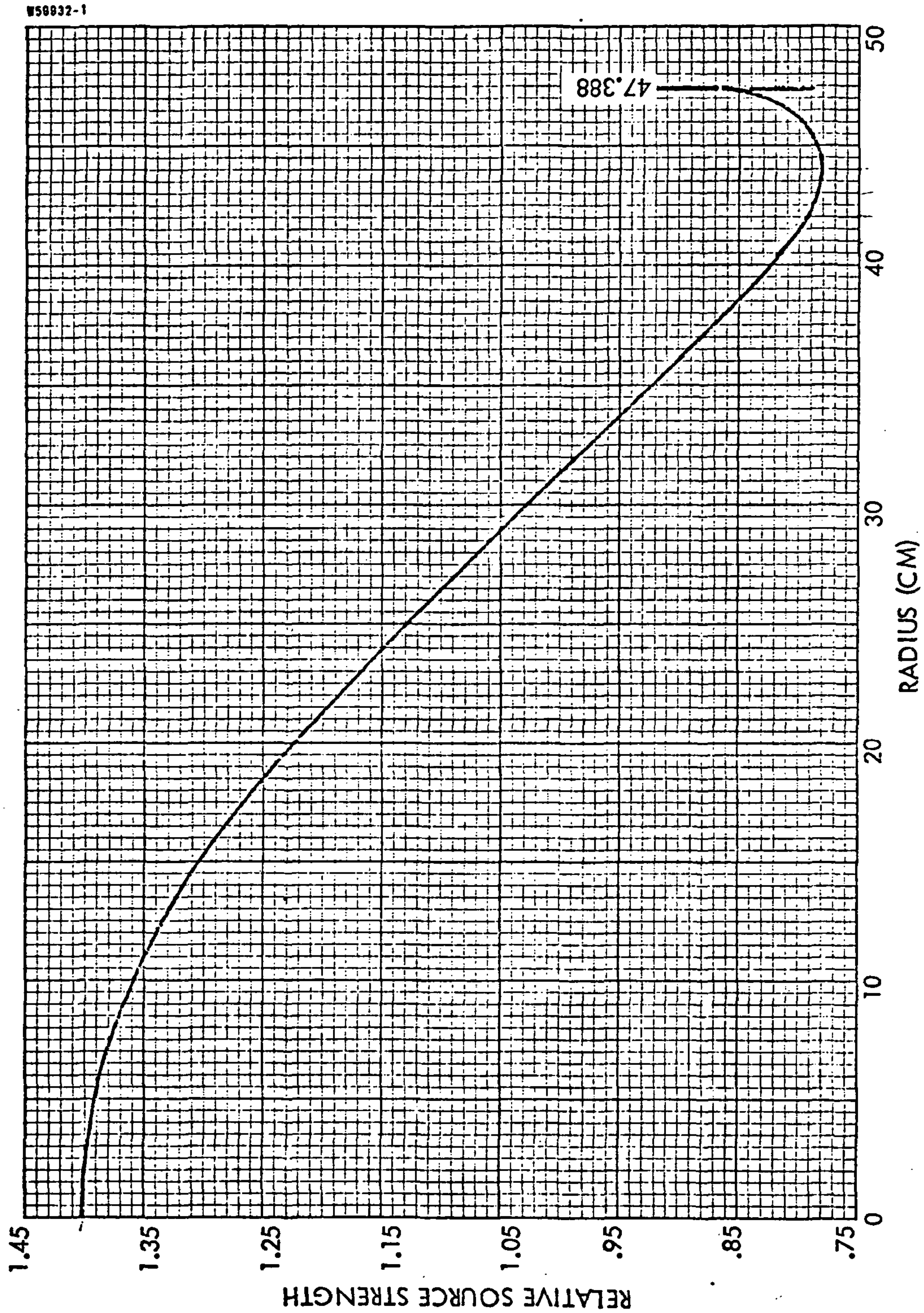


FIGURE 21

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 10 CORE PLENUM

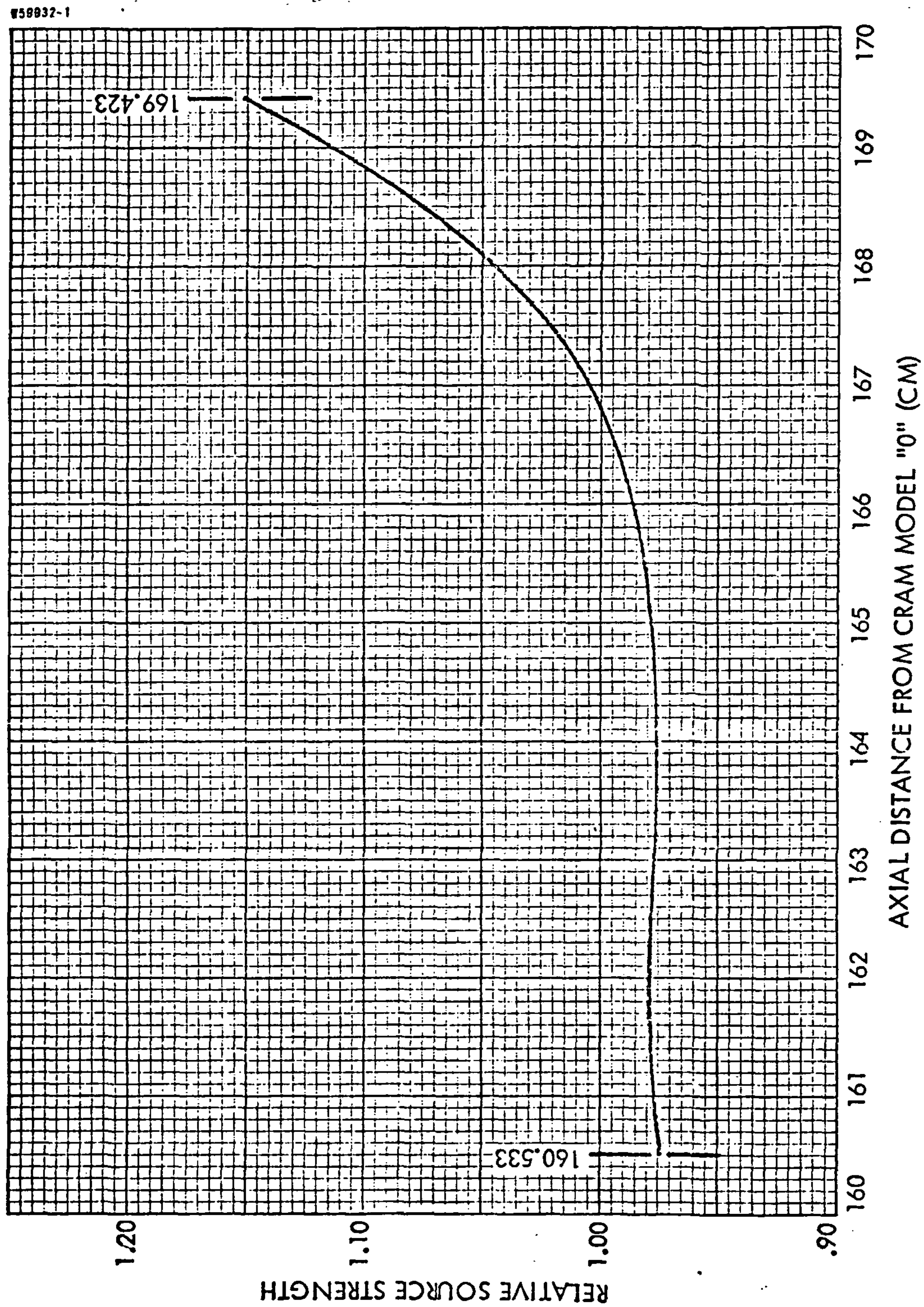


FIGURE 22

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 11

LATERAL SUPPORT FORWARD

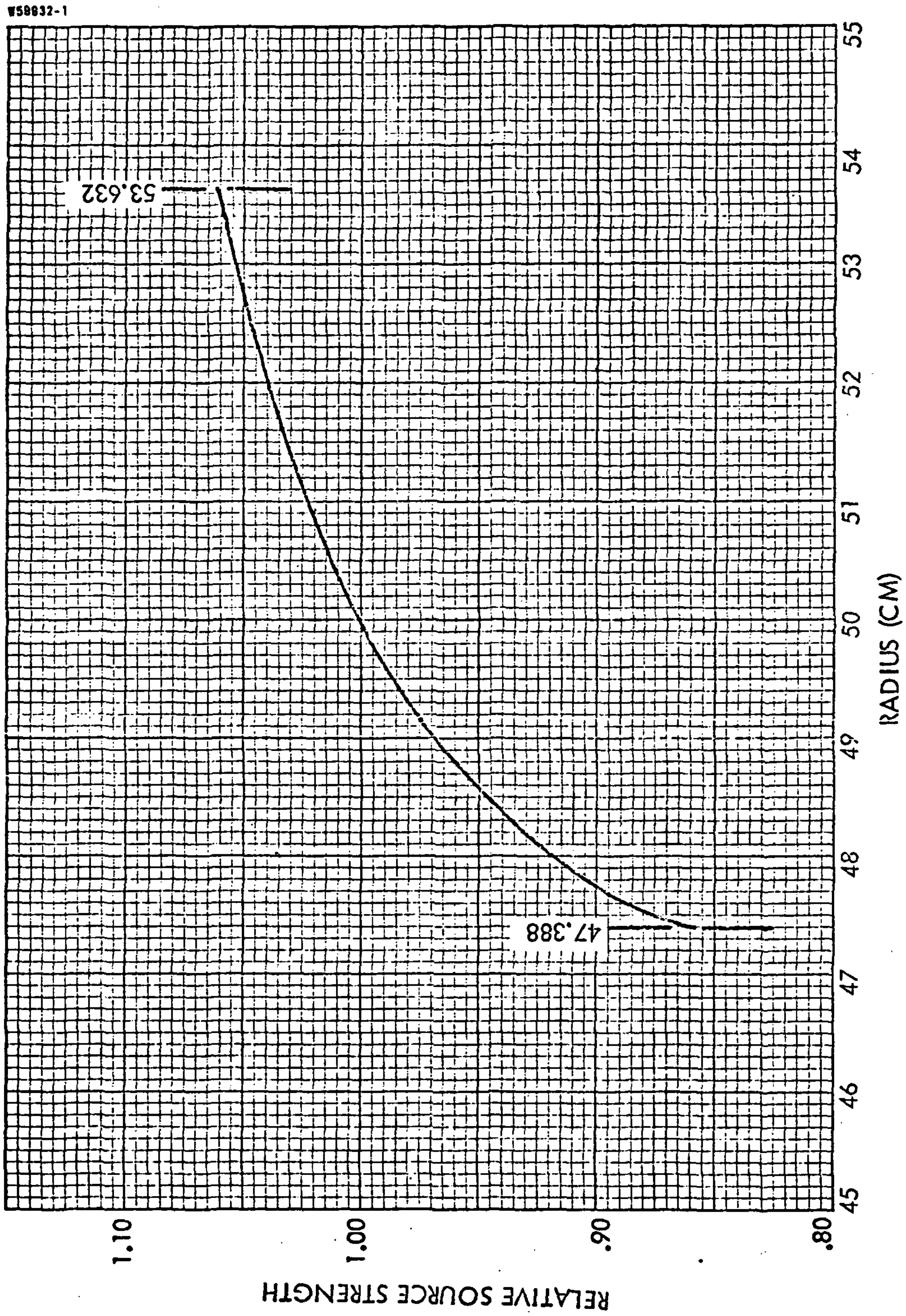


FIGURE 23

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 11
LATERAL SUPPORT FORWARD

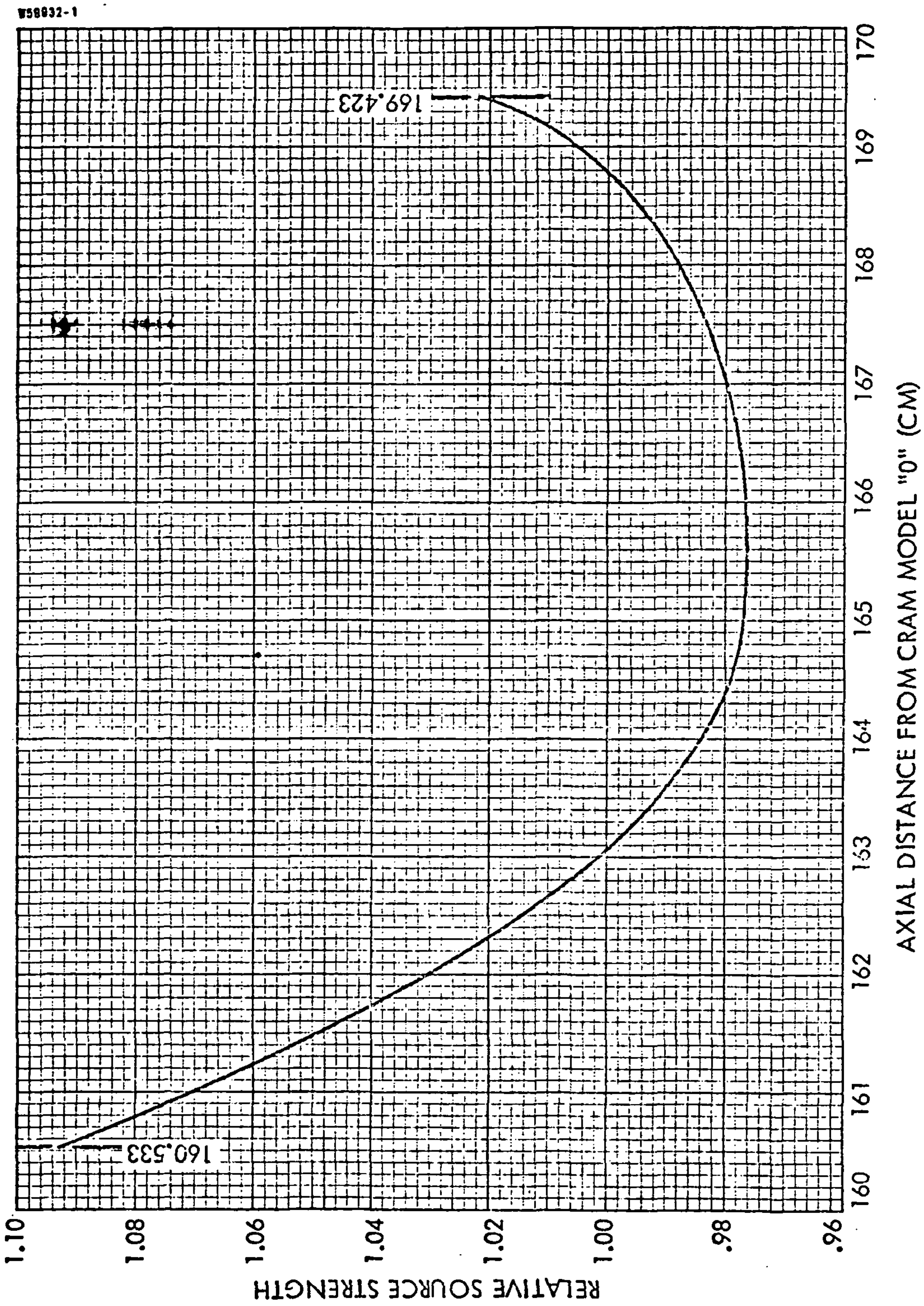


FIGURE 24

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 12
SUPPORT PLATE

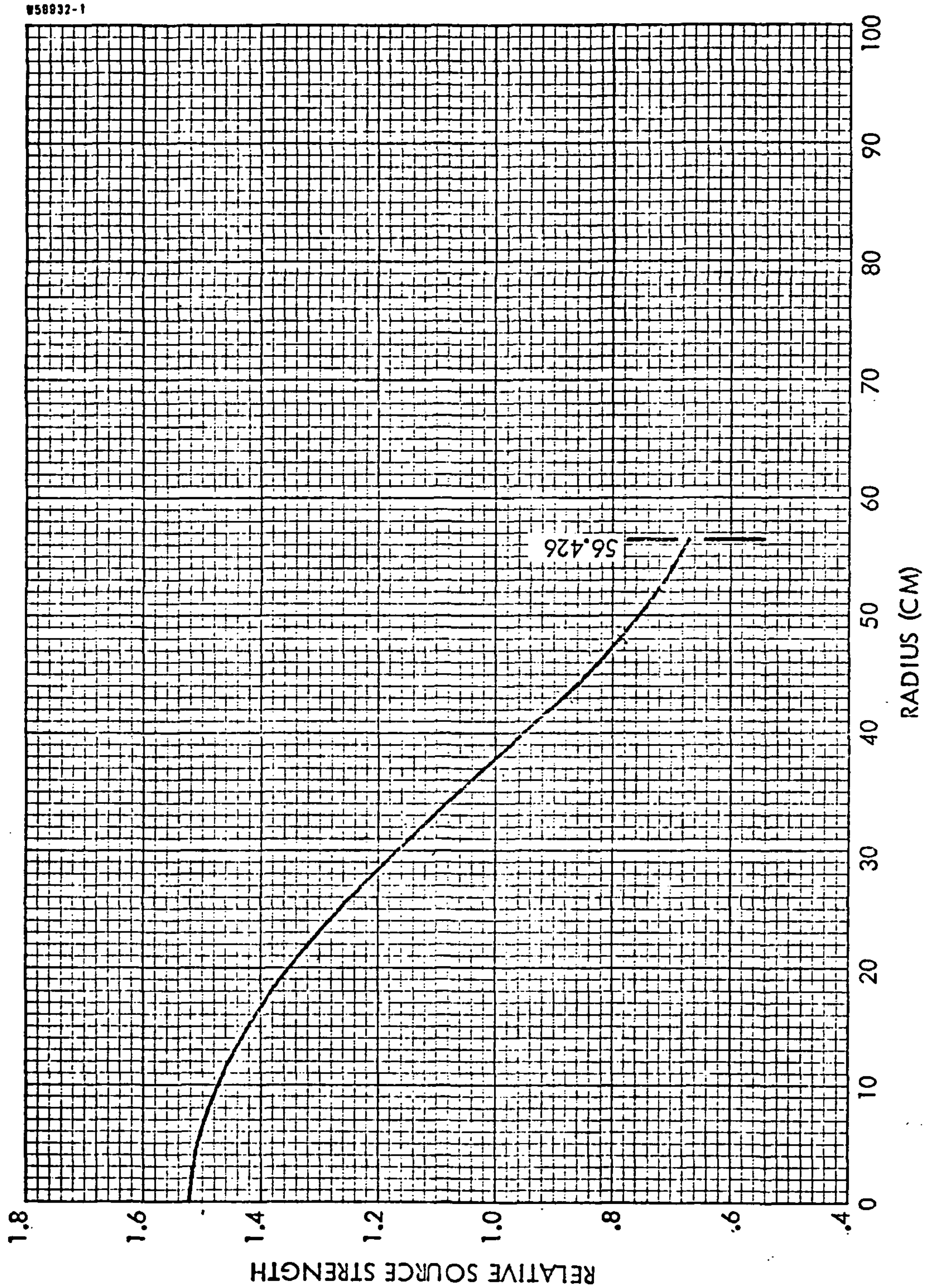


FIGURE 25
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 12
SUPPORT PLATE

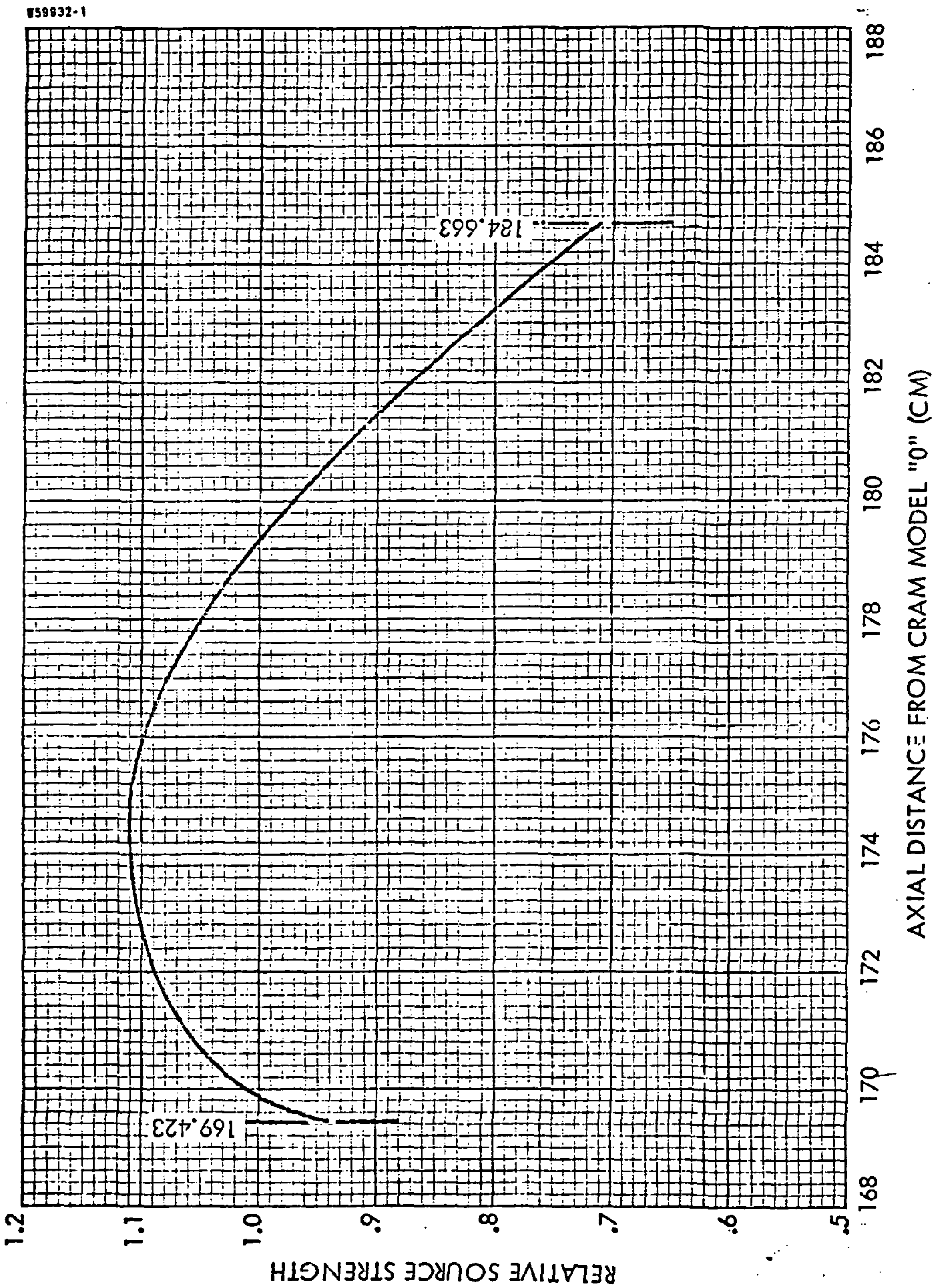


FIGURE 26

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 13
FORWARD REFLECTOR HARDWARE I

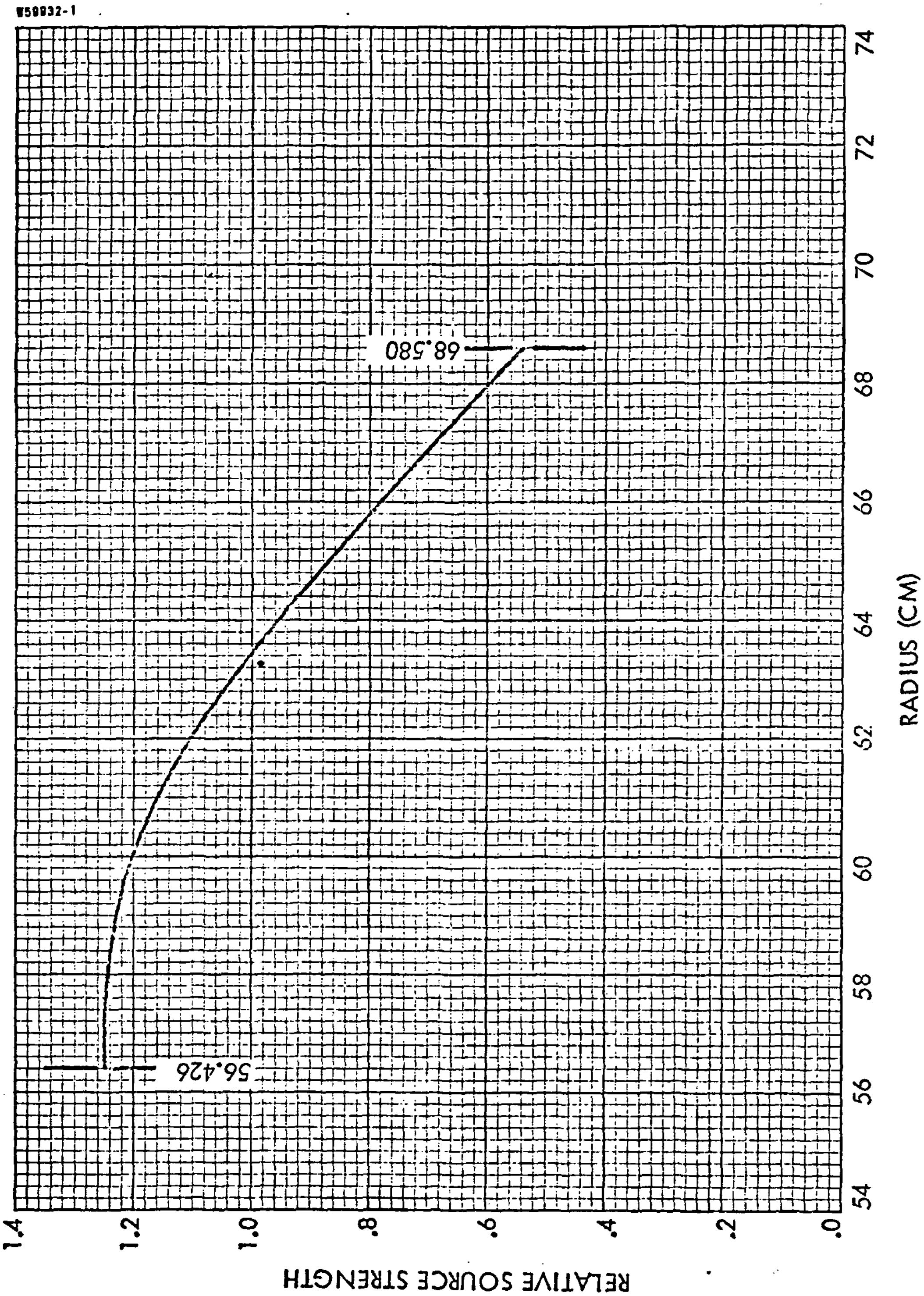


FIGURE 27

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 13
FORWARD REFLECTOR HARDWARE I

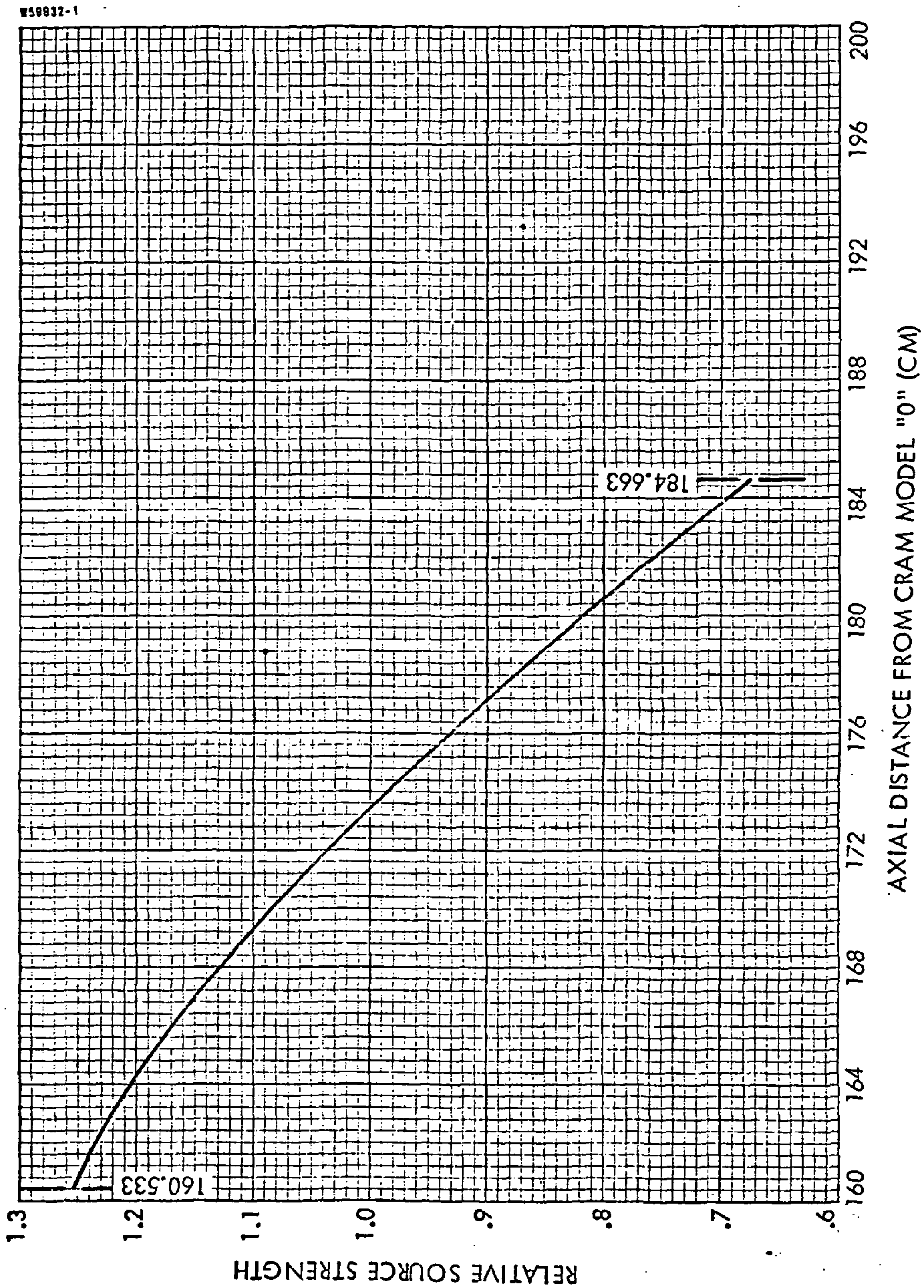
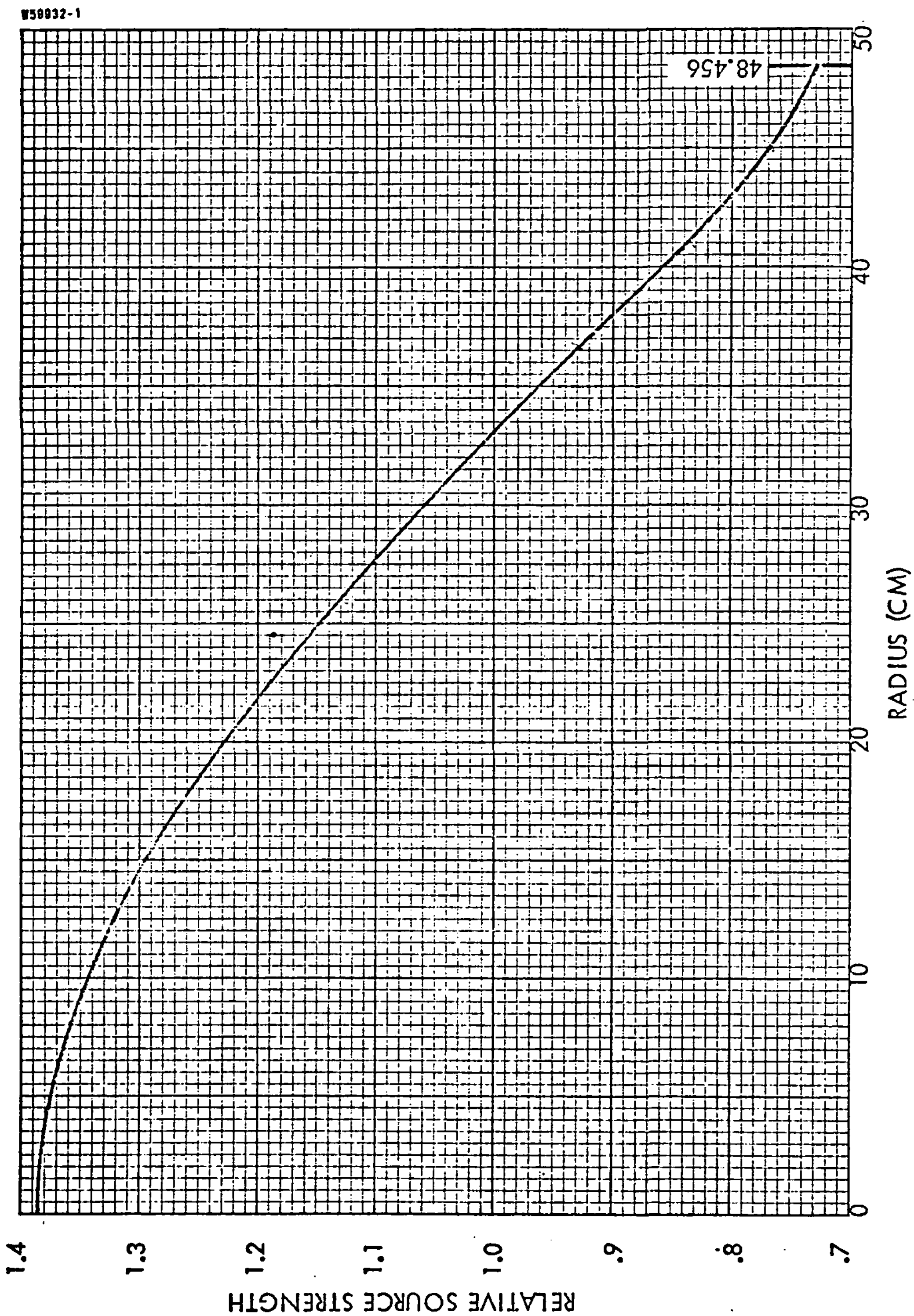


FIGURE 28

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 14 SUPPORT PLATE PLENUM



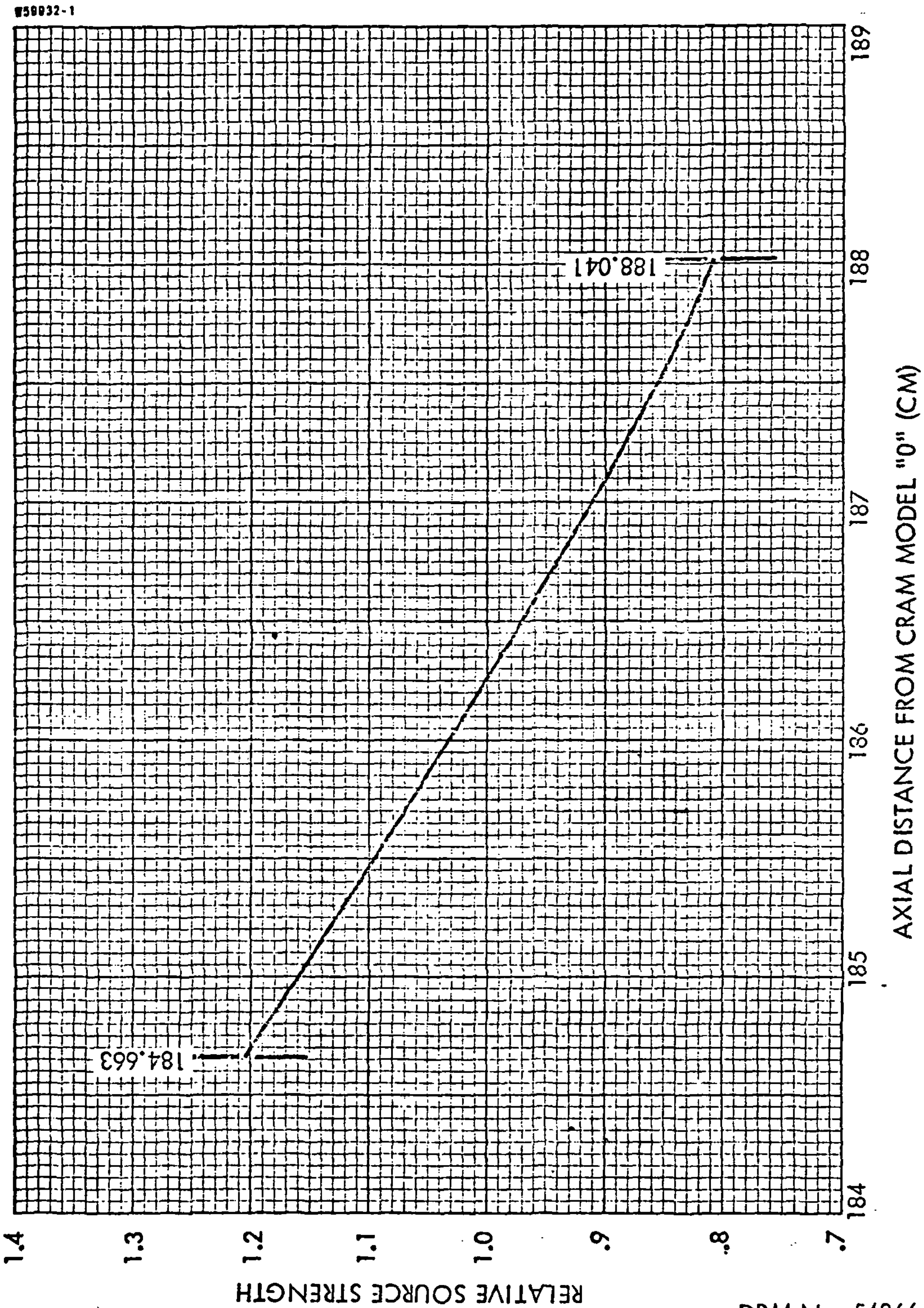


FIGURE 29
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 14
SUPPORT PLATE PLENUM

FIGURE 30

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 15
CENTRAL SHIELD PLATE - AFT

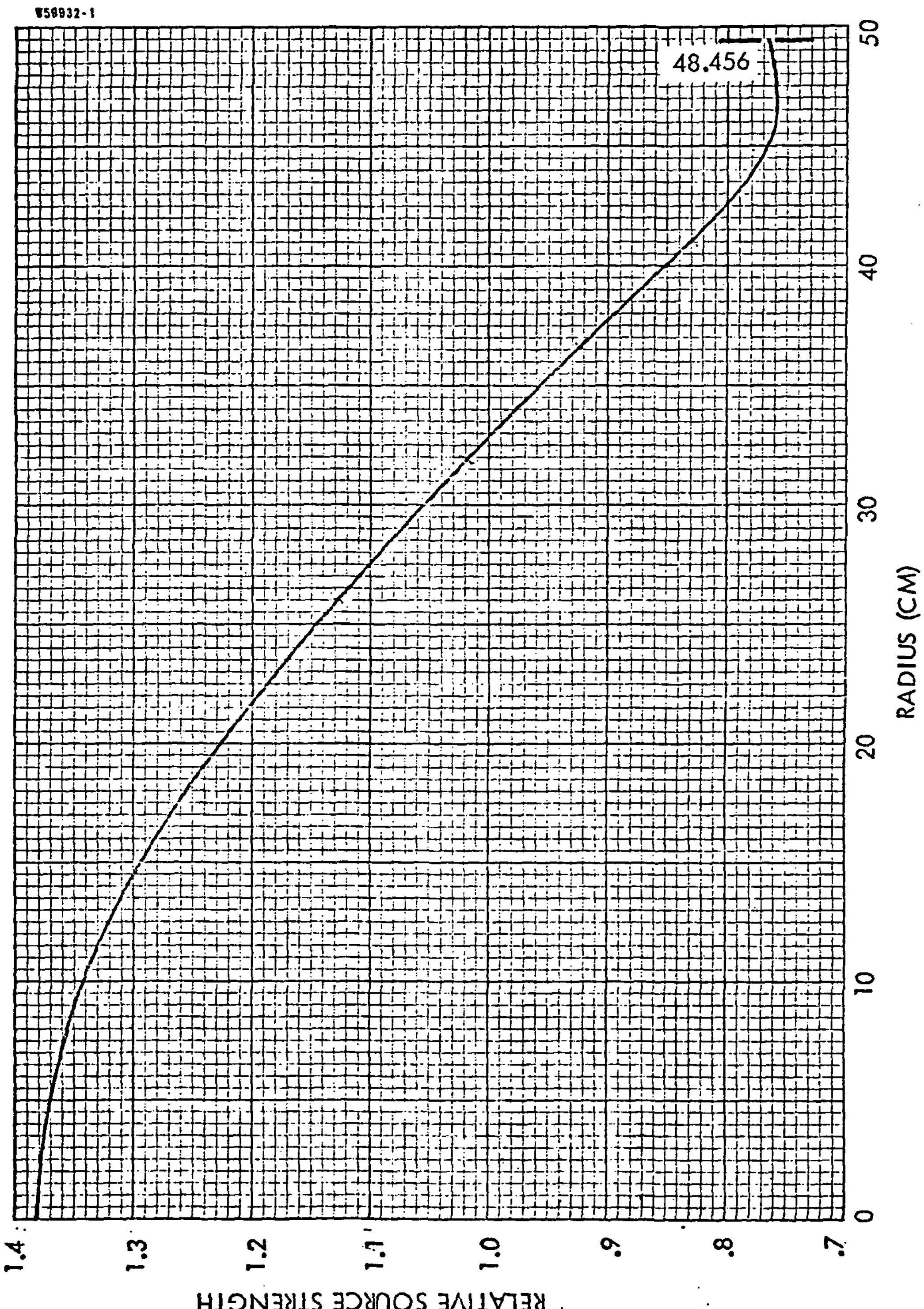


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FIGURE 31

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 15
CENTRAL SHIELD PLATE - AFT

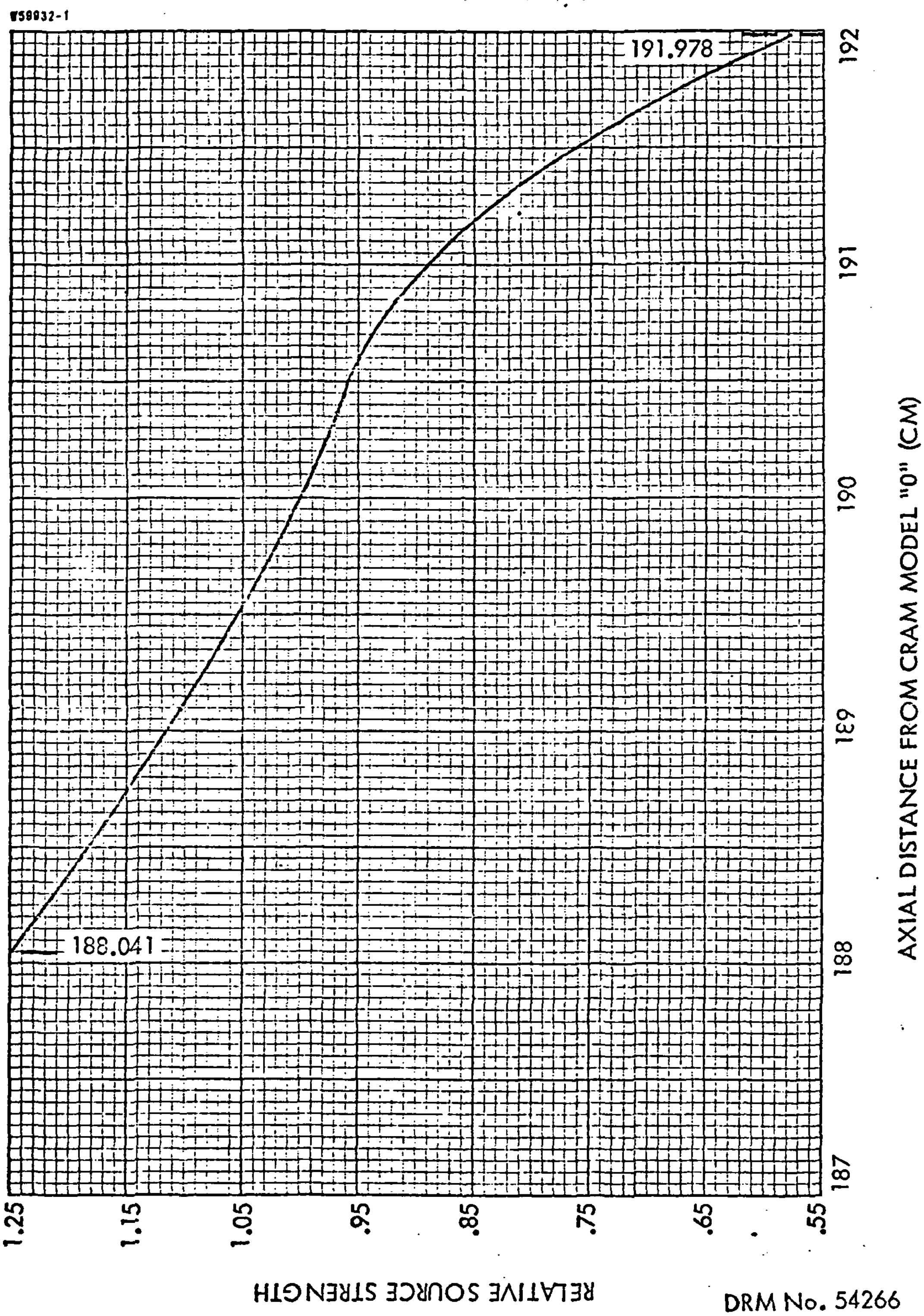

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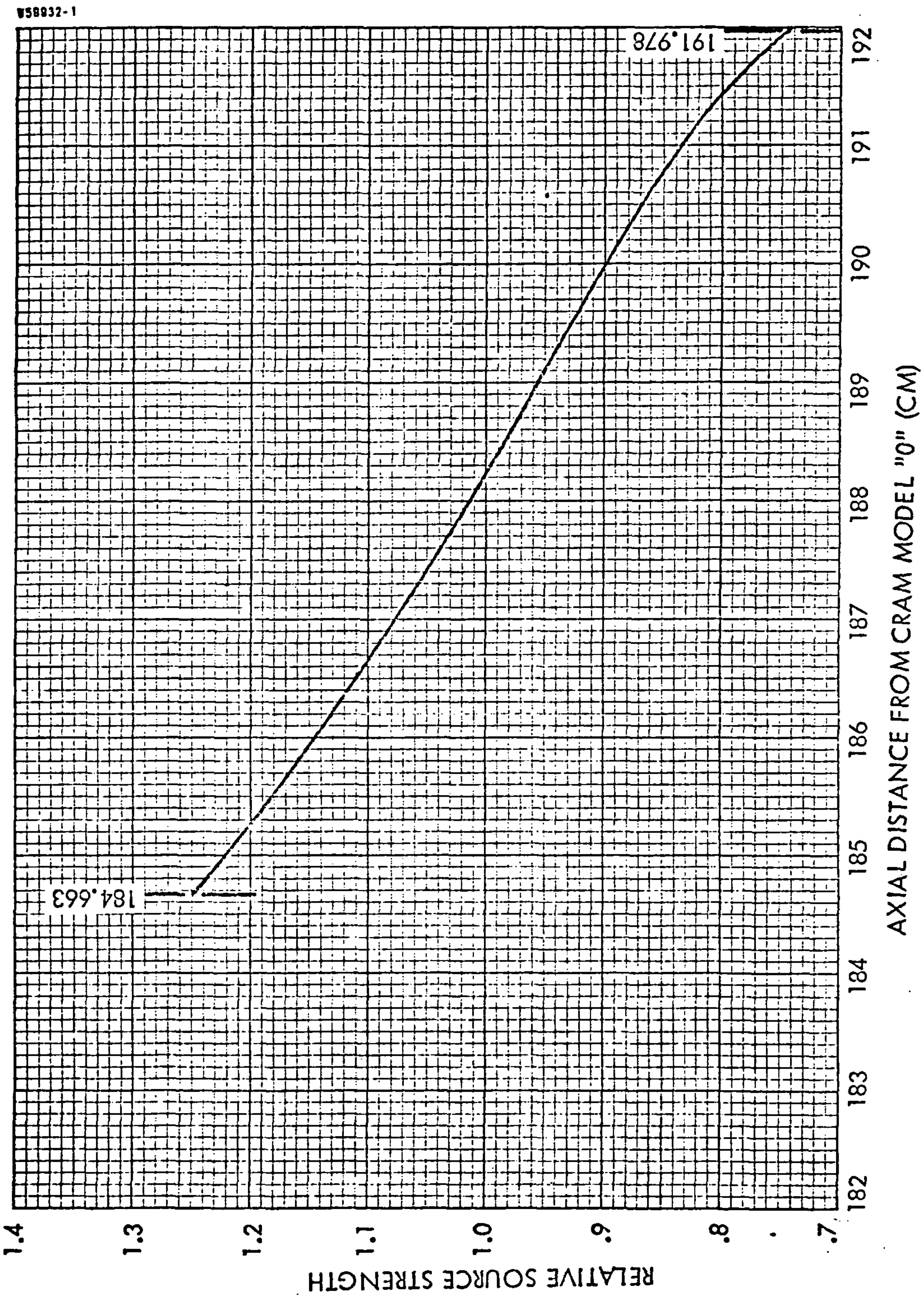
FIGURE 32

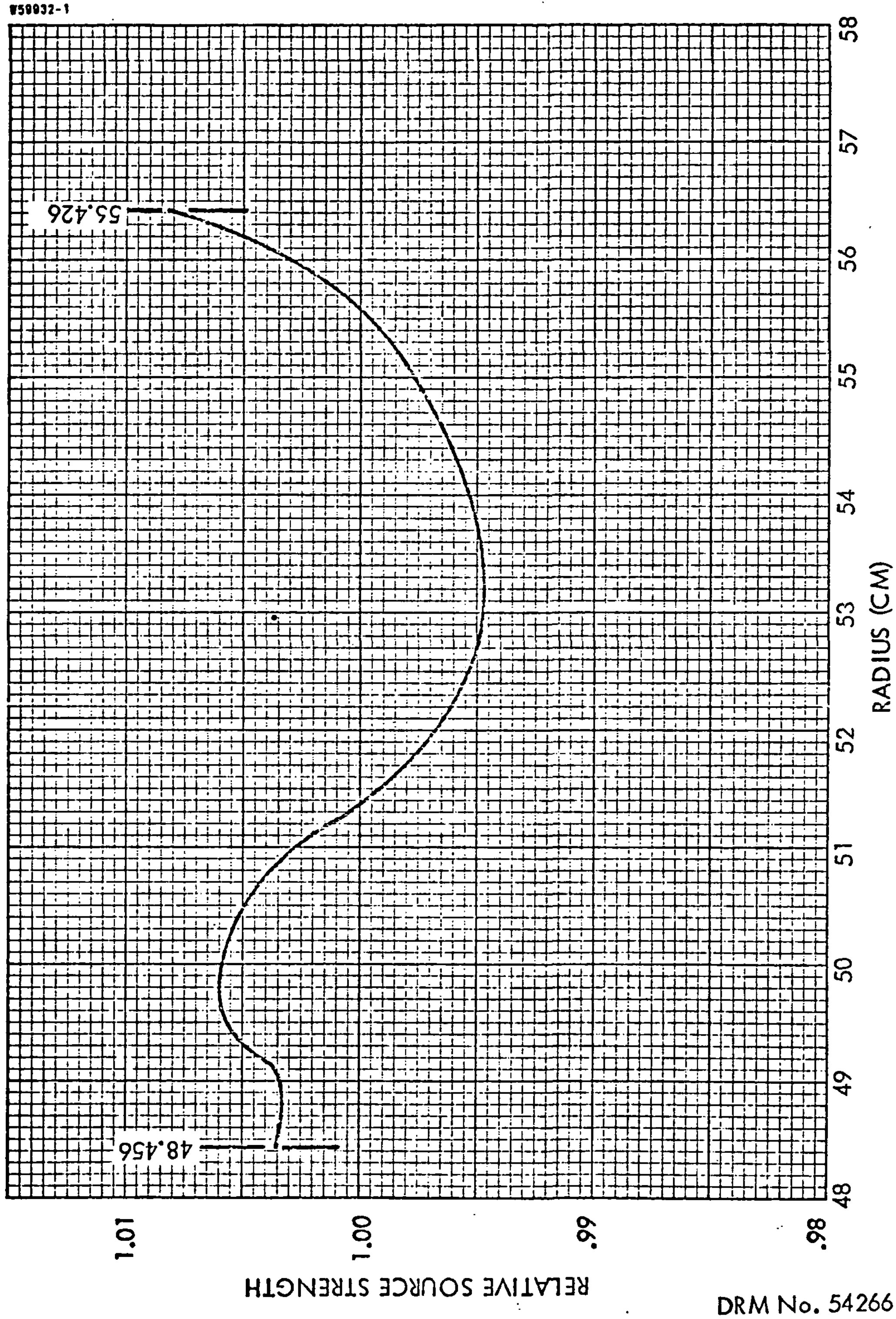
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 16
INSTRUMENTATION RING



W59932-1

FIGURE 33

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 16 INSTRUMENTATION RING



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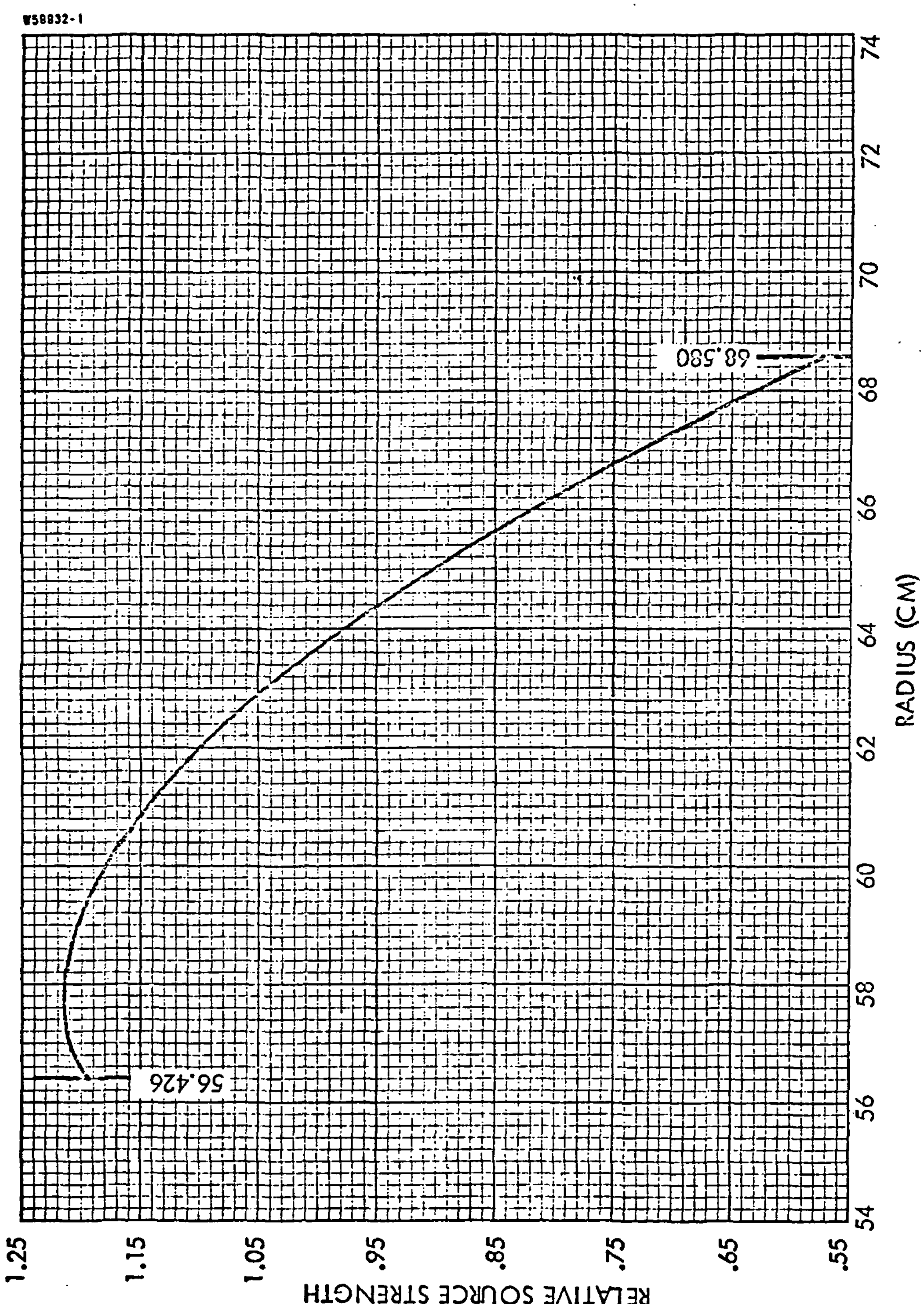


FIGURE 34

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 17
FORWARD REFLECTOR HARDWARE II

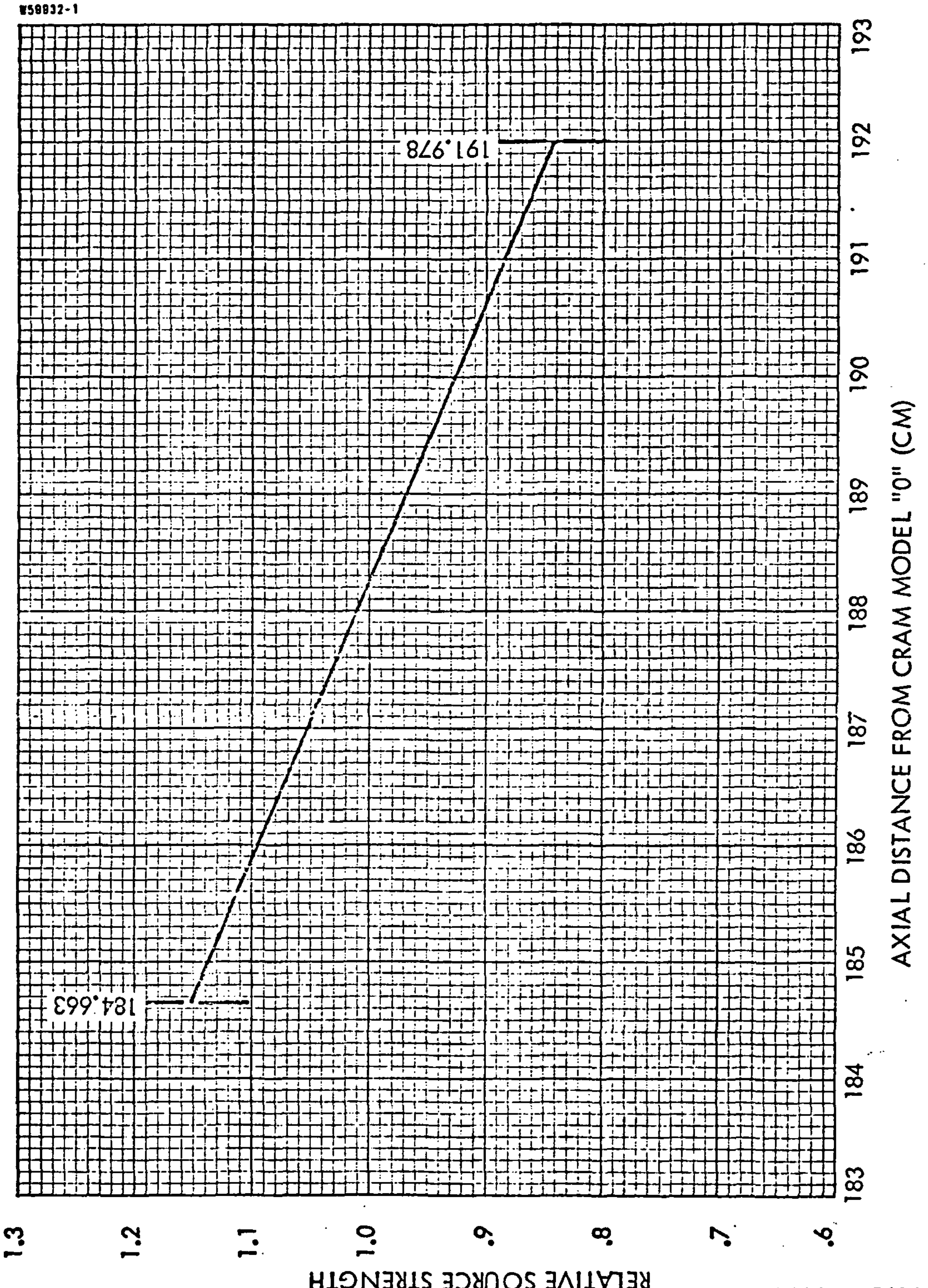


FIGURE 35

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 17
FORWARD REFLECTOR HARDWARE II

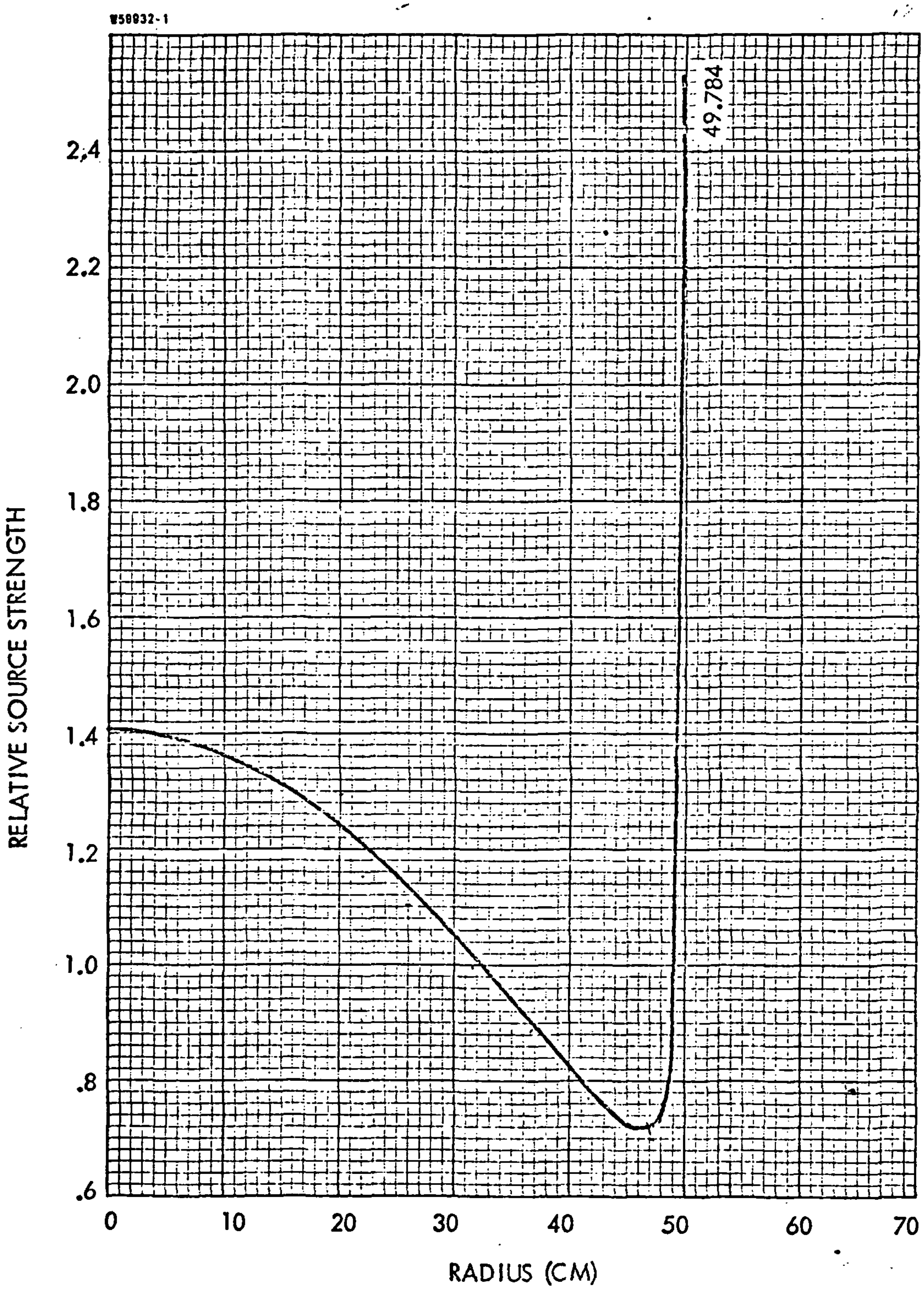
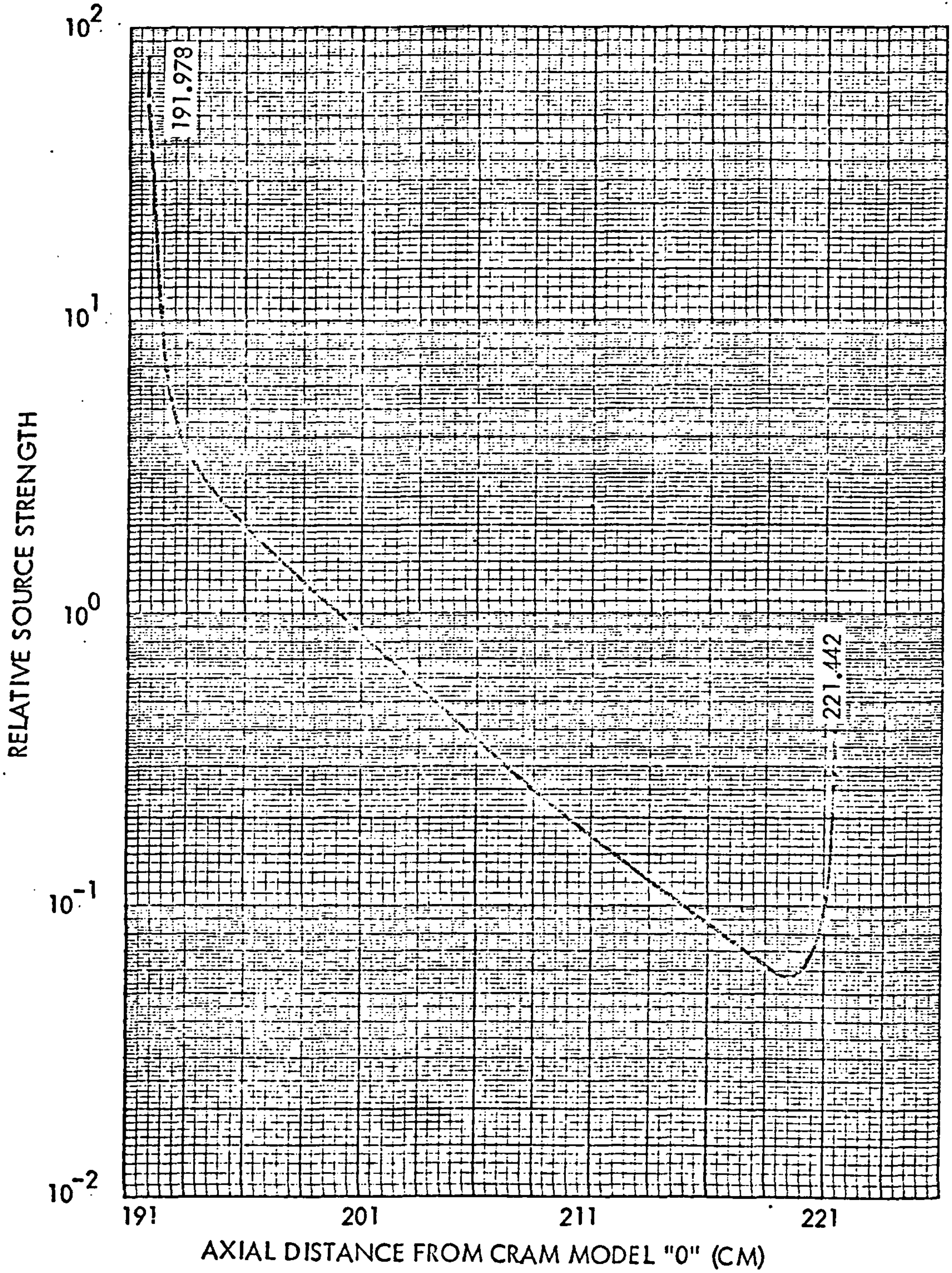


FIGURE 36
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 18
BATH CENTRAL SHIELD



RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 18
BATH CENTRAL SHIELD

FIGURE 37

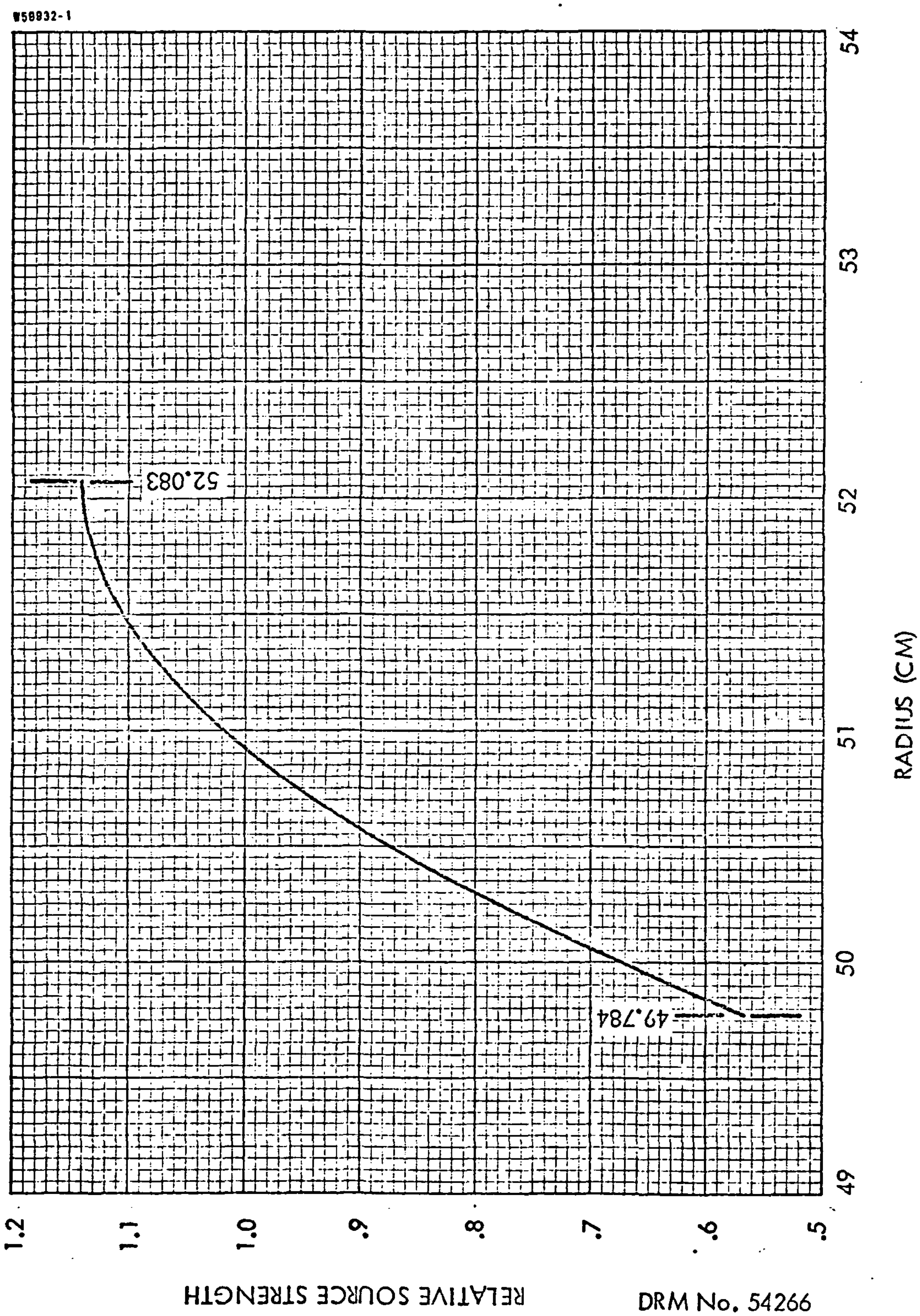
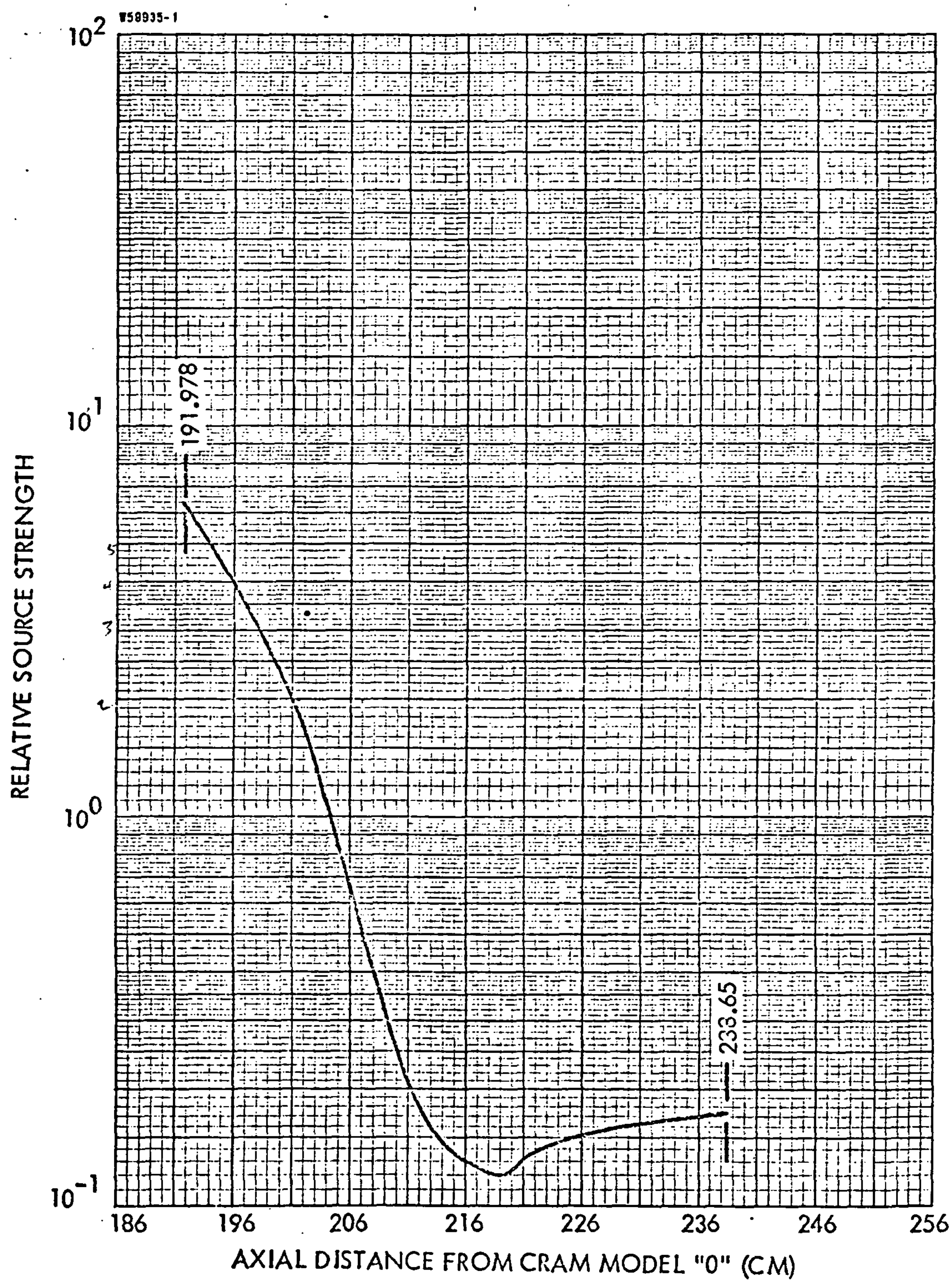


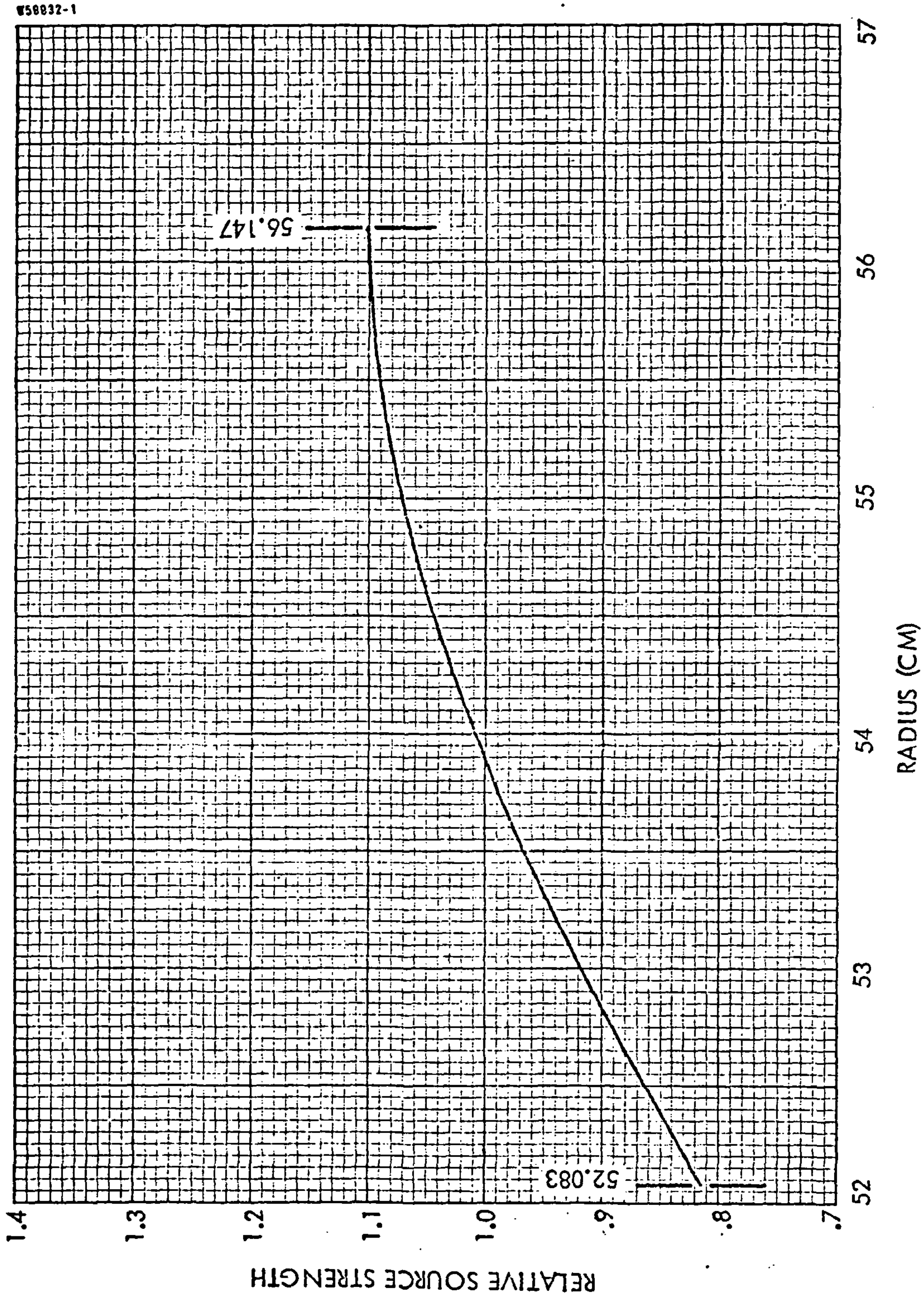
FIGURE 38
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 19
FLOW BAFFLE I

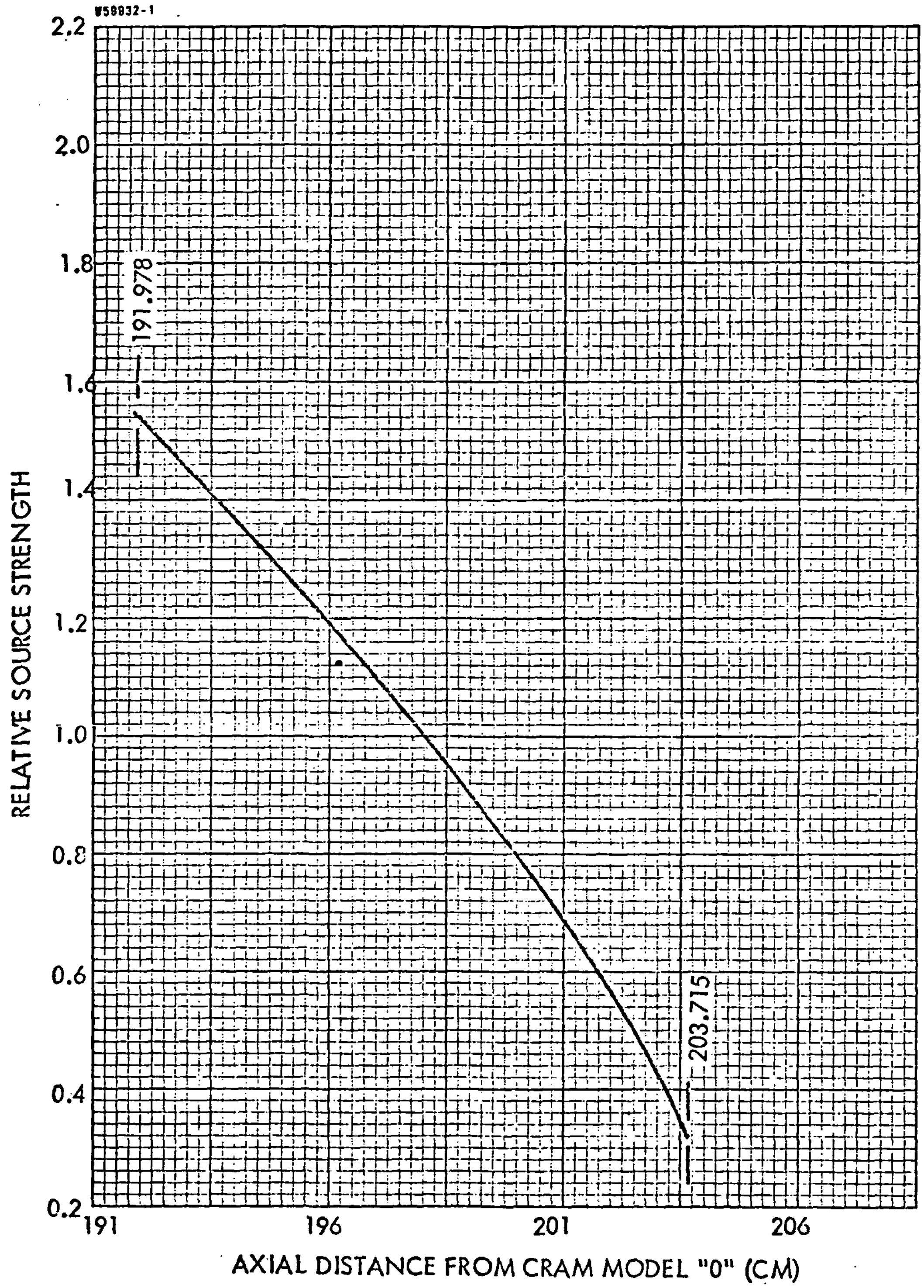


RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 19
FLOW BAFFLE I

FIGURE 39

FIGURE 40
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 20
FORWARD REFLECTOR PLENUM I



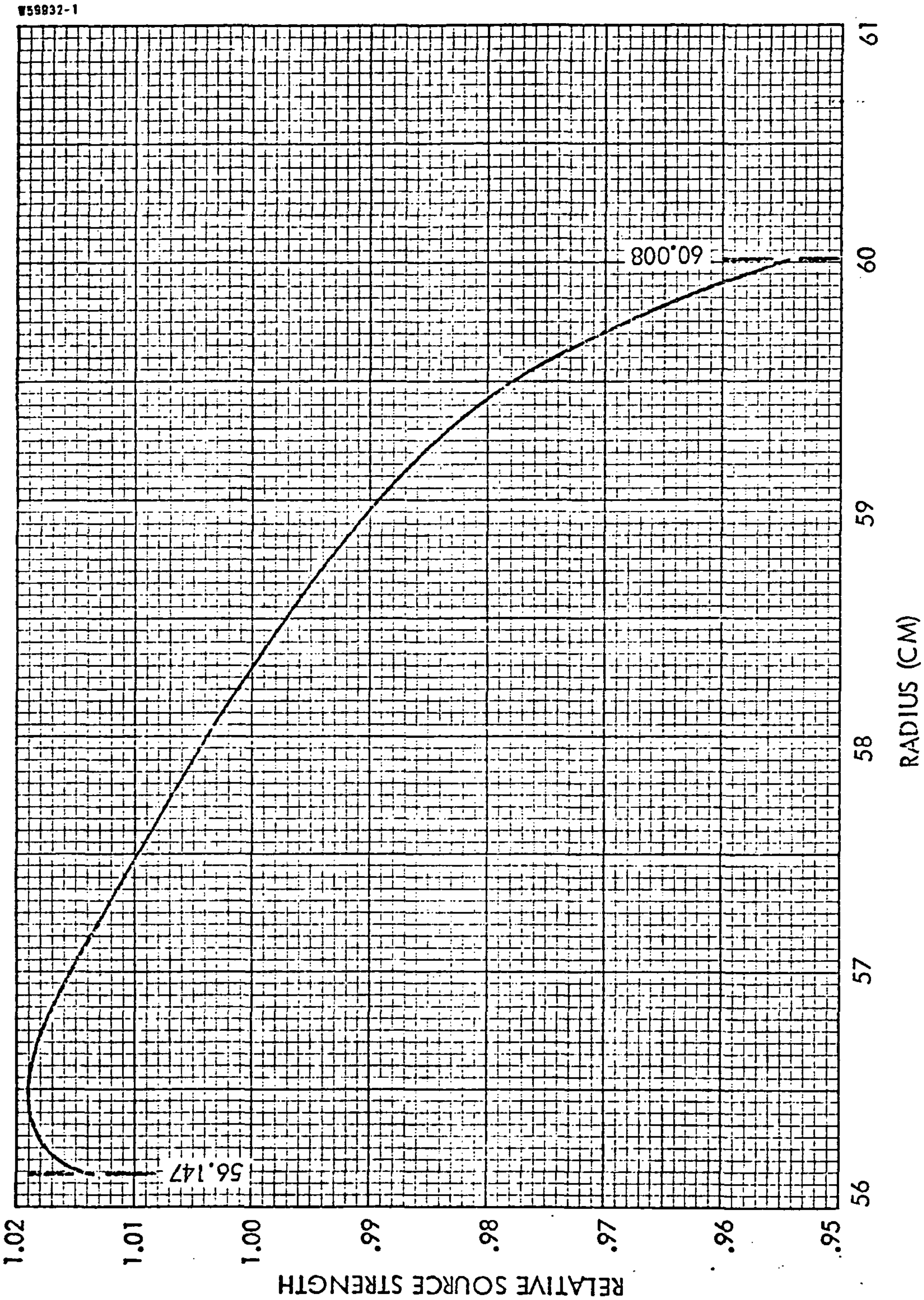


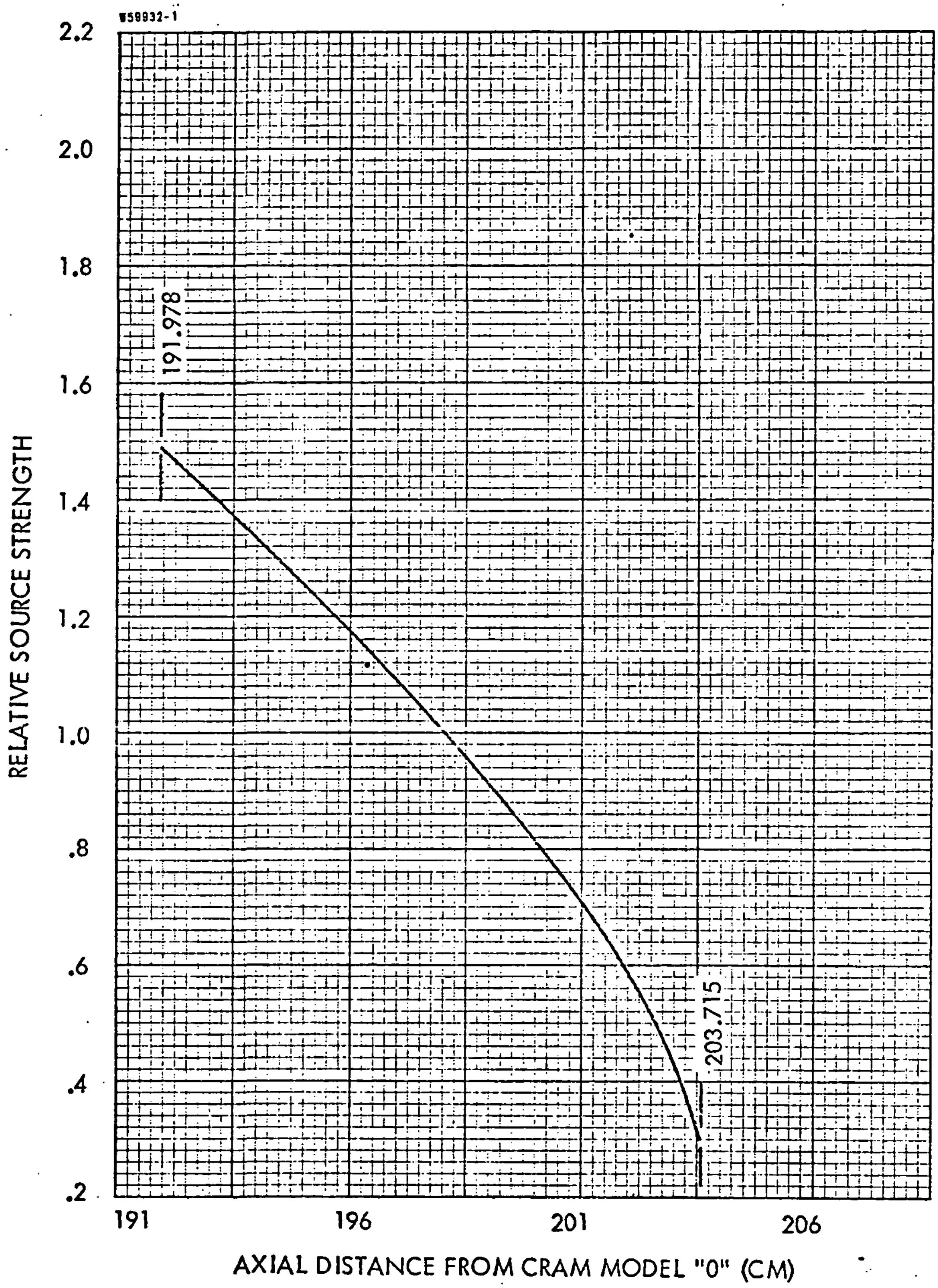
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 20
FORWARD REFLECTOR PLENUM I

FIGURE 41

FIGURE 42

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 21
FORWARD REFLECTOR PLENUM II



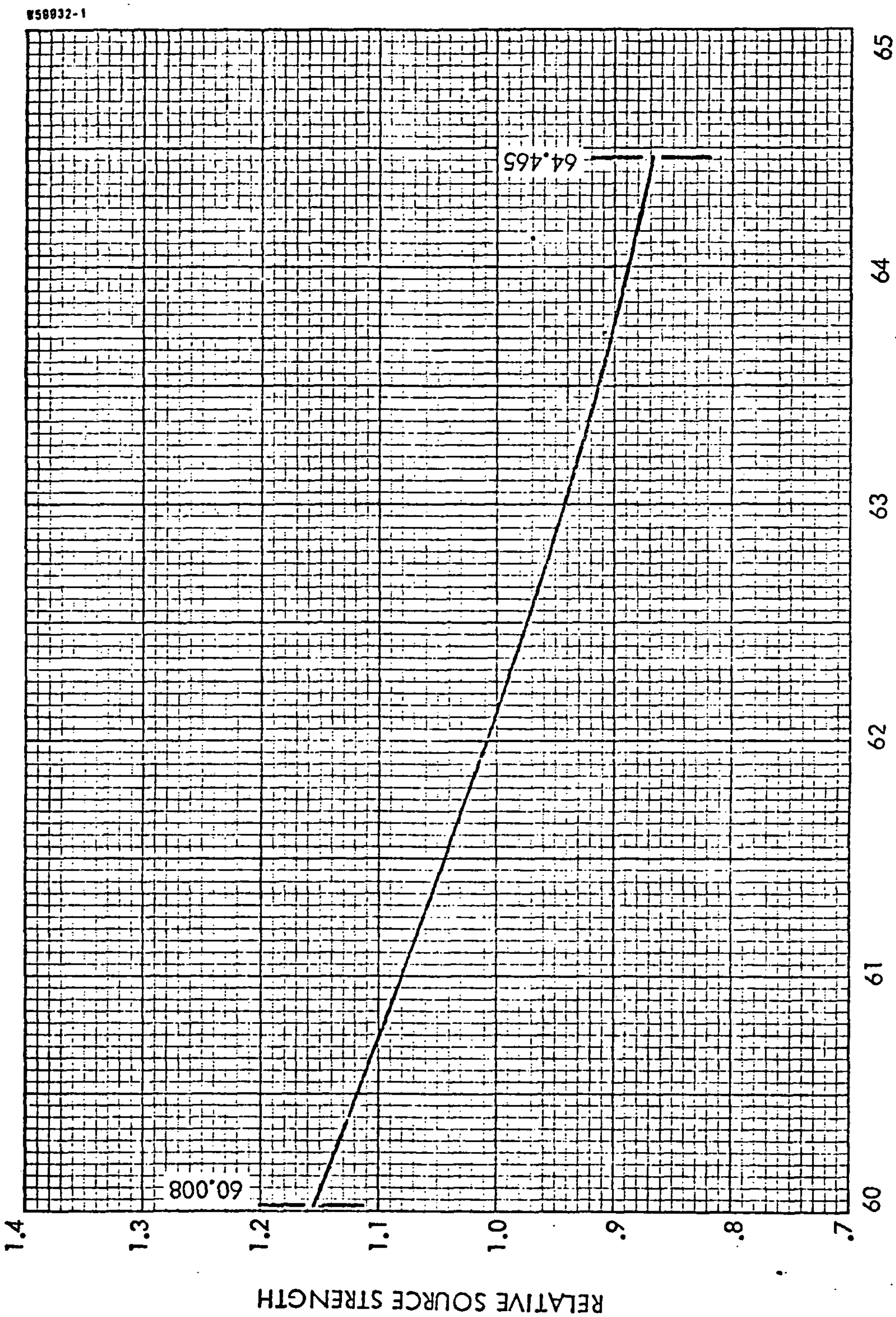


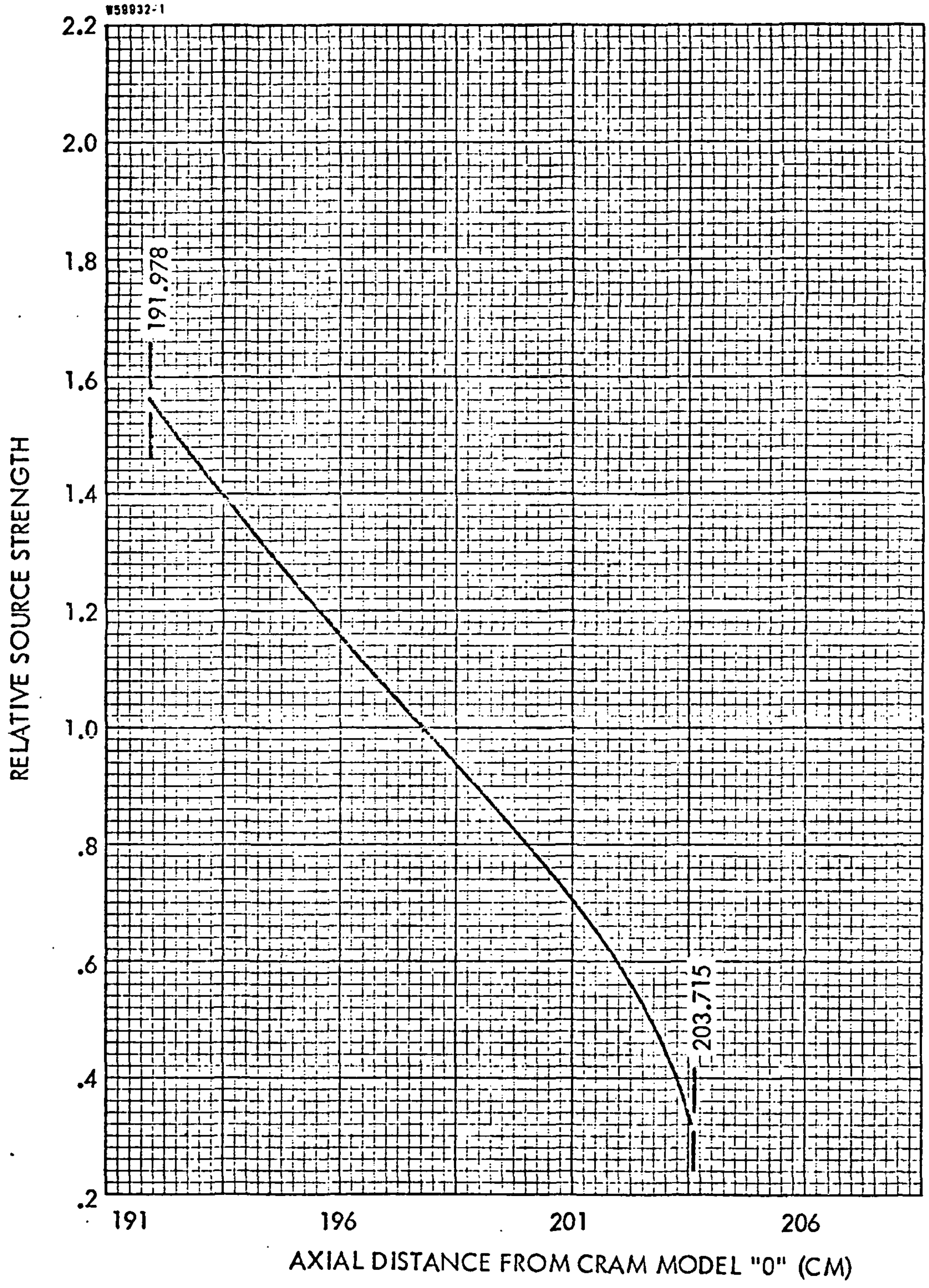
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURVE IN REGION 21
FORWARD REFLECTOR PLENUM II

FIGURE 43

FIGURE 44

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 22
FORWARD REFLECTOR PLENUM III

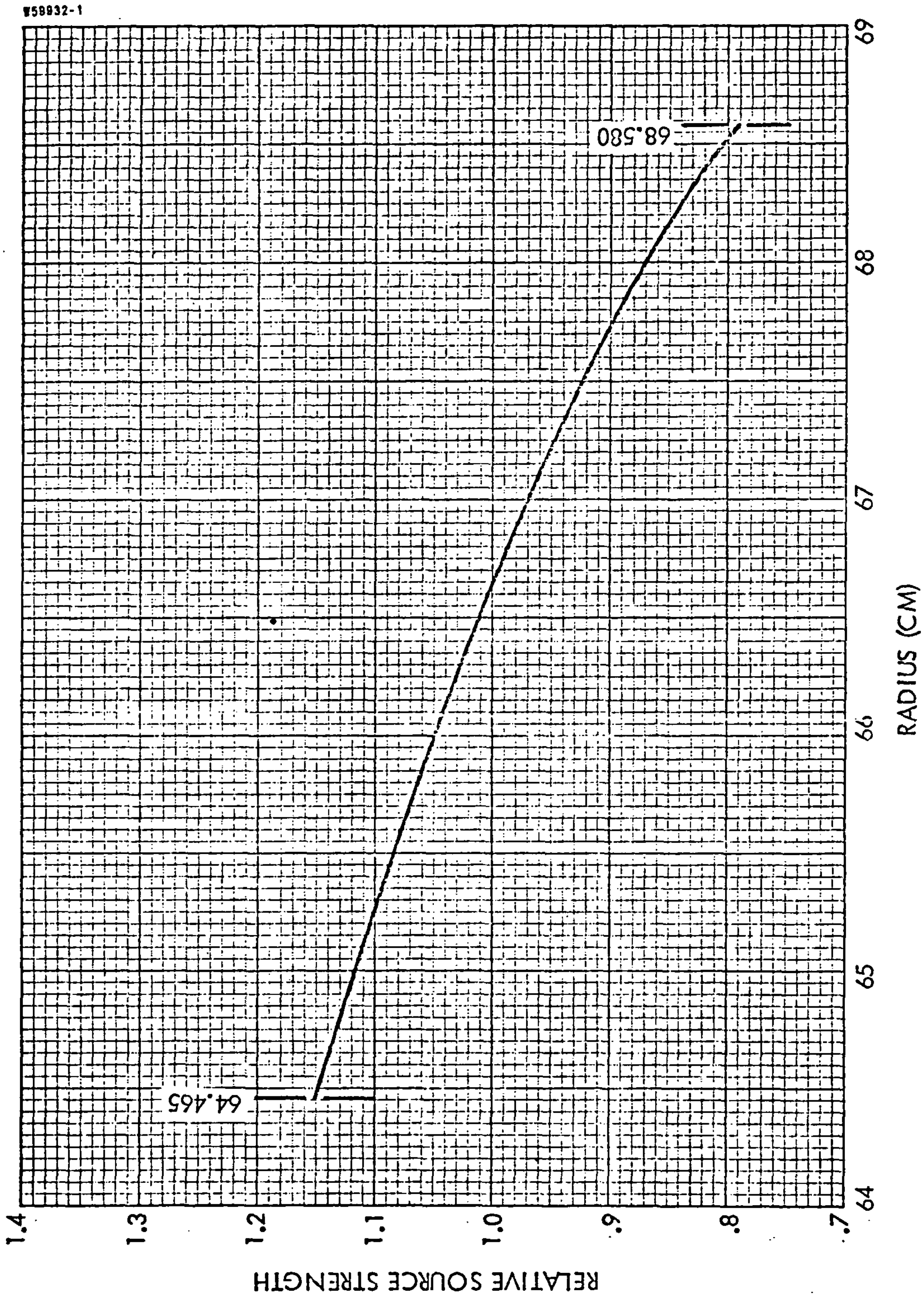


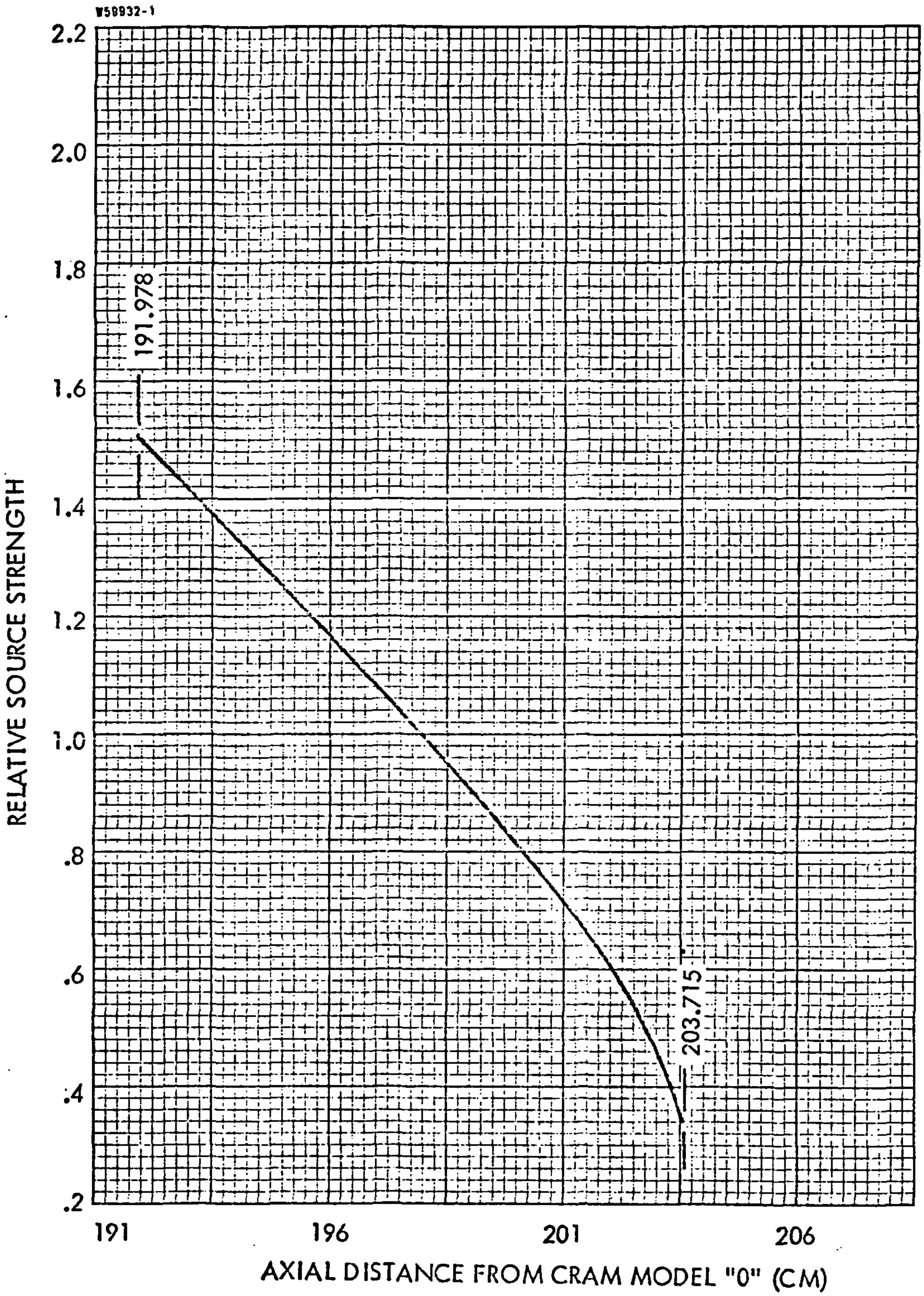


RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 22
FORWARD REFLECTOR PLENUM III

FIGURE 45

FIGURE 46
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 23
FORWARD REFLECTOR PLENUM IV





RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 23
FORWARD REFLECTOR PLENUM IV

FIGURE 47

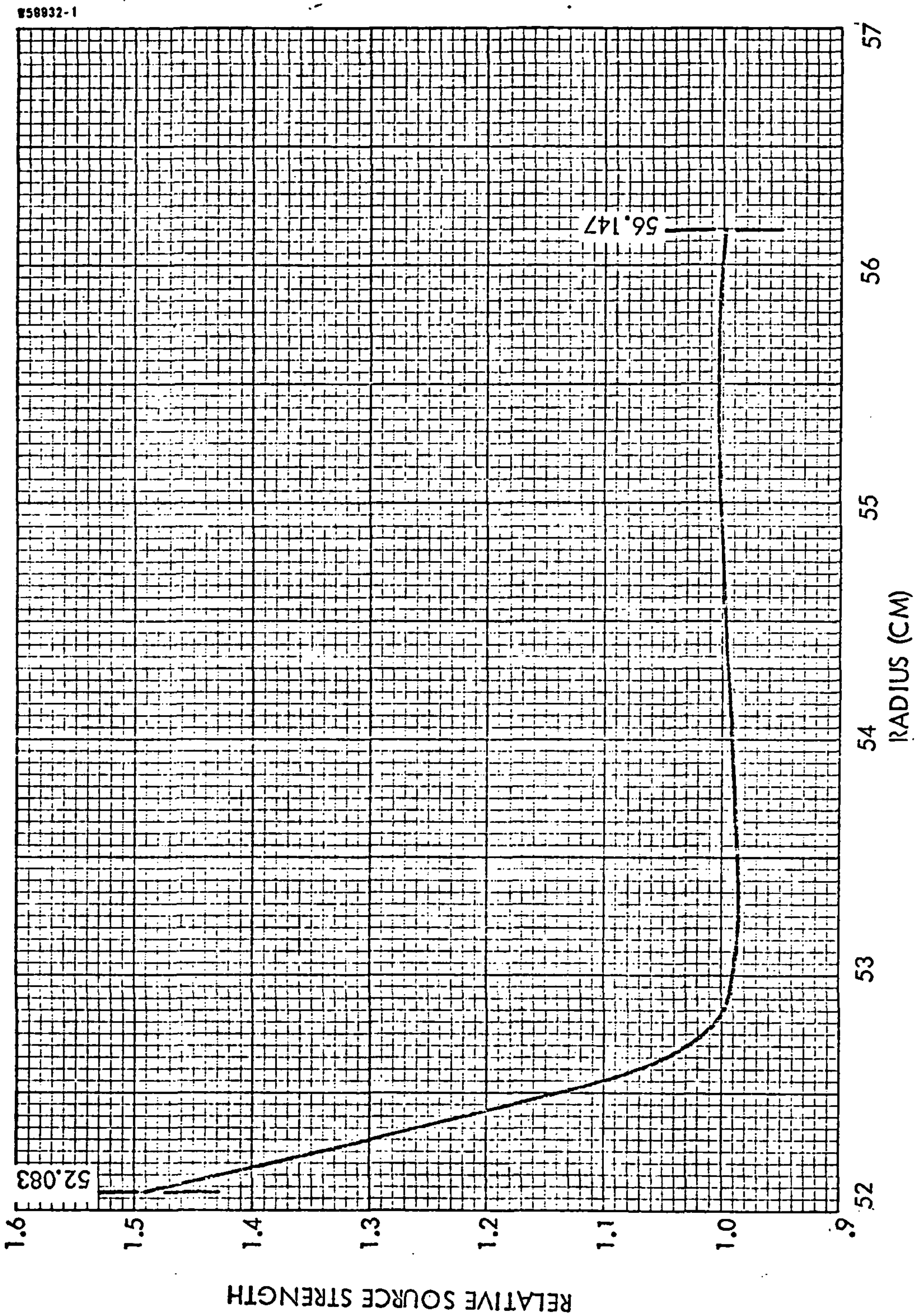


FIGURE 48
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 24
PERIPHERAL SHIELD 1

2 4

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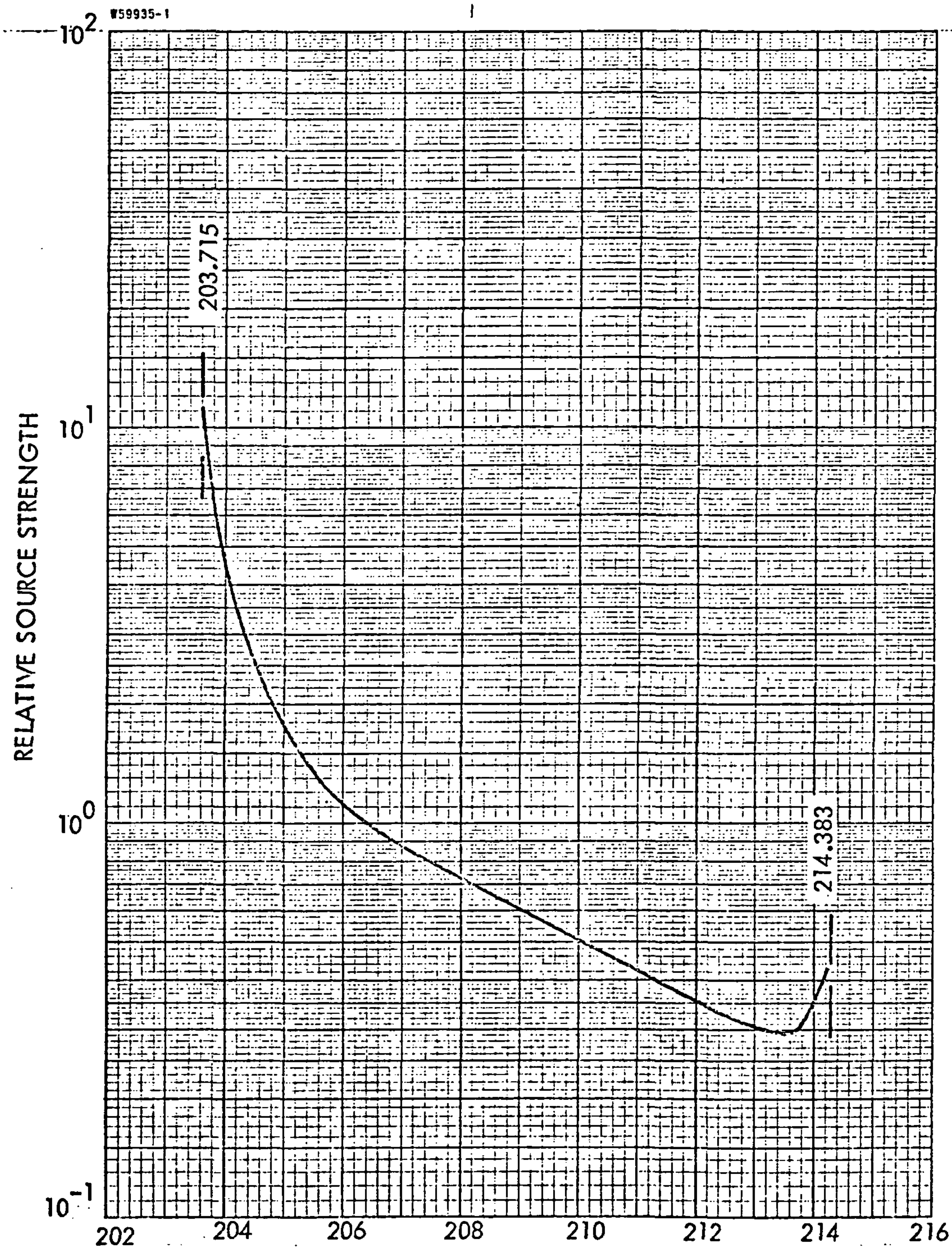
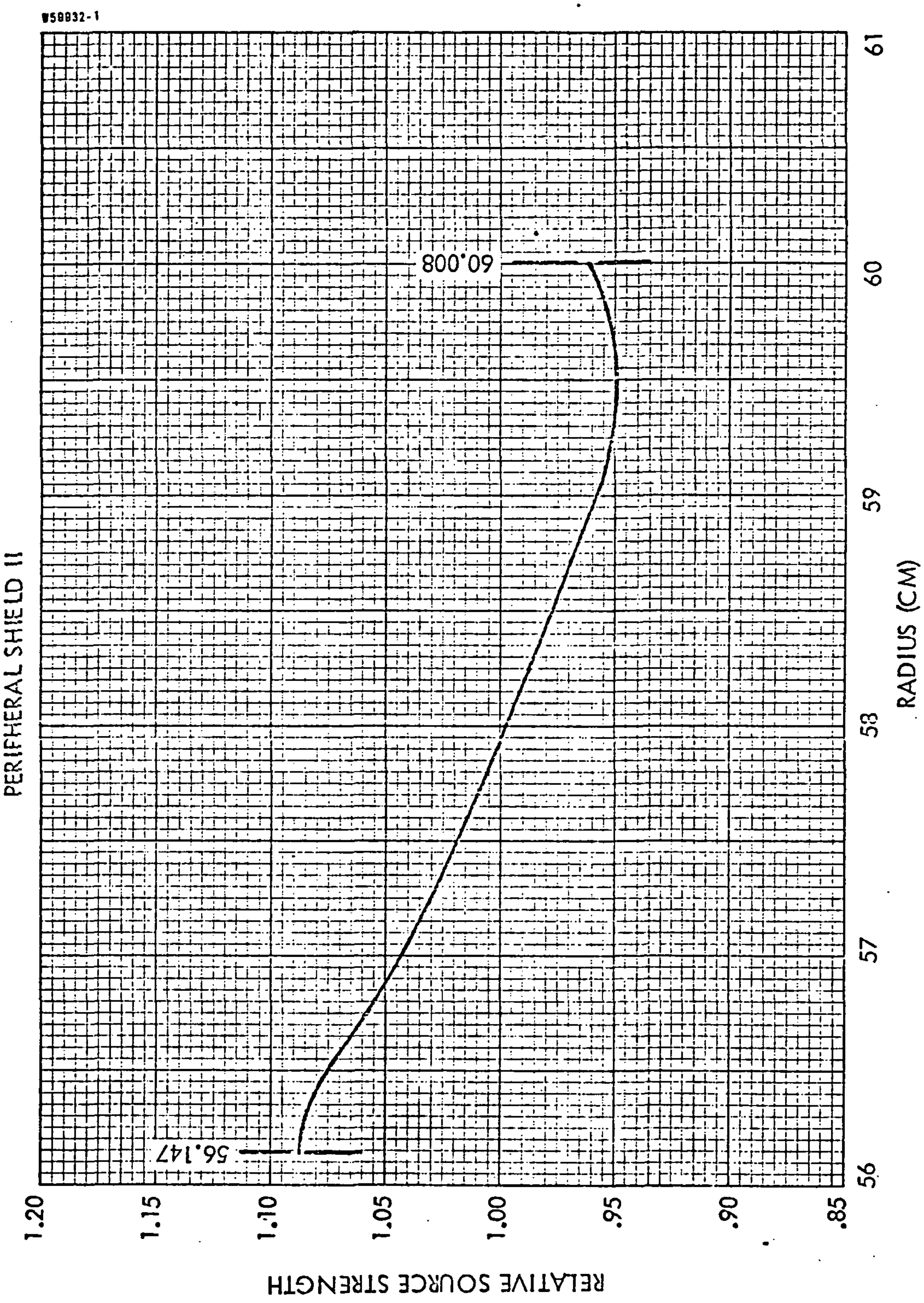


RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 24
PERIPHERAL SHIELD I

FIGURE 49

FIGURE 50

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 25
PERIPHERAL SHIELD II



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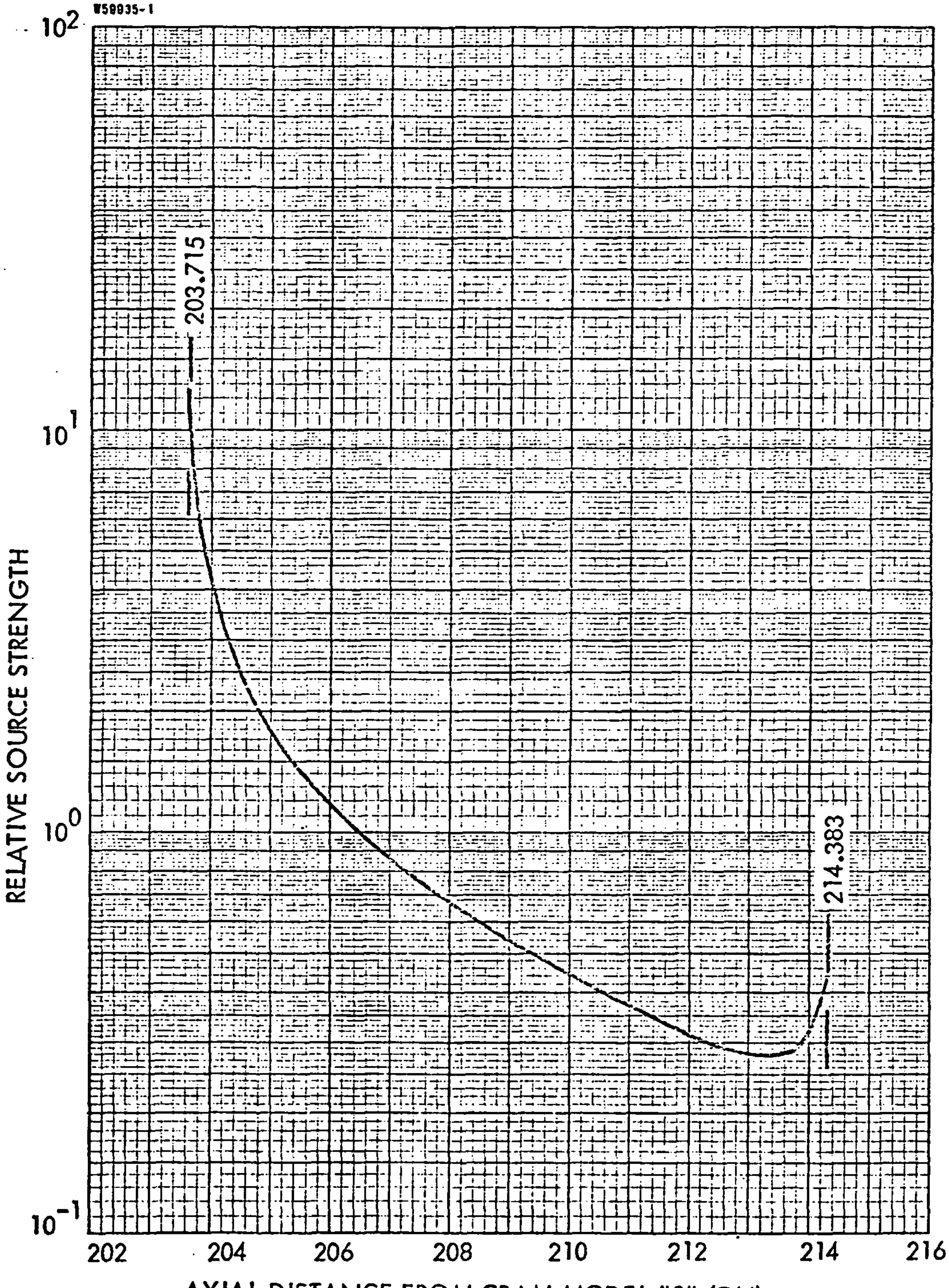


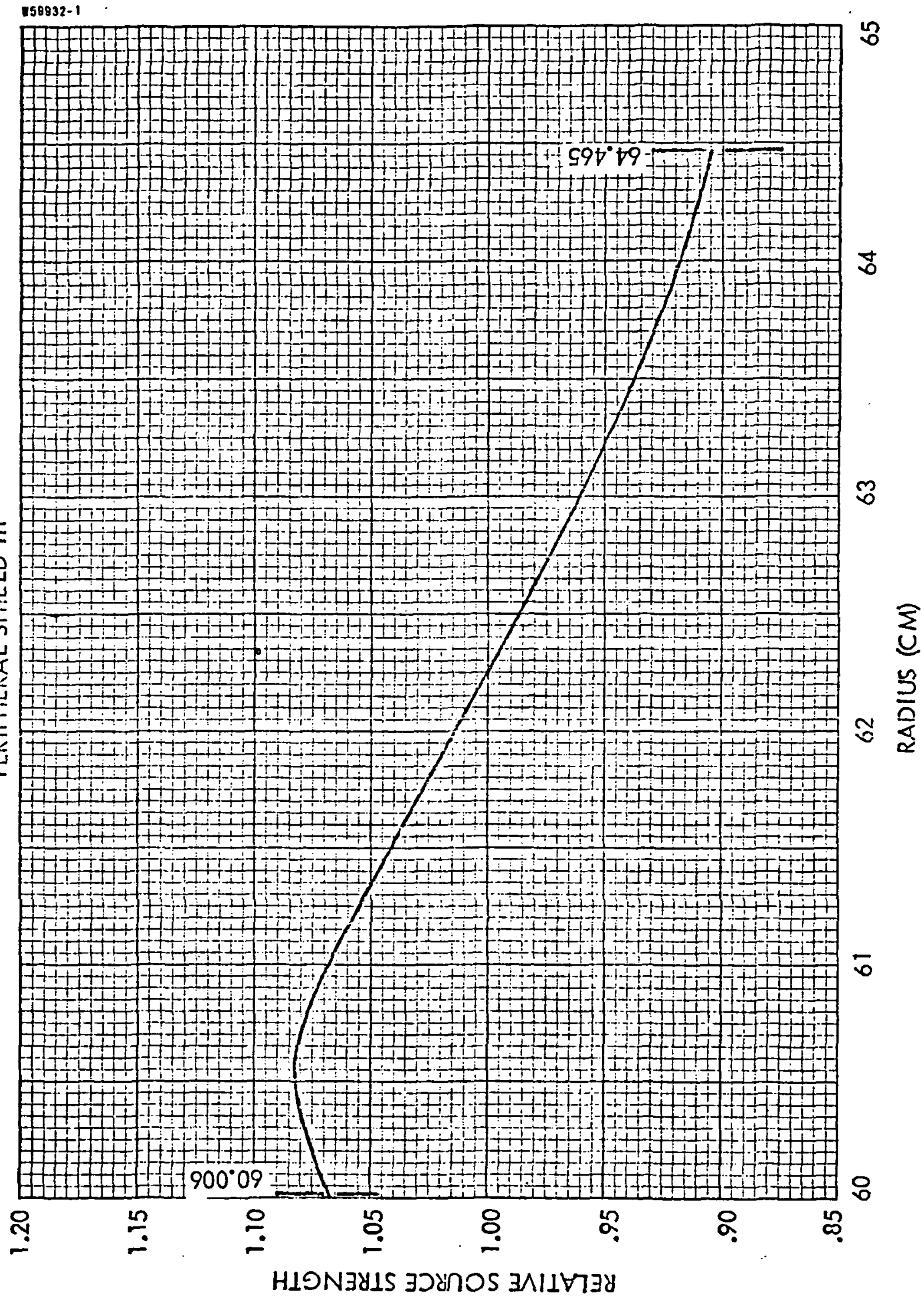
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 25
PERIPHERAL SHIELD II

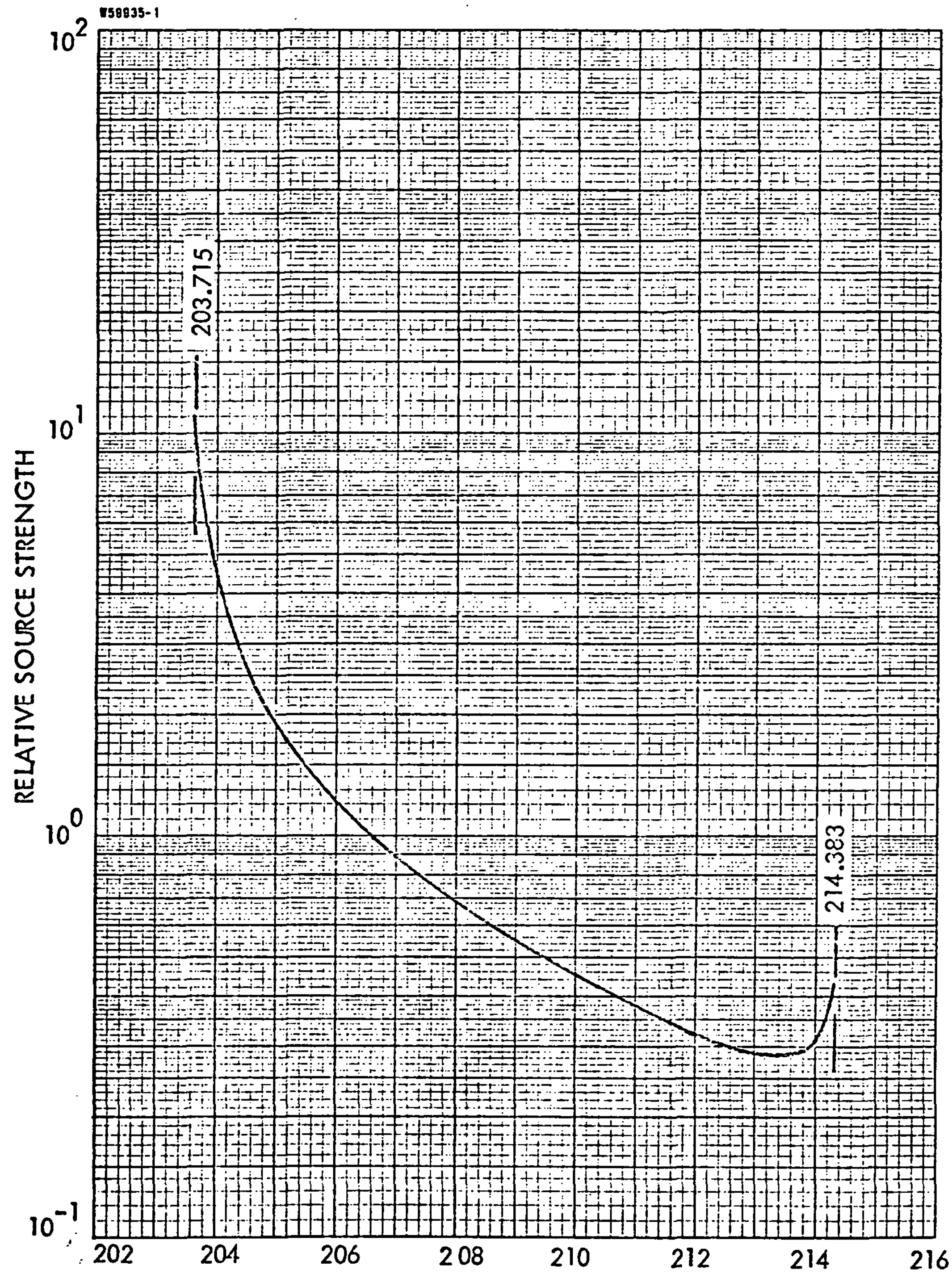
FIGURE 51

FIGURE 52

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 26

PERIPHERAL SHIELD III





RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 26
PERIPHERAL SHIELD III

FIGURE 53

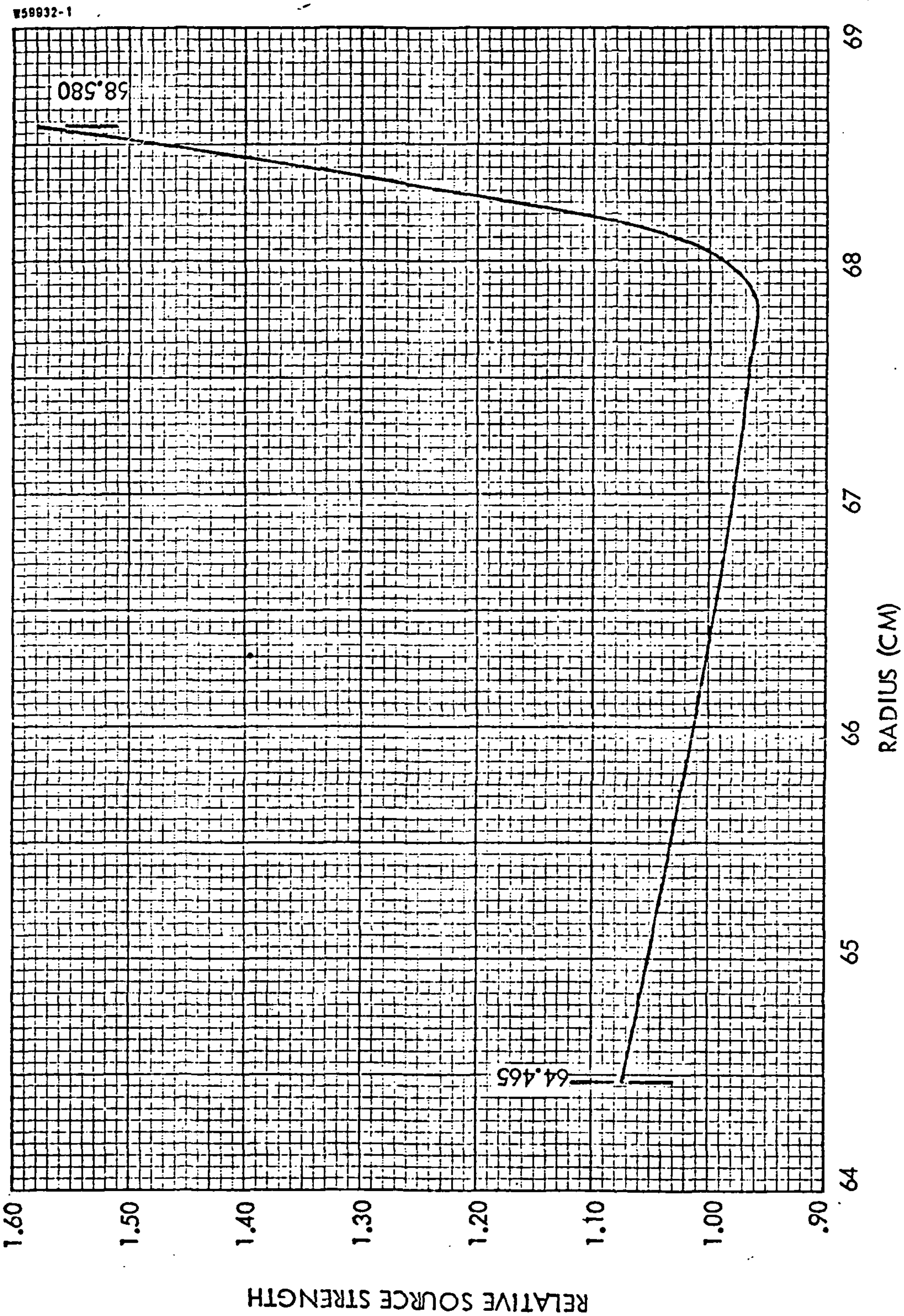
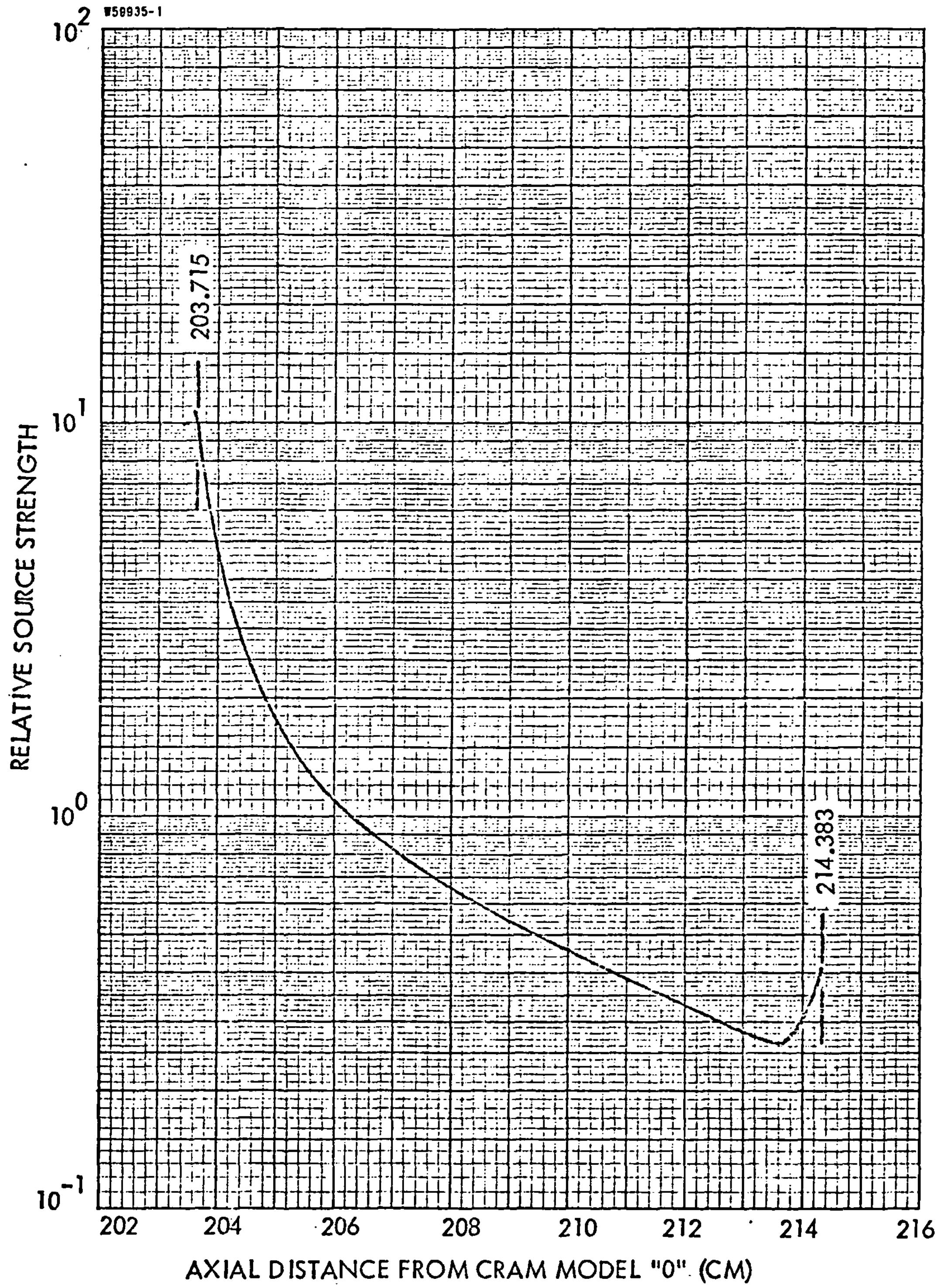


FIGURE 54
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 27
PERIPHERAL SHIELD IV



RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 27
PERIPHERAL SHIELD IV

FIGURE 55

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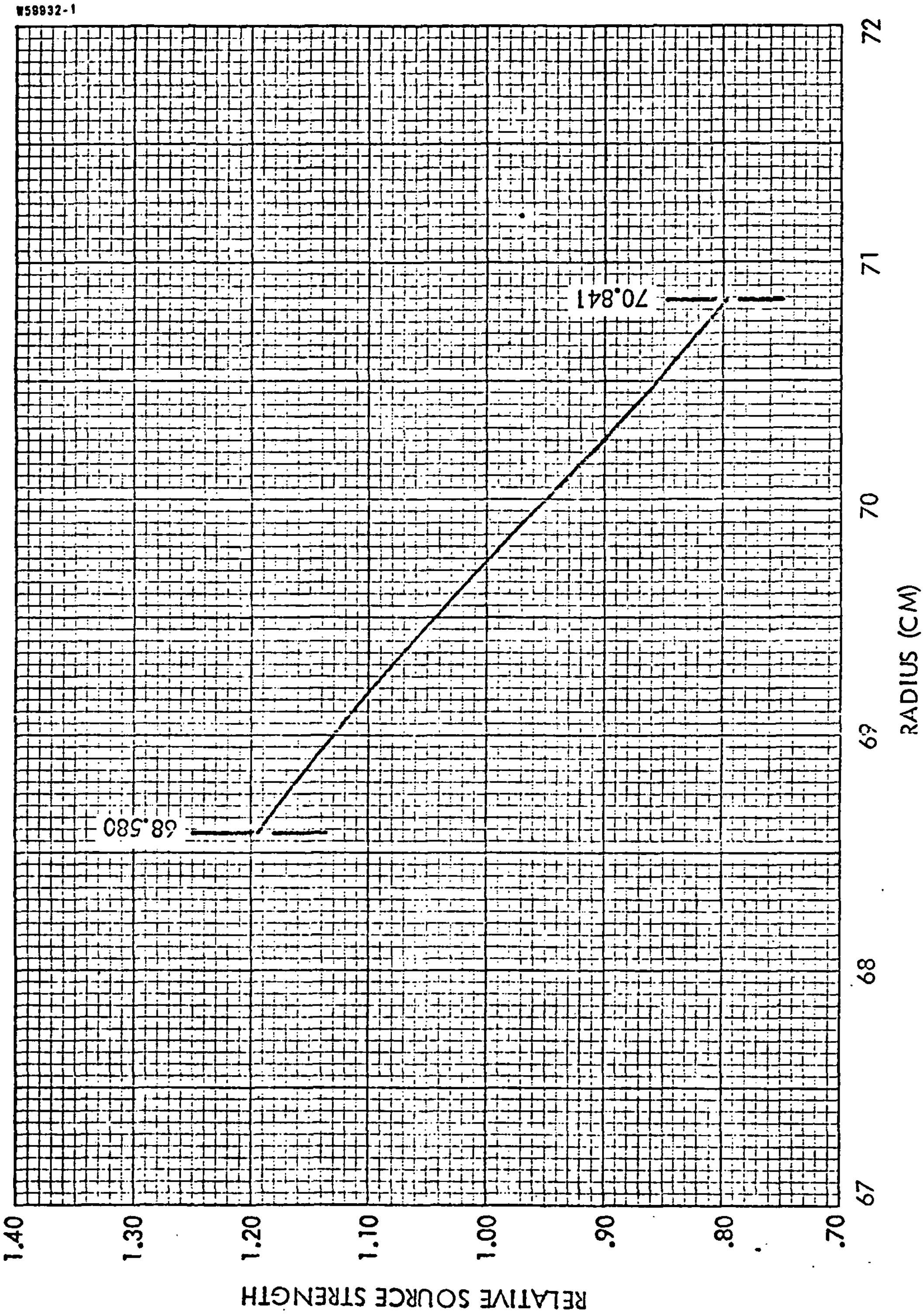
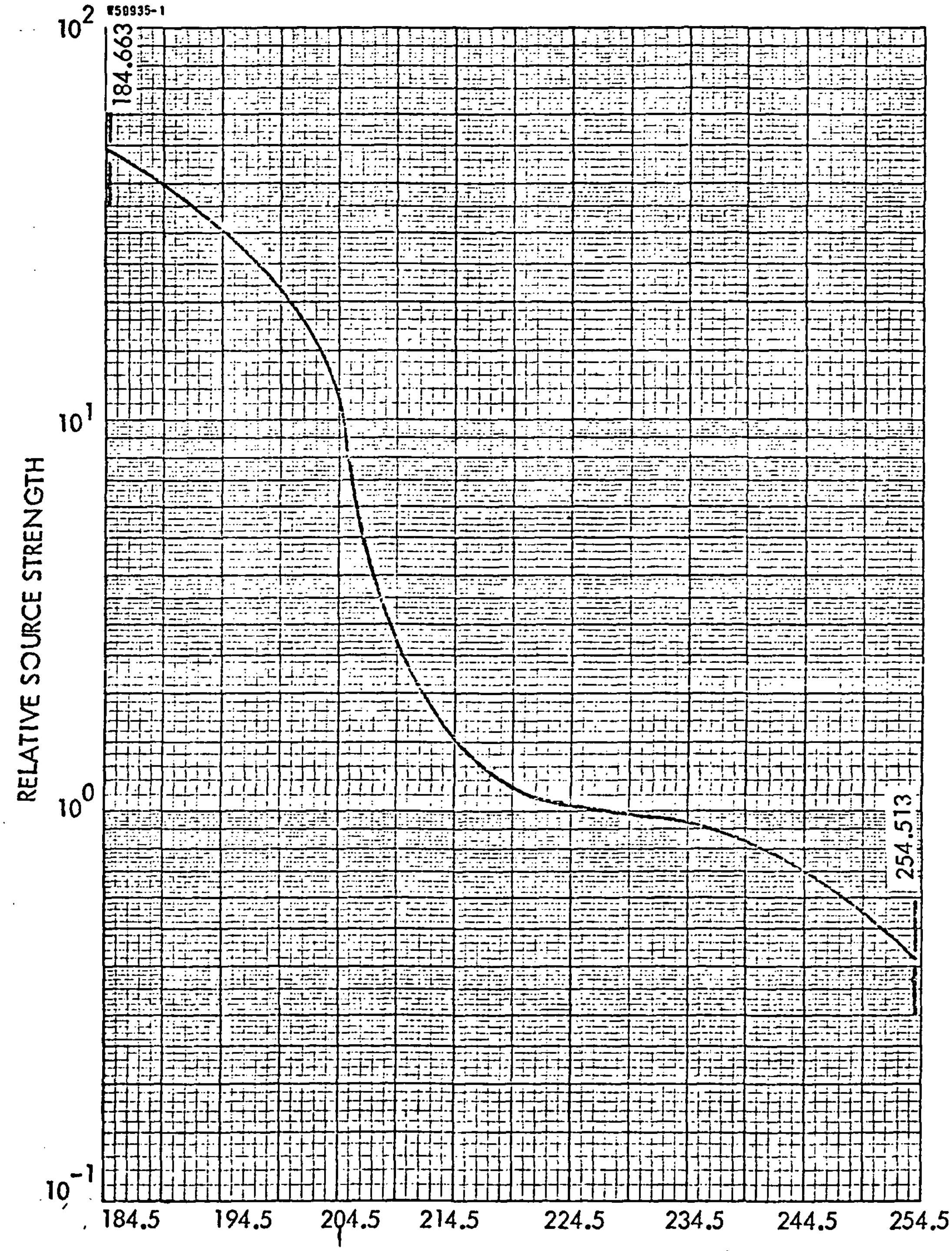
FIGURE 56

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 28

PRESSURE VESSEL SIDE-B





RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 28
PRESSURE VESSEL SIDE-B

FIGURE 57

FIGURE 58
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 29
LEAD CENTRAL SHIELD

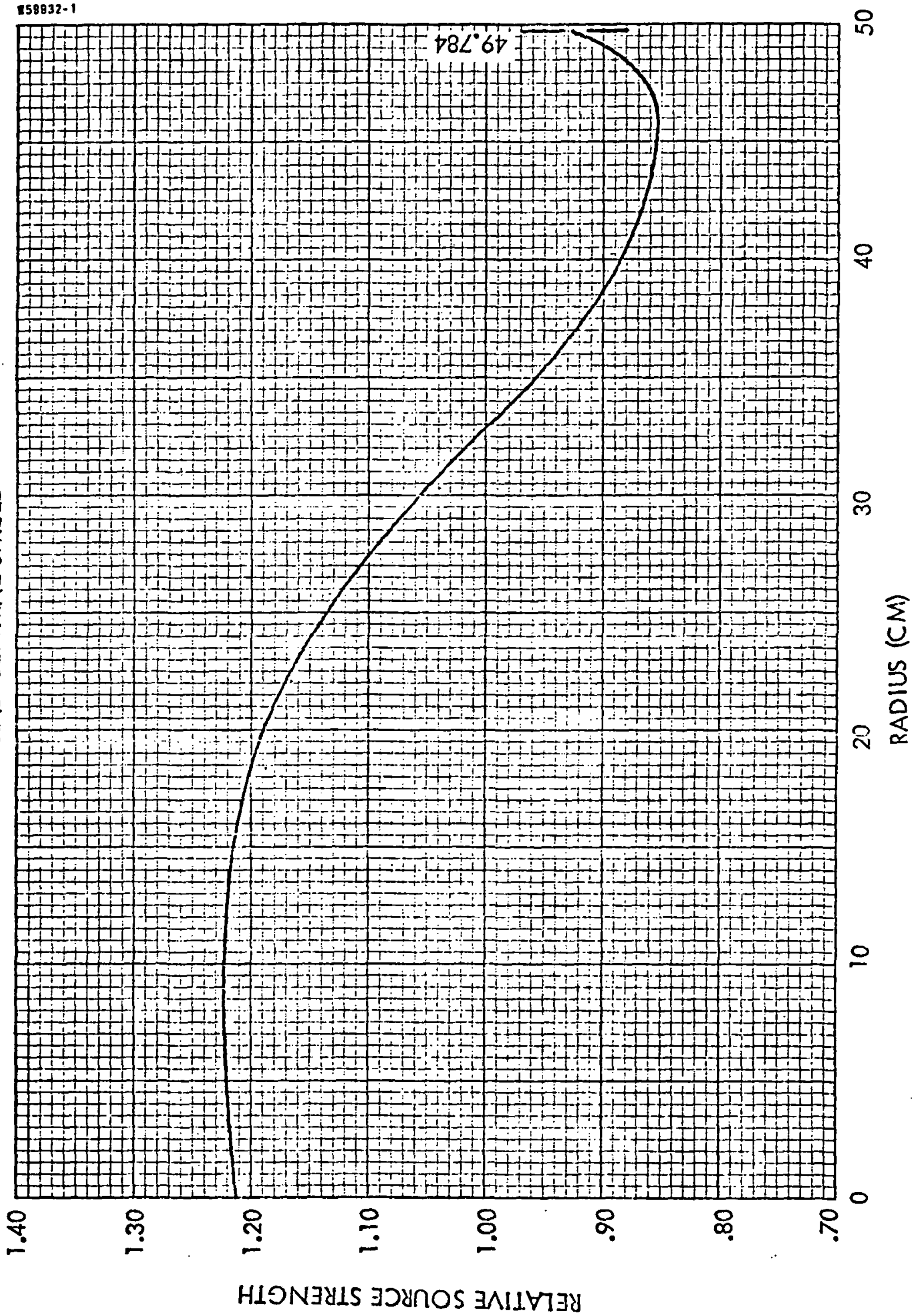
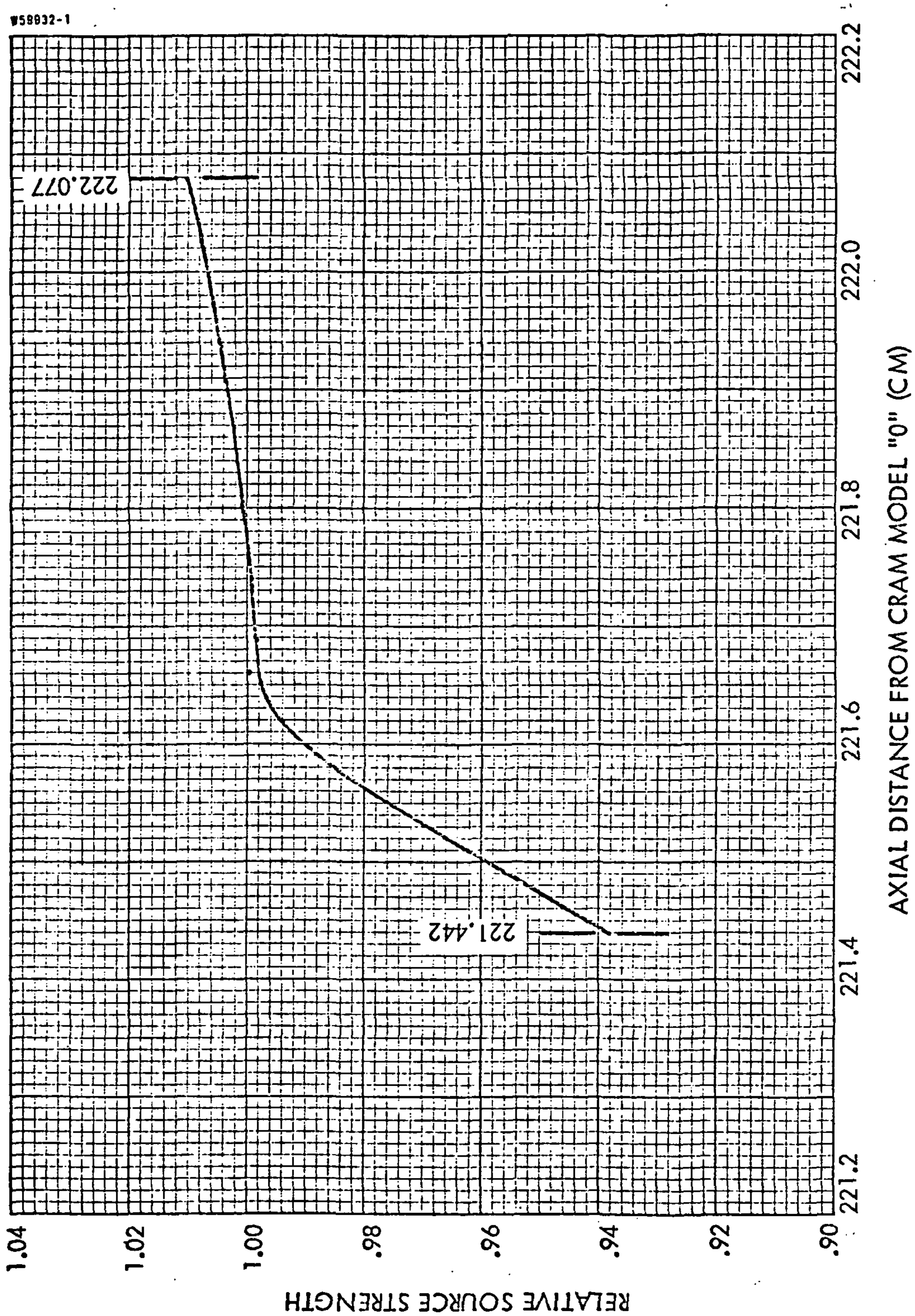


FIGURE 59
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 29
LEAD CENTRAL SHIELD



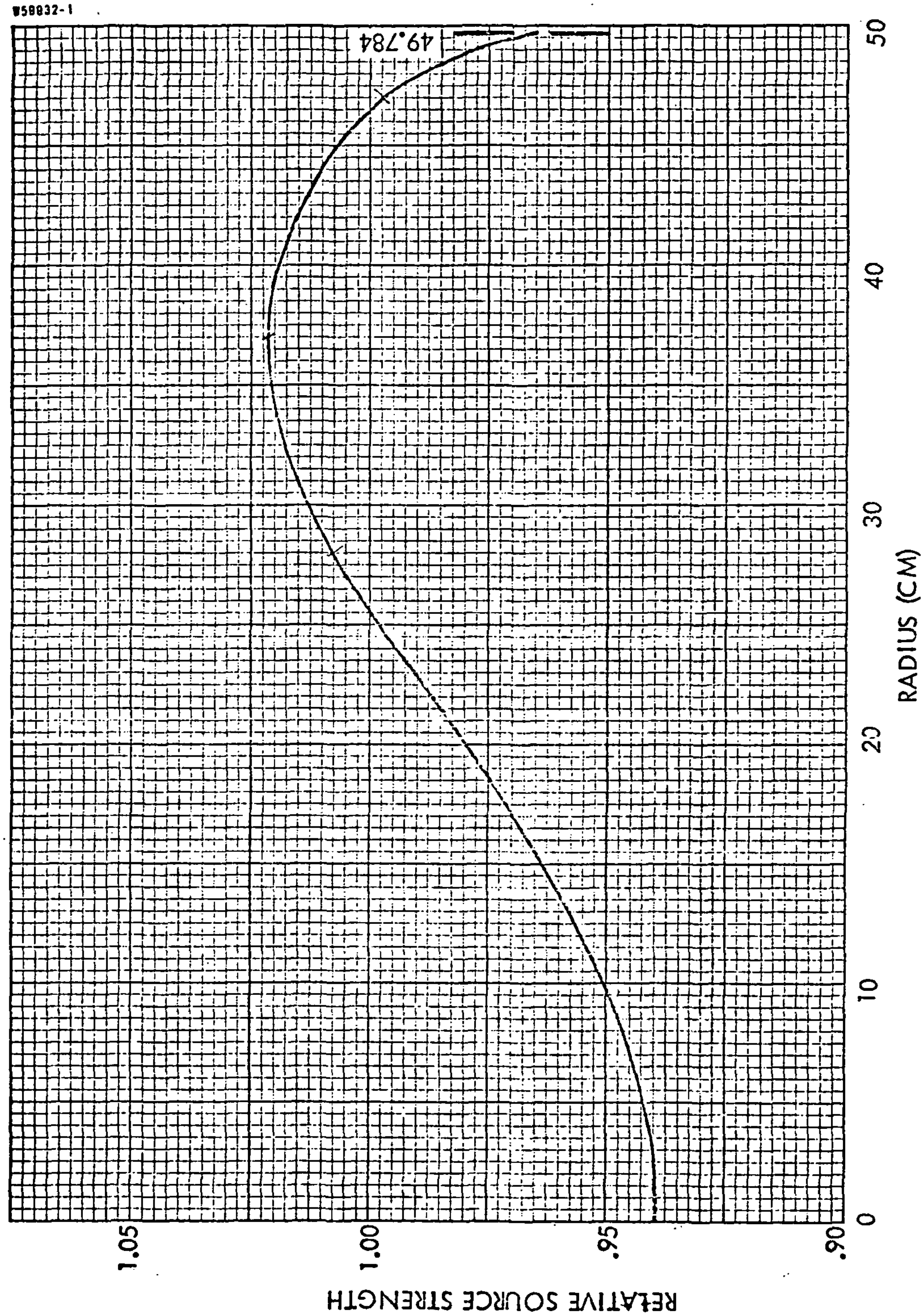


FIGURE 60
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 30
SHIELD PLENUM

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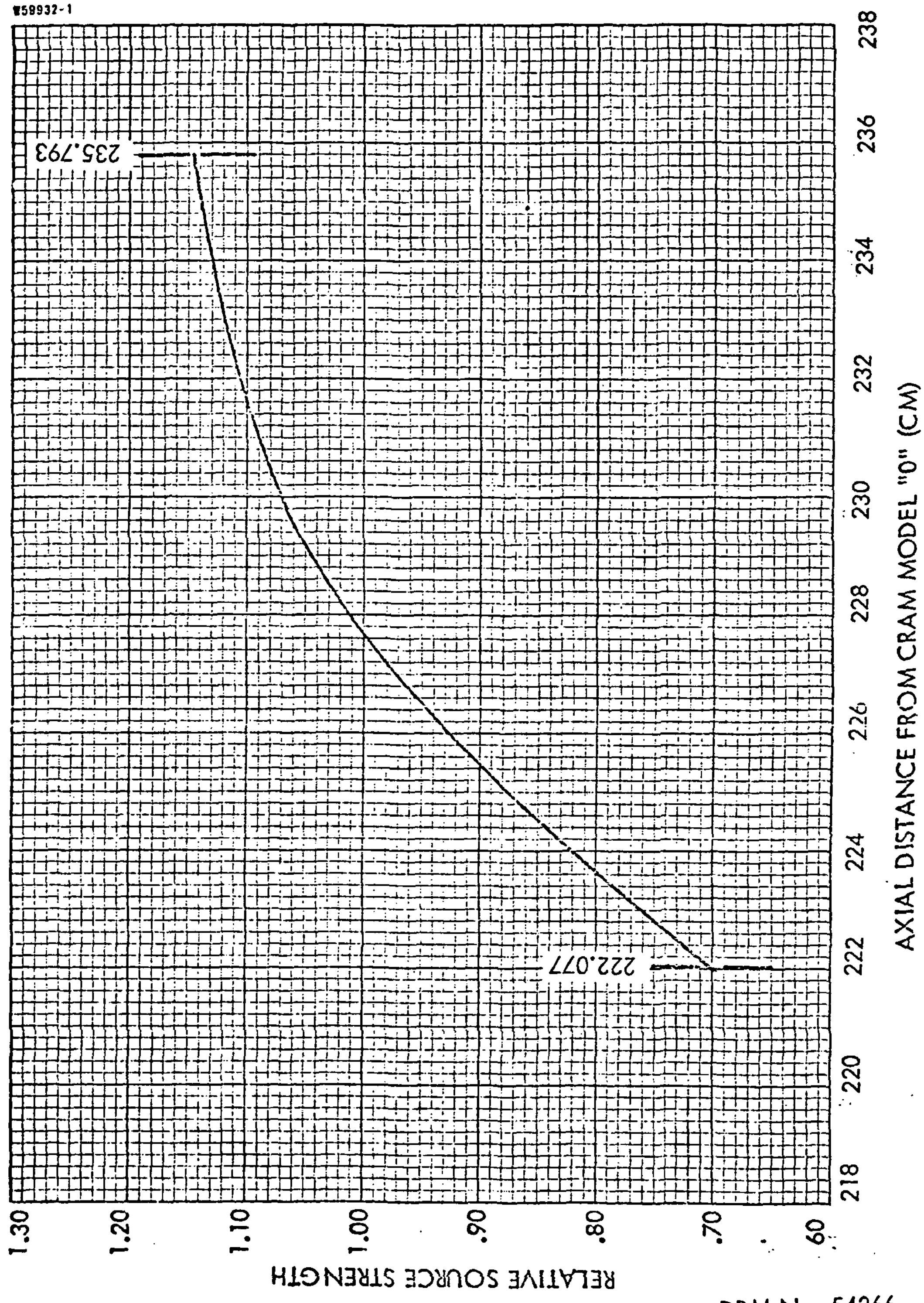
FIGURE 61
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 30
SHIELD PLENUM



E

FIGURE 62

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 31
FLOW BAFFLE II

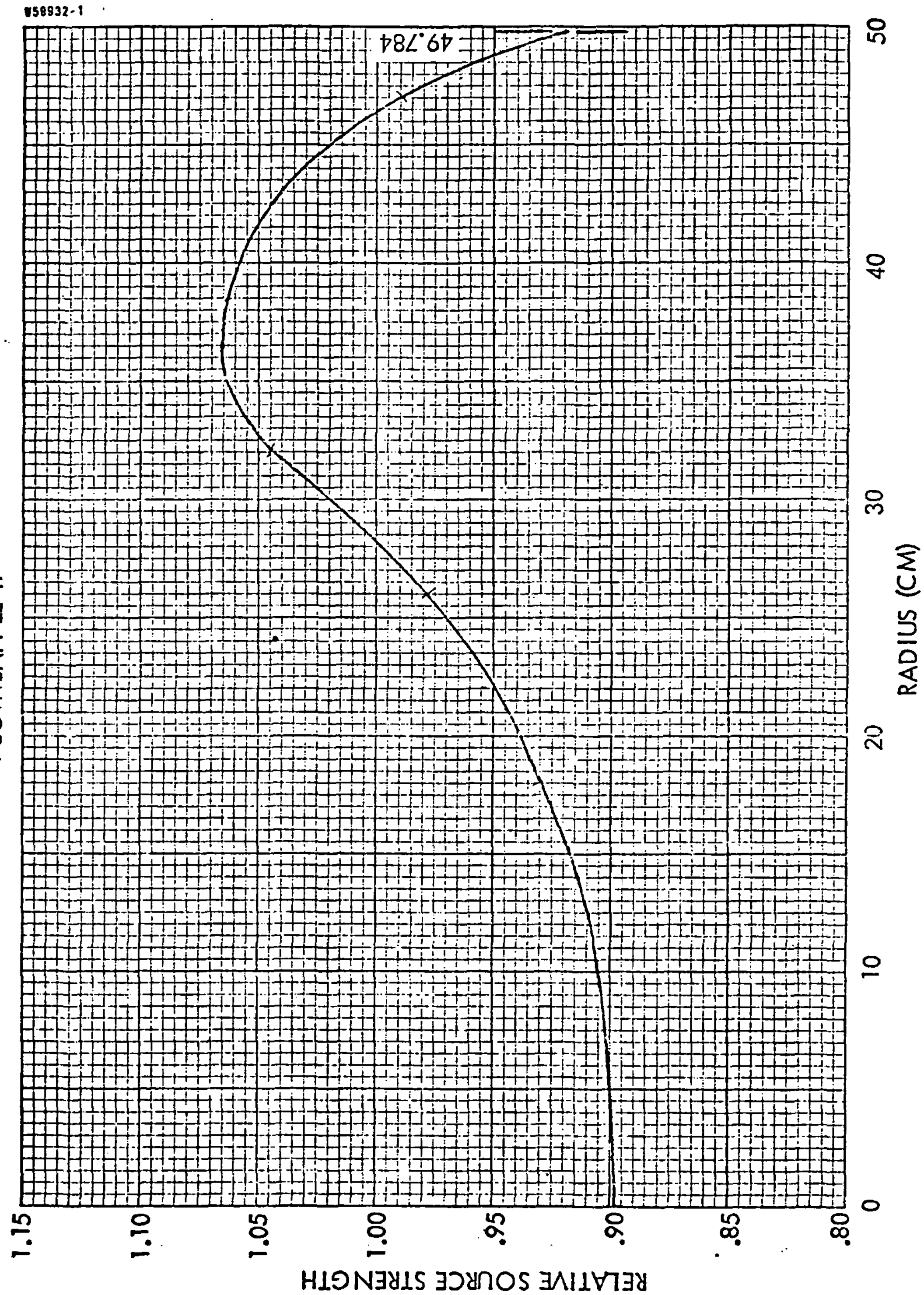


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FIGURE 63

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 31
FLOW BAFFLE II

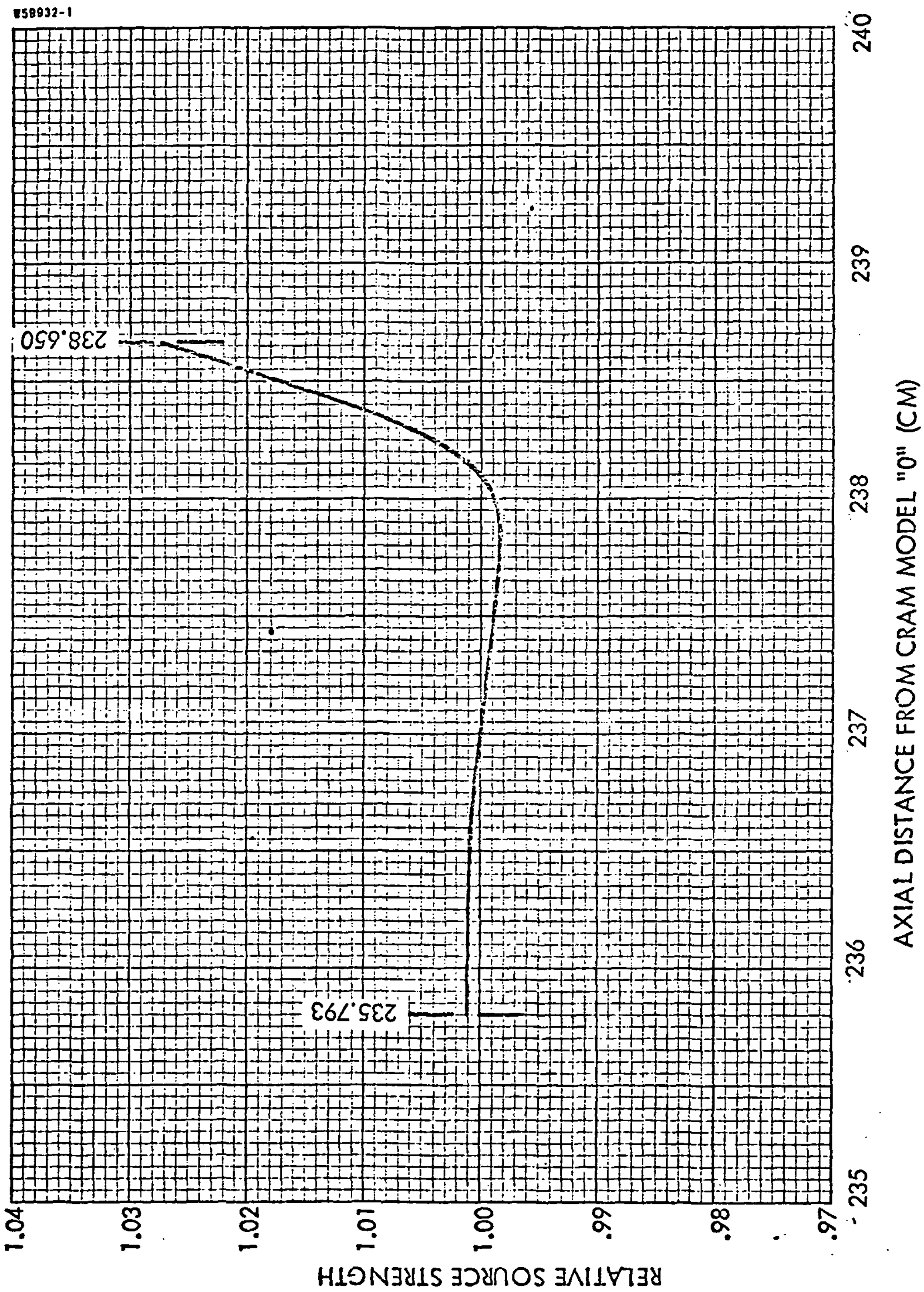

FIGURE 64

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 32
CENTRAL DOME PLENUM

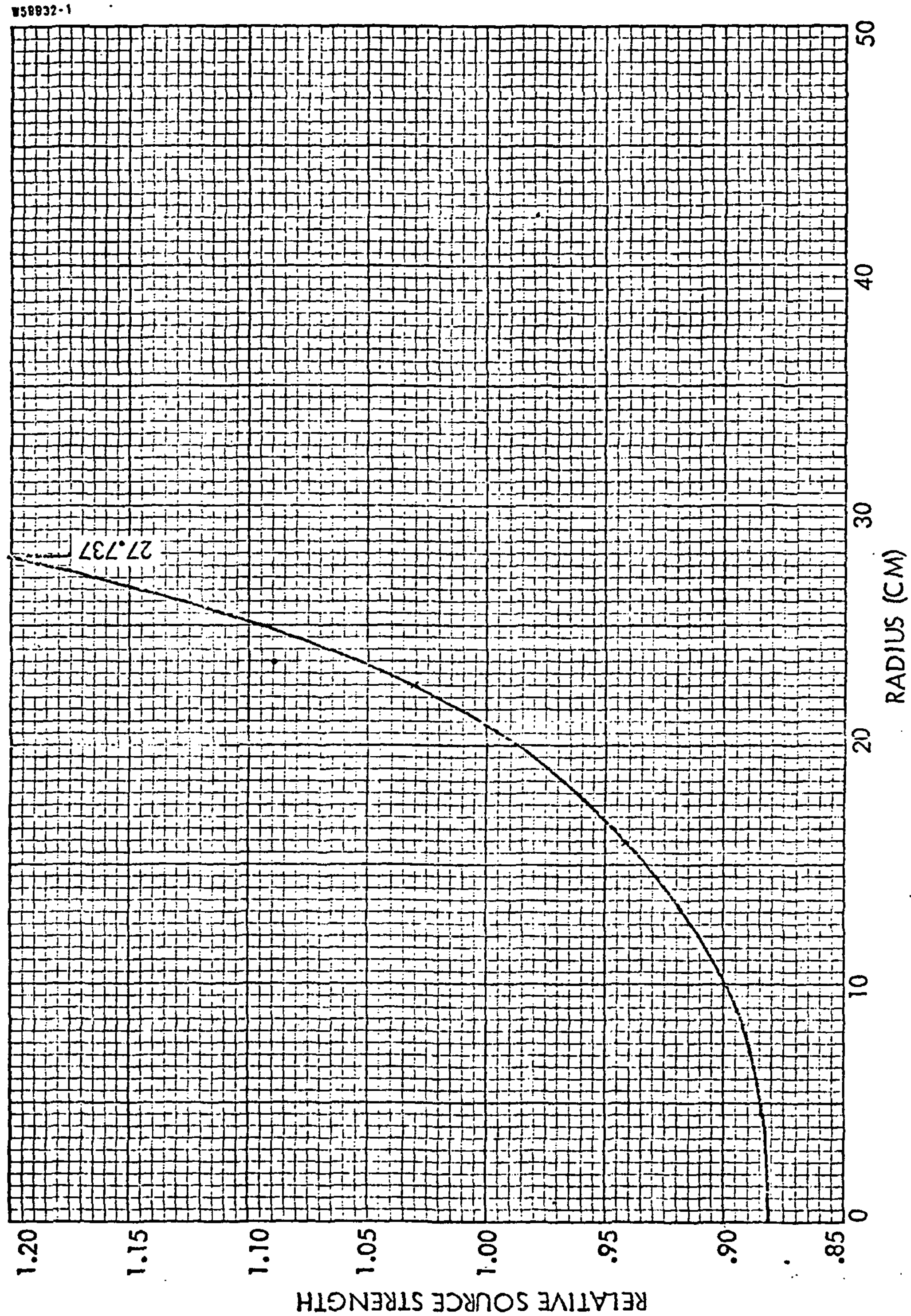

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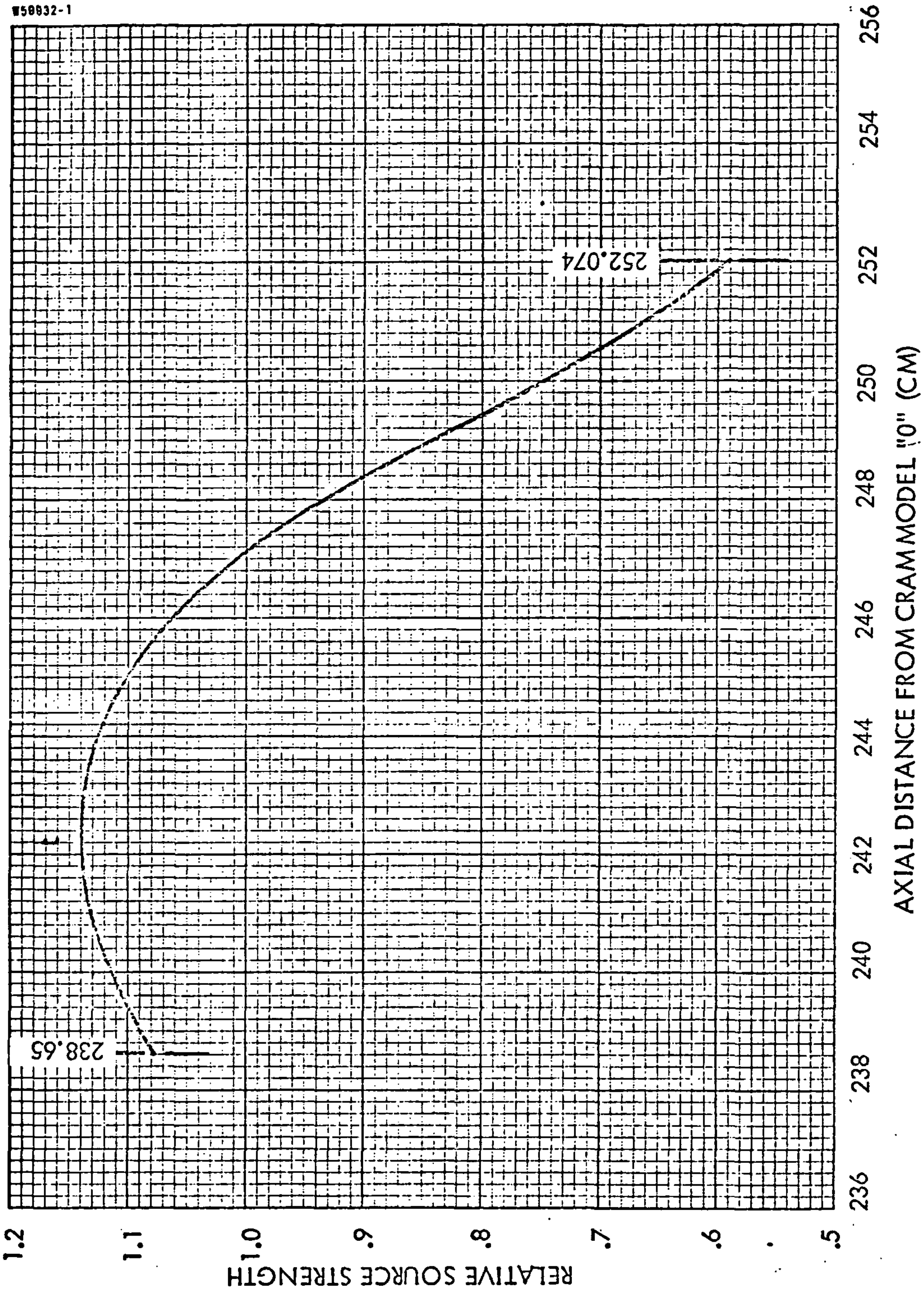
FIGURE 65
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 32
CENTRAL DOME PLENUM



W5PS32-1

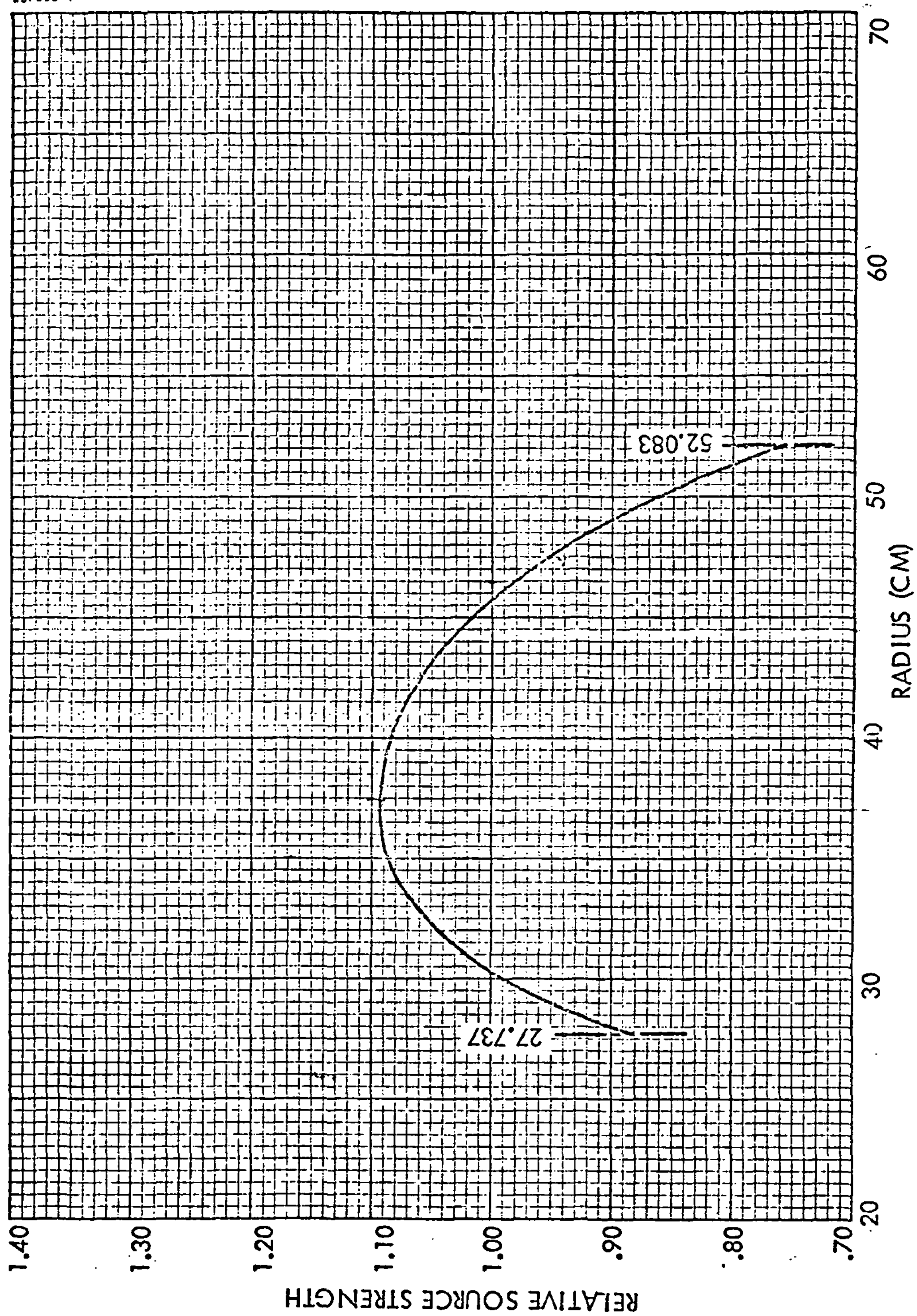


FIGURE 66

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 33
PERIPHERAL DOME PLENUM I

FIGURE 67
RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 33
PERIPHERAL DOME PLENUM I

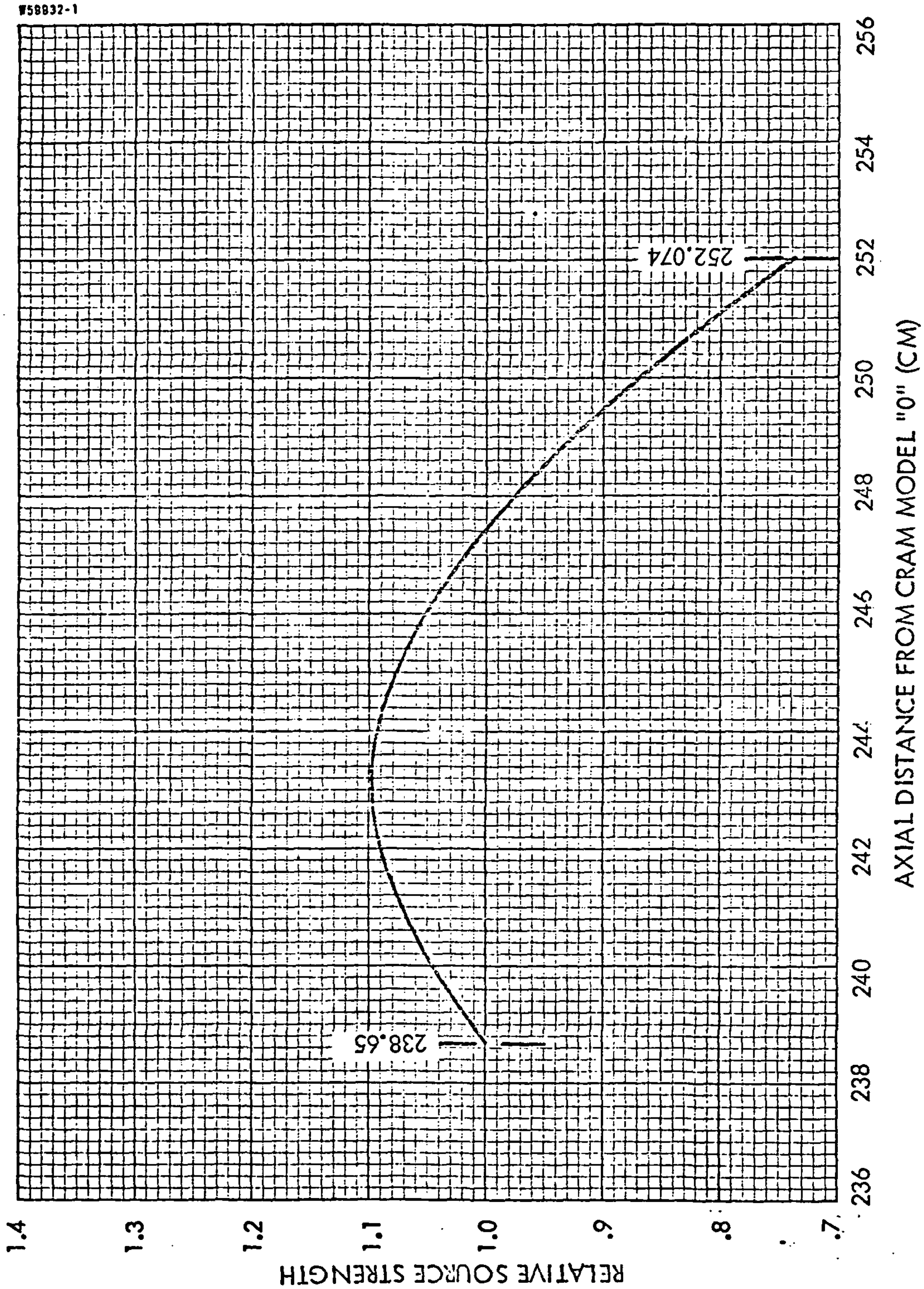


FIGURE 68

RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 34

PERIPHERAL SHIELD PLATE

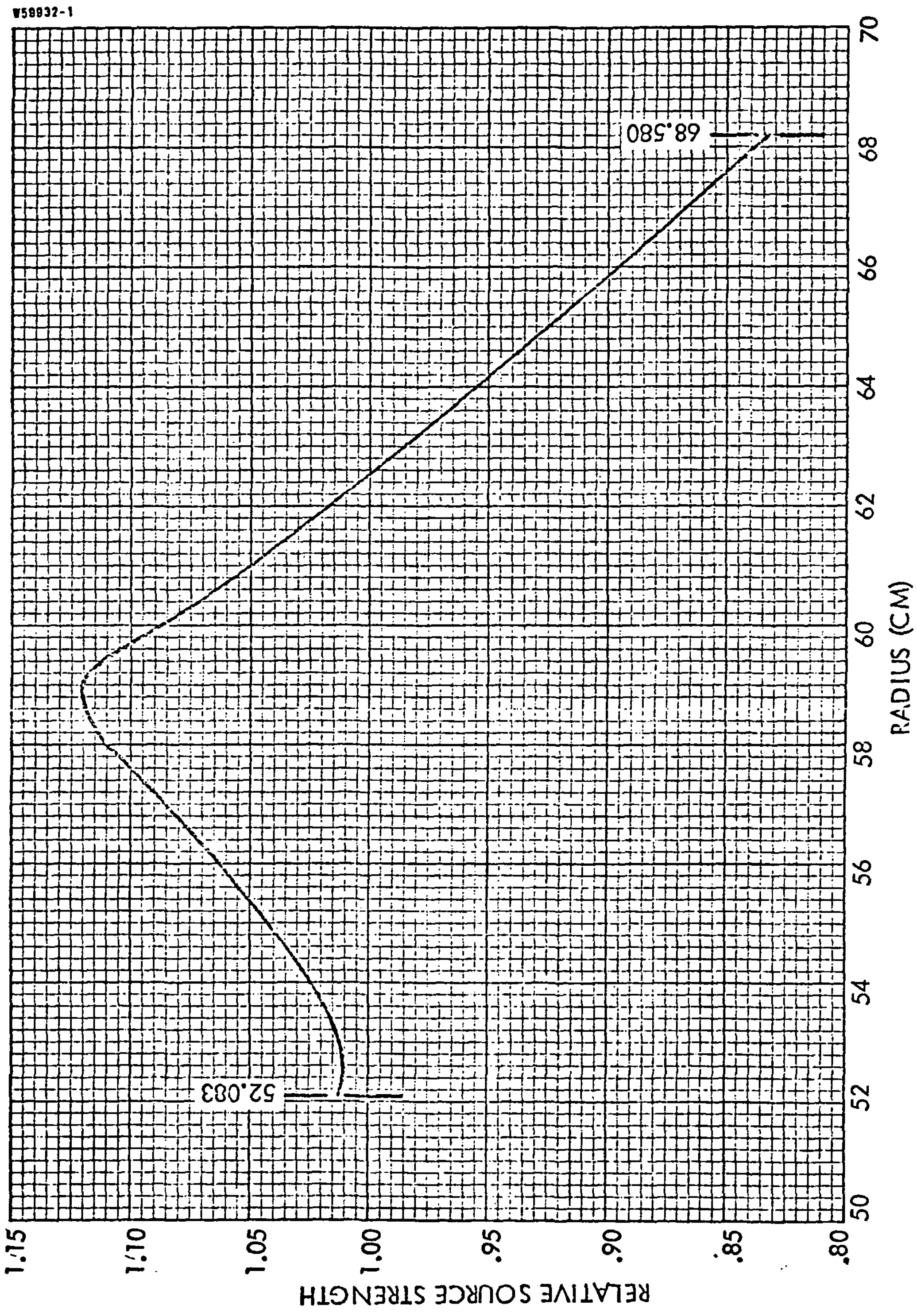


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FIGURE 69

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 34

PERIPHERAL SHIELD PLATE

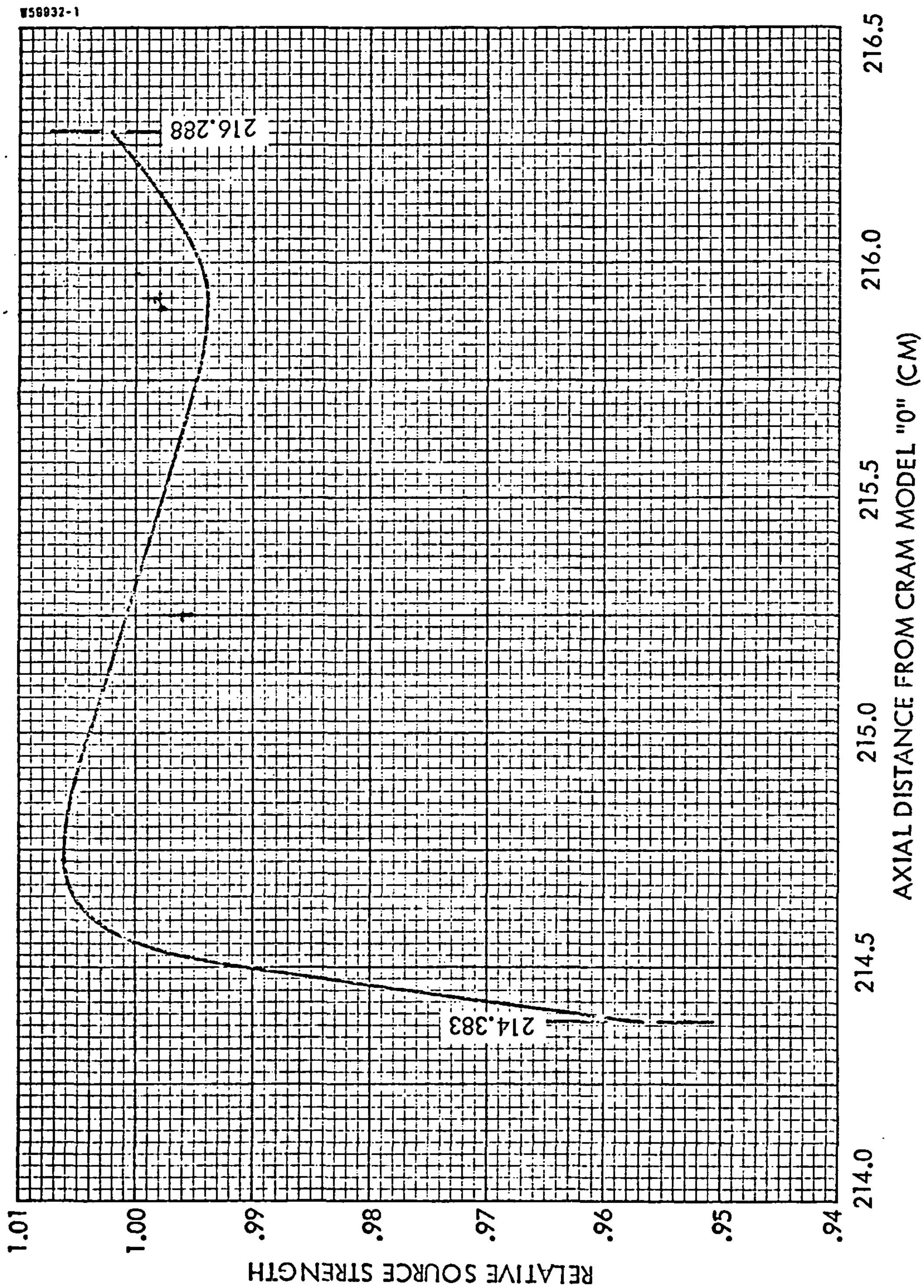

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FIGURE 70
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 35
PERIPHERAL DOME PLENUM II

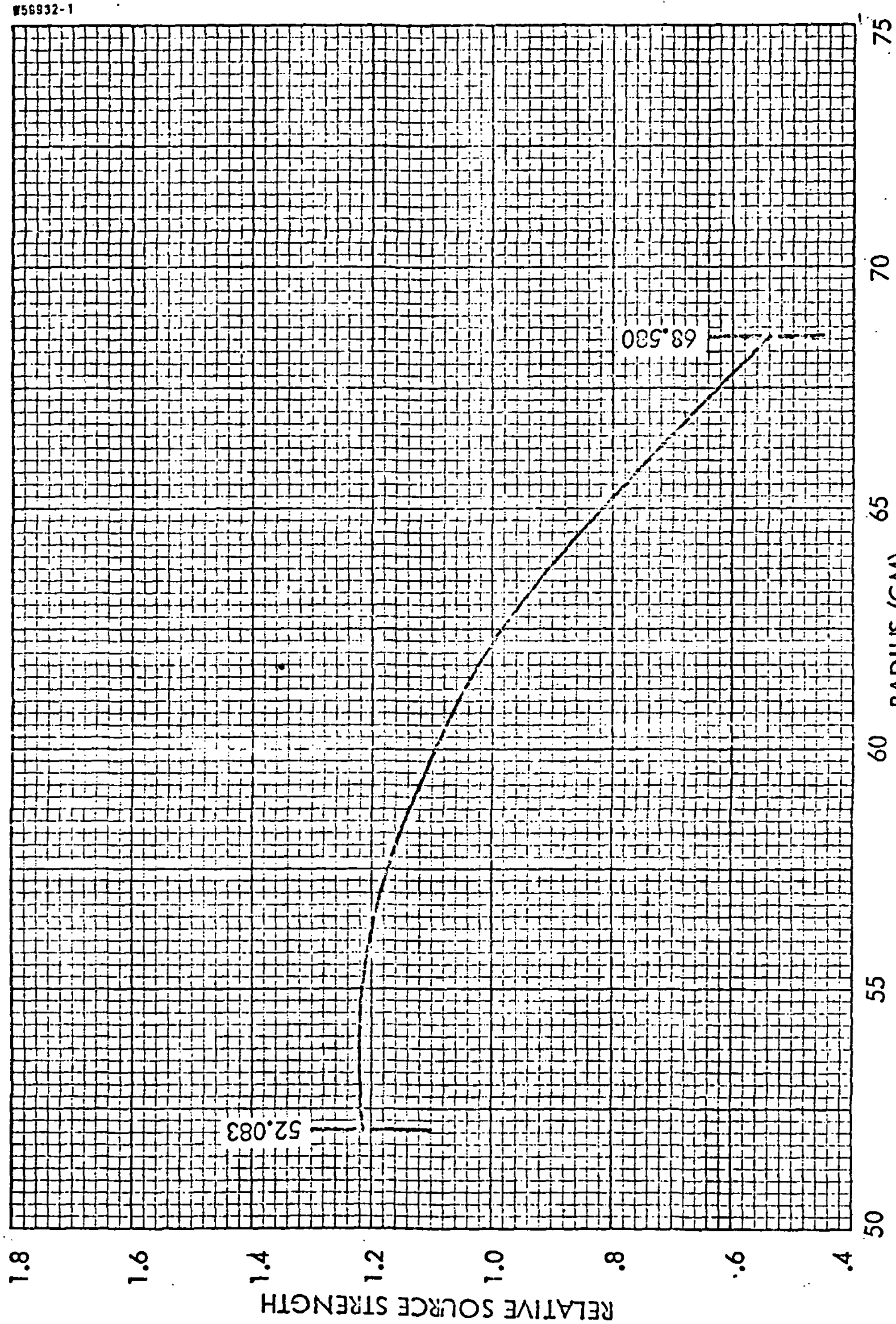

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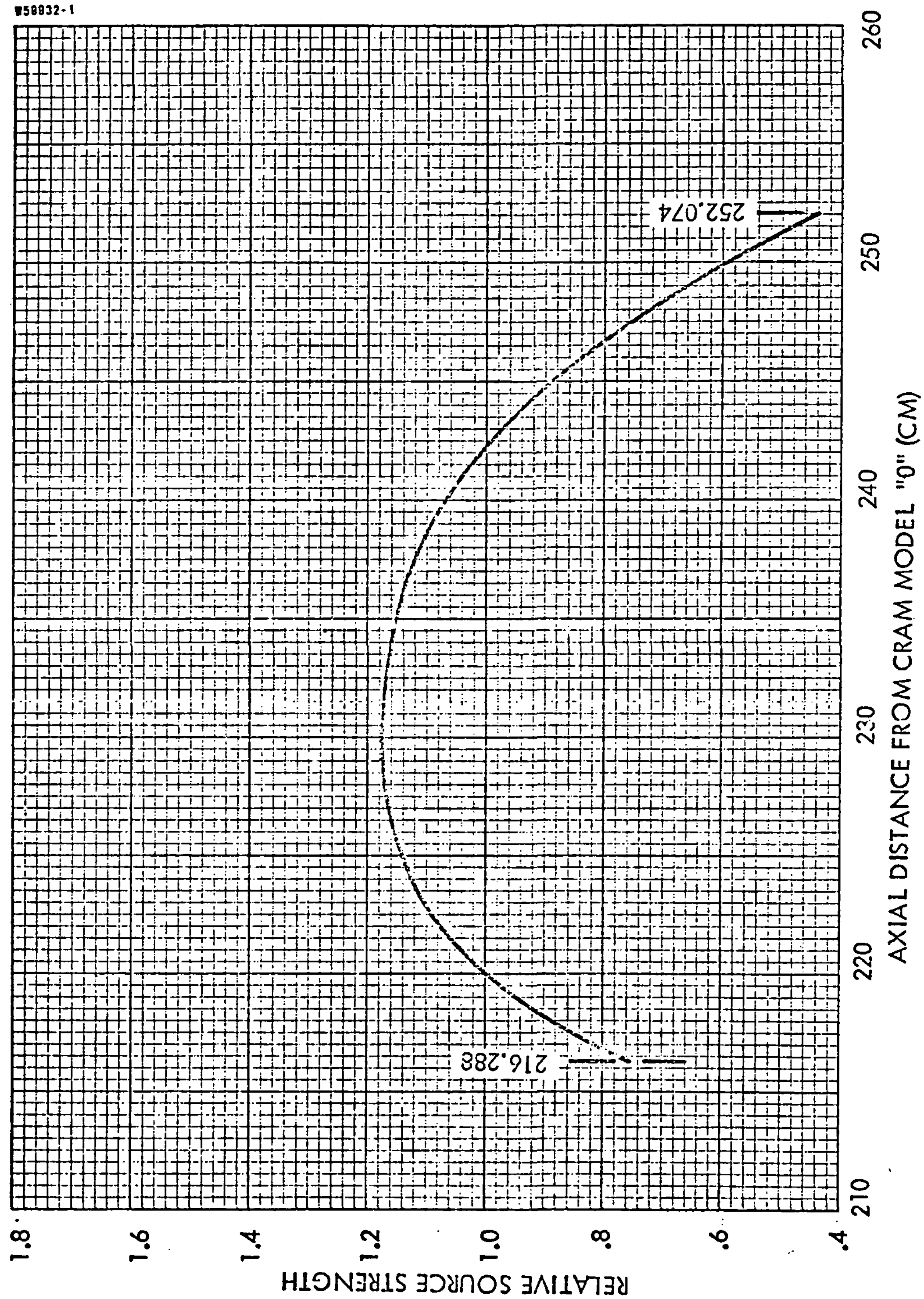
FIGURE 71

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 35
PERIPHERAL DOME PLENUM II



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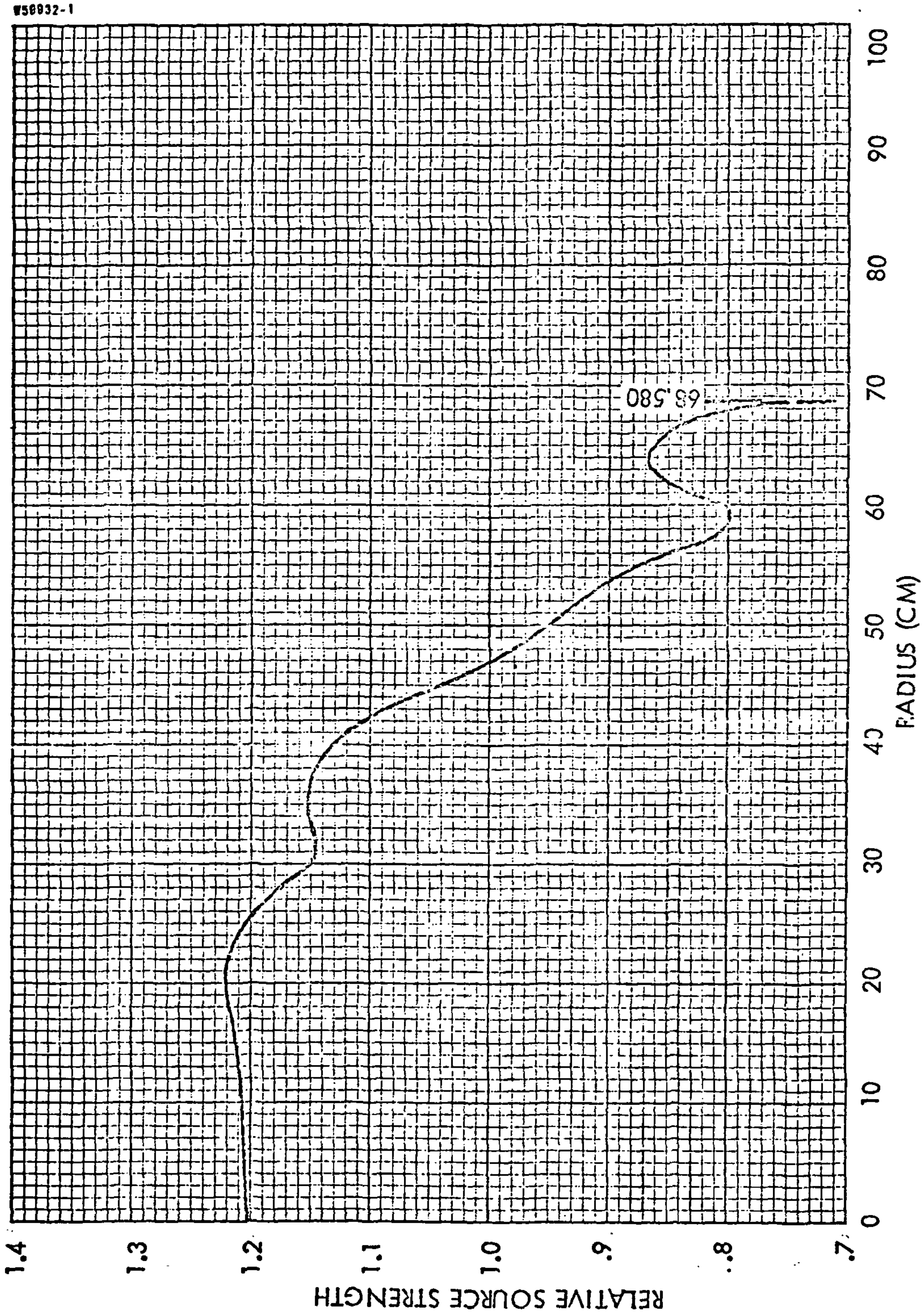
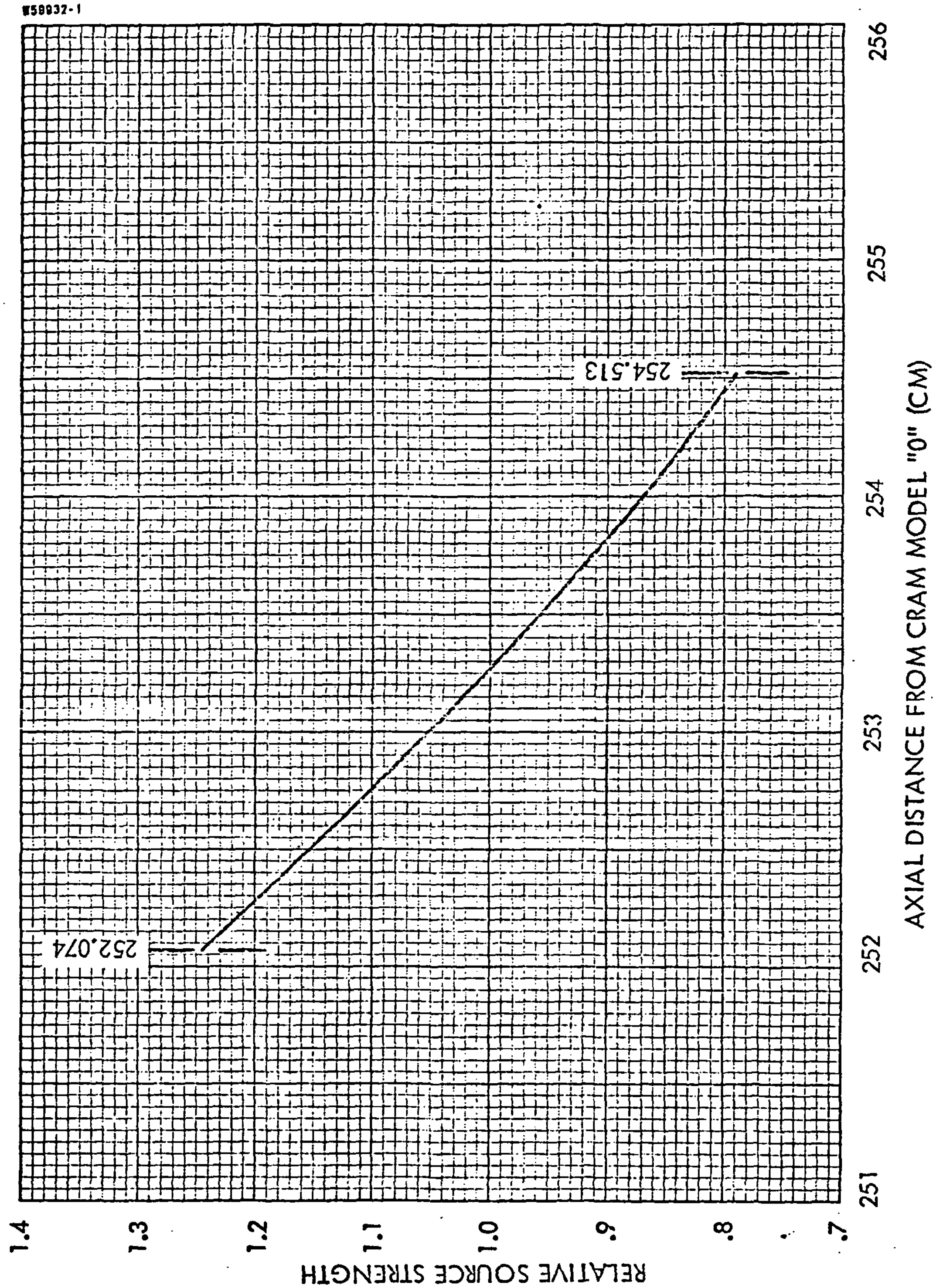


FIGURE 72
RELATIVE RADIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 36
PRESSURE VESSEL DOME

FIGURE 73

RELATIVE AXIAL DISTRIBUTION OF PHOTON SOURCE IN REGION 36

PRESSURE VESSEL DOME



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N8140:R-72-0014

APPENDIX A

FASTER GEOMETRY DESCRIPTIONS
FOR NON NUCLEAR COMPONENTS

TABLE A.1.

BOUNDARY DESCRIPTIONS FOR
FORWARD NON-NUCLEAR COMPONENTS

Boundary Number	Equation Type	Coefficients for Boundary Equations					
1	3	293.62					
2	12		127.0		127.0		
3	3	319.02					
4	12		27.94		27.94		
5	12		27.69		27.69		
6	3	423.67					
7	3	437.42					
8	12		57.15		57.15		
9	12	49.53	10.24	49.53	10.24		
10	12	-49.53	10.24	49.53	10.24		
11	3	459.975					
12	3	465.311					
13	3	482.42					
14	12		27.6		27.6		
15	12		27.015		27.015		
16	3	525.6					
17	9			27.6	482.42	73.66	525.48
18	3	391.7					
19	3	396.37					
20	3	405.69					
21	3	418.855					
22	3	457.33					
23	3	254.03					
24	3	610.40					
25	3	255.1					
26	3	287.24					
27	3	277.75					
28	1	64.4					
29	1	-64.4					
30	3	8038.48					
31	3	8039.48					
32	3	8040.5					
33	3	8049.5					
34	3	8042.48					
35	3	8043.48					
36	3	8044.5					
37	3	8045.5					
38	3	8046.5					
39	1						
40	2						
41	2	151.64					
42	2	-179.755					
43	12	88.9	17.795		17.795		
44	12	88.9	11.43		11.43		
45	12	88.9	5.0		5.0		
46	12	-88.9	17.795		17.795		
47	12	-88.9	11.43		11.43		
48	12	-88.9	5.0		5.0		
49	12		210.		210.		
50	11		9.525	277.75	9.525		
51	11		9.21	277.75	9.21		
52	11		9.4	277.75	9.4		
53	11		9.1	277.75	9.1		
54	12		19.05		19.05		
55	12		18.9		18.9		
56	12		9.4		9.4		
57	12		9.1		9.1		
58	12		48.26		48.26		
59	12		47.55		47.55		
60	12		10011.		10011.		

F

TABLE A.1. (CONTINUED)

[illegible]	3	[illegible]			
63	3	609.33			
64	12	88.9	11.43		11.43
65	12	-88.9	13.59		13.59
66	12	-88.9	11.43		11.43
67	3	413.585			
68	1	-55.63			
69	1	55.63			
70	2	-26.7			
71	2	-60.6			
72	2	-121.92			
73	12		9.525	-170.21	9.525
74	12		9.21	-170.21	9.21
75	11		9.525	404.36	9.525
76	11		8.245	404.36	8.245
77	10	-109.25	9.525	404.36	9.525
78	10	-109.25	8.245	404.36	8.245
79	11	88.9	9.525	404.36	9.525
80	11	88.9	8.82	404.36	8.82
81	11	-88.9	9.525	404.36	9.525
82	11	-88.9	8.82	404.36	8.82
83	2	63.862			
84	2	-56.238			
85	2	-131.38			
86	11	64.4	10.16	366.1	10.16
87	11	64.4	9.765	366.1	9.765
88	11	-64.4	10.16	366.1	10.16
89	11	-64.4	9.765	366.1	9.765
90	10	-113.58	10.16	366.1	10.16
91	10	-113.58	9.79	366.1	9.79
92	12		9.4	142.24	9.4
93	12		9.1	142.24	9.1
94	10	72.9	8.75	375.41	8.75
95	10	72.9	9.4	375.41	9.4
96	11		9.4	375.41	9.4
97	11		7.85	375.41	7.85
98	3	630.48			
99	1	-132.0			
100	1	132.0			
101	11	88.9	9.4	375.41	9.4
102	11	88.9	8.75	375.41	8.75
103	11	-88.9	9.4	375.41	9.4
104	11	-88.9	8.75	375.41	8.75
105	2	8.9			
106	2	2.9			
107	3	485.42			
108	12	25.4	6.35	138.6	6.35
109	12	25.4	5.55	138.6	5.55
110	11	25.4	6.35	417.32	6.35
111	11	25.4	5.2	417.32	5.2
112	10	72.6	6.5	417.17	6.5
113	11	88.9	6.35	417.32	6.35
114	11	88.9	4.845	417.32	4.845
115	11	-88.9	6.35	417.32	6.35
116	11	-88.9	4.845	417.32	4.845
117	3	423.67			
118	2	24.3			
119	12	17.8	6.35	-138.2	6.35
120	12	17.8	5.56	-138.2	5.56
121	3	451.005			
122	3	474.59			
123	6	-59.52	-39.4	25.14	-117.2
124	6	-92.58	-39.4	9.46	-134.366

TABLE A.1. (CONTINUED)

127	6	[illegible]	-190.72	[illegible]	-150.81
128	11	-64.0	1.891	388.3	1.891
129	11	-64.0	3.5	388.3	3.5
130	3	384.31			
131	3	355.5			
132	2	142.24			
133	2	138.60			
134	2	-170.21			
135	2	72.90			
136	2	-103.25			
137	1	-83.9			
138	1	88.9			
139	2	-39.			
140	12	-64.	1.891	-39.	1.891
141	12	-64.	3.5	-39.	3.5

TABLE A.2.

REGION DESCRIPTIONS FOR

FORWARD NON-NUCLEAR COMPONENTS

Region Number		Material Number	Boundaries									Coordinates of Point in Region X	Y	Z
1		0	23	25	49									255.0
2	0	0	3	5	6	0	0	0	0	0	0			360.
3	0	5	3	4	6	5	0	0	0	0	0	27.8		360.
4		9	6	7	8	117								425.
5	0	16	7	13	9	0	0	0	0	0	0	49.53	49.53	460.
6	0	15	7	13	10	0	0	0	0	0	0	-49.53	49.53	460.
7	0	12	11	12	15	0	0	0	0	0	0			460.
8		12	7	13	14	15						27.4		459.
9	0	13	13	16	17									490.
10	0	14	18	19	43	0	0	0	0	0	0	88.9		394.
11	0	14	19	22	43	44	0	0	0	0	0	104.		400.
12	0	04	19	20	44	0	0	0	0	0	0	88.9		400.
13	0	7	20	21	44	0	0	0	0	0	0	88.9		410.
14	0	03	21	22	44	45	0	0	0	0	0	95.0		421.
15	0	7	21	22	45	0	0	0	0	0	0	88.9		421.
16	0	14	18	19	46	0	0	0	0	0	0	-88.9		393.
17	0	14	19	22	46	47	0	0	0	0	0	-104.		400.
18	0	04	19	20	47	0	0	0	0	0	0	-88.9		400.
19	0	7	20	21	47	0	0	0	0	0	0	-88.9		410.
20	0	03	21	22	47	48	0	0	0	0	0	-95.0		420.
21	0	7	21	22	48	0	0	0	0	0	0	-88.9		420.
22	0	03	22	62	64	0	0	0	0	0	0	88.9		460.
23	0	6	22	62	64	61	0	0	0	0	0	100.9		460.
24	0	15	62	63	61	0	0	0	0	0	0	88.9		530.
25	0	3	22	62	66	0	0	0	0	0	0	-88.9		460.
26	0	15	62	63	65	0	0	0	0	0	0	-88.9		530.
27	0	6	22	62	66	65	0	0	0	0	0	-100.9		460.
28	0	5	27	67	73	74	50						-179.61	330.
29	0	3	77	78	79	81	137	138	0	0	0		-109.25	395.16
30	0	4	78	79	81	137	138	0	0	0	0		-109.25	404.36
31	0	8	70	71	79	80	0	0	0	0	0	88.9	-30.	395.16
32	0	04	70	71	80	0	0	0	0	0	0	88.9	-30.	404.36
33	0	11	71	72	79	0	0	0	0	0	0	88.9	-90.	404.36
34	0	5	75	76	77	73	136	134	0	0	0		-160.	395.16
35	0	04	73	76	77	136	134	0	0	0	0		-160.	404.36
36	0	8	70	71	81	82	0	0	0	0	0	-88.9	-30.	395.16
37	0	04	70	71	82	0	0	0	0	0	0	-88.9	-30.	404.36
38	0	11	71	72	81	0	0	0	0	0	0	-88.9	-90.	404.36
39	0	04	83	84	87	0	0	0	0	0	0	64.4	40.0	366.1
40	0	3	83	84	86	87	0	0	0	0	0	64.4	40.0	356.28
41	0	11	84	85	86	0	0	0	0	0	0	64.4	-113.6	366.1
42	0	04	86	91	88	28	29	0	0	0	0		-113.58	366.1
43	0	8	86	91	90	84	28	29	0	0	0		-113.58	356.28
44	0	8	83	84	88	89	0	0	0	0	0	-64.4	40.0	356.28
45	0	04	83	84	89	0	0	0	0	0	0	-64.4	40.0	366.1
46	0	11	84	85	88	0	0	0	0	0	0	-64.4	-113.60	366.1
47		4	27	130	93	52							142.24	300.
48	0	5	27	130	93	92	52	0	0	0	0		151.44	300.

TABLE A.2. (CONTINUED)

```
 ..  0  . . . .     0  0  0  0  0  0                      72.9 375.41
 52  0  8 95100 94 95  0  0  0  0  0                      72.9 384.51
 53  0 11101 95105135  0  0  0  0  0              88.9     10. 375.41
 54  0  8101102105106  0  0  0  0  0              88.9     5.0 384.48
 55  0 04102105106  0  0  0  0  0  0              88.9     5.0 375.41
 56  0 11 95103105135  0  0  0  0  0             -88.9     10. 375.41
 57  0  3103105104106  0  0  0  0  0             -88.9     5.0 384.48
 58  0 04104105106  0  0  0  0  0  0             -88.9     5.0 375.41
 59  0 03 25117109  0  0  0  0  0  0              25.4   138.6   300.
 60  0  5 25117109108  0  0  0  0  0              25.4  132.65   300.
 61  0 10 99100112  0  0  0  0  0  0                      72.6 417.32
 62  0  5108110111112133135  0  0  0              25.4    100. 411.82
 63  0 0310811111213З135  0  0  0  0              25.4    100. 417.32
 64  0  8112113114118135  0  0  0  0              88.9     50. 411.82
 65  0 03112114118135  0  0  0  0  0              88.9     50. 417.32
 66  0 03112116118135  0  0  0  0  0             -88.9     50. 417.32
 67  0  8112115116118135  0  0  0  0             -88.9     50. 411.82
 68  0 05 25121120  0  0  0  0  0  0              17.8  -138.0   443.
 69  0  8 25120121119  0  0  0  0  0              17.8  -132.2   443.
 70  0 1012112212312412712б  0  0  0             -26.7   -88.9  462.8
 71      3139125141128                        -64.                388.31
 72      8139125128141129                     -64.                 390.3
 73  0 04 27 67 74  0  0  0  0  0  0                   -170.21     300
 74  0  0  1  2  3 73 92108119 49            130.                  300.
 75  0  0131130 88 86106 83  4 28 29          30.           5.     370.
 76  0  0 3131  4 73 92108119 49  0           60.                  320.
 77  0  0135132 95130 92 99100131 -1          40.         140.     365.
108 96     0  0  0  0  0  0  0  0  0
 78  0  0131130 85 73119 49                   40.        -135.     365.
 79  0  0130131 83106 88103 29 49            -76.          50.     365.
 80  0  0130131 83106 86101 28 49             76.          50.     365.
 81  0  0130131 85 90 86 88 28 29 -1                     -130.     365.
 4106      0  0  0  0  0  0  0  0  0
 82  0  0130131 85 88106 29 49              -88.9        -100.     365.
 83  0  0130131106 85 85 49 28  0  0         100.           0.     365.
 84  0  0130131 83100132 49                  150.         100.     365.
 85  0  0130131132108 92 49                               200.     365.
 86     0 18130  4125129139141               100.                  388.
 87  0  0 67117 73                                       -170.     418.
 88  0  0 18117134 73 49                                 -200.     400.
 89  0  0 18117134 72 73 75119 49            -20.        -125.     400.
 90  0  0 18117 72 77 81 79136137 -1                     -120.     414.
138 75
 91  0  0 18117 81 72 70137 49              -100.        -100.     400.
 92  0  0 18117 81137 79138 77136 -1                      -30.     400.
 71  4
 93  0  0 18117 79138 70 72 49               100.        -100.     400.
 94  0  0 18117 70118 46  4 49141 39        -200.                  400.
 95  0  0 18117118 70 43  4 49 39             200.                  400.
 96  0  0 18117118135100 49                  140.          70.     400.
 97  0  0 18117118135 99 49                 -140.          70.     400.
 98  0  0 18117118135100112113 99 -1                       30.     400.
115  4
 99  0  0 18117135133 99 49                 -140.          80.     400.
100  0  0 18117 99100133135112110108                       80.     400.
101  0  0 18117100133135 49                  140.          80.     400.
102  0  0 18117133108 49                                  200.     400.
103  0  0 73 50 27 25                                  -170.21     256.
104  0  0 92 52 27 25                                   142.24     256.
105     0  6  7  8 46 43119117141 49         -60.         -60.     430.
106     0  7121 46119 14 43  9 10 -1         -40.         -40.     444.
141 49
107     0121 22127124126 49                -100.0       -100.0     454.
10.  0  0121 22123127126 43  9 14 49          60.                   45.
```

TABLE A.2. (CONTINUED)

103	0	0 [illegible] 27 25		-170.21	255.
104	0	0 92 52 27 25		142.24	256.
105		0 6 7 8 46 43119117141 49	-60.	-60.	430.
106		0 7121 46119 14 43 9 10 -1	-40.	-40.	444.
141	49				
107		0121 22127124126 49	-100.0	-100.0	454.
108	0	0121 22123127126 43 9 14 49	60.		454.
109		0121 22126 10 46 14 49	-100.	-50.	454.
110	0	0121 22127 49	200.		454.
111		0 22122127126124 49	-100.	-100.	460.
112	0	0 22122123127126 14 61 9 49	60.		460.
113	0	0 22122127 49	200.		460.
114	0	0 22122126 10 65 14 49	-200.		460.
115		0 1 2 3			300.0
116	0	0122 13 14 61 9 10 65 49		100.	478.
117	0	0 13 16 17 65 61 49	200.		510.
118	0	0 16 63 61 65 49			530.
119	0	0 63 24 49			609.5
120	0	0 15 13 12 0 0 0 0 0 0			470.
121	0	0 7 11 15 0 0 0 0 0 0			444.
122	0	0130131 83 99132 49	-150.	100.	367.
123		3140141121130	-62.	-39.	430.
124		0 18130139141 4 73119 49		-200.	386.
125		0 18130125108 49		200.	386.
126		3140121130	-64.	-39.	430.
127		5 50 51 54 40 42		-80.	287.11
128		4 51 54 40 42		-80.	277.75
129		5 52 54 53 40 41		80.	287.
130		4 53 54 40 41		80.	277.75
131		5 54 55 25 26		19.0	260.
132		4 55 56 25 26		18.8	260.
133		5 56 57 25 26		9.20	260.
134		4 57 25 26			260.
135		0 40 54 26 50 59 25		-40.	258.
136		0 58 42119 25 1 50 40 73		-49.	258.
137		0 1 25 49 41		153.	258.
138		5 58 59 25 1 52 40		48.	258.
139		0 1 25 49 42119		-180.	258.
140		0 59 26 1		2.	293.
141		0 40 54 26 52 59 25		40.	258.
142		0 58 41100 25 1 52 40 92		49.	258.
143		5 58 59 25 1 50 40		-48.	258.
144		0 99100101103 95135 83130131		65.	358.
145	0	0 24			100000.
146	0	0 23			-600.
147		0 23 24 49		500.0	300.0

TABLE A.3.

REGION DESCRIPTIONS FOR NOZZLE AND NOZZLE EXTENSION MODEL

AO2 FLUX OUTPUT END LEAKAGE PART 1- 17723 NEUTS,101320 COLL DATE 01 MAR 72 PAGE 21

Region Number		Material Number	Region Boundary Numbers									Hydrogen Density in Region	Dimension of Point in Region		
													X	Y	Z
15	0	9	0.0000			0.0000			5.4407+01			-3.0500+00	1.7577+01	-3.9505+01	0.0000
16	0	9	0.0000			0.0000			5.4407+01			-6.7200+00	1.6796+01	-3.9505+01	0.0000
17	0	3	-3.9505+01			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
18	0	12	0.0000			1.5474+01			0.0000			1.5474+01	0.0000	0.0000	0.0000
19	0	12	0.0000			1.6426+01			0.0000			1.6426+01	0.0000	0.0000	0.0000
20	0	12	0.0000			1.7219+01			0.0000			1.7219+01	0.0000	0.0000	0.0000
21	0	3	-5.2070+01			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
22	6	0	-3.0949+02			0.0000			0.0000			-2.2263+01	1.0000+00	1.0000+00	-3.9974-01
23	6	0	-2.9290+02			0.0000			0.0000			-2.1662+01	1.0000+00	1.0000+00	-3.9974-01
24	6	0	-2.5871+02			0.0000			0.0000			-2.0339+01	1.0000+00	1.0000+00	-3.9974-01
25	0	3	-1.1138+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
26	5	0	2.0000+03			0.0000			0.0000			4.3000+01	1.0000+00	1.0000+00	0.0000
27	5	0	1.9250+03			0.0000			0.0000			4.3300+01	1.0000+00	1.0000+00	0.0000
28	5	0	1.9250+03			0.0000			0.0000			4.3700+01	1.0000+00	1.0000+00	0.0000
29	0	3	-1.6000+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
30	0	12	0.0000			7.6918+01			0.0000			7.6918+01	0.0000	0.0000	0.0000
31	0	12	0.0000			7.9426+01			0.0000			7.9426+01	0.0000	0.0000	0.0000
32	0	3	-1.4908+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
33	0	3	-1.4999+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
34	0	3	-1.5949+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
35	0	3	-1.6171+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
36	0	12	0.0000			7.3501+01			0.0000			7.3501+01	0.0000	0.0000	0.0000
37	0	12	0.0000			7.6073+01			0.0000			7.6073+01	0.0000	0.0000	0.0000
38	5	0	3.1563+03			0.0000			0.0000			4.9994+01	1.0000+00	1.0000+00	0.0000
39	5	0	3.1260+03			0.0000			0.0000			5.0015+01	1.0000+00	1.0000+00	0.0000
40	5	0	2.4610+03			0.0000			0.0000			5.5200+01	1.0000+00	1.0000+00	0.0000
41	0	3	-1.8766+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
42	0	3	-2.1466+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
43	0	3	-2.4313+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
44	0	3	-2.7313+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
45	0	3	-3.0313+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
46	0	3	-3.3313+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
47	0	3	-3.6230+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
48	0	3	-4.0460+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
49	0	3	-4.6230+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
50	0	3	-5.1450+02			0.0000			0.0000			0.0000	0.0000	0.0000	0.0000
51	5	0	-5.7640+03			0.0000			0.0000			2.8000+01	1.0000+00	1.0000+00	0.0000
52	5	0	-5.7650+03			0.0000			0.0000			2.8015+01	1.0000+00	1.0000+00	0.0000
53	5	0	-7.3620+03			0.0000			0.0000			3.0700+01	1.0000+00	1.0000+00	0.0000
1	0	0	1	2	3	0	0	0	0	0	0	0.0000	0.0000	0.0000	2.3000+01
2	0	11	2	4	14	17	0	0	0	0	0	0.0000	0.0000	0.0000	0.0000
3	0	10	17	18	21	0	0	0	0	0	0	0.0000	0.0000	0.0000	-4.5000+01
4	0	9	21	22	25	0	0	0	0	0	0	0.0000	0.0000	0.0000	-7.5000+01
5	0	8	25	26	29	0	0	0	0	0	0	0.0000	0.0000	0.0000	-1.2500+02
6	0	12	2	4	5	15	17	0	0	0	0	0.0000	0.0000	5.4000+01	0.0000
7	0	13	4	14	15	17	0	0	0	0	0	0.0000	0.0000	1.7000+01	-3.9500+01
8	0	14	17	18	19	21	0	0	0	0	0	0.0000	0.0000	1.6000+01	-4.5000+01
9	0	15	21	22	23	25	0	0	0	0	0	0.0000	0.0000	1.5600+01	-5.2000+01
10	0	16	25	26	27	29	0	0	0	0	0	0.0000	0.0000	6.9770+01	-1.5000+02
11	0	2	2	6	5	13	0	0	0	0	0	0.0000	0.0000	5.5000+01	0.0000
12	0	2	5	15	16	17	0	0	0	0	0	0.0000	0.0000	1.8000+01	-3.9500+01
13	0	2	17	19	20	21	0	0	0	0	0	0.0000	0.0000	1.7000+01	-4.5000+01
14	0	2	21	23	24	25	0	0	0	0	0	0.0000	0.0000	1.6300+01	-5.2000+01
15	0	2	25	27	28	29	0	0	0	0	0	0.0000	0.0000	7.0400+01	-1.5000+02
16	0	3	2	6	7	11	0	0	0	0	0	0.0000	0.0000	6.0000+01	1.5000+01
17	0	3	2	7	9	11	0	0	0	0	0	0.0000	0.0000	6.3000+01	2.2000+01
18	0	1	2	7	9	10	0	0	0	0	0	0.0000	0.0000	6.3000+01	5.0000+00
19	0	1	6	7	11	12	0	0	0	0	0	0.0000	0.0000	6.0000+01	2.0000+00
20	0	2	6	8	12	13	0	0	0	0	0	0.0000	0.0000	6.0000+01	-2.0000+00
21	0	2	28	30	32	33	0	0	0	0	0	0.0000	0.0000	7.8000+01	-1.4950+02

TABLE A.3. (CONTINUED)

AN2 FLUX OUTPUT END LEAKAGE PART 1- 17723 NEUTS,101320 COLL DATE 01 MAR 72 PAGE 22

22	0	2	29	30	31	32	0	0	0	0	0	0.0000	0.0000	7.9000+01	-1.5500+02
23	0	4	28	30	33	34	0	0	0	0	0	0.0000	0.0000	7.8000+01	-1.5500+02
24	0	2	28	29	30	34	0	0	0	0	0	0.0000	0.0000	7.8000+01	-1.5970+02
25	0	5	29	38	39	41	0	0	0	0	0	0.0000	0.0000	7.4580+01	-1.7383+02
26	0	5	38	39	41	42	0	0	0	0	0	0.0000	0.0000	8.3240+01	-2.0116+02
27	0	5	38	39	42	43	0	0	0	0	0	0.0000	0.0000	9.1190+01	-2.2889+02
28	0	5	38	39	43	44	0	0	0	0	0	0.0000	0.0000	9.8890+01	-2.5813+02
29	0	5	38	39	44	45	0	0	0	0	0	0.0000	0.0000	1.0620+02	-2.8813+02
30	0	5	38	39	45	46	0	0	0	0	0	0.0000	0.0000	1.1304+02	-3.1813+02
31	0	5	38	39	46	47	0	0	0	0	0	0.0000	0.0000	1.1941+02	-3.4772+02
32	0	5	38	39	47	48	0	0	0	0	0	0.0000	0.0000	1.2565+02	-3.8335+02
33	0	5	48	50	51	52	0	0	0	0	0	0.0000	0.0000	1.3380+02	-4.3335+02
34	0	5	29	35	36	39	0	0	0	0	0	0.0000	0.0000	7.3400+01	-1.6050+02
35	0	5	29	35	36	37	0	0	0	0	0	0.0000	0.0000	7.4100+01	-1.6050+02
36	0	0	35	39	40	41	0	0	0	0	0	0.0000	0.0000	8.0000+01	-1.7383+02
37	0	0	39	40	41	42	0	0	0	0	0	0.0000	0.0000	8.8000+01	-2.0116+02
38	0	0	39	40	42	43	0	0	0	0	0	0.0000	0.0000	9.6000+01	-2.2889+02
39	0	0	39	40	43	44	0	0	0	0	0	0.0000	0.0000	1.0400+02	-2.5813+02
40	0	0	39	40	44	45	0	0	0	0	0	0.0000	0.0000	1.1100+02	-2.8813+02
41	0	0	39	40	45	46	0	0	0	0	0	0.0000	0.0000	1.1800+02	-3.1813+02
42	0	0	39	40	46	47	0	0	0	0	0	0.0000	0.0000	1.2400+02	-3.4772+02
43	0	0	39	40	47	48	0	0	0	0	0	0.0000	0.0000	1.3200+02	-3.8335+02
44	0	0	48	49	52	53	0	0	0	0	0	0.0000	0.0000	1.3900+02	-4.3335+02
45	0	0	49	56	52	53	0	0	0	0	0	0.0000	0.0000	1.4500+02	-4.8830+02
46	0	7	29	38	48	0	0	0	0	0	0	0.0000	0.0000	0.0000	-3.0000+02
47	0	6	48	50	53	0	0	0	0	0	0	0.0000	0.0000	0.0000	-5.0000+02
48	0	0	5	16	17	0	0	0	0	0	0	0.0000	0.0000	5.0000+01	-3.0000+01
49	0	0	2	7	10	12	3	0	0	0	0	0.0000	0.0000	1.0000+02	1.0000+01
50	0	0	8	12	13	3	0	0	0	0	0	0.0000	0.0000	1.0000+02	-3.0000+00
51	0	0	5	13	17	3	0	0	0	0	0	0.0000	0.0000	1.0000+02	-2.0000+01
52	0	0	17	20	21	3	0	0	0	0	0	0.0000	0.0000	4.5000+01	-4.5000+01
53	0	0	21	24	25	3	0	0	0	0	0	0.0000	0.0000	7.5000+01	-7.5000+01
54	0	0	25	28	32	3	0	0	0	0	0	0.0000	0.0000	1.2500+02	-1.2500+02
55	0	0	29	31	32	3	0	0	0	0	0	0.0000	0.0000	1.5500+02	-1.5500+02
56	0	0	29	35	37	3	0	0	0	0	0	0.0000	0.0000	1.6000+02	-1.6100+02
57	0	0	35	40	48	3	0	0	0	0	0	0.0000	0.0000	1.9900+02	-3.0000+02
58	0	0	48	50	53	3	0	0	0	0	0	0.0000	0.0000	1.9900+02	-5.0000+02
59	0	0	50	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000	-5.5000+02
60	0	0	1	50	3	0	0	0	0	0	0	0.0000	0.0000	2.3000+02	2.3000+01
61	0	0	1	0	0	0	0	0	0	0	0	0.0000	0.0000	0.0000	1.0000+07