JUN 15 1964

UNCLASSIFIED

CLASSIFICATION LEVEL
(S, C, OR U)

ATOMICS INTERNATIONAL
A Division of North American Aviation, Inc.

A

4

NAA-SR-MEMO 8968

This document contains 45 pages

This is copy _____ of _____ series _____

Do not remove
this sheet

REPRODUCED FROM BEST
AVAILABLE COPY

Facsimile Price \$ 4.60
Microfilm Price \$ 1.55

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D. C.

MASTER

CLASSIFICATION TYPE
(RD OR DI)

*NAA-SR-MEMOs are working papers and may be expanded,
modified, or withdrawn at any time,
and are intended for internal use only.*

This report may not be published without the approval of the Patent Branch, AEC.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

UNCLASSIFIED

CLASSIFICATION LEVEL
(S, C, OR U)

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

ATOMICS INTERNATIONAL <small>A Division of North American Aviation, Inc.</small>		NAA-SR- TDR NO 8968		APPROVALS <i>K. L. Roach</i>	
TECHNICAL DATA RECORD		PAGE 1 OF 45		<i>W. J. R. H.</i>	
AUTHOR W. B. Green		DEPT & GROUP NO. 721-13		DATE 9-13-63	
		GO NO. 7569			
TITLE The RATRAP Code - A Modification of the FARSE Method for SNAP Shield Geometry		S/A NO. 2003		TWR	
		SECURITY CLASSIFICATION			
		(CHECK ONE BOX ONLY)		(CHECK ONE BOX ONLY)	
PROGRAM General Supporting Technology		SUBACCOUNT TITLE Basic Shielding Analysis			
				UNCL. ☒ AEC ☐ DOD ☐ CONF. ☐ SECRET ☐	
				RESTRICTED DATA ☐ DEFENSE INFO. ☐	
DISTRIBUTION				AUTHORIZED CLASSIFIER SIGNATURE <i>K. L. Roach</i>	
				DATE 10-17-63	
		STATEMENT OF PROBLEM The RATRAP code has been written to compute a first order approximation to particle attenuation in shields for SNAP systems.			
		ABSTRACT: <p>The RATRAP code is now available for use on the IBM 7094 digital computer; it is a revision of the FARSE code (Reference 1) that is designed for use in preliminary investigation of shield sizes and weights for SNAP systems.</p> <p>The code computes total dose deposit at specified spatial points due to a specified source mesh; an attenuation model based on mean free paths traversed along a straight line is used. The removal cross sections used incorporate multi-scattering effects.</p>			

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968
DATE 9-13-63
PAGE 2 OF 45

METHOD USED - DESCRIPTION OF CODE

A. Source Specification:

The core-reflector system is considered to be segmented axially into M slices, radially into P divisions, and azimuthally into N segments, where N is even (see Figure 1).

The source is defined at the center point of each unit volume. The coordinates of the center point of the ijk^{th} unit are given by

$$\left. \begin{aligned} X_{ijk} &= \Delta r \left(j - \frac{1}{2}\right) \cos \left[\frac{2\pi}{N} \left(k - \frac{1}{2}\right) \right] \\ Y_{ijk} &= \Delta r \left(j - \frac{1}{2}\right) \sin \left[\frac{2\pi}{N} \left(k - \frac{1}{2}\right) \right] \\ Z_{ijk} &= \Delta h \left(i - \frac{1}{2}\right) \end{aligned} \right\} \quad (1)$$

for $i=1,2,\dots,M$; $j=1,2,\dots,P$; $k=1,2,\dots,N$; and

$$\begin{aligned} \Delta r &= R/P \\ \Delta h &= H/M \end{aligned} \quad (2)$$

where R is the outer radius, and H the length, of the core-reflector assembly.

At each source point, the radius from the core center is computed,

$$r_{ijk} = \sqrt{X_{ijk}^2 + Y_{ijk}^2} \quad (3)$$

r_{ijk} is compared to the core radius r_c . If $r_{ijk} > r_c$, the source point is in the reflector, and the source is given by

$$S_{ijk} = A_c \cos \left[G \left(z - h_0 - \frac{H}{2} \right) \right] \exp \left[-B(r_{ijk} - r_c) \right] \times (4) \\ \times (2j-1) (\Delta r)^2 \Delta z \frac{\pi}{N}$$

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968
DATE 9-13-63
PAGE 3 OF 45

where A_0 , G , and B are input, and H is the total reflector length (see Figure 1). If A_0 is input as zero, no further computation is made, and a new source point is selected.

If $r_{ijk} \leq r_c$, the source point is in the core, and the source is given by

$$S_{ijk} = S_0 \cos \left[G \left(z - \frac{H}{2} \right) \right] J_0(\omega r) (2j-1) (\Delta r)^2 \Delta z \frac{\pi}{N} \quad (5)$$

where S_0 and ω are input, and J_0 is a zero order Bessel function. If S_0 is input as zero, no further computation is made, and a new source point is selected.

B. Shield Specification

The shield system is composed of a grid region, a coolant region, and a shield region, as shown in Figure 2. The system is assumed to be symmetric about the Z axis.

The size of each component is completely arbitrary. For example, any of the radii r_5 , r_6 , r_7 , may be greater than, equal to, or less than any of the others; to run a case with no coolant region, simply enter $r_5 = 0$ and $h_5 = h_6$.

C. Attenuation Calculation

Each source particle is assumed to travel in a straight line between the source point and specified dose point. Using the methods of solid analytic geometry, the straight line distance l_n travelled through each n^{th} component of the system is computed. The total distance L_{ijk} , and number of mean free paths λ_{ijk} , traversed by the ijk^{th} source particle are then given by:

$$L_{ijk} = \sqrt{(x_0 - x_{ijk})^2 + y_{ijk}^2 + (z_0 - z_{ijk})^2} \quad (6)$$

$$\lambda_{ijk} = \sum_n l_n \Sigma_n \quad (7)$$

FIGURE I

Core- Reflector Description

FIGURE II

Description of Shield System Geometry

The Σ_n are the removal cross sections for each component of the system. These are input, and should incorporate multiscattering effects.

The calculation is performed for each source point in both core and reflector. The total dose rate at a specified dose point is then given by

$$D = \sum_{i,j,k} \frac{S_{ijk} \exp(-\lambda_{ijk})}{4\pi L_{ijk}^2} \quad (8)$$

D. Calculation of Shield Weights

For the system shown in Figure 2, the shield weights are computed as:

$$W_{grid} = \pi R_6^2 (h_7 - h_6) \rho_{grid} \quad (9)$$

$$W_{coolant} = \pi R_5^2 (h_6 - h_5) \rho_{coolant} \quad (10)$$

$$W_{shield} = \pi \rho_{shield} \left\{ (R_{c1}^2 - Z_{c1}^2)(h_4 - h_3) + Z_{c1}(h_4^2 - h_3^2) - \frac{h_4^3 - h_3^3}{3} + (h_3 - h_2) [R_3^2 + (R_3 + h_3 \tan \phi)^2] - \tan \phi \left[2(h_3^2 - h_2^2)(R_3 - h_3 \tan \phi) - \tan \phi \frac{h_3^3 - h_2^3}{3} \right] + (R_{c2}^2 - Z_{c2}^2)(h_2 - h_1) + Z_{c2}(h_2^2 - h_1^2) - \frac{h_2^3 - h_1^3}{3} \right\} \quad (11)$$

$$W_{total} = W_{grid} + W_{coolant} + W_{shield} \quad (12)$$

where

$$\tan \phi = \frac{r_2 - r_3}{h_3 - h_2} \quad (13)$$

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968

DATE 9-13-63

PAGE 6 OF 45

Densities are considered to be in gm/cc, regardless of the units in which dimensions are entered.

R_{c1} and R_{c2} are the radii of curvature of the left-hand and right-hand spherical shield sections respectively (assuming the shield system to be oriented as in Figure 2), and are computed by the code:

$$R_{c1} = \sqrt{z_{c1}^2 - \ell_1} = z_{c1} - h_1 \quad (14)$$

where

$$z_{c1} = \frac{r_3^2 + h_3^2 - h_4^2}{2(h_3 - h_4)}$$

$$\ell_1 = h_4(2z_{c1} - h_4)$$

and

$$R_{c2} = \sqrt{z_{c2}^2 - \ell_2} = h_4 - z_{c2} \quad (15)$$

where

$$z_{c2} = \frac{r_2^2 + h_2^2 - h_1^2}{2(h_2 - h_1)}$$

$$\ell_2 = h_1(2z_{c2} - h_1)$$

E. Description of Output

The output is in three sections. Section one is a listing of input data. Section two contains a printout of dose rate per point;

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-OR-MEMO-8968

DATE 9-13-63

PAGE 7 OF 45

the coordinates of the dose points are printed in both centimeters and inches. The third section contains the shield weights, in grams.

F. Description of Input Data

Thirty-two pieces of input data are required for each case, in addition to the pairs of (r,Z) coordinates describing the dose points. An option allows length dimensions to be entered in either centimeters or inches. It is also possible to run a problem with a core source only (input $A_0 = 0$), a reflector source only (input $S_0 = 0$), or both a core and reflector source.

A complete description of the input data follows:

Card 1: Format (72H)

Identifying information up to 72 BCD characters. This information is used as a page heading on the output.

Card 2: Format (5I4)

LM = Number of axial slice in core-reflector assembly $1 \leq LM \leq 10$

LP = Number of radial divisions $1 \leq LP \leq 10$

LN = Number of azimuthal segments (must be even or 1) $1 \leq LN \leq 10$

ND = Number of dose points $1 \leq ND \leq 50$

IUNIT = 0, length dimensions are in cm
= 1, length dimensions are in inches

Cards 3 to N: (FORED Input Format)

<u>Location</u>	<u>Symbol</u>	<u>Fortran Name</u>	<u>Description</u>
Q(1)	S_0	SO	Core source strength peak (n/cm^3 -sec)
Q(2)	G	G	Core source constants (see Equation 5) (cm^{-1})
Q(3)	ω	ϕ MEGA)	
Q(4)	A_0	AO	Reflector source strength Peak(n/cm^3 -sec)
Q(5)	B	B	Reflector source constant (see Eqn. 4) (cm^{-1})
Q(6)	Σ_c	SIGMAC	Core removal cross section (cm^{-1})
Q(7)	Σ_R	SIGMAR	Reflector removal cross section (cm^{-1})

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968
 DATE 9-13-63
 PAGE 8 OF 45

(Continued)

<u>Location</u>	<u>Symbol</u>	<u>Fortran Name</u>	<u>Description</u>
Q(8)	Σ_G	SIGMAG	Grid removal cross section (cm^{-1})
Q(9)	Σ_{cool}	SGC ool L	Coolant removal cross section (cm^{-1})
Q(10)	Σ_{shield}	SIGSHL	Shield removal cross section (cm^{-1})
Q(11)	r_2	R2	Radial coordinates describing shield configuration (see Figure 2) - in inches if IUNIT = 1, in cm if IUNIT = 0 on card 2.
Q(12)	r_3	R3	
Q(13)	r_5	R5	
Q(14)	r_6	R6	
Q(15)	r_7	R7	
Q(16)	r_8	R8	
Q(17)	h_1	H1	Axial coordinates describing shield configuration (see Figure 2) - in inches if IUNIT = 1, in cm if IUNIT = 2 on card 2.
Q(18)	h_2	H2	
Q(19)	h_3	H3	
Q(20)	h_4	H4	
Q(21)	h_5	H5	
Q(22)	h_6	H6	
Q(23)	h_7	H7	
Q(24)	h_8	H8	
Q(25)	ρ_{grid}	RH o G	Grid density (gm/cc)
Q(26)	ρ_{coolant}	RH o C	Coolant density (gm/cc)
Q(27)	ρ_{shield}	RH o SHL	Shield density (gm/cc)
Q(30)	(r_i, z_i)	C o RD(I)	(r,z) coordinates for each dose point. Entered $r_1, z_1, r_2, z_2, r_3, z_3, \dots, r_{\text{ND}}, z_{\text{ND}}$. In inches or in cm, depending on the value of IUNIT on card 2

Running time can be estimated from the fact that the code runs about 100 points/second, where total number of points = $LM \cdot LN \cdot LP \cdot ND$.

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968
DATE 9-13-63
PAGE 9 OF 45

Reference

1. Rooney, K. L. and M. A. Boling, "FARSE - A First Order Approximation of Reactor Shield for SNAP Systems. AI-TDR-5772, 10-11-60.

APPENDIX A

Sample Case

The input forms and output from a sample case are shown on the following pages. The geometry is indicated in Figure 3.

Figure 3
Sample Case Configuration

FORTRAN FIXED 10 DIGIT DECIMAL DATA

NAA-SR-MEMO 8968
9-13-63
Page 11 of 45
JOB NO. _____

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____

NUMBER	IDENTIFICATION	DESCRIPTION DO NOT KEY PUNCH
1 R A T R A P T E S T		
13 C A S E * W G R		
25 E E N * S E P T .		
37 1 9 6 3		
49	73 80	
61	1	
1 1 0 1 0 8		LM, LP, LN
13 1 0 0		ND IUNIT - 10 dose pts, units in cm
25		
37		
49	73 80	
61	2	
1 1		FORED Input
13 . 1 6 + 2 0		S _o
25 . 0 9 5		G $S_{core} = 1.6 \times 10^{19} \cos \left[.095 \left(Z - \frac{H}{2} \right) \right] J_o (.137 R)$
37 . 1 3 7		W
49 . 9 7 1 + 1 9	73 80	A _o $S_{refl} = 9.71 \times 10^{18} \cos \left[.095 \left(Z - \frac{H}{2} \right) \right] \exp(-.205(R-R_c))$
61 . 2 0 5	3	B
1 6		
13 . 1 3 6		$\sum_{core}$
25 . 1 2 6		$\sum_{refl}$
37 . 0 9 6 1		$\sum_{grid} \text{ cm}^{-1}$
49 . 0 2 2 4	73 80	$\sum_{coolant}$
61 . 1 5 5	4	$\sum_{shield}$

FORTRAN FIXED 10 DIGIT DECIMAL DATA

NAA-SR-MEMO-8968

9-13-63

Page 12 of 45

JOB NO. _____

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____

NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH
1 1			
2 6 . 7 7		r ₂	All in cm
2 1 . 1		r ₃	
1 1 .		r ₅	
1 1 .	73 80	r ₆	
1 6 . 9 9 2 6	5	r ₇	
1 6			
1 0 1 2 2 1		r ₈	
1 9 9 . 7		h ₁	
2 1 5 . 2 5		h ₂	
2 6 3 . 9 1	73 80	h ₃	
2 6 4 . 1 6	6	h ₄	
2 1			
2 6 4 . 1 6		h ₅	
2 6 7 . 3 7 8		h ₆	
2 6 9 . 1 3 8		h ₇	
3 0 0 . 2 5 3	73 80	h ₈	
. 0 1	7	p _{grid}	
2 6			
. 0 1		p _{coolant}	
. 0 1		p _{shield}	
	73 80		
	8		

FORTRAN FIXED 10 DIGIT DECIMAL DATA

NAA-SR-MEMO-8968

9-13-63

Page 13 of 45

DECK NO. _____ PROGRAMMER _____ DATE _____ PAGE _____ of _____ JOB NO. _____

	NUMBER	IDENTIFICATION	DESCRIPTION	DO NOT KEY PUNCH
1	3 0		Dose Point Coordinates (cm)	
13	0 .		r _{D1}	
25	1 9 5 .		z _{D1}	
37	1 6 .		r _{D2}	
49	2 0 3 . 2	73 80	z _{D2}	
61	2 5 .	9	r _{D3}	
1	3 5		z _{D3}	
13	2 4 0 .		r _{D4}	
25	3 0 .		z _{D4}	
37	2 7 0 .		'	
49	1 0 .	73 80	'	
61	1 5 0 .	1 0	'	
1	4 0		'	
13	3 0 .		'	
25	1 5 0 .		'	
37	5 0 .		'	
49	1 5 0 .	73 80	'	
61	7 0 .	1 1	'	
1	4 5		'	
13	1 5 0 .		'	
25	4 0 .		'	
37	0 .		'	
49	9 0 .	73 80	r _{D10}	(ND = 10)
61	0 .	1 2	z _{D10}	

SOURCE SPECIFICATION--

M = 10

P = 8

N = 10

ND = 10

CORE SOURCE = $1.600000E-19 * J0(1.370000E-01 * R) * C0S(9.500000E-02 * (Z - H/2))$ REFLECTOR SOURCE = $9.710000E-18 * C0S(9.500000E-02 * (Z - H/2)) * EXP(-2.050000E-01 * (R - RC))$

SHIELD SPECIFICATION (CM.)--

R2= 2.677000E 01 R3= 2.110000E 01 R5= 1.100000E 01 R6= 1.100000E 01

R7= 1.699260E 01 R8= 1.022100E 01 H1= 1.997000E 02 H2= 2.152500E 02

H3= 2.639100E 02 H4= 2.641600E 02 H5= 2.641600E 02 H6= 2.673780E 02

H7= 2.691380E 02 H8= 3.002530E 02

MATERIAL PROPERTIES--

	CORE	REFLECTOR	GRID	C00LANT	SHIELD
DENSITIES			10.000000E-03	10.000000E-03	10.000000E-03
CROSS SECTION	1.360000E-01	1.260000E-01	9.610000E-02	2.240000E-02	1.550000E-01

9-13-63

Page 15 of 45

RATRAP TEST CASE * W GREEN * SEPT. 1963

DIRECT DOSE RATE PER POINT

				DIRECT DOSE RATE		
R	Z	R	Z	FROM	FROM	TOTAL
(CM.)	(CM.)	(IN.)	(IN.)	CORE	REFL	
0.	195.00	0.	76.83	6.8417913E 12	4.6376059E 12	1.1479397E 13
16.00	203.20	6.30	80.06	1.2592098E 13	9.1127002E 12	2.1704798E 13
25.00	240.00	9.85	94.56	8.3513917E 15	1.5170761E 16	2.3522153E 16
30.00	270.00	11.82	106.38	8.4444624E 17	1.4278724E 18	2.2723186E 18
10.00	150.00	3.94	59.10	3.1864389E 12	2.6367790E 12	5.8232179E 12
30.00	150.00	11.82	59.10	5.2312889E 12	5.2534200E 12	1.0484709E 13
50.00	150.00	19.70	59.10	4.2514701E 13	4.9092576E 15	4.9517723E 15
70.00	150.00	27.58	59.10	1.7050486E 15	1.7510297E 16	1.9215345E 16
40.00	0.	15.76	0.	8.5451289E 11	9.6333605E 11	1.8178489E 12
90.00	0.	35.46	0.	4.6410791E 12	1.2989478E 15	1.3035889E 15

9-13-63

Page 16 of 45

SHIELD WEIGHTS

(GM.)

GRID=	6.69
COOLANT=	12.23
SHIELD=	7830.12
TOTAL=	7849.04

ATOMICS INTERNATIONAL

A Division of North American Aviation, Inc.

NO. NAA-SR-MEMO-8968
DATE 9-13-63
PAGE 17 OF 45

APPENDIX B

Listing of the Code


```

C      THE RATRAP CODE                                000
C INPUT VARIABLES--                                00009006
C      LM=NO. OF AXIAL CORE DIVISIONS    LP=NO. OF RADIAL CORE DIVISIONS 00009008
C      LN=NO. OF ANGULAR CORE DIVISIONS ND=NO. OF DOSE POINTS           00009010
C      IUNIT=0, DIMENSIONS IN CM. =1 IN. SIGMAC=CORE X-SECTION           00009012
C      SIGMAR=REFLECTOR X-SECTION        SIGMAG=GRID X-SECTION           00009014
C      SGCOOL=COOLANT X-SECTION          SIGSHL=SHIELD X-SECTION          00009016
C      RHOG=GRID DENSITY                  RHOC=COOLANT DENSITY            00009018
C      RHOSHL=SHIELD DENSITY              00009020
C      ZC1,ZC2,RAD1,RAD2=CENTER POINTS AND RAD. OF CURVATURE OF SPHERES 00009024
C      R2,R3,R5,R7 = (X,Z) COORDINATES DESCRIBING THE CORE-REFLECTOR-GRID 00009026
C      H1,H2,...,H8= -COOLANT-SHIELD ASSEMBLY CONFIGURATION             00009028
C      COORD=AN ARRAY CONTAINING UP TO 50 PAIRS OF DOSE PT. COORDINATES 00009030
C      SO,G,OMEGA=CORE SOURCE CONSTS- S=SO*J0(OMEGA*R)*COS(G*(Z-H12)) 00009031
C      AO,B=REFLECTOR SOURCE CONSTS- S=AO*COS(G*(Z-H12))*EXP(-B*(R-R8)) 00009032
C      00009033
C SUBROUTINES--                                00009034
C      PRINTI-CHECKS, PRINTS INPUT          PRINTO-PRINTS OUTPUT         00009036
C      ADVANC-GIVEN PATH LENGTH AND DIRECTION COSINES, CALCS. NEW X,Y,Z 00009038
C      SPHERE,CONE,ROOTS-THE DIST. TO A SPHERE OR CONE FROM A GIVEN POINT 00009040
C      (X,Y,Z) IS GIVEN BY THE SOLUTION OF A QUAD. EQN-00009042
C      A*L**2+B*L+C=0. SPHERE CALCS. A,B,C FOR INTERSECT 00009044
C      WITH SPHERE. CONE DOES SAME FOR CONE. ROOTS 00009046
C      SOLVES FOR L, USING LARGEST + ROOT FOR KFLAG=2, 00009048
C      SMALLEST + ROOT FOR KFLAG=1. 00009050
C      CORE-FOLLOWS PARTICLE FROM CORE TO DOSE POINT(GAMMA +) OR THROUGH 00009052
C      GRID/COOLANT ASSEMBLY TO VOID(GAMMA -) 00009054
C      RFLCT-FOLLOWS PARTICLE FROM REFLECTOR SOURCE POINT TO DOSE POINT 00009056
C      (GAMMA +), OR THRU GRID/COOLANT ASSEMBLY (GAMMA -). 00009058
C      00009060
C
C COMMON KALPHA
C COMMON ND0SE
C COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, DOSE, 00000006
C      2 I, IN, J, K, KOUT, PATH, PI, Q, 00000007
C      3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z, 00000008
C      4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK 00000009
C      DIMENSION Q(150),KK(5),COORD(100),RD(50),ZD(50),DOSE(2,50) 00000010
C      EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

```

NAA-SR-MEMO-8968

9-13-63

Page 18 of 45

NAA-SR-MEMO-8968

9-13-63

Page 19 of 45

```

1      (5)), (R8, RC), (ABSPSI, AB SGAM)
EQUIVALENCE (S0, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (A0, Q(4)), (B, Q(5)),
2      (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L, 00000021
2      Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022
3      (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18 00000023
5      ), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,
6      Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL,
7      Q(27)), (C00RD, Q(30))

```

C
C
C

** W B GREEN-AUG 196300009004

```

      WORD=2HMP 00000050
      IN=5 00009904
      KOUT=6 00009905
2 READ INPUT TAPE IN,3 00010002
3 FORMAT(72H 00010004
2 00010006
      WRITE OUTPUT TAPE KOUT,3 00010007
      READ INPUT TAPE IN,4, (KK(I), I=1,5) 00010008
4 FORMAT(5I4) 00010010
      CALL F0RED(Q,N) 00010012
C CHECK AND PRINT INPUT 00010014
      CALL PRINTI(KG00F) 00010015
      GO TO (6,2), KG00F 00010017
C SET CONSTANTS 00010020
6 PI=3.1415927 00010025
      ZM=LM 00010030
      ZP=LP 00010035
      ZN=LN 00010040
      PIZN=(PI+PI)/ZN 00010045
      DELTAR=R7/ZP 00010050
      DELTAZ=(H8-H7)/ZM 00010055
      TANPHI=(R2-R3)/(H3-H2) 00010057
      TANSQD=TANPHI*TANPHI 00010058
      H0VER2=(H8-H7)/2.0 00010059
      VOL = PI*DELTAR*(DELTAR**2)/ZN 00010059
      IF (IUNIT) 8,10,8 00010058
C CHANGE OMEGA FROM 1/CM TO 1/IN 00010059
8 OMEGA = 2.540005*OMEGA 00010060

```

G = 2.540005*G
 B = 2.540005*B
 VOL = VOL*2.540005**3

00010060

00010061

00010062

00010060

00010060

00010061

00010063

00010064

00010066

00010061

00010063

0010065

00010066

00010067

00010069

00010070

00010072

00010075

00010080

00010085

00010090

00010095

00010100

00010105

00010110

00010115

00010120

00010125

00010130

00010135

00010140

00010145

NAA-SR-MEMO-8968

9-13-63

Page 20 of 45

C
C

CALCULATE CENTER POINTS AND RADII OF CURVATURE FOR THE 2 SPHERES

10 ZC1 = (R3**2 + H3**2 - H4**2)/(2.*(H3-H4))

RAD1 = H4-ZC1

ZC2 = (R2**2 + H2**2 - H1**2)/(2.*(H2-H1))

RAD2 = ZC2-H1

ND0SE=0

KKK2=ND+ND

D0 500 LL=1, KKK2, 2

ND0SE=ND0SE+1

RD(ND0SE)=C00RD(LL)

ZD(ND0SE)=C00RD(LL+1)

D0SE(1,ND0SE) = 0.

D0SE(2,ND0SE) = 0.

D0 300 I=1, LM

ZI=I

ZIM12=ZI-0.5

D0 300 J=1, LP

ZJ=J

ZJM12=ZJ-0.5

ZJ0DD=ZJ+ZJ-1.0

D0 300 K=1, LN

ZK=K

ZKM12=ZK-0.5

C
C
C

DEFINE SOURCE POINT

X=DELTAR*ZJM12*C0SF(PIZN*ZKM12)

Y=DELTAR*ZJM12*SINF(PIZN*ZKM12)

Z=DELTAZ*ZIM12+H7

SAVE1=X

SAVE2=Y

SAVE3=Z

14 RADIUS=SQRTF(X**2+Y**2)

C FIND DIRECTION COSINES OF LINE BETWEEN SOURCE AND D0SE POINT...

DIST=SQRTF((RD(ND0SE)-X)**2 + Y*Y + (ZD(ND0SE)-Z)**2)

00010175

00010180

```

      ALPHA=(RD(ND0SE)-X)/DIST
      BETA=-Y/DIST
      GAMMA=(ZD(ND0SE)-Z)/DIST
      IF (IUNIT) 16,18,16
C      CONVERT PATH TO CM
      16 PATH = 2.54005*DIST
      GO TO 391
      18 PATH = DIST
      391 IF(ALPHA) 106,109,108
      106 KALPHA=1
      GO TO 110
      108 KALPHA=2
      GO TO 110
      109 KALPHA = 3
      110 IF(RADIUS-R8) 20,20,40
C      DEFINE CORE SOURCE POINT...
      20 IF (S0) 300,300,22
      22 SHAPE = OMEGA*RADIUS
      SV = S0*COSF( G*((Z-H7)-H0VER2) )*BESELF(SHAPE,0,1)
      SV = SV*ZJ0DD*V0L
      KD0SE = 1
      KG0 = 1
      CALL CORE(KG0,KRETRN)
      GO TO (180,280,2),KRETRN
C      DEFINE REFLECTOR SOURCE POINT...
      40 IF (A0) 300,300,42
      42 SV = A0*COSF( G*((Z-H7)-H0VER2) )*EXPF(-B*(RADIUS-R8))
      SV = SV*ZJ0DD*V0L
      KD0SE = 2
      CALL RFLECT (KRETRN)
      GO TO (180,280,2),KRETRN
C
C CALCULATE DISTANCE THROUGH VOID TO INTERCEPT WITH SHIELD SURFACE.
C
      180 KFLAG=1
      182 CALL SPHERE(RAD1,ZC1)
      IF(CONSTB**2-4.*CONSTA*CONSTC) 190,184,184
      184 CALL ROOTS(KFLAG,KURSE)
      X2=X+ALPHA*ZL

```

```

00010185
00010190
00010195
00010197
00010199
00010201
00010203
00010205
00010225
00010235
00010240
00010242
00010244
00010200
00010210
00010220
00010230
00010240
00010252
00010252
00010250
00010260
00010270
00010280
00010290
00010300
00010301
00010302
00010310
00010320
00010635
00010640
00010645
00010650
00010680
00010682
00010685
00010686

```

NAA-SR-MEMO-8968
9-13-63
Page 21 of 45

```

      Y2=Y+BETA*ZL
      IF(X2**2+Y2**2-R3**2) 185,185,190
185  X=X+ALPHA*ZL
      Y=Y+BETA*ZL
      Z=Z+GAMMA*ZL
      GO TO 195
190  ZL=(H2-Z)/GAMMA
      X2=X+ALPHA*ZL
      Y2=Y+BETA*ZL
      IF (X2**2+Y2**2-R2**2) 192,192,280
192  CALL CONE
194  CALL ROOTS(KFLAG,KURSE)
      GO TO (185,280),KURSE
C      DETERMINE DISTANCE TRAVELLED THROUGH SHIELD
195  KFLAG=2
      ZL=(H2-Z)/GAMMA
      X2=X+ALPHA*ZL
      Y2=Y+BETA*ZL
      IF(X2**2+Y2**2-R2**2) 200,200,210
C      HITS SPHERE 2 ON EXIT
200  CALL SPHERE(RAD2,ZC2)
205  CALL ROOTS(KFLAG,KURSE)
      GO TO (206,502),KURSE
206  CALL ADVANC(SIGSHL)
      GO TO 280
C      IF DOESNT HIT SPHERE 2, AND Z L.T.H3, MUST HIT CONE ON EXIT...
210  IF(Z-H3) 225,225,212
212  ZL=(H3-Z)/GAMMA
      X2=X+ALPHA*ZL
      Y2=Y+BETA*ZL
      IF(X2**2+Y2**2-R3**2) 225,225,230
C      HITS CONE
225  CALL CONE
      GO TO 205
C      HITS SPHERE 1 ON EXIT
230  CALL SPHERE(RAD1,ZC1)
      GO TO 205
280  DOSE(KDOSE,ND0SE) = DOSE(KDOSE,ND0SE)+SV*EXPF((-ZLAMDA)/(4.*PI*
2      PATH**2)

```

00010687
00010688
00010690
00010695
00010700
00010705

NAA-SR-MEMO-8968
9-13-63
Page 22 of 45

00010735
00010740

00010745
00010750
00010755
00010760
00010765
00010770
00010775
00010780
00010785
00010787

00010795
00010800
00010805
00010810
00010815
00010820
00010825
00010830
00010835
00010840
00010845
00010850
00010855
00010860
00010867
00010868

```
300 CONTINUE
500 CONTINUE
    WRITE OUTPUT TAPE KOUT,3
    CALL PRINT0
    GO TO 2
502 WRITE OUTPUT TAPE 6,504,X,Y,Z,ALPHA,BETA,GAMMA,ZL,ZLAMDA,CNSTA,
    2  CONSTB,CNSTC,I,J,K,SAVE1,SAVE2,SAVE3,RD(ND0SE),ZD(ND0SE)
    ND=ND0SE
    CALL PRINT0
    GO TO 2
504 FORMAT(9H1**ERROR-/17H0X,Y,Z,ALPHA,ETC=6E15.7/16H0ZL,ZLAMDA,A,B,C
    2  1H=5E15.7/20H0IJK,SOURCE C00RDS= 3I4,3E15.7/9H0D0SE PT=2E20.8)
    END(1,0,0,0,0,0,0,1,0,0,0,1,0,0,0,0,0)
```

00010870
00010900
00010905
00011000
00011005

NAA-SR-MEMO-8968
9-13-63
Page 23 of 45

SUBROUTINE ADVANC(SIGGIE)

00020010

COMMON KALPHA

COMMON NDOSE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, DOSE, 00000006

2 I, IN, J, K, KOUT, PATH, PI, Q, 00000007

3 RAD1, RAD2, RC, TANPHI, TANSQD, X, Y, Z, 00000008

4 ZC1, ZC2, ZD, ZL, ZLANDA, G, KK 00000009

DIMENSION Q(150), KK(5), COORD(100), RD(50), ZD(50), DOSE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

I (5)), (R8, RC), (ABSPSI, ABSCAM)

EQUIVALENCE (SC, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGCCCL, 00000021

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18) 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,

6 Q(23)), (H8, Q(24)), (RHCG, Q(25)), (RHOC, Q(26)), (RHCSHL,

7 Q(27)), (COORD, Q(30))

** H B GREEN-AUG 196300009004

X=X+ALPHA*ZL 00020015

Y=Y+BETA*ZL 00020020

Z=Z+GAMMA*ZL 00020025

IF(IUNIT)2,4,2

2 ZL=ZL*2.54

4 ZLANDA = ZLANDA+ZL*SIGGIE 00020035

RETURN 00020040

END(1,1,0,0,0,0,1,1,0,1,0,0,0,0,0)

NAA-SR-MEMO-8968

9-13-63

Page 24 of 45

SUBROUTINE CONE

00040015

NAA-SR-MEMO-8968

9-13-63

Page 25 of 45

COMMON KALPHA

COMMON ND0SE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, KOUT, PATH, PI, Q,

3 RAD1, RAD2, RC, TANPHI, TANSQD, X, Y, Z,

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK

DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK 00000010

I (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (S0, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L,

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7, 00000024

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL, 00000025

7 Q(27)), (C00RD, Q(30)) 00000026

CONSTA=ALPHA**2+BETA**2-TANSQD*GAMMA**2

00040020

CONSTB=2.*(ALPHA*X+BETA*Y)+2.*GAMMA*TANSQD*(H3-Z)+2.*R3*GAMMA*

00040025

2 TANPHI

00040030

CONSTC=X*X+Y*Y-TANSQD*(H3-Z)**2-R3* (2.*TANPHI*(H3-Z)+R3)

00040035

RETURN

00040045

END(1,1,0,0,0,0,0,1,1,0,1,0,0,0,0,0)

SUBROUTINE CORE(KG0,KRETRN)

00016010

COMMON KALPHA

COMMON ND0SE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, KOUT, PATH, PI, Q, 00000007

3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z, 00000008

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK 00000009

DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

I (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (SO, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC0CL, 00000021

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18) 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL,

7 Q(27)), (C00RD, Q(30))

KALPHA=KALPHA

00016015

KFLAG=1

00016017

1 GO TO (2, 10, 100, 150, 300, 400), KG0

00016020

2 ZLAMDA=0.

00016030

IF (GAMMA) 100, 400, 10

00016035

10 ZL=(H8-Z)/GAMMA

00016040

XX=X+ALPHA*ZL

00016045

YY=Y+BETA*ZL

00016050

CONSTC=XX**2+YY**2-R8**2

00016052

IF (CONSTC) 20, 20, 30

00016055

EXIT CORE THRU END

00016060

20 CALL ADVANC(SIGMAC)

00016065

22 KRETRN=2

00016070

RETURN

00016075

EXITS CORE BY PASSING THRU REFLECTOR

00016080

30 CONSTA=ALPHA**2+BETA**2

00016085

CONSTB=2.*(ALPHA*X+BETA*Y)

00016090

CONSTC=X**2+Y**2-R8**2

CALL R0CTS(KFLAG, KURSE)

GO TO (38, 4030), KURSE

00016100

NAA-SR-MEMO-8968

9-13-63

Page 26 of 45

NAA-SR-MEMO-8968

9-13-63

Page 27 of 45

38	CALL ADVANC(SIGMAC)	00016110
	ZL=(H8-Z)/GAMMA	00016115
	XX=X+ALPHA*ZL	00016120
	YY=Y+BETA*ZL	00016125
	CONSTC=XX**2+YY**2-R7**2	00016128
	IF(CONSTC) 40,40,50	00016130
C	HITS REFLECTOR END	00016132
40	CALL ADVANC(SIGMAR)	00016135
	GO TO 22	00016140
C	HITS REFLECTOR SIDE	00016145
50	CONSTA=ALPHA**2+BETA**2	00016150
	CONSTB=2.*(ALPHA*X+BETA*Y)	00016155
	CONSTC=X**2+Y**2-R7**2	
	CALL ROOTS(KFLAG,KURSE)	00016160
	GO TO (40,4030),KURSE	00016165
C	*** GAMMA NEGATIVE ***	00016180
100	ZL=(H7-Z)/GAMMA	00016185
	X2=X+ALPHA*ZL	00016190
	Y2=Y+BETA*ZL	00016195
	CONSTC=X2**2+Y2**2-R8**2	00016198
	IF(CONSTC) 110,110,120	00013200
C	EXITS CORE THRU END...	00016205
110	CALL ADVANC(SIGMAC)	00016210
	GO TO 150	00016215
C	PARTICLE PASSES FROM CORE INTO REFLECTOR...	00016220
120	CONSTA=ALPHA**2+BETA**2	00016225
	CONSTB=2.*(ALPHA*X+BETA*Y)	00016230
	CONSTC=X**2+Y**2-R8**2	
	CALL ROOTS(KFLAG,KURSE)	00016240
	GO TO (127,4030),KURSE	00016245
127	CALL ADVANC(SIGMAC)	00016250
	ZL=(H7-Z)/GAMMA	00016255
	X2=X+ALPHA*ZL	00016260
	Y2=Y+BETA*ZL	00016265
	CONSTC=X2**2+Y2**2-R7**2	00016268
	IF(CONSTC) 130,130,140	00016270
C	PARTICLE EXITS THRU REFLECTOR END...	00016275
130	CALL ADVANC(SIGMAR)	00016280
	GO TO 150	00016285

```

C      PARTICLE EXITS THRU REFLECTOR SIDE...
140  CONSTA=ALPHA**2+BETA**2
      CONSTB=2.*(ALPHA*X+BETA*Y)
      CONSTC=X**2+Y**2-R7**2
      CALL ROOTS(KFLAG,KURSE)
      GO TO (147,4030),KURSE
147  CALL ADVAN (SIGMAR)
      GO TO 300

C      *
C      * PARTICLE ON END OF REFLECTOR/CORE ASSEMBLY, GAMMA - *
C      *
150  IF (X**2+Y**2-R6**2) 152,152,180
C      PARTICLE ENTERS GRID
152  ZL=(H6-Z)/GAMMA
      X2=X+ALPHA*ZL
      Y2=Y+BETA*ZL
      CONSTC=X2**2+Y2**2-R6**2
      IF(CONSTC) 156,156,200
C      LEAVES GRID THRU END
156  CALL ADVANC(SIGMAG)
157  IF(X**2+Y**2-R5**2) 158,158,170
C      HITS COOLANT ON END
158  ZL=(H5-Z)/GAMMA
      X2=X+ALPHA*ZL
      Y2=Y+BETA*ZL
      CONSTC=X2**2+Y2**2-R5**2
      IF(CONSTC) 160,160,162
C      LEAVES COOLANT THRU END
160  CALL ADVANC(SGCOOL)
161  KRETRN=1
      RETURN
162  CONSTA=ALPHA**2+BETA**2
      CONSTB=2.*(ALPHA*X+BETA*Y)
      CONSTC=X**2+Y**2-R5**2
      CALL ROOTS(KFLAG,KURSE)
      GO TO (160,4030),KURSE
C      CHECK FOR INTERCEPT OF COOLANT EDGE...
170  IF(R5) 161,161,175
175  CONSTA=ALPHA**2+BETA**2

```

```

00016290
00016295
00016300
00016310
00016315
00016320
00016325
00016330
00016335
00016340
00016345
00016350
00016355
00016360
00016365
00016368
00016370
00016375
00016380
00016385
00016390
00016395
00016400
00016405
00016407
00016410
00016415
00016420
00016425
00016430
00016415
00016420
00016425
00016430
00016430
00016465
00016482
00016487

```

NAA-SR-MEMO-8968

9-13-63

Page 28 of 45

```

CONSTB=2.*(ALPHA*X+BETA*Y)
CONSTC=X*X+Y*Y-R5*R5
KFLAG=1
CALL ROOTS(KFLAG,KURSE)
GO TO (7775,161),KURSE
7775 ZZ=Z+GAMMA*ZL
    IF (ZZ-H6) 176,176,161
176 IF (ZZ-H5) 161,177,177
177 X=X+ALPHA*ZL
    Y=Y+BETA*ZL
    Z=Z+GAMMA*ZL
    GO TO 158
C      CHECK FOR GRID HIT...
180 IF(R6) 170,170,1851
1851 CONSTA=ALPHA**2+BETA**2
    CONSTB=2.*(ALPHA*X+BETA*Y)
    CONSTC=X*X+Y*Y-R6*R6
    KFLAG=1
    CALL ROOTS(KFLAG,KURSE)
    GO TO (7851,2190),KURSE
7851 ZZ=Z+GAMMA*ZL
    IF(ZZ-H7)187,187,2190
187 IF(ZZ-H6)2190,2190,188
188 X=X+ALPHA*ZL
    Y=Y+BETA*ZL
    Z=Z+GAMMA*ZL
    GO TO 152
2190 ZL=(H6-Z)/GAMMA
    X=X+ALPHA*ZL
    Y=Y+BETA*ZL
    Z=Z+GAMMA*ZL
    GO TO 157
C      CHECK FOR COOLANT HIT BY PARTICLE LEAVING GRID EDGE...
200 CONSTA=ALPHA**2+BETA**2
    CONSTB=2.*(ALPHA*X+BETA*Y)
    CONSTC=X**2+Y**2-R6**2
    CALL ROOTS KFLAG,KURSE)
    GO TO (201,4030),KURSE
201 CALL ADVANC(SIGMAG)

```

```

00016490
00016500
00016505
00016510
00016512
00016515
00016520
00016525
00016530
00016535
00016540
00016545
00016550
00016567
00016570
00016575
00016580
00016585
00016590
00016592
00016595
00016600
00016605
00016610
00016615
00016620
00016625
00016626
00016627
00016628
00016629
00016629
00016630
000
00016663
00016634
00016634
00016636

```

NAA-SR-MEMO-8968
 9-13-63
 Page 29 of 45

NAA-SR-MEMO-8968
9-13-63
Page 30 of 45

```

2010 IF(R6-R5) 202,202,161
202 ZL=(H6-Z)/GAMMA
    X2=X+ALPHA*ZL
    Y2=Y+BETA*ZL
    IF(X2**2 + Y2**2 - R5**2) 205,205,161
C    HITS COOLANT
205 X=X+ALPHA*ZL
    Y=Y+BETA*ZL
    Z=Z+GAMMA*ZL
    GO TO 158

C
C    *
C    * PARTICLE ON EDGE OF CORE/REFLECTOR ASSEMBLY *
C    *
300 IF(R7-R6) 320,305,305
305 IF (R7-R5) 202,202,161
320 ZL=(H7-Z)/GAMMA
    X2=X+ALPHA*ZL
    Y2=Y+BETA*ZL
    IF-(X2**2 + Y2**2 - R6**2) 188,188,325
325 IF (R7-R5) 202,202,161
400 CONSTA=ALPHA**2+BETA**2
    CONSTB=2.*(ALPHA*X+BETA*Y)
    CONSTC=X*X+Y*Y-R8*R8
    KFLAG=1
    CALL ROOTS(KFLAG,KURSE)
    GO TO (402,404),KURSE
402 CALL ADVANC(SIGMAC)
404 CONSTB=2.*(ALPHA*X+BETA*Y)
    CONSTC=X*X+Y*Y-R7*R7
    CALL ROOTS(KFLAG,KURSE)
    GO TO 40
4000 KRETRN=3
    ND=ND0SE
    CALL PRINT0
    RETURN
4030 WRITE OUTPUT TAPE 6,4032,X,Y,Z,ALPHA,BETA,GAMMA,CONSTA,CONSTB,
2    CONSTC,ZL,ZLAMDA,RD(ND0SE),ZD(ND0SE),I,J,K
4032 FORMAT(13H1**CORE ERROR /1X,6E15.6/1X,3E15.6/1X,4E15.6/1X,
2    3I4)

```

00016637
00016640
00016645
00016650
00016655
00016660
00016665
00016670
00016675
00016680
00016695
00016685
00016690
00016700
00016705
00016710
00016715
00016720
00016725
00016730
00016740
00016750
00016755
00016760
00016765
00016767
00016770
00016775
00016780
00016785
00016790
00016795
000
000
00016800
00016796
00016797
000

CORE

10/08/63 PAGE 6

GO TO 4000

00016799

END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)

NAA-SR-MEMO-8968

9-13-63

Page 31 of 45

```

SUBROUTINE PRINTI(KG00F)                                00070020
COMMON KALPHA
COMMON ND0SE
COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, DOSE,
2      I, IN, J, K, KOUT, PATH, PI, Q,
3      RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z,
4      ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK
DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), DOSE(2,50) 00000010
EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK 00000010
1      (5)), (R8, RC), (ABSPSI, ABSGAM)
EQUIVALENCE (S0, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (A0, Q(4)), (B, Q(5)),
2      (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L,
2      Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022
3      (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18 00000023
5      ), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7, 00000024
6      Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL, 00000025
7      Q(27)), (C00RD, Q(30)) 00000026

C
DO 2 I=1,4
IF (KK(I)) 100,100,2
2 CONTINUE
DO 4 II=1,3
IF (KK(II)-10)4,4,104
4 CONTINUE
8 IF (ND-50) 10,10,108
10 IF (LN-1) 12,14,12
12 IF (LN-2*(LN/2)) 110,14,110
14 IF (IUNIT) 160,180,160
160 UNIT = 4H IN.
GO TO 200
180 UNIT = 4H CM.
200 WRITE OUTPUT TAPE KOUT,22,LM,LP,LN,ND
22 FORMAT(1H0,24H SOURCE SPECIFICATION--/1H0,9X,4HM = I2,19X,4HP =
2      I2,19X,4HN = I2,19X,5HND = I2) 00070190
WRITE OUTPUT TAPE KOUT,16,S0,OMEGA,G,A0,G,B 00070210
16 FORMAT(1H0,9X,14HCORE SOURCE = 1PE13.6,6H * JO(1PE13.6,10H*R) * C000070220
2S(1PE13.6,13H * (Z - H/2))/1H0,9X,19HREFLECTOR SOURCE = 1PE13.6, 00070230
37H * C0S(1PE13.6,21H * (Z - H/2)) * EXP(-1PE13.6,11H*(R - RC) ) 00070240
WRITE OUTPUT TAPE KOUT,20,UNIT,(Q(I),I=11,24) 00070280

```

NAA-SR-MEMO-8968
9-13-63
Page 32 of 45


```
20 FORMAT(25H0 SHIELD SPECIFICATION (A6,3H)--/1H0,20X,3HR2=1PE13.6, 00070290
27H R3=1PE13.6,7H R5=1PE13.6,7H R6=1PE13.6/1H0,20X,3HR7= 00070300
31PE13.6,7H R8=1PE13.6,7H H1=1PE13.6,7H H2=1PE13.6/1H0,20X00070310
4,3HH3=1PE13.6,7H H4=1PE13.6,7H H5=1PE13.6,7H H6=1PE13.6/ 00070320
5 1H0,40X,3HH7=1PE13.6,7H H8=1PE13.6) 00070330
WRITE OUTPUT TAPE KOUT,26,(Q(II),II=25,27),(Q(JJ),JJ=6,10) 00070340
26 FORMAT(24H0 MATERIAL PROPERTIES--/1H0,25X,4HCORE,10X,9HREFLECTOR, 00070350
2 11X,4HGRID,11X,7HCOOLANT,11X,6HSHIELD/1H0,8X,9HDENSITIES,34X, 00070360
33(2X,1PE15.6)/18H0 CROSS SECTION,5(2X,1PE15.6)) 00070370
KG00F=1 00070400
RETURN 00070410
100 WRITE OUTPUT TAPE KOUT,102 00070420
101 KG00F=2 00070430
RETURN 00070440
102 FORMAT(44H0**ERROR-M, P, N, OR ND IS NEGATIVE OR ZERO ) 00010132
104 WRITE OUTPUT TAPE KOUT,106 00070460
GO TO 101 00070470
106 FORMAT(29H0**ERROR-M,P, OR N EXCEEDS 10) 00070480
108 WRITE OUTPUT TAPE KOUT,109 00070490
GO TO 101 00070500
109 FORMAT(23H0**ERROR-ND TOO LARGE ) 00070510
110 WRITE OUTPUT TAPE KOUT,111 00070520
GO TO 101 00070530
111 FORMAT(17H0**ERROR-N IS ODD) 00070540
END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)
```

NAA-SR-MEMO-8968

9-13-63

Page 33 of 45

SUBROUTINE PRINTO

00070010

NAA-SR-MEMO-8968

9-13-63

Page 34 of 45

C

COMMON KALPHA

COMMON ND0SE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, K0UT, PATH, PI, Q, 00000007

3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z, 00000008

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK 00000009

DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

I (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (SO, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L, 00000021

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18) 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL,

7 Q(27)), (C00RD, Q(30))

C

IF (IUNIT) 2,4,2

00060020

C UNITS ARE IN INCHES

00060030

2 CONST = 2.54

00060040

UNIT1 = 6H (IN.)

00060050

UNIT2 = 6H (CM.)

00060060

C CONVERT RH0 (GM/CC) TO RH0 (GM/IN**3)

00060070

RH0C = .06102*RH0C

00060080

RH0G = .06102*RH0G

00060090

RH0SHL = .06102*RH0SHL

00060100

G0 TO 6

00060110

4 CONST = .394

00060120

UNIT1 = 6H (CM.)

00060130

UNIT2 = 6H (IN.)

00060140

6 UNIT3 = 6H (GM.)

00060150

WRITE OUTPUT TAPE K0UT, 10, UNIT1, UNIT1, UNIT2, UNIT2

00060160

10 FORMAT(1H0, 42X, 26HDIRECT D0SE RATE PER P0INT/1H0, 67X, 16HDIRECT D0S 00060170

2E RATE/17X, 1HR, 9X, 1HZ, 9X, 1HR, 9X, 1HZ, 13X, 4HFROM, 12X, 4HFROM/14X, A6, 00060180

34X, A6, 4X, A6, 4X, A6, 11X, 4HC0RE, 12X, 4HREFL, 12X, 5HTOTAL) 00060190

NUMBER = 0

00060200

D0 14 JJ=1, ND

00060210

```

RR = CONST*RD(JJ)                                00060220
ZZ = CONST*ZD(JJ)                                00060230
DTOT = D0SE(1,JJ)+D0SE(2,JJ)                    00060240
WRITE OUTPUT TAPE KOUT,16, RD(JJ),ZD(JJ),RR,ZZ,D0SE(1,JJ),D0SE(2,JJ) 00060250
2) DTOT                                           00060260
NUMBER = NUMBER+1                                00060270
IF (NUMBER-5) 14,12,12                          00060280
12 WRITE OUTPUT TAPE KOUT,13                    00060290
13 FORMAT(1H )                                  00060300
NUMBER=0                                         00060310
14 CONTINUE                                     00060320
16 FORMAT(10X,4(3X,F7.2),3X,3(3X,1PE13.7))      00060330
C      COMPUTE SHIELD WTS...                    00060490
WGRID = RHOG*PI*R6*R6*(H7-H6)                  00060500
WC00L = RHOC*PI*R5*R5*(H6-H5)                  00060510
WS1 = PI*((RAD1**2-ZC1**2)*(H4-H3) + ZC1*(H4**2-H3**2) -
2      (H4**3-H3**3)/3.)                      00060530
WCONE = PI*((H3-H2)*(R3**2+(R3+H3*TANPHI)**2)- TANPHI*(2.*(H3**2
2      -H2**2)*(R3-H3*TANPHI) - TANPHI*(H3**3-H2**3)/3.) ) 00060540
WS2 = PI*((RAD2**2-ZC2**2)*(H2-H1) + ZC2*(H2**2-H1**2)-
2      (H2**3-H1**3)/3.)                      00060560
WSHLD = RHOSHL*(WS1+WCONE+WS2)                  00060570
WTOT = WGRID + WC00L + WSHLD                    00060580
WRITE OUTPUT TAPE KOUT,28,UNIT3, WGRID,WC00L,WSHLD,WTOT 00060590
28 FORMAT(1H1,53X,14HSHIELD WEIGHTS/1H0,58X,A6/1H0,53X,5HGRID=F9.2/ 00060600
2      51X,8HC00LANT=F9.2/52X,7HSHIELD=F9.2/1H0,52X,6HTOTAL=F9.2) 00060610
RETURN                                           00060620
END(1,0,0,0,0,0,1,0,0,1,0,0,0,0,0)

```

NAA-SR-MEMO-8968

9-13-63

Page 35 of 45

SUBROUTINE RFLECT(KRETRN)

00031010

NAA-SR-MEMO-8968

9-13-63

Page 36 of 45

COMMON KALPHA

COMMON ND0SE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, K0UT, PATH, PI, Q, 00000007

3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z, 00000008

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK 00000009

DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

I (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (S0, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)), 000

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L, 00000021

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18) 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL,

7 Q(27)), (C00RD, Q(30))

ZLAMDA = 0.

00031015

KFLAG=1

00031013

KALPHA = KALPHA

00031025

IF (GAMMA) 100, 200, 10

00031030

WILL MISS C0RE...

00031035

20 ZL=(H8-Z)/GAMMA

00031055

XX=X+ALPHA*ZL

00031060

YY=Y+BETA*ZL

00031065

CONSTC=XX**2+YY**2-R7**2

00031070

IF (CONSTC) 22, 22, 30

00031072

LEAVES THRU REFLECTOR END

00031075

22 CALL ADVANC(SIGMAR)

00031080

KRETRN=2

00031085

RETURN

00031090

LEAVES THRU REFLECTOR EDGE

00031095

CONSTA=ALPHA**2+BETA**2

00031100

CONSTB=2.*(ALPHA*X+BETA*Y)

00031105

CONSTC=X**2+Y**2-R7**2

00031110

CALL ROOTS(KFLAG, KURSE)

00031115

```

      GO TO (22,6030),KURSE
C      MAY HIT CORE...
      10 IF(R8) 20,20,41
      41 CONSTA=ALPHA**2+BETA**2
        CONSTB=2.*(ALPHA*X + BETA*Y)
        CONSTC=X*X + Y*Y -R8*R8
        KFLAG=1
        CALL ROOTS(KFLAG,KURSE)
        GO TO (4441,20),KURSE
      4441 ZZ=Z+GAMMA*ZL
          IF (ZZ-H8) 42,42,20
          42 IF (ZZ-H7) 20,46,46
C      HITS CORE
      46 CALL ADVANC(SIGMAR)
        KGC=2
        CALL CORE(KGC,KBACK)
        KRETRN=KBACK
        RETURN

C      *
C      * NEGATIVE GAMMA *
C      *
      120 ZL=(H7-Z)/GAMMA
        XX=X+ALPHA*ZL
        YY=Y+BETA*ZL
        CONSTC=XX**2+YY**2-R7**2
        IF(CONSTC) 122,122,130
C      EXIT THRU REFLECTOR END
      122 CALL ADVANC(SIGMAR)
        KGC=4
      126 CALL CORE(KGC,KBACK)
        KRETRN=KBACK
        RETURN
      130 CONSTA=ALPHA**2+BETA**2
        CONSTB=2.*(ALPHA*X+BETA*Y)
        CONSTC=X**2+Y**2-R7**2
        CALL ROOTS(KFLAG,KURSE)
        GO TO (136,6030),KURSE
      136 CALL ADVANC(SIGMAR)
        KGC=5

```

```

00031120
00031135
00031138
00031140
00031145
00031150
00031155
00031160
00031162
00031165
00031170
00031175
00031190
00031195
00031200
00031205
00031210
00031215
00031220
00031225
00031230
00031255
00031260
00031265
00031267
00031270
00031275
00031280
00031285
00031290
00031295
00031300
00031310
00031310
00031320
00031325
00013
000

```

NAA-SR-MEMO-8968
 9-13-63
 Page 37 of 45

	GO TO 126	00031335
C	MAY HIT CORE	00031350
100	IF(R8) 120,120,141	00031353
141	CONSTA=ALPHA**2+BETA**2	00031355
	CONSTB=2.*(ALPHA*X+BETA*Y)	00031360
	CONSTC=X*X+Y*Y-R8*R8	00031365
	KFLAG=1	00031370
	CALL ROOTS(KFLAG,KURSE)	00031375
	GO TO (4141,120),KURSE	00031377
4141	ZZ=Z+GAMMA*ZL	00031380
	IF(ZZ-H8) 142,142,120	000
142	IF(ZZ-H7) 120,146,146	000
C	HITS CORE	00031405
146	CALL ADVANC(SIGMAR)	00031410
	KGC=3	00031415
	GO TO 126	00031420
200	CONSTA=ALPHA**2+BETA**2	000
	CONSTB=2.*(ALPHA*X+BETA*Y)	000
	CONSTC=X*X+Y*Y-R8*R8	000
	IF(CONSTB**2-4.*CONSTA*CONSTC) 204,204,210	000
204	CONSTC=X*X+Y*Y-R7*R7	000
	KFLAG=1	000
	CALL ROOTS(KFLAG,KURSE)	00031455
	GO TO (206,6000),KURSE	00031457
206	CALL ADVANC(SIGMAR)	00031460
	KRETRN=2	000
	RETURN	000
210	KFLAG=1	
	CALL ROOTS(KFLAG,KURSE)	00031485
	GO TO (212,204),KURSE	
212	CALL ADVANC(SIGMAR)	
	X=X+.01*ALPHA	000
	Y=Y+.01*BETA	000
	KGC=6	000
	CALL CORE(KGC,KBACK)	000
	KRETRN=KBACK	000
	RETURN	000
6000	KRETRN=3	00031600
	ND=ND0SE	

NAA-SR-MEMO-8968

9-13-63

Page 38 of 45

RFLECT

10/08/63 PAGE 4

```
      CALL PRINT0  
      RETURN  
6030 WRITE OUTPUT TAPE 6,6032,X,Y,Z,ALPHA,BETA,GAMMA,CONSTA,CONSTB,  
  2  CONSTC,ZL,ZLAMDA,RD(ND0SE),ZD(ND0SE),I,J,K  
      GO TO 6000  
6032 FORMAT(15H1**RFLECT ERROR /1X,6E15.6/1X,3E15.6/1X,4E15.6/1X,  
  2  3I3)  
      END(1,0,0,0,0,0,0,1,0,0,0,1,0,0,0,0,0)
```

000
00031610

NAA-SR-MEMO-8968
9-13-63
Page 39 of 45

SUBROUTINE ROOTS (KFLAG,KURSE)

00050015

NAA-SR-MEMO-8968

9-13-63

Page 40 of 45

COMMON KALPHA

COMMON ND0SE

COMMON ABSPSI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, KOUT, PATH, PI, Q, 00000007

3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z, 00000008

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK 00000009

DIMENSION Q(150), KK(5), CCORD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK

1 (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (SC, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L, 00000021

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18) 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7,

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL,

7 Q(27)), (CCORD, Q(30))

C SOLVES $A*L**2 + B*L + C = 0$ FOR L, GIVEN A, B, AND C. SELECTS 00050018

C SMALLEST + ROOT IF KFLAG=1, LARGEST + ROOT IF KFLAG=2. 00050016

C SQT=CONSTB**2-4.*CONSTA*CONSTC 00050017

IF (SQT) 20,4,4 00050020

4 SQT=SQRTF(SQT) 00050025

ROOT1=(-CONSTB+SQT)/(CONSTA+CONSTA) 00050030

ROOT2=(-CONSTB-SQT)/(CONSTA+CONSTA) 00050035

IF (ROOT1) 6,10,10 00050040

6 IF (ROOT2) 20,7,7 00050045

7 ZL=ROOT2 00050050

KURSE=1 00050055

RETURN 00050057

10 IF (ROOT2) 11,14,14 00050060

11 ZL=ROOT1 00050065

KURSE=1 00050070

RETURN 00050075

14 GO TO (16,18), KFLAG 00050078

16 IF (ROOT1-ROOT2) 11,11,7 00050080

18 IF (ROOT1-ROOT2) 7,11,11 00050082

ROOTS

10/08/63 PAGE 2

C

20

KURSE=2

RETURN

END(1,1,0,0,0,0,1,1,0,1,0,0,0,0,0)

00050085

00050090

00050095

NAA-SR-MEMO-8968

9-13-63

Page 41 of 45

SUBROUTINE SPHERE(RADIUS,CENTER)

00030010

COMMON KALPHA

COMMON ND0SE

COMMON ABS SI, ALPHA, BETA, GAMMA, CONSTA, CONSTB, CONSTC, D0SE, 00000006

2 I, IN, J, K, KOUT, PATH, PI, Q,

3 RAD1, RAD2, RD, TANPHI, TANSQD, X, Y, Z,

4 ZC1, ZC2, ZD, ZL, ZLAMDA, Q, KK

DIMENSION Q(150), KK(5), C00RD(100), RD(50), ZD(50), D0SE(2,50) 00000010

EQUIVALENCE (LM, KK(1)), (LP, KK(2)), (LN, KK(3)), (ND, KK(4)), (IUNIT, KK 00000010

I (5)), (R8, RC), (ABSPSI, ABSGAM)

EQUIVALENCE (S0, Q(1)), (G, Q(2)), (OMEGA, Q(3)), (AO, Q(4)), (B, Q(5)),

2 (SIGMAC, Q(6)), (SIGMAR, Q(7)), (SIGMAG, Q(8)), (SGC00L,

2 Q(9)), (SIGSHL, Q(10)), (R2, Q(11)), (R3, Q(12)), (R5, Q(13)), 00000022

3 (R6, Q(14)), (R7, Q(15)), (R8, Q(16)), (H1, Q(17)), (H2, Q(18 00000023

5), (H3, Q(19)), (H4, Q(20)), (H5, Q(21)), (H6, Q(22)), (H7, 00000024

6 Q(23)), (H8, Q(24)), (RH0G, Q(25)), (RH0C, Q(26)), (RH0SHL, 00000025

7 Q(27)), (C00RD, Q(30)) 00000026

CONSTB=2.0*(ALPHA*X+BETA*Y+GAMMA*(Z-CENTER))

00030015

CONSTC=X*X+Y*Y+Z*Z+CENTER*(CENTER-Z-Z)-RADIUS*RADIUS

00030020

CONSTA=1.0

00030025

RETURN

00030035

END(1,1,0,0,0,0,1,1,0,1,0,0,0,0,0)

NAA-SR-MEMO-8968

9-13-63

Page 42 of 45

STORAGE NOT USED BY PROGRAM

DEC OCT
920 01630

DEC OCT
32179 76663

NAA-SR-MEMO-8968
9-13-63
Page 43 of 45

STORAGE LOCATIONS FOR VARIABLES APPEARING IN COMMON STATEMENTS

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT				
AO	32553	77451	ABSGAM	32406	77226	ABSPSI	32406	77226	ALPHA	32403	77223
BETA	32402	77222	B	32552	77450	CONSTA	32400	77220	CONSTB	32399	77217
CONSTC	32398	77216	COORD	32527	77417	DOSE	32397	77215	GAMMA	32401	77221
G	32555	77453	H1	32540	77434	H2	32539	77433	H3	32538	77432
H4	32537	77431	H5	32536	77430	H6	32535	77427	H7	32534	77426
H8	32533	77425	IN	32296	77050	I	32297	77051	IUNIT	32557	77455
J	32295	77047	KALPHA	32405	77225	KK	32561	77461	KOUT	32293	77045
K	32294	77046	LM	32561	77461	LN	32559	77457	LP	32560	77460
ND0SE	32404	77224	ND	32558	77456	OMEGA	32554	77452	PATH	32292	77044
PI	32291	77043	Q	32556	77454	R2	32546	77442	R3	32545	77441
R5	32544	77440	R6	32543	77437	R7	32542	77436	R8	32541	77435
RAD1	32290	77042	RAD2	32289	77041	RC	32541	77435	RD	32288	77040
RH0C	32531	77423	RH0G	32532	77424	RH0SHL	32530	77422	S0	32556	77454
SGC00L	32548	77444	SIGMAC	32551	77447	SIGMAG	32549	77445	SIGMAR	32550	77446
SIGSHL	32547	77443	TANPHI	32238	76756	TANSQD	32237	76755	X	32236	76754
Y	32235	76753	ZC1	32233	76751	ZC2	32232	76750	ZD	32231	76747
ZLAMDA	32180	76664	ZL	32181	76665	Z	32234	76752			

STORAGE LOCATIONS FOR VARIABLES NOT APPEARING IN COMMON, DIMENSION, OR EQUIVALENCE STATEMENTS

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT				
DELTAR	919	01627	DELTAZ	918	01626	DIST	917	01625	HOVER2	916	01624
KD0SE	915	01623	KFLAG	914	01622	KG00F	913	01621	KG0	912	01620
KKK2	911	01617	KRETRN	910	01616	KURSE	909	01615	LL	908	01614
N	907	01613	PIZN	906	01612	RADIUS	905	01611	SAVE1	904	01610
SAVE2	903	01607	SAVE3	902	01606	SHAPE	901	01605	SV	900	01604
V0L	899	01603	WORD	898	01602	X2	897	01601	Y2	896	01600
ZIM12	895	01577	ZI	894	01576	ZJM12	893	01575	ZJ0DD	892	01574
ZJ	891	01573	ZKM12	890	01572	ZK	889	01571	ZM	888	01570
ZN	887	01567	ZP	886	01566						

NAA-SR-MEMO-8968

9-13-63

Page 44 of 45

SYMBOLS AND LOCATIONS FOR SOURCE PROGRAM FORMAT STATEMENTS

EFN	LOC	EFN	LOC	EFN	LOC	EFN	LOC
813	3 01546	814	4 01530	81F0	504 01527		

LOCATIONS FOR OTHER SYMBOLS NOT APPEARING IN SOURCE PROGRAM

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
1)	871 01547	2)	813 01455	3)	821 01465	4)	32767 77777
6)	829 01475	A1100	791 01427	A1101	800 01440	B)	819 01463
C)G1	876 01554	C)G2	877 01555	C)G3	878 01556	C)G4	879 01557
C)G5	880 01560	C)100	881 01561	C)101	882 01562	C)200	883 01563
C)201	884 01564	C)202	885 01565	D)201	37 00045	D)20J	372 00564
D)200	491 00753	D)20R	554 01052	D)216	695 01267	D)217	714 01312
D)301	36 00044	D)300	490 00752	D)316	694 01266	D)317	713 01311
E)4	67 00103	E)7	198 00306	E)J	371 00563	E)L	432 00660
E)R	553 01051	E)U	620 01154	E)14	679 01247	E)114	679 01247

LOCATIONS OF NAMES IN TRANSFER VECTOR

DEC	OCT	DEC	OCT	DEC	OCT	DEC	OCT
ADVANC	17 00021	BESEL	10 00012	CONE	16 00020	CORE	11 00013
COS	7 00007	EXP	12 00014	FORED	5 00005	PRINTI	6 00006
PRINT0	18 00022	RFLECT	13 00015	ROOTS	15 00017	SIN	8 00010
SPHERE	14 00016	SQRT	9 00011	(FIL)	4 00004	(FPT)	0 00000
(RTN)	2 00002	(STH)	3 00003	(TSH)	1 00001		

ENTRY POINTS TO SUBROUTINES NOT OUTPUT FROM LIBRARY

ADVANC	BESEL	CONE	CORE	COS	EXP	FORED	PRINTI
PRINT0	RFLECT	ROOTS	SIN	SPHERE	SQRT	(FIL)	(FPT)
(RTN)	(STH)	(TSH)					

EXTERNAL FORMULA NUMBERS WITH CORRESPONDING INTERNAL FORMULA NUMBERS AND OCTAL LOCATIONS

EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC	EFN	IFN	LOC
2	14	00046	6	26	00104	8	38	00170	10	42	00211
14	70	00451	16	76	00532	18	78	00536	391	79	00540
106	80	00543	108	82	00546	109	84	00551	110	85	00553

RATRAP

T H E R A T R A P C O D E

10/15/23 PAGE 9

20 86 00557
180 102 00754
190 115 01053
205 130 01164
225 141 01250
500 148 01330

22 87 00565
182 103 00756
192 119 01103
206 133 01203
230 143 01256
502 152 01342

40 95 00661
184 106 01000
195 123 01122
210 136 01212
280 146 01270

42 96 00665
185 111 01034
200 128 01155
212 137 01217
300 147 01313

NAA-SR-MEMO-8968
9-13-63
Page 45 of 45