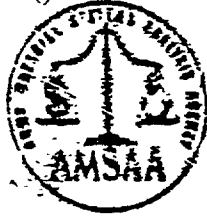


AMSAA TM 98



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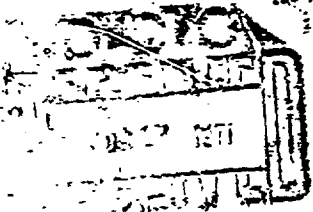
AMSAA

TECHNICAL MEMORANDUM NO. 98

THE FIRST CONFERENCE OF USERS OF
THE MAGIC AND SAM-C PROGRAMS

R. A. Marking

May 1971



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AD 728124

U.S. ARMY ARTILLERY RESEARCH AND DEVELOPMENT CENTER
ARMY MATERIAL SYSTEMS ANALYSIS AGENCY
CAMP BUELL, PROving GROUNDS, MARIETTA

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ARMY MATERIEL SYSTEMS ANALYSIS AGENCY

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RDT&E Project No. 1T562601A259

ABERDEEN PROVING GROUND, MARYLAND

ARMY MATERIEL SYSTEMS ANALYSIS AGENCY

TECHNICAL MEMORANDUM NO. 98

RAMarking/paw
Aberdeen Proving Ground, Md.

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Also included are the addresses, in expanded form, of the principal users of the two programs. These addresses included corrections and improvements to the two codes.

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THE FIRST CONFERENCE OF USERS OF
THE MAGIC AND SAM-C PROGRAMS

1. INTRODUCTION AND PURPOSE

This report presents the proceedings of the first large-scale conference of the users of the MAGIC and SAM-C computer programs. The conference convened at 0915 on August 6, 1969, in Building 328 at Aberdeen Proving Ground, Maryland. Early in the afternoon of the 7th the conferees divided themselves into two groups: those interested in the MAGIC code and those interested in the SAM-C. The conference closed shortly after noon on Friday the 8th.

The following sections contain abridged versions of the announcement letter and of the opening address.

1.1 Copy of Conference Announcement (Abridged).

"AMXRD-AWF

"SUBJECT: Conference for Users of the MAGIC/SAM-C Computer Programs

"1. References:

a. The MAGIC SAM-C Target Analysis Technique, AMSAA Technical Reports 4, 10, 11, 13, and 14.

b. A Geometric Description Technique Suitable for Computer Analysis of Both the Nuclear and Conventional Vulnerability of Armored Military Vehicles, MAGI-6701 (AD 847576).

c. UNC-SAM-2: A FORTRAN Monte Carlo Program Treating Time-Dependent Neutron and Photon Transport Through Matter, UNC-5157 (AD 647470).

"2. The SAM-C Monte Carlo radiation transport program and the MAGIC conventional projectile ray-tracing program were developed by MAGI (Mathematical Applications Group, Inc) under Contract No. DAAD05-67-C-0041 for this agency (ref. a). MAGIC is the computer code that assembles data along selected rays through a target by employing the MAGI originated Combinatorial Geometry technique (ref. b) which utilizes combinations of certain basic solids such as boxes, wedges, etc., to

describe the target. SAM-C is the UNC-SAM-2 Monte Carlo nuclear radiation transport code (ref. c) with the original geometry routines replaced by those of the Combinatorial Geometry technique. These programs have been disseminated to a number of interested government agencies for their use and will be made available to others upon request.

"5. Recent activity with MAGIC has resulted in several advances including the addition of new "library" solids, additional input checking, and faster input processing. These advances are clearly applicable to SAM-C as well and are thus of general interest to both groups. On the other hand, recent activity with SAM-C indicates that the flux-at-a-point routine is incorrectly coded, versions for different computing systems have non-trivial differences in logic/organization, and the computational procedure for carrying out a complete set of calculations is unacceptably complicated.

"4. As a result of the many questions, comments, and suggestions from the personnel involved in using SAM-C/MAGIC, it is clear that everyone involved can benefit from an informal discussion of problem areas and a concerted attack on areas of mutual interest. It is the purpose of this letter to announce an informal, unclassified conference to define and solve problems in the MAGIC and SAM-C computer codes developed under the auspices of this agency.

"5. It is envisioned that the conference will begin on 6 August 1969 at 0900 hours in the Conference Room of ARDC Building 328 under the chairmanship of Mr. R. A. Marking of AMSAA. At this writing it is envisioned that 2 days will be required with a third day allotted only to provide a buffer period.

"6. The first day will be devoted to introductory, informal discussions of individual problems, solutions, and changes to the various codes plus presentations (on MAGIC by Mr. Larry Bain, Methodology Office, AMSAA, and on SAM-C by Dr. Wayne Coleman, Nuclear Physics Branch, NEL) of information gathered too late for inclusion into the reports of reference a. The item, "Introduction of Participants," is envisioned as an opportunity for each participant to identify which program(s) his agency is using, what problems have been encountered, any solutions that have been created, and what specific problem areas he would like to see addressed during the conference period. About 20 minutes will be allotted for each individual.

"7. The second day is planned for the creation of ad hoc working groups to achieve solutions of the problems defined on the first day. An additional day is scheduled to allow an orderly conclusion of the working group projects and the conference as a whole if necessary; the form and content of a conference report will be decided on the last day.

"8. Two items have been of special interest to all those contacted thus far: (1) the establishment of FORTRAN source decks for MAGIC and SAM-C that are not subject to the vagaries of day-to-day changes and are available to be copied by new user agencies or in the event that serious problems develop with an existing source deck; and (2) the creation of "benchmark" test problems that will provide valid tests of all features/options operational using the "archival" or "library" source deck. It is expected that these two items can be introduced in the afternoon of the first day of the conference.

"9. Participation in the conference is encouraged to promote the utility of the SAM-C and MAGIC programs. Representation from your organization is invited. The distribution list is not considered exhaustive and interested personnel within government may be invited to attend by contacting Mr. Marking. Participants are encouraged to bring listings of the current working versions of their program(s).

"10. It is intended that the meeting will result in documented improvements in the SAM-C and MAGIC source programs and/or implementation procedures. This documentation is expected to be in the form of a letter or technical note and copies will be sent to all participants.

"11. The desirability of scheduling similar meetings at regular intervals will be discussed as a means of maintaining lines of communications between MAGIC-SAM-C users."

12. (Administrative)

13. (Administrative)

FOR THE DIRECTOR:

/s/ Morgan G. Smith
MORGAN G. SMITH
Chief, Ground Warfare Division

1 Incl
as
(CF)

PROPOSED CONFERENCE AGENDA

DAY 1

"Introduction and Purpose
Introduction of Participants
Recent AMSAA Activity with MAGIC
Recent NEL Activity with SAM-C
Definition of MAGIC and SAM-C Capabilities and
Creation of Appropriate Source Decks
Creation of Benchmark Problems

DAY 2

Conclusion of the Creation of Archival Source
Decks and Benchmark Problems
Formation of Sub-groups to Solve the Problems
Defined on Day 1
Discussion and Drafting of Documentation
Consideration of Future Meetings

DAY 3 (If Necessary)

Conclusion of Unfinished Business"

Incl 1 to 1tr

1.2 Opening Address.

"Welcome to the 1st Conference of Users of the MAGIC and SAM-C Programs.

"As stated in the Conference letter-announcement, this is to be an informal, unclassified conference of the users of the MAGIC and/or SAM-C computer programs (as well as any of the peripheral programs that might be of mutual interest).

"The purpose of this conference is three-fold:

- to find out where we stand with respect to the actual operation of both SAM-C and MAGIC
 - who is using what
 - on what machines are the codes operating
 - what changes of substance (e.g., packing into 36-bit v. 48-bit words) have been made
 - what kinds of problem areas are being considered (e.g., deep penetration as opposed to close-in transport problems, penetrator fragmentation, x-ray or thermal neutron problems, etc.)
 - what sort of functional and/or theoretical problems are being encountered in operating these codes (e.g., functional identifiers of "0", incorrect evaluation of the uncollided flux, improper coding of SAM-C for inelastic scattering, etc.)
- to define what SAM-C and MAGIC should be capable of
 - there are a number of versions of SAM-C several of which are different enough to require separate operating manuals
 - changes have significantly increased the speed of MAGIC thus making here-to-fore impractical applications worth considering
 - should SAM-C be modified along the lines of UNC-SAM-3 (ENDF/B cross-sections and a non-common energy mesh)
 - should MAGIC calculate vulnerable areas
 - should the geometry processing routines (e.g., GENI, RPPIN, ALBERT, etc.) be called MAGIC and the "driving" or controlling routines such as VOLUM and GRID be handled as separate "packages"
 - should MAGIC employ packing and what effect would its absence have on SAM-C

- to create benchmark problems
 - compatibility of geometric input between MAGIC and SAM-C
 - should they be mathematical tests of all the options or tests of physical acceptability of some combination of both...."

2. INTRODUCTION OF PARTICIPANTS

At the beginning of the Conference the individual participants indicated (1) which program they were using, (2) on which computers was it routinely used (or intended to be used), (3) what were the nature and complexity of the problems treated, (4) what program innovations had been made, and (5) what problems or errors had been encountered. Additionally, it was requested that participants indicate specific program problems to discuss during the Conference.

To accomplish these introductions in an orderly manner, a form covering all of the obvious points of interest was used. Since some of the agencies were represented by more than one person, representatives from the same group using the same program caucused to present a unified picture of their work and problems.

The participants' introductions follow the list of agencies; they are in alphabetical order.

List of Agencies Represented

Aeronautical Systems Division
(Wright-Patterson)

Air Force Armament Laboratory
(Eglin)

Air Force Weapons Laboratory
(Kirtland)

Ground Warfare Division (AMSAA)
(Aberdeen)

Methodology Office (AMSAA)
(Aberdeen)

Naval Weapons Laboratory*
(Dahlgren)

Nuclear Effects Laboratory (BRL)*
(Edgewood)

* No Participant Introduction Form available.

List of Agencies Represented (Cont'd)

SMUPA-DW6*
(Picatinny)

SMUPA-SS
(Picatinny)

SMUPA-TW3
(Picatinny)

SMUPA-VC1
(Picatinny)

RSIC (ORNL)
(Oak Ridge)

Signature & Propagation Laboratory**
(Aberdeen)

Terminal Ballistics Laboratory (BRL)*
(Aberdeen)

Vulnerability Laboratory (BRL)
(Aberdeen)

* No Participant Introduction Form available.

** Observer only, no Participant Introduction Form included.

PARTICIPANT INTRODUCTION FORM

Agency: USAF, ASD (ASBRS), WPAFB, Ohio 45433

Name(s) of Representative(s): Gerald Bennett (ASBRS)
Roy Hilbrand (ASVCP)

Program Used: MAGIC

Purpose: To provide target descriptions for use in aircraft vulnerability analyses.

Computer(s) Used: Name IBM Direct Coupled 7044/7094 Word Size 36 bits

Memory Size: Total 32768 Available Unk

Tape Drives: No. 16 No. of Channels 4 1401-Compatible? Yes

Program Requirements: Storage 28K Packed Word Size 35 bits

Tape Drives 2 Links? Yes, 1

Dependence on Assembly Language None

Planned Program Usage: To generate target description for aircraft vulnerable area computation.

Planned Program Changes: Addition of plotting, presented area, and volume subroutines; modifications as required to generate and store data for efficient processing in vulnerable area computation program; further simplifications, as possible, to input descriptive data.

Program Innovations: The use of any body as a target volume subdivision (i.e., as an RPP); the streamlining of MAGIC by stripping out about 16 of the subroutines and recoding of others; restructuring of the Master-Aster array (M-A) deleting some items from the M-A array; recoding and repacking for 36 bit words, viz., 35 bits and one sign bit; changed grid cell generation; changed printout; allowing the attack plane to be outside of the enclosing volume; and disposal of random number generator requirement.

Program Problems/Errors: Core storage (too large); complexity in preparation of data. (Various program errors have been corrected and the corrected listings have been forwarded to AMSAA.)

Program Changes of Immediate Interest: Addition of an airfoil shape to the solid library; a more extensive ARB of perhaps 10 to 12 sides; introduction of "canned" standard aircraft component descriptions (e.g., a pilot).

PARTICIPANT INTRODUCTION FORM

Agency: Air Force Armament Laboratory

Name(s) of Representative(s): Sue Gibson

Program Used: MAGIC

Purpose: To be used with a vulnerable area program to produce vulnerable area program to produce vulnerable areas of foreign targets.

Computer(s) Used: Name CDC 6600 Word Size 60 bits

Memory Size: Total 100,000 Available 32,000

Tape Drives: No. 16 No. of Channels Unk 1401-Compatible? No

Program Requirements: Storage 32,000 Packed Word Size 36 bits

Tape Drives 7 Links? Yes, 4

Dependence on Assembly Language None

Planned Program Usage: Describe foreign air and ground targets in terms of line of sight data.

Planned Program Changes: Complete conversion from IBM 7094 to CDC 6600. Omit TESTG and other unnecessary subroutines to allow room for addition of new figure subroutines.

Program Innovations: Point Burst subroutine has been added and is being checked.

Program Problems/Errors: Lack of storage due to amount of storage allowed to each user, not to the total amount of storage in the CDC 6600.

Program Changes of Immediate Interest: Addition of new figures and reduction of amount of storage required.

PARTICIPANT INTRODUCTION FORM

Agency: AFWL, Kirtland AFB, New Mexico 87117

Name(s) of Representative(s): Michael J. Paul - AFWL (WLRAS)
A. Kris Widdison - AFWL (WLCP-M)

Program Used: SAM-C

Purpose: Both deep-penetration (in air) and close-in transport (concrete) problems, primarily neutrons, but including prompt and secondary gammas.

Computer(s) Used: Name CDC 6600 Word Size 60 bits

Memory Size: Total 300K (w/o extended core) Available 1Mg
(w/extended core) .325Kg (w/o extended core)

Tape Drives: No. 10 No. of Channels 9 1401-Compatible? Unk

Program Requirements: Storage generally 120K Packed Word Size 45 or
Tape Drives 1-3 Links? None 60 bits
Dependence on Assembly Language some, but easily
changed

Planned Program Usage: Hard-rock silo configurations and state-of-art neutron and gamma transport problems.

Planned Program Changes: Complete revision of input to be more understandable and logical and easier to punch. Combined time-energy-angular dependent source input (allowing input of flux from a preliminary discrete ordinates code).

Program Innovations: Free-form reading routine (eliminates need for formatting input). Cut down flux printing by 50% by eliminating extraneous lines (e.g., ΔE). Eliminate need to change NXS = and NDQ.... cards (e.g., add a parameter, say ENDM, to end of master array (COMMON DUM (250), MASTER (30000), ENDM), then NDQ = LOCF (ENDM) - LOCF (Master)).

Program Problems/Errors: None.

Program Changes of Immediate Interest: ENDF/B cross sections, inelastic scattering improvements; graphic geometry display; better geometry checking.

PARTICIPANT INTRODUCTION FORM

Agency: AMSAA, Ground Warfare Division (GWD); Methodology Office (MO)
Aberdeen Proving Ground, Maryland 21005

Name(s) of Representative(s): L. Bain (MO)
R. Lake (GWD)
J. Brewer (GWD)

Program Used: MAGIC

Purpose: Conventional vulnerability by 4" cells and/or areas for
combat vehicles and aircraft.

Computer(s) Used: Name BRLESC I & II Word Size 68 bits

Memory Size: Total 96K Available 48K

Tape Drives: No. 8 No. of Channels 4 1401-Compatible? Yes

Program Requirements: Storage 48 Packed Word Size 30

Tape Drives 4 Links? No

Dependence on Assembly Language Yes but easily
avoided

Planned Program Usage: Conventional vulnerability of combat vehicles and
aircraft (both rotary and fixed wing types).

Planned Program Changes:

- 1) Thirty bit packing for triplets and scalars.
- 2) Shielded areas.

Program Innovations: Rewrite program flow to minimize presence of
unnecessary steps, extraneous comments, and blank cards.

Program Problems/Errors: None.

Program Changes of Immediate Interest: No genuinely pressing problems.

PARTICIPANT INTRODUCTION FORM

Agency: Picatinny Arsenal, Dover, N. J.

Name(s) or Representative(s): Robert Kesselman - VC-1
John Saarmann - VC-1
Robert Barnas - SS
John Burgio - TW3

Program Used: SAM-C NEL Version

Purpose: To obtain running version on IBM 360 for radiation transport and shielding calculations.

Computer(s) Used: Name IBM 360 Word Size 32/64 bits

Memory Size: Total Unk Available 200K

Tape Drives: No. 8 No. of Channels 9 1401-Compatible? Yes

Program Requirements: Storage 200K Packed Word Size 64 bits

Tape Drives 3 Links? Unk

Dependence on Assembly Language one subroutine

Planned Program Usage: Transport and Shielding

Planned Program Changes: In January 1970 Picatinny Arsenal will start using CDC 6500; therefore, the debugging effort on the conversion has been suspended.

Program Innovations: (See comment above.)

Program Problems/Errors: (See comment above.)

Program Changes of Immediate Interest: (See comment above.)

PARTICIPANT INTRODUCTION FORM

(Observer)

Agency: Radiation Shielding Information Center
Oak Ridge National Laboratory
P. O. Box X
Oak Ridge, Tennessee 37830

Name(s) of Representative(s): Robert W. Roussin

Program Used: SAM-C

Purpose: For distribution to anyone who wants the program. (RSIC operations are sponsored by the AEC, NASA, and NASA.)
We have the CDC 6600 version for distribution (but no 6600 at ORNL).

Computer(s) Used: Name Word Size

Memory Size: Available

Tape Drives: No. of Channels 1401-Compatible?

Program Requirements: Storage Packed Word Size
Tape Drives Links?
Dependence on Assembly Language

Planned Program Usage:

Planned Program Changes:

Program Innovations We are Interested in:

- 1) IBM 360 version.
- 2) Version with ENDF/B cross sections.

Program Problems/Errors:

Program Changes of Immediate Interest:

PARTICIPANT INTRODUCTION FORM

Agency: BRL, Vulnerability Laboratory, Aberdeen Proving Ground, Md. 21005

Name(s) of Representative(s): M. J. Reisinger

Program Used: MAGIC

Purpose: Currently being used to debug target descriptions for Electronics Command, Army Tank Automotive Command, Missile Command, Munitions Command, Weapons Command, Nuclear Effects Laboratory, Test & Evaluation Command and Falcon Research & Development.

Computer(s) Used: Name BRLESC Word Size 68 bits

Memory Size: Total 120K Available 80K

Tape Drives: No. 3 No. of Channels 7/9 1401-Compatible? Yes

Program Requirements: Storage 48 Packed Word Size 30

Tape Drives 4 Links? No

Dependence on Assembly Language Depends on version

Planned Program Usage:

- 1) "Graphic Program" being developed from NASA program by L. Bain and M. J. Reisinger.
- 2) Recognition of heat projectile improper detonation from target description.
- 3) Point burst program with emphasis on components.

Planned Program Changes: Generalized Ellipsoid (i.e., not restricted to ellipsoids of revolution). Elimination of enter-leave table philosophy in favor of a more direct approach which is intended to reduce tracking time.

Program Innovations: Graphics Package.

Program Problems/Errors: A more detailed description of targets than done in the past (example, M60A1 with approximately 2500 bodies) is rapidly approaching our computer system time and size limit: a 1300 body description is using 64K, will 2500 bodies use less than the available 80K? Computer time on our system forces partial runs for graphics (need about four hours, large memory). Summation: need better computer.

Program Changes of Immediate Interest:

- 1) Development of support subroutines such as generalized components (wheels, ammunition, engine, etc.) that require location, orientation, and relative size that lead to computer generated bodies (solids).
- 2) Development of programs that would construct the optimized solid for a body from an input consisting of point data read directly from engineering drawings.

3. RECENT ACTIVITY WITH MAGIC AND SAM-C

The three sections that follow consist of the material presented verbally at the conference plus one or two minor additions or modifications.

3.1 Recent Activity with MAGIC at AMSAA. (Presentation by Larry Bain)

The recent activity with MAGIC at AMSAA falls into one of two categories: program changes or proposed plans. Each category is discussed separately.

3.1.1 Changes to MAGIC. This category is divided into three subtopics:

- Additions.
- Modifications.
- Corrections.

a) Additions. Of primary interest, three new solids have been added:

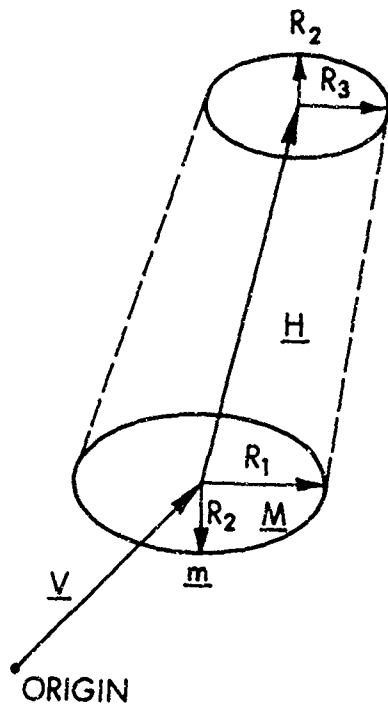
- TEC (Truncated Elliptic Cone).
 - i) Height vector does not need to be perpendicular to the base ellipse.
 - ii) Specify (Table 3.1)
 - V - vertex of base ellipse,
 - H - height vector,
 - M - semimajor axis of base ellipse,
 - m - semiminor axis of base ellipse, and
 - R - ratio (base ellipse/top ellipse),
viz., $R = (R1/R3) = (R2/R4)$.

(The normal height vector is computed in GENI; $\underline{n} = \underline{M} \times \underline{m}$; it is necessary to change the sign of \underline{n} if $\underline{H} \cdot \underline{n} < 0$.)

TABLE 3.1 CARD INPUT FOR THE NEW SOLIDS

Body Type	3-Letter ID			41-50	51-60	61-70	No. of Cards Needed
	4	5	6				
Truncated Elliptic Cone	TEC			H_x m_x^*	H_y m_y^*	H_z m_z^*	1 of 3 2 of 3
Torus	TOR			V_x $R1$	V_y $R2$	V_z	3 of 3 1 of 2 2 of 2
Arbitrary Curved Surface	ARS			M $X(1,1)$.	N $Y(1,1)$ $Z(1,1)$	$Z(1,2)$ $Y(1,2)$ $X(1,2)$	1 of n 3 of n
				$X(1,N)$ $X(2,1)$.	$Y(1,N)$ $Z(1,N)$		N+2 of n
				$X(M,1)$.			
				$X(M,N)$	$Y(M,N)$	$Z(M,N)$	

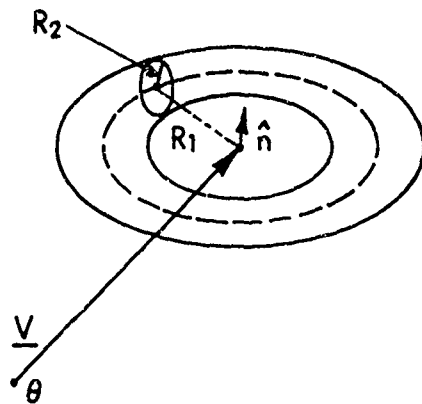
* \underline{M} → semimajor axis
 \underline{m} → semiminor axis



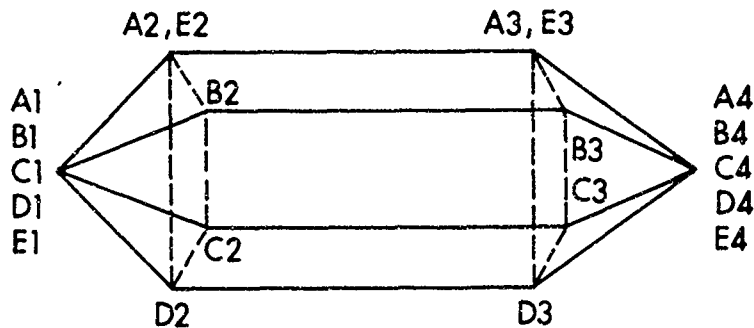
● TOR (Torus)

Specify (Table 3.1)

- V - vertex,
- n - normal vector (normal to the plane bisecting the torus),
- R1 - radius from V to the mid-point of the torus' cross section, and
- R2 - cross sectional radius ($R1 \geq R2$).



- ARS (Arbitrary Surface)
 - i) Specify M curves of N points (see Table 3.1).
 - ii) The number of words of memory is $92 + M*N*4$.
 - iii) An ARS can be described in more than one way.



Example (using the figure above).

<u>One Approach (Solid Lines)</u>		<u>Another Approach (Dashed Lines)</u>	
M = 5	N = 4	M = 4	N = 5
curve 1	pt A1, A2, A3, A4	curve 1	pt A1, B1, C1, D1, E1
curve 2	pt B1, B2, B3, B4	curve 2	pt A2, B2, C2, D2, E2
curve 3	pt C1, C2, C3, C4	curve 3	pt A3, B3, C3, D3, E3
curve 4	pt D1, D2, D3, D4	curve 4	pt A4, B4, C4, D4, E4
curve 5	pt E1, E2, E3, E4		
Figure closed by duplicate curve		Figure closed by duplicate points	
Note: pt A1 = B1 = C1 = D1 = E1		pt A2 = E2	
pt A4 = B4 = C4 = D4 = E4		pt A3 = E3	

The addition of these new solids has required the addition of auxiliary subroutines:

- QRTIC to solve 4th degree equation.
- CUBIC to aid QRTIC.

- CROSS to compute vector cross products.
- DOT to compute dot products.
- UNIT to compute unit vectors.
- ARIN to process the ARS input.

Additional coding is also similarly required in subroutine CALC to compute normals and in GENI, G1, and WOWI.

Quite apart from the new solids, coding has been incorporated in Geni to increase input checking as follows:

- Checks of vector perpendicularity in BOX, RAW, REC, and TEC.
- Checks of TRC radii to ensure that $R_B \neq R_T$.
- Checks of TOR radii to ensure that R_1 is not less than R_2 (v.s.).

Schematically, an option has been added to suppress tape 8 (the monitor output) output (except for error messages) when writing tape 1.

Finally, two control subroutines have been created to assess quantities other than line-of-sight thickness:

- AREA to compute presented areas (the ray is traced to its first contact).
- MOMENT to compute moments of inertia (and as a by-product, the center of gravity, total weight, total volume, mean angle of incidence, and the mean cosine of incidence are also computed).

b) Modifications. Seven modifications have been made:

- The ELL input has been optimized.
 - i) Present input (cc 7-10 = 0 on card 1) is both foci plus the length of the major axis.
 - ii) Optimal input (cc 7-10 \neq 0 on card 1) requires the vertex, a vector representing the semimajor axis, and the scalar length of the semiminor axis.
- Computer word packing has been converted from 45 bits/word to 30 bits/word (it is estimated that 30 bit packing runs about 30 percent faster on BRLSEC I and II).

- The solid input section has been revised by eliminating FLOCON and DIGCON and substituting the F-type format specification.
- SENSESWITCH settings have been eliminated and their control data read in on punch-cards.
- The data output coding in TRACK has been revised to eliminate SETUP and ISIGN by using I and F-type format specifications.
- A version of MAGIC has been written in "standard" FORTRAN (incidentally, this version runs slower on the BRLESCs than any of the versions already mentioned).
- The control logic in the main program has been modified so that VOLUM can be run without reading in the Identification Table.

c) Corrections. Four major subroutines were found to have more or less subtle errors:

- VOLUM faltered when G1 tried to combine regions of the same "item" code because VOLUM requires that each region be processed separately; a special exit was added to G1 to correct this condition.
- TESTG suffered a similar fate but to a greater extent since the item data was not loaded into core prior to the execution of TESTG; an additional special exit was added to G1 to rectify this condition.
- GENI computes data for the normal vector to the base ellipse in the TEC but failed to ensure that the normal was an inward rather than an outward normal; a check was added so that if $H \cdot \underline{n}$ is negative the direction of \underline{n} is reversed.
- CALC was unable to correctly calculate normal thickness through adjacent regions with the same item code (cf., VOLUM and TESTG); a modification to the existing exit in G1 to compare the item code of the next region with the item code of the previous region was made to allow continuing the normal ray.

3.1.2 Proposed Plans for MAGIC. Activity in four areas is being carried on:

- Compatibility with SAM-C - let MAGIC do some of the geometry processing for SAM-C.
- Eliminate part or all computer word packing.

- Couple the target description ray tracing directly to outputs such as vulnerable area, kill probabilities, etc.
- Addition of a graphics capability via plotters, line-printers, CRT displays, or all three.

3.1.3 Concluding Remarks. The actual changes required to implement the three new solids are discussed in the MAGI report, A Description of Three Additional Bodies for the MAGIC Conventional Vulnerability Program, by J. R. Davis and M. Moskowitz (MAGI report MR 6902, May 1969). An abridged version of this report consisting of the main portion of the text appears as Appendix B.

In any direct dealings with the coding of the MAGIC program, a knowledge of the core storage layout, input data requirements, etc., is essential. Figures 3.1 through 3.4 supply the requisite data:

- Figure 3.1 is a map of the MASTER/ASTER array showing storage for the processed geometry data. Both 45-bit and 30-bit packing versions are shown. Variable names beginning with L are the locations of each set of data in the MASTER/ASTER array.
- Figure 3.2 concludes the map of the MASTER/ASTER array showing storage of the identification table and the "working" storage used at run time.
- Figure 3.3 is a map of the pointers to the location of the solid data.
- Figure 3.4 is the map of the storage for the arbitrary surface (ARS).

Finally, to appreciate the relationships between various routines, Figure 3.5 displays the many auxiliary routines of MAGIC and their relationship to the main of "driver" routines.

3.1.4 Additional Information. In October, 1969, several runs were made using the AMSAA "Revised Standard MAGIC" (Appendix D) on a number of different computing systems. The geometry input consisted of a description which we shall call the "December '68 Master Target." This target is comprised of 701 solids and 904 regions; none of the three new solids were used. About 5 man-months were required to create the description. The following driver routines and their input were used:

GRID	0° Az 0° Elev	1015 cells
VOLUM	Head-on	1015 cells
AREA	Head-on	4189 cells
TESTG	-----	2 rays

Storage in MASTER-ASTER Array Start at LBASE (usually=1) to NDQ (Set at 30000)

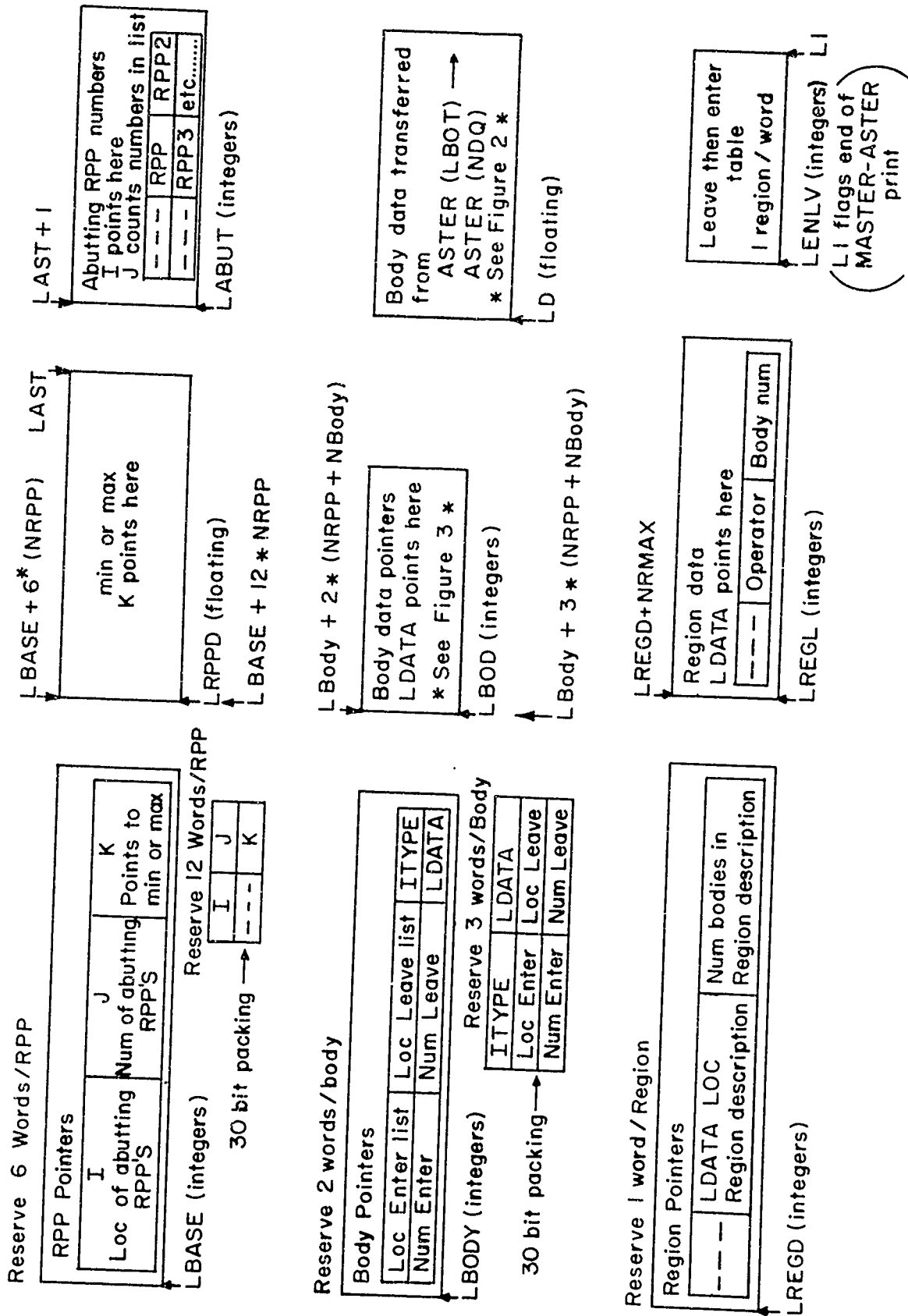


Figure 3.1 Partial Map of the MASTER-ASTER Array

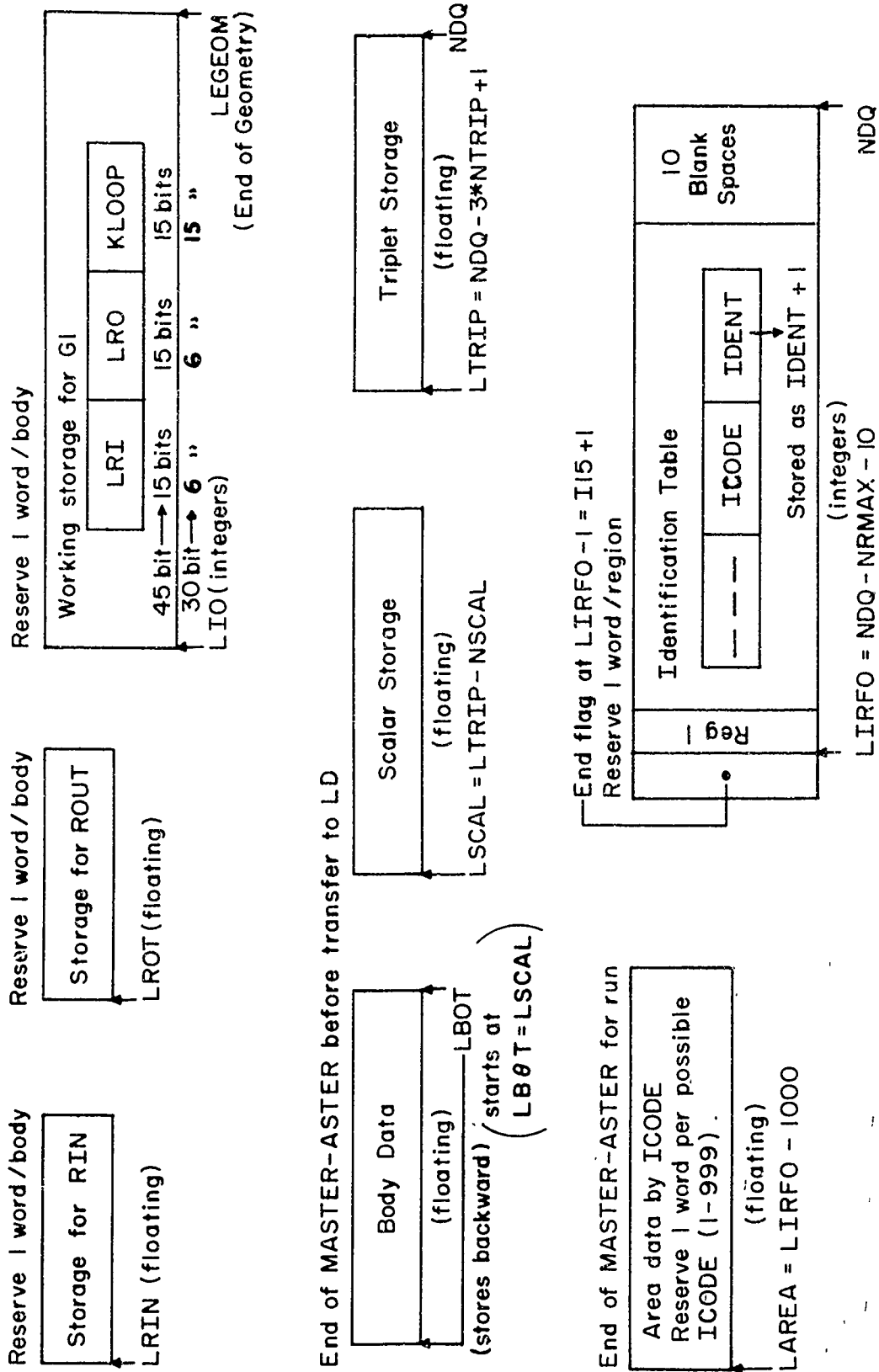


Figure 3.2 Map of the Remainder of the MASTER-ASTER Array

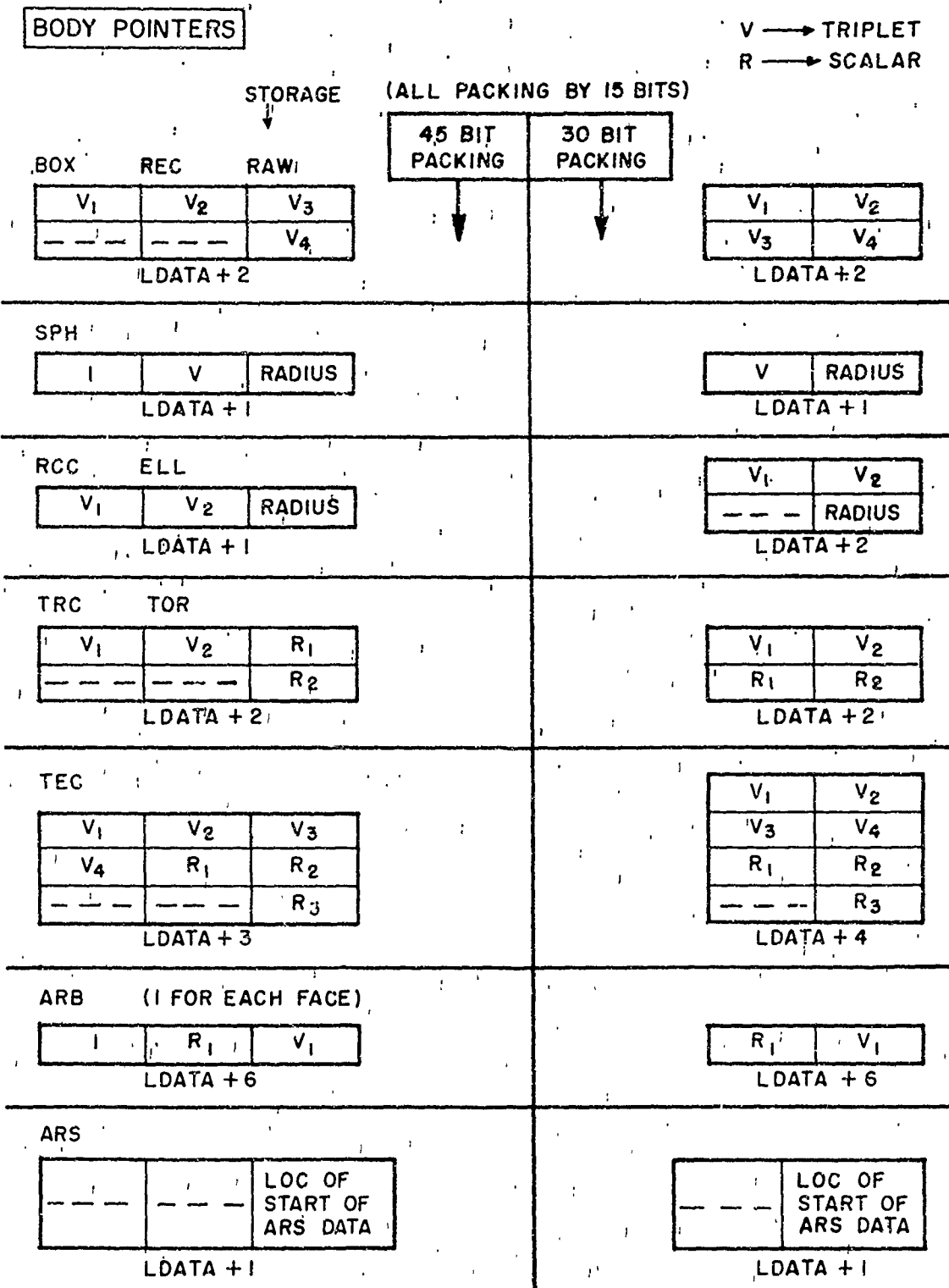


Figure 3.3 Map of Pointers to Solid Data

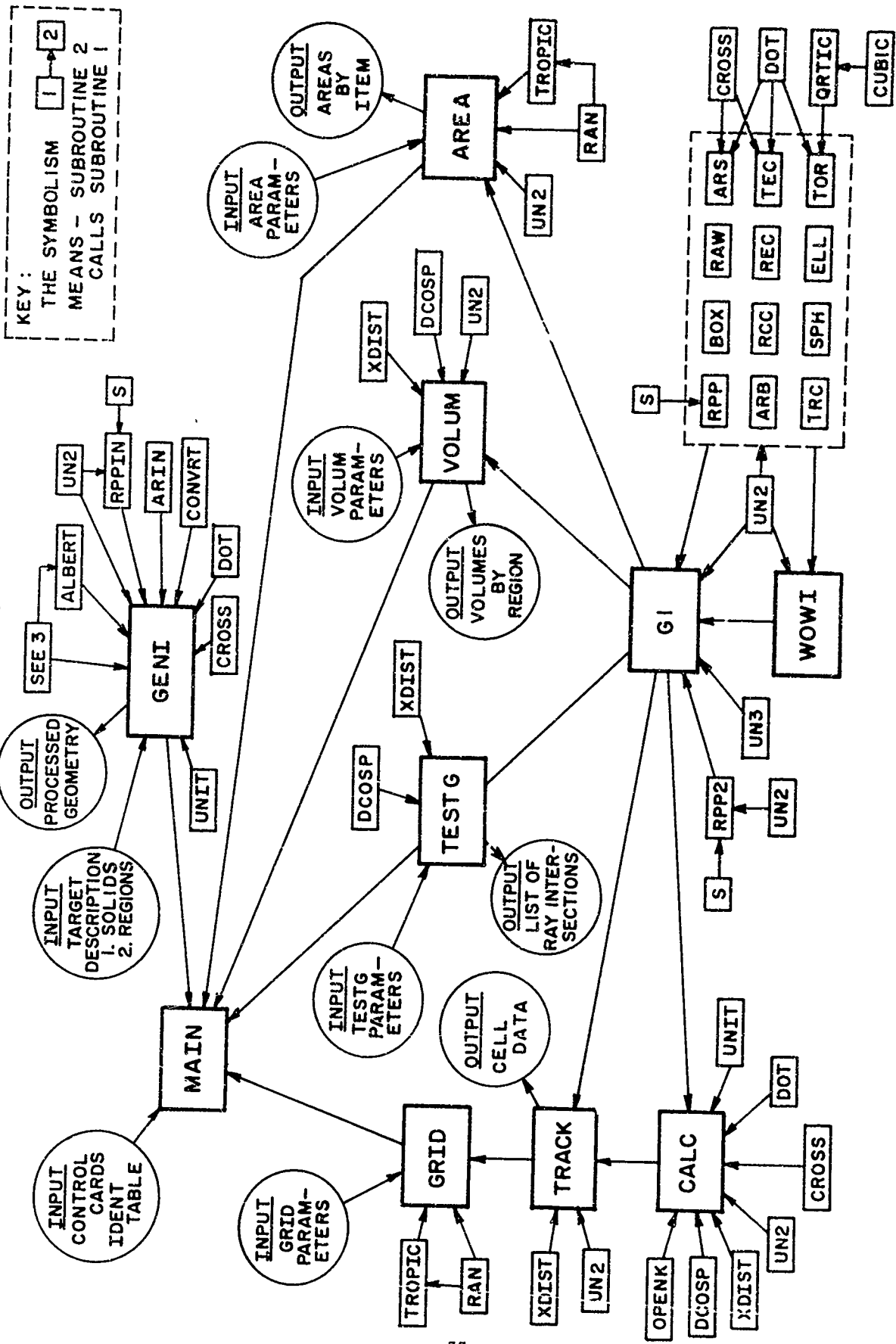


Figure 3.5 Interrelationships of MAGIC Routines

Table 3.2 presents the results of the various computer runs.

TABLE 3.2 COMPUTER SYSTEM TIME REQUIREMENTS

System	Location	Time (in minutes)	Ratio
BRLESC I	ARDC, APG, Md	133	1
BRLESC II	ARDC, APG, Md	55*	.41
CDC 6600	New York Univ	15	.11

* Using the on-line printing capability instead of "dumping" onto tape for off-line tabulation.

3.2 Recent Activity with SAM-C at NEL. (Presentation by Wayne Coleman)

The recent activity with SAM-C at NEL falls into one of three categories: recent calculations completed using SAM-C, completed corrections and improvements to the SAM-C code, and plans for the future.

3.2.1 Recent Calculations. This category is divided into three subtopics:

- Calculation of the energy dependent gamma flux at 3 feet above an infinite Co-60 "fallout" field.
- Calculation of the energy dependent and total neutron fluence at various positions within the Ralph J. Truex (Tandem Van de Graff) accelerator at the Nuclear Effects Laboratory (Edgewood Arsenal).
- Calculation of the energy dependent neutron fluence in an environment simulating that used in Operation HENRE.

a) Infinite Fallout. Although these calculations did not constitute a comprehensive test of the geometric capabilities of SAM-C, very good agreement with the known solution of this problem was obtained.

b) Accelerator. These calculations include the most complex geometries that have been simulated to date at NEL and were included for that reason. The physical results unfortunately cannot be compared directly to any results of experiments or any other calculations.

c) HENRE. This problem demonstrates how, under certain restrictions, ad hoc changes can be made to produce results for source angular distributions other than 4π -isotropic or monodirectional. The results compared favorably with unfolded flux spectra from experimental activation measurements when the SAM-C results were used as an "input guess spectrum" in the unfolding calculations.

3.2.2 Corrections/Improvements. Corrections are indicated by "C" while changes that are more in the category of improvements are indicated by "CI." C/CI's are by order of their appearance in the program.

a) Variable Dimensioning (CI). On machines that assign priority based on memory requirements, adjustable sizes of blank common and labeled common CROSA are an operational necessity. Variable dimensioning in SAM-C is accomplished by creating an artificial "main" program in which dimensioning is accomplished.

b) SEEK (C). Change E = 1 to I = 1 in TUNC and MONTE.

c) SOUCAL (C). Set "KKMAX = K-1" between FORTRAN statement numbers (S.N.) 780 and 925.

d) CARLO (C). The calculation of flux-at-a-point following an inelastic collision is incorrect. See the August RSIC Newsletter (No. 57) for details.

e) SOUPIC (C/CI). Volume source additions may be made by modifying the coding shortly after FORTRAN S.N. 800.

f) ARB (C). T was inadvertently used as a variable name to represent time in a labeled common and temporary storage in the routine (S.N. 50 and 50 + 1).

g) FAP (CI). The coding for identifying point flux contributions by region appears here.

h) FAP (C). To correctly calculate flux-at-a-point add COMMON/LSU/LSURF.

i) GE (C). (1) The scattering problem look-up for neutrons was referencing the wrong area of common for neutron anisotropic scattering; cf., the RSIC version. (2) The third argument in the call to SEEK (S.N. 185) should be 10 and not 11. (3) Format 106 ends incorrectly - replace "10" with any desired E- or F-type format.

j) SUBED (C). Change "NRMAX" to "NDET" at S.N. 121.

k) SOUCAL (C). Change Format 402 (not all versions). (CI) finally changes to compute statistics on the total flux or fluence for flux-at-a-point would be desirable.

3.2.3 Improvements in Progress. Modifications to calculate flux at a point as a function of angle or direction as well as energy are well underway at NEL.

3.2.4 Planned Improvements. Neutron cross section representation is earmarked for extensive study. Key inputs or approaches to this subject include UNC-SAM-3, an ENDF/B cross-section processor, and a thorough examination of the representation of neutron elastic, angular scattering distributions. Total, elastic, and non-elastic cross section data are also expected to be involved.

3.3 Coordination of MAGIC and SAM-C.

Both MAGIC and SAM-C process card-image target description data and store the results in the MASTER/ASTER array. Both can compute volumes. If the conventional component/space code table has been created, a trivial program (Program COMPAS) exists to convert this data to a region/chemical composition assignment table. The following two sections describe the changes required so that target descriptions can be utilized by either MAGIC or SAM on a wide variety of computational equipment with a minimum of difficulty. The goal, of course, is to permit the creation of a library of target descriptions which can serve two purposes: they can reduce duplication of effort and they can lend insight into what a given agency considers an adequate degree of descriptive detail.

3.3.1 Discussion. This category is divided into two subtopics: a description of the proposed tape's contents and a discussion of how the tape should be created.

a) Description of the Tape Contents. The first step is to identify the data available for the library tape; these data are displayed in Table 3.3.

TABLE 3.3 TARGET DESCRIPTION DATA AVAILABLE

MAGIC	SAM-C
"Processed" (GENI) Target	Output Data (MASTER-ASTER*)
Region Identification Table	Composition Assignment Table
Volumes (Optional)	Chemical Composition Definitions
Region Weights (Optional)	"Processed" (BAND/BEDIT) Cross Section Data (MASTER-ASTER)
Moment of Inertia (Optional)	Volumes (ASTER)
Target Description Title	
"Raw" (Card-Image) Target Description Solid & Region Data	

*The SAM-C program stores these data in a location different from that used by MAGIC.

TABLE 3.4 LIBRARY TAPE CONTENTS: PARTS 1 AND 2

"Block" 1. Identification (80A1)

Target Description Title

"Block" 2. Table of Contents

(1) Solid/Region Table Format (cc 1-5)

0 : GENI Input form

≠ 0 : GENI Output form

For (2) through (8), 0 means the category was not included while a non-zero entry indicates that the data was included

(2) Region Identification Table (cc 6 - 10)

(3) Composition Assignment Table (cc 11 - 15)

(4) Volumes (cc 16 - 20)

(5) Chemical Composition Data (cc 21 - 25)

(6) Region Total Weights (cc 26 - 30)

(7) "Organized" Cross-Section Data (cc 31 - 35)

(8) Moment of Inertia Data (cc 36 - 40)

(9)-(10) (Spares) (cc 41 - 50)

cc 51-52 Unit Systems (Examples: IP for inches, pounds (& seconds),
CG for centimeters, grams, seconds, etc.)

cc 53 Coordinate System "Handedness" L = left, R = right

cc 54-80 Location of Geometric Origin with respect to the Reference
Origin (e.g., for "tanks" the reference origin is frequently
the intersection of the turret datum line and the vehicle
centerline) (3E9.2)

The second step is to determine the data to be loaded and in what order. Clearly, the target description title plus some type of flagging to indicate the data categories available should appear near the start of the tape to minimize the time spent in identifying the tape contents. It is therefore proposed that the first tape "block" consist of ten flag words as described in Table 3.4. Beyond these two points, any data that describe the target are suitable for inclusion on the tape.

b) Approach. It was the consensus of the program users that, while all library tapes should be in BCD format for transmittal, the basic target description solid and region data should be in card-image rather than in "processed" (GENI output) form; except for a few installations, the computer time spent in reprocessing the "raw" data is negligible compared with the time that would be used to convert the data into the form required by those of a different installation. It was also agreed that the raw data approach would place the least number of restrictions on the internal operating procedures of any given MAGIC or SAM-C program user.

3.3.2 Program Changes. Some coding changes of a very minor nature will be required. The routines affected are:

a) MAGIC. The main program plus GENI, VOLUM, the moment of inertia, and the vulnerable area routines will require modification.

b) SAM-C. TUNC, GENI, DR, and VOLUM are involved. In SAM-C, VOLUM will generally only require an additional output statement.

4. DEFINITION OF MAGIC AND SAM-C; CREATION OF SOURCE DECKS

This provided the first opportunity of the conference for the conferees to determine the course of action to be followed. The two sections that follow present the consensus achieved by the conferees in defining what the capabilities of the two programs should be and in determining how these capabilities should be achieved.

4.1 MAGIC.

The following sections represent the major areas discussed at the conference together with the results of these discussions.

4.1.1 Standard Version. A consensus was achieved in four areas:

- a) Input. The input to MAGIC will consist of
- RPP Data,
 - Solid Description Data, and
 - Region Description Data.

b) Subprograms. The subprograms are characterized as "geometry processing" (including some testing):

- GENI,
- ALBERT,
- RPPIN, and
- ARIN,

or "ray tracking" (but not in the sense of GRID which is considered a "driver routine"):

- G1,
- WOWI/RPP2,
- RPP/body routines + TOR, ARS & TEC, and
- Auxiliary body routines such as QRTIC, UNIT, etc.

c) Program Features.

- No packing.
- It should be possible to use an RPP to subdivide the target, itself.
- Drop TESTG.
- Drop FLOCON and DIGCON.
- Output the processed geometry which should consist of titling data, the geometry data, and the functional identification table.

d) Tests. It was agreed that TESTG as a random but supposedly complete test of the description is inefficient and should be dropped; in its place, a driver routine of interest - such as GRID - should be used. Input testing was considered valid and at least the following tests should be available:

- Legitimacy of solid names.
- Vector perpendicularity for boxes, RAW's, and the REC.
- Equal radii in the TRC.
- Region checking (on an optional basis).
- "4-points-in-a-plane" in the ARB.
- Degenerate plane in the ARB.

- Proper ordering of RPP input.
- Proper structure creation by contiguous RPP's (since the structure that would enclose all RPP's must be in the shape of an RPP).

4.1.2 Ad Hoc Problems. Although there was not enough time for the formal formation of working groups to solve ad hoc problems, the following problems were defined for solution by any interested groups or individuals.

- The creation of a technique for the arbitrary designation of solids to have the special characteristics currently displayed by the RPP.
- The identification of methodological differences in the routines that form MAGIC between versions held by the several agencies using MAGIC.
- The establishment of a methodology for creating "library" routines (for such configurations as wheels, people, etc.) which can be processed as a unit rather than a set of distinct subsolids.
- The establishment of a uniform system of flags for transmittal of the processed geometry.

4.2 SAM-C.

SAM-C was not the subject of serious discussion until late in the afternoon of the second day. Because the SAM-C program is so large and complex, our attitude toward it is considerably different than our attitude toward MAGIC. In the first place (and of overriding importance), there are few computing facilities capable of efficiently executing the SAM-C programs; secondly, a substantial amount of understanding of the code and the manner in which it attempts to solve problems, and of the problems themselves, is required to achieve any sort of successful solution. Keeping these points in mind, the following sections present the consensus reached.

4.2.1 Standard Version. For the time being at least, the standard version of SAM-C will be that obtainable from RSIC at Oak Ridge. In brief, this version features Combinatorial Geometry inputs identical to those of Standard MAGIC with one important difference: triplet and scalar inputs will be allowed.

4.2.2 Ad Hoc Problems. Although time was again insufficient, the following study/problem areas were defined:

- The abolishment of computer word packing to the greatest practical extent.

- The incorporation of ENDF/B cross sections - preferably using a noncommon energy mesh.
- Bonafide time dependence: time dependence currently assumes the source is a separable function of time.
- Simplification of input preparation.

5. CREATION OF BENCHMARK PROBLEMS

Although time constraints precluded the actual creation of test problem input, it was possible to indicate what the benchmark problems should include.

5.1 MAGIC.

The test problem input should meet five conditions:

- Use only the solids generally available; place the three new solids at the end of the solid table for possible deletion.
- Use all three region operator symbols (+, -, OR).
- Use 1 RPP to enclose the target (Wright-Patterson AFB will use a BOX).
- Employ solids in such a way that they present overlaps and contiguities.
- Similarly, ensure that at least one situation arises where more than one following region has the same functional identification code as the region in front (to ensure that the correct normal thickness is being computed).

In addition, it is desirable to introduce a few deliberate errors to ensure that internal error checks are operative.

5.2 SAM-C.

It was decided that more than one benchmark problem should be created to enable checking the modeling of the physical solution and the execution of the code. Two benchmark problems were agreed upon:

- The "infinite" fallout problem (RSIC Benchmark Problem No. 4), and
- AFWL "Rocket" Geometry.

Physical/code input for these problems is presented in Appendix C.

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APPENDIX A. MAGIC/SAM-C CONFERENCE PARTICIPANTS

<u>Name</u>	<u>Agency</u>	<u>City, State</u>
1. Robert E. Barnas	Picatinny Arsenal	Dover, New Jersey
2. Sue Gibson	AFATL	Eglin AFB, Florida
3. Larry Bain	AMSAA (Methodology)	APG, Md.
4. Matthew J. Reisinger	BRL (VL)	APG, Md.
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9. Robert E. Walther	BRL (VL)	APG, Md.
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15. George H. Connor, Jr.	BRL (NEL)	Edgewood Arsenal, Md.
16. Robert W. Roussin	ORNL - RSIC	Oak Ridge, Tennessee
17. Wayne A. Coleman	BRL (NEL)	Edgewood Arsenal, Md.
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19. Janet Lacetera	BRL (NEL)	Edgewood Arsenal, Md.
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21. William Ralph	NWL	Dahlgren, Virginia
22. Robert E. Gray	NWL	Dahlgren, Virginia
23. Roy R. Hilbrand	ASD	Dayton, Ohio
24. Gerald Bennett	ASD	Wright-Patterson AFB, Ohio
25. Robert Kesselman	Picatinny Arsenal	Dover, New Jersey
26. Joe Burgio	Picatinny Arsenal	Dover, New Jersey
27. Norman S. Banks	BRL (TBL)	APG, Md.
28. Robert Lake	AMSAA (ASA)	APG, Md.
29. Ronald Marking	AMSAA (ASA)	APG, Md.

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B.1 ORGANIZATION OF THE NEW MAGIC PROGRAM

The general organization of the MAGIC program remains as before. The following subroutines were changed: CALC, GENI, G1, WOWI. The following routines were added: TEC, TOR, ARS, DOT, CROSS, UNIT, QRTIC, CUBIC, ARIN. A description of the changes to existing subroutines and the new subroutines follows:

B.1.1 Changes to CALC.

CALC - Statement 18 - Change the computed "go to" by adding locations for computing the normals in the new bodies.

Statement 500

This section computes the normals to the elliptic cone. If the point of intersection was the top or bottom the normal is the same as the normal received as input. If the point is on the side of the cone the following equation is used.

$$(1) \quad \bar{W}_B = \frac{(\)_1}{\tau} \bar{A}^* - \frac{\bar{H} \cdot \bar{A}^*}{\bar{H} \cdot \bar{\eta}} \bar{\eta} + \frac{(\)_2}{1} \bar{K}^* - \frac{\bar{H} \cdot \bar{K}^*}{\bar{H} \cdot \bar{\eta}} \bar{\eta} - m(r_4 - r_2) \frac{\bar{\eta}}{\bar{H} \cdot \bar{\eta}},$$

where $(\)_1 = (\bar{X} - \frac{\bar{X} \cdot \bar{\eta}}{\bar{H} \cdot \bar{\eta}} \bar{H} - \bar{V} + \frac{\bar{V} \cdot \bar{\eta}}{\bar{H} \cdot \bar{\eta}} \bar{H}) \cdot \bar{A}^*$, and

$(\)_2 = (\)_1$ with \bar{K}^* instead of \bar{A}^*

The terms are defined as follows:

\bar{H} = height vector of cone,
 \bar{A}^* = unit vector - direction of major axis,
 \bar{K}^* = unit vector - direction of minor axis,
 τ = ratio of major to minor axis squared,

$$m = \frac{(\bar{X} - \bar{V}) \cdot \bar{\eta}}{\bar{H} \cdot \bar{\eta}} (r_4 - r_2) + r_2$$

\bar{X} = point of intersection,
 $\bar{\eta}$ = normal to cutting plane, and
 \bar{V} = center of base ellipse.

The derivation is shown on the following page.

The equation for the ellipse parallel to the base ellipse and through the point of intersection \bar{X} is

$$(2) \quad \frac{((\bar{X}-\bar{V}-\gamma\bar{H}) \cdot \bar{A}^*)^2}{\tau m^2} + \frac{((\bar{X}-\bar{V}-\gamma\bar{H}) \cdot \bar{K}^*)^2}{m^2} = 1 ,$$

$$(3) \quad \gamma = \frac{(\bar{X}-\bar{V}) \cdot \bar{n}}{\bar{H} \cdot \bar{n}} , \text{ and}$$

$$(4) \quad m = \gamma r_1 + (1-\gamma)r_2 .$$

NOTE: γ and τ and \bar{X} are known.

Expanding we get

$$0 = \left(\frac{\bar{X} \cdot \bar{n}}{\bar{H} \cdot \bar{n}} \frac{\bar{H} \cdot \bar{V}}{\bar{H} \cdot \bar{n}} - \frac{\bar{V} \cdot \bar{n}}{\bar{H} \cdot \bar{n}} \right) \frac{1}{\tau} \cdot \bar{A}^* \right)^2 + \left(\frac{\bar{X} \cdot \bar{n}}{\bar{H} \cdot \bar{n}} \frac{\bar{H} \cdot \bar{V}}{\bar{H} \cdot \bar{n}} - \frac{\bar{V} \cdot \bar{n}}{\bar{H} \cdot \bar{n}} \right) \frac{1}{1} \cdot \bar{K}^* \right)^2 - m^2 .$$

Differentiating, with respect to X , Y , and Z , and taking the unit vector of the result gives us Equation (1).

Statement 550

The section computes the normal to the torus at the point of intersection. The equation used is:

$$(1) \quad \bar{W}_B = \frac{\bar{X} - (\bar{C} + r_1 \bar{d}^*)}{r_2}$$

where \bar{X} is point of intersection,

\bar{C} is center of torus,

r_1 is distance from center to the locus of mid-point of circular cross section

$\bar{d}^* = \text{unit } \{\bar{d}\}$,

$\bar{d} = \{\bar{n} \times (\bar{X} - \bar{C})\} \times \bar{n} = \text{direction of } r_1 \text{ in plane, and}$

r_2 is radius of circular cross section.

Statement 575

This coding examines the intersection with the arbitrary surface (XI), selects the proper normal from those left in the MASTER/ASTER array by ARS, and places this normal into WB. See write-up of ARS routine to determine details of computation.

B.1.2 Changes to GENI.

GENI - Change all computed GO TO's involving body type to add three new bodies. Add conversion routines to store TORUS and Elliptic Cone data in either floating point or triplet and scalar form. Add coding to store Arbitrary Surface in floating point format. (Subroutine ARIN).

B.1.3 Changes to G1.

G1 - For a new ray, processing remains the same, except for changing the computed GO TO to check the new bodies. For continuation of a ray, a check is made for TORUS or ARBITRARY SURFACE. If the body is neither of these, the previously computed value is used. However, if the body type is one of these a check is made to see if the distance we have traveled is greater than ROUT. If it is not then we use the existing values for RIN and ROUT. Otherwise, we reenter the body routine and compute the next RIN/ROUT set (if any).

B.1.4 Changes to WOWI.

WOWI - The same changes as were made to G1 apply here. A description of the new routines follow.

B.1.5 Addition of TEC.

TEC - Body routine for truncated elliptic cone. Computes RIN, ROUT, LRI, LRO for intersection of ray and cone. Uses DOT, CROSS, and SQRT.

B.1.6 Addition of TOR.

TOR - Body routine for torus. Computes RIN and ROUT; LRI and LRO are 1. If four roots are found it selects the first pair greater than DIST as RIN and ROUT. Uses QRTIC and CUBIC.

B.1.7 Addition of QRTIC.

QRTIC (A,B,C) - Solves quartic polynomial equation with unit leading coefficient, $X^4 + C_1X^3 + C_2X^2 + C_3X + C_4 = 0$.

Method is from J. V. Uspensky, "Theory of Equations," pp 94-95. Used by TOR.

A = Array of coefficients

B = Array of roots

C = Number of real roots

B.1.8 Addition of CUBIC.

CUBIC (A,B,C) - Solves cubic polynomial equation with unit leading coefficient, $X^3 + C_1X^2 + C_2X + C_3 = 0$.

Method is from J. V. Uspensky, "Theory of Equations," pp 84-93. Used by TOR.

A = Array of coefficients

B = Array of roots

C = Number of real roots

B.i.9 Addition of DOT.

DOT (A,B) - Computes the dot product of vectors \bar{A} and \bar{B} .

B.1.10 Addition of CROSS.

CROSS (A,B,C) - Computes the cross product of vectors \bar{B} and \bar{C} and stores result in vector \bar{A} .

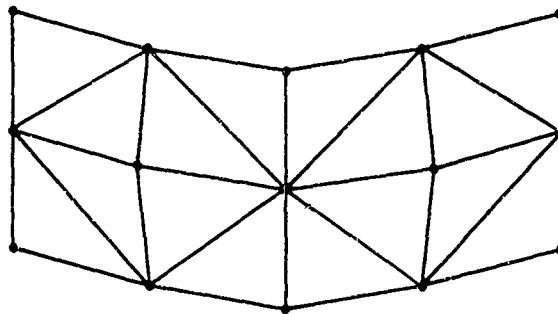
B.1.11 Addition of UNIT.

UNIT (A) - Computes unit vector of \bar{A} and stores back in \bar{A} .

B.1.12 Addition of ARS.

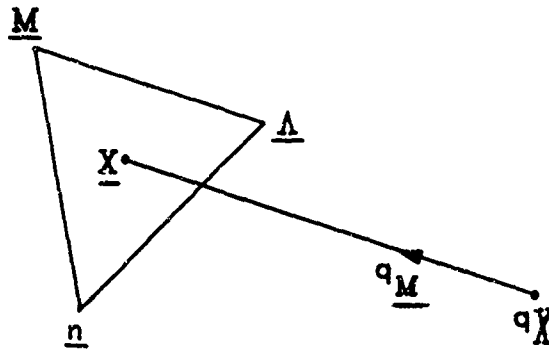
ARS - Body routine for arbitrary surface. Computes RIN, ROUT. LRI and LRO are always 1.

For the purposes of determining intersections and normals, the routine constructs a series of triangles, as below, and utilizes these triangles to determine intersections and the associated normals.



When entered for a new ray, the intersections are stored in the MASTER/ASTER array, together with the normals at these points. Upon reentry for the same ray, the RIN, ROUT pair appropriate to DIST are selected and returned to the calling routine.

To determine the intersection and normals, the ray is tested against each triangle for which at least one point of the triangle lies within the projection of the grid square. The calculation is done as follows:



By the rules of convex figures in 2-space, for \bar{x} within the triangle, there must exist α, β, γ such that

$$(1) \quad \alpha \bar{u} + \beta \bar{v} + \gamma \bar{w} = \bar{x} = \bar{x}_b + s \bar{w}_b$$

$$\alpha + \beta + \gamma = 1; \alpha, \beta, \gamma > 0 ;$$

then

$$\gamma = 1 - \alpha - \beta ,$$

$$(2) \quad \alpha \bar{u} + \beta \bar{v} + (1 - \alpha - \beta) \bar{w} = \bar{x}_b + s \bar{w}_b , \text{ and}$$

$$(3) \quad \alpha(\bar{u} - \bar{w}) + \beta(\bar{v} - \bar{w}) - s \bar{w}_b = \bar{x}_b - \bar{w} .$$

These are simply three equations in three unknowns.

Using determinants to solve this set of simultaneous equations we obtain α, β, γ , and s . After verifying that $\alpha + \beta + \gamma = 1$ and $\alpha, \beta, \gamma \geq 0$, we record the s value as well as a unit normal to the triangle. If α, β, γ fail to meet these requirements, the ray missed this triangle.

After performing the calculations for each triangle, the resulting s values and normals are placed in the MASTER/ASTER array. Sufficient space is provided for up to ten pairs of RIN and ROUT. The variable DIST is used to determine which pair of RIN and ROUT should be returned to the calling routine.

B.2 DESCRIPTION OF INPUT PARAMETERS

B.2.1 Truncated Elliptic Cone.

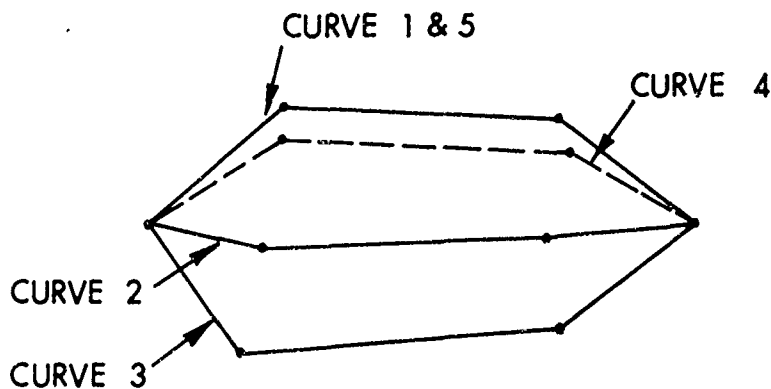
Specify a vertex V at the center of the larger ellipse, the height vector H , expressed in terms of its x, y, z components, the direction of the major axis A , the direction of the normal N , and three scalars - $R1$, the length of the major axis of the larger ellipse, $R2$, the length of the minor axis of the larger ellipse, and P , the ratio of the larger to the smaller ellipse.

B.2.2 Torus.

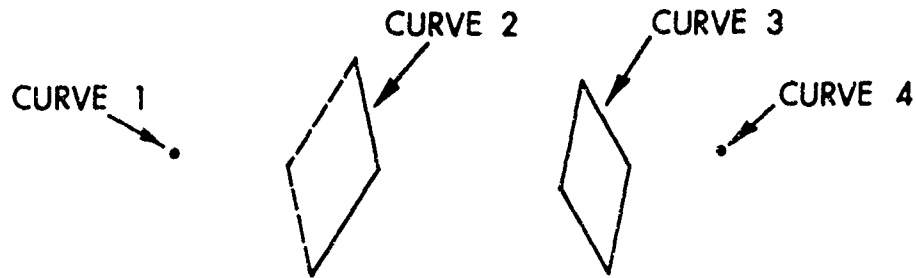
Specify a vertex V at the center of the torus, the normal to the plane in which the locus of mid-points of the circular cross sections lie, N , and two scalars - $R1$, the distance from the center to the mid-point of circular cross section, and $R2$, the radius of circular cross section.

B.2.3 Arbitrary Surface.

Specify the number of curves (M) to be specified and the number of points (N) which will be specified on each curve. A surface is constructed between curve 1 and curve 2, between curve 2 and curve 3, etc. The user must be careful that the described figure is closed and solid.



In the previous example, the first and last point of each curve is identical, and the first curve is identical to the last, and one can see that the figure is solid.



In this example, curve 1 consists of the same point repeated five times, curve 2 of five points (the first and fifth point being the same), curve 3 is defined similar to curve 2, and curve 4 similar to curve 1. It can also be seen that this figure is solid.

To further illustrate this figure, note in the figure that

M = 4	N = 5
Curve 1	pt. A ₁
	B ₁
	C ₁
	D ₁
	E ₁
Curve 2	pt. A ₂
	B ₂
	C ₂
	D ₂
	E ₂

M = 4

Curve 3

Curve 4

N = 5

pt. A₃

B₃

C₃

D₃

E₃

pt. A₄

B₄

C₄

D₄

E₄

is identically the same figure as

M = 5

Curve 1

Curve 2

Curve 3

N = 4

pt. A₁

A₂

A₃

A₄

pt. B₁

B₂

B₃

B₄

pt. C₁

C₂

C₃

C₄

M = 5	N = 4
Curve 4	pt. D ₁
	D ₂
	D ₃
	D ₄
Curve 5	pt. E ₁
	E ₂
	E ₃
	E ₄

The user should use this isomorphism as a check on whether the figure defined is truly closed and solid.

B.3 BODY CARDS

The data describing each body must be input using the format described in Table B.1. This table is similar to Table 3.1 (page 37 in the original document) and should be viewed as an extension of that table.

B.4 NEW VARIABLES IN COMMON

<u>Variable Name</u>	<u>Labeled Common</u>	<u>Definition</u>
IGRID	DAVIS	The grid square of the origin of the current ray (XBS)
LOOP	DAVIS	Set by G1 upon entry to a body routine to reflect ray number of last ray fired at the body.
INORM	DAVIS	Set by G1 to indicate if the ray is being fired normal to a surface (normal is computed by CALC)

B.5 NEW ERROR STOPS

<u>Routine</u>	<u>Message</u>	<u>Explanation</u>
CALC	ARS DID NOT FIND NORMAL	Data in MASTER/ASTER Array inconsistent. Some routine has destroyed portions of MASTER/ASTER.

TABLE B.1

Body Type	3 Letter ID	11-20	21-30	31-40	41-50	51-60	61-70	No. of Cards Needed
Truncated Elliptic Cone	TEC	V_x	V_y	V_z	H_x	H_y	H_z	1 of 3
		N_x^*	N_y^*	N_z^*	A_x^*	A_y^*	A_z^*	2 of 3
Torus	TOR	R1	R2	P	N_x	N_y	N_z	3 of 3
		V_x	V_y	V_z				1 of 2
Arbitrary Curved Surface	ARS	R1	R2					2 of 2
		M	N					1 of n
		$X(1,1)$	$Y(1,1)$	$Z(1,1)$	$X(1,2)$	$Y(1,2)$	$Z(1,2)$	3 of n
		\vdots						
		$X(1,N)$	$Y(1,N)$	$Z(1,N)$				
		$X(2,1)$						
		\vdots						
		$X(M,1)$						
		\vdots						
		$X(M,N)$	$Y(M,N)$	$Z(M,N)$				N+2 of n

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APPENDIX C
SAM-C BENCHMARK PROBLEM INPUT

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C.1 SHIELDING BENCHMARK PROBLEM 4.0 (Abridged)

Gamma-Ray Dose Above a
Plane Source of ^{60}Co on an
Air/Ground Interface

Original Submitted by:

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Radiation Research Associates, Inc.*
8404 Westmont Court
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2 December 1968

Accepted by BPG:
December, 1968

This Abridged Version prepared September, 1969

* Corporate offices located in Fort Worth, Texas.

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"1. INTRODUCTION

The dose rate three feet above an air/ground interface contaminated with gamma-ray emitting isotopes is often used as a basic normalizing parameter in fallout radiation environment studies and fallout shielding methodology. For example, the dose rate three feet above a fallout field is the basic quantity to which geometric and barrier factors are applied in the currently-used "Engineering Method" (References 1,2*). This technique predicts shield effectiveness in fallout situations. There have been experimental measurements of the dose above fallout fields in several weapons test (References 3,4) and several calculations (References 1,5) of the same quantity have been made.

"However, because of the obvious difficulties associated with measurements of actual fallout, many studies have concerned themselves with the radiation environment above interface planes contaminated with a single isotope. In particular, ^{137}Cs and ^{60}Co have been extensively used in these investigations.

"2. THE AIR/GROUND INTERFACE PROBLEM

This benchmark problem is concerned with the theoretical computation of various quantities above an ideal air/ground interface uniformly contaminated with ^{60}Co . A discussion of experimental results is also included for comparative purposes.

"2.1 Problem Geometry

Figure C1 illustrates the geometry for the theoretical benchmark. A receiver (detector) point is located three feet above the air/ground interface which is assumed to be smooth and infinite in extent. ^{60}Co is uniformly distributed on the interface. Although ^{60}Co emits one 1.17 MeV photon and one 1.33 MeV photon per disintegration, many studies assume an average photon energy of 1.25 MeV. This assumption introduces negligible errors, and the benchmark data are normalized to a source strength of one 1.25 MeV photon emitted isotropically per cm^2 of interface area per second. [For SAM C the photon energy of 1.33 MeV was used.]

*References are not included in this abridged version. Ed.

BASED ON ORNL-DWG 69-2121 IN SHIELDING BENCHMARK PROBLEM 4.0.

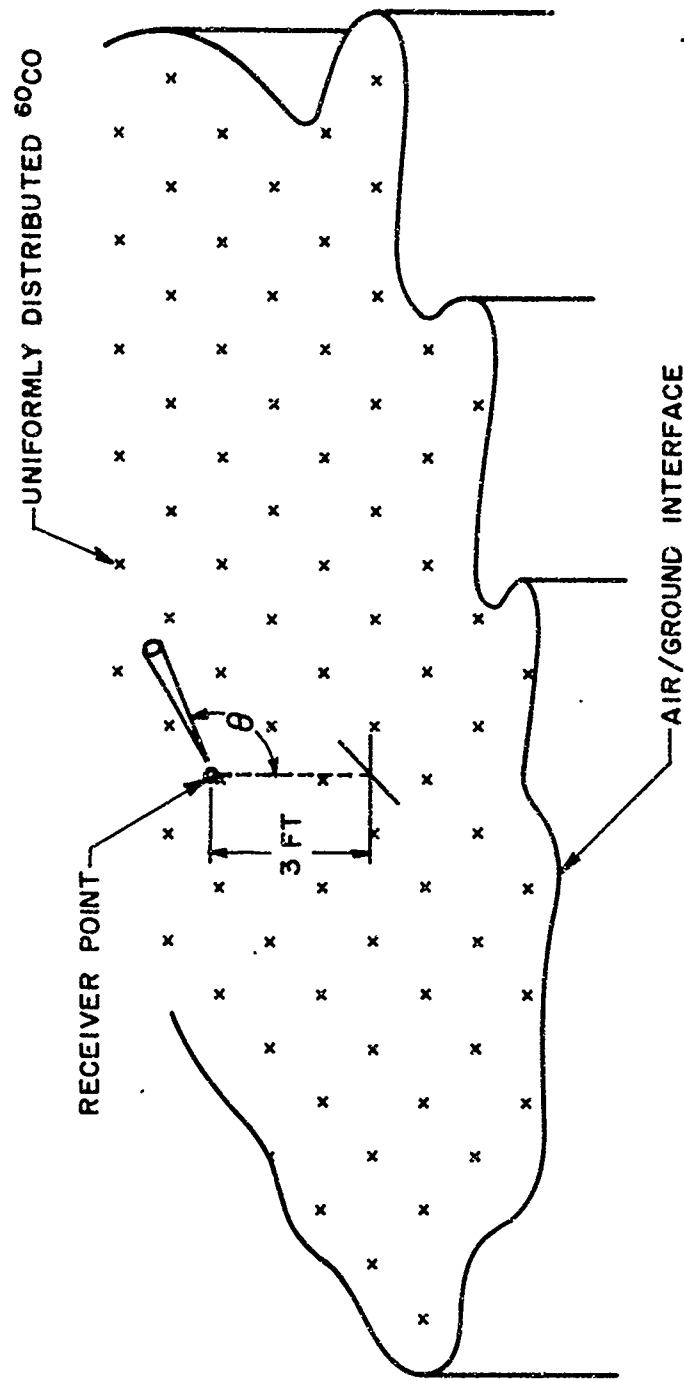


Figure C1. Air Over Ground Geometry

"Table I lists the constituents of the air and ground. The air density is $1.29 \times 10^{-3} \text{ g/cm}^3$; the ground is assumed to have a composition similar to Nevada Test Site soil (Reference 6).

TABLE I AIR AND GROUND COMPOSITIONS

	Element	Atomic Concentration (atoms/cm ³)
Air*	Nitrogen	4.19×10^{19}
	Oxygen	1.13×10^{19}
	Argon	2.53×10^{17}
Ground	Hydrogen	8.55×10^{21}
	Oxygen	2.27×10^{22}
	Aluminum	2.01×10^{21}
	Silicon	9.53×10^{21}

*There has been a slight change in format. Ed.

"2.2 Quantities Calculated

Quantities calculated at the receiver point are: (1) the total kerma rate,** T, in air; (2) the kerma rate,** D, in air from uncollided photons; (3) the dose buildup factor, B; and (4) the differential angle and energy distribution of the number flux density, $\phi(E,\theta)$, where θ is the receiver polar angle (Figure C1). The number flux density energy spectrum, I(E), [is the only quantity calculated by SAM C]"[calculated results appear in Tabular Form in Table IV and in graphical form in Figure C2].

** For the photon energies and geometry of this problem, the numerical difference between kerma rate and absorbed dose rate in air is small and can be ignored. Other studies quote kerma rate in tissue, and adjustments should be made to compare the results of such studies with this benchmark.

TABLE IV* SCATTERED PHOTON KERMA RATES THREE FEET ABOVE AN INFINITE
⁶⁰Co CONTAMINATED PLANE

Energy Interval (MeV)	K(E) (ergs=cm ² /g)	Flux Density (Photons/cm ² -sec)	Kerma Rate (ergs/g-sec)
.02 - .03	1.06(-8)	1.47(-3)	1.56(-11)
.03 - .04	5.28(-9)	1.55(-2)	8.18(-11)
.04 - .06	3.06(-9)	9.32(-2)	2.85(-10)
.06 - .10	3.06(-9)	2.10(-1)	6.43(-10)
.10 - .18	5.56(-9)	2.99(-1)	1.66(- 9)
.18 - .30	1.08(-8)	2.94(-1)	3.18(- 9)
.30 - .50	1.89(-8)	1.93(-1)	3.65(- 9)
.50 - .75	2.92(-8)	1.08(-1)	3.15(- 9)
.75 - 1.00	3.97(-8)	8.31(-2)	3.30(- 9)
1.00 - 1.25	5.00(-8)	1.69(-1)	8.45(- 9)
	TOTALS:	1.47(0)	2.44(- 8)

NOTE: Read 1.06(-8) as 1.06×10^{-8}

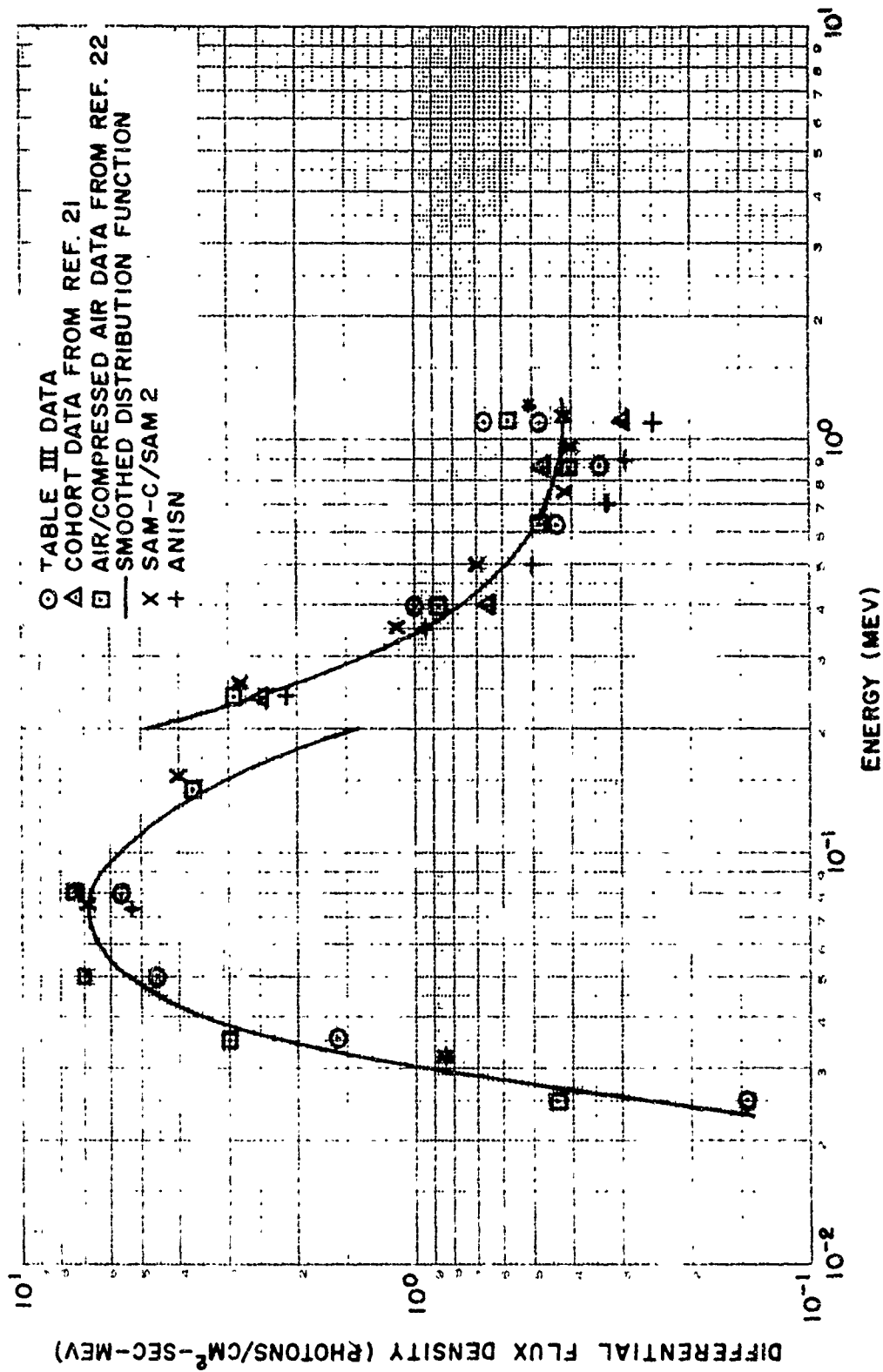
* Tables II and III have been omitted in this version. Ed.

[Results]

"On Figure C2 (Figure 6 in original document), differential scattered photon flux density energy spectra are plotted for the two cases shown on Figure 4,* along with data from a 7,000 history air/ground COHORT Monte Carlo study by French (Reference 21). Although neither the Table III or the COHORT data was smoothed in any way prior to constructing Figure 5, adjustments had to be made in the three lowest energy groups of the air/compressed air case. In that case, a severe fluctuation (visible on Figure 4) occurred in the 30° - 40° angle interval in each of the three energy bins. The solid curve on Figure 5 was obtained by intuitively smoothing all available data and, in addition, making use of two known facts; the magnitude of the discontinuity at the first scattering cutoff energy (0.212 MeV) and the value at the source energy (1.25 MeV). As described in Reference 24, these values can be easily and accurately computed. The value computed for the energy spectrum at 1.25 MeV is 0.43 photons/cm²-sec-MeV, and the magnitude of the discontinuity is 3.40 photons/cm²-sec-MeV.

* Figures 2, 3, 4, and 5 of original document have been omitted. Ed.

BASED ON ORNL-DWG 69-3429 IN SHIELDING BENCHMARK PROBLEM 4.0



* Plotted Incorrectly on Original.

Figure C2 Monte Carlo Scattered Flux Density Energy Spectra.

"In conclusion, it is to be emphasized that the differential data and smoothed curves presented on Figures 3, 4, and 5 contain rather large uncertainties, and must not be taken as absolute standards...."

C.2 AIR FORCE WEAPON LAB "ROCKET" GEOMETRY

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FORTRAN CODING FORM AND DATA SHEET

PROGRAM SAM-C GEOMETRY (CONT.)		LINES		PAGE	
PROGRAMMER A. KRIS WIDDISON		LAB	DATE	1 - ONE Ø - ALPHA 1	2 - TWO R - ALPHA 2
STATEMENT NUMBER	FORTRAN STATEMENT	Ø - ZERO Ø - ALPHA 0	1 - ONE I - ALPHA 1	2 - TWO R - ALPHA 2	PAGE
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FORM 15-20 MAY 70 (REPLACES ANS-10 FORM 11-9 MAR 60)

APPENDIX D
LISTING OF THE AMSAA OCTOBER REVISED STANDARD MAGIC PROGRAM

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C	DIMENSION MASTER(30000),A(6)	MAIN	1
	COMMON/ASTER(30000)	MAIN	2
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERK,DIST	MAIN	3
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	MAIN	4
	I LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	MAIN	5
	COMMON/TEMPOR/XS(6),X(6),IX(8),IT(10),IA(9),IN(9)	MAIN	6
	COMMON/WALT/LIRFC,NGIFRR	MAIN	7
	COMMON/CONTRL/ITESTG,IRAYSK,IENTLV,IVOLUM,IWGT,ITAPEB,NO,IYES	MAIN	8
	COMMON/ENGEOM/LFCFGM	MAIN	9
	COMMON/SIZE/NDQ	MAIN	10
	COMMON/ERR/IERR	MAIN	11
	COMMON/XANDM/IRANDM	MAIN	12
	EQUIVALENCE (ASTER,MASTER)	MAIN	13
C	901 FORMAT(1H1,32HTHIS IS THE 11 APR 69 VERSION OF /	MAIN	14
	I 1H ,32HTHE BRLESC MAGIC PROGRAM ***** //)	MAIN	15
	902 FORMAT(16H BEGIN EXECUTION)	MAIN	16
	903 FORMAT(P110)	MAIN	17
	904 FORMAT(1H0,10X,42HTHE TAPE 4 USED FOR THIS RUN HAS THE TITLE /	MAIN	18
	I 10A6/)	MAIN	19
	905 FORMAT(1H0,10HENTER GENI)	MAIN	20
	906 FORMAT(1H0,12HLEAVING GENI)	MAIN	21
	907 FORMAT(1H0,35HTERMINATION ON GEOMETRY INPUT ERROR,5X,5HIERR=,15)	MAIN	22
	908 FORMAT(1H1,15HTESTG IS CALLED)	MAIN	23
	909 FORMAT(1H0,13HLEAVING TESTG)	MAIN	24
	910 FORMAT(1H1,24HREGION TYPE DATA FOLLOWS, 8X,6HLEFTFO=,110/	MAIN	25
	I 1H ,6HREGION,6X,4HCODE,6X,4HTYPE,6X,11HDESCRIPTION/)	MAIN	26
	911 FORMAT(3I10,10X,6A6)	MAIN	27
	912 FORMAT(16,110,19,7X,6A6)	MAIN	28
	913 FORMAT(1H0,23HNO ROOM FOR IDENT TABLE,5X,7HLEGEOM=,17,5X,	MAIN	29
	I 6HLEFTFO=,17)	MAIN	30
	914 FORMAT(1H0,32HWRITE TAPE 1 OPTION IS SPECIFIED)	MAIN	31
	915 FORMAT(15,1)X,10A6)	MAIN	32
	916 FORMAT(1H1,11HENTER VOLUM)	MAIN	33
	917 FORMAT(1H0,13HLEAVING VOLUM)	MAIN	34
	918 FORMAT(1H ,6H 999.9)	MAIN	35
	919 FORMAT(1H1,11HEND OF CASE,15)	MAIN	36
	925 FORMAT(1H1,32HNUM OF ASPECT ANGLES FOR GRID IS,15)	MAIN	37
	927 FORMAT(10I5)	MAIN	38
	928 FORMAT(1H1,32HNUM OF ASPECT ANGLES FOR AREA IS,15)	MAIN	39
	929 FORMAT(1H0,31HNUMBER OF GI ERRORS ENCOUNTERED,15)	MAIN	40
	930 FORMAT(1H0,31HNUMBER OF U ITEMS ENCOUNTERED,15)	MAIN	41
	999 FORMAT(1H0,10HEND OF RUN)	MAIN	42
C	IRANDM=0	MAIN	43
	WRITE (5,901)	MAIN	44
	WRITE (6,902)	MAIN	45
C	I15=2**15	MAIN	46
	I30=2**30	MAIN	47
	PINF=1.0E50	MAIN	48
	NU=0	MAIN	49
	IYES=1	MAIN	50
	IERK=C	MAIN	51
	LBASE=1	MAIN	52
	KLOOP=0	MAIN	53
	NDQ=30000	MAIN	54
C	READ (5,903)IRDTP4,IWRIP4,ITESTG,IRAYSK,ICARDI,IENTLV,IVOLUM	MAIN	55
		MAIN	56
		MAIN	57
		MAIN	58
		MAIN	59
		MAIN	60

	IF(IRDTP4.NE.0)IRDTP4=IYES	MAIN 61
	IF(IWRTP4.NE.0)IWRTP4=IYES	MAIN 62
	IF(ITESTG.NE.0)ITESTG=IYES	MAIN 63
	IF(IRAYSK.NE.C)IRAYSK=IYES	MAIN 64
	IF(ICARDI.NE.0)ICARDI=IYES	MAIN 65
	IF(IENTLV.NE.0)IENTLV=IYES	MAIN 66
	IF(IVOLUM.NE.0)IVOLUM=IYES	MAIN 67
C		MAIN 68
	IF(IRDTP4.EQ.NO) GOTO 10	MAIN 69
	READ (4) DUMMY,ASTER,LBASE,PINF,IERR,NRPP,NTRIP,NSCAL,	MAIN 70
	1 NBDY,NRMAX,LTRIP,LSCAL,LREGD,LDATA,LRIN,LROT,LIO,LOCDA,	MAIN 71
	2 LBDY,LIRFO,SCALE,LRI,LRO,PINF,IT	MAIN 72
	WRITE (6,904)(IT(I),I=1,10)	MAIN 73
	GOTO 20	MAIN 74
C		MAIN 75
C	PROCESS GEOMETRY	MAIN 76
C		MAIN 77
	10 DO 11 I=LBASE,NDQ	MAIN 78
	ASTER(I)=0.	MAIN 79
	11 CONTINUE	MAIN 80
C		MAIN 81
	WRITE (6,905)	MAIN 82
	CALL GENI	MAIN 83
	WRITE (6,906)	MAIN 84
	IERR=0	MAIN 85
	IF(IERR.LE.0)GOTO 12	MAIN 86
	WRITE (6,907)IERR	MAIN 87
	STOP	MAIN 88
C		MAIN 89
	12 IF(IWRTP4.EQ.NO)GOTO 20	MAIN 90
	WRITE(4) DUMMY,ASTER,LBASE,PINF,IERR,NRPP,NTRIP,NSCAL,	MAIN 91
	1 NBDY,NRMAX,LTRIP,LSCAL,LREGD,LDATA,LRIN,LROT,LIO,LOCDA,	MAIN 92
	2 LBDY,LIRFO,SCALE,LRI,LRO,PINF,IT	MAIN 93
		MAIN 94
C	TEST G	MAIN 95
C		MAIN 96
	20 IF(ITESTG.EQ.NO)GOTO 30	MAIN 97
	WRITE (6,908)	MAIN 98
	CALL TESTG	MAIN 99
	WRITE (6,909)	MAIN 100
	ITESTG=NO	MAIN 101
C		MAIN 102
C	VOLUM	MAIN 103
C		MAIN 104
	30 IF(IVOLUM.EQ.NO)GOTO 40	MAIN 105
	WRITE (6,916)	MAIN 106
	CALL VOLUM	MAIN 107
	WRITE (6,917)	MAIN 108
	IVOLUM=NO	MAIN 109
C		MAIN 110
C	REGION TYPE DATA / ICODE / IDENT /	MAIN 111
C		MAIN 112
C	IRN = REGION NUMBER	MAIN 113
C	ICODE = ITEM CODE	MAIN 114
C	IDENT = SPACE CODE AND SPECIAL IDENTIFICATION	MAIN 115
C	0 NO IDENT CODE	MAIN 116
C	10,20,30,40,50,60,70,80,90 SPECIAL IDENTIFICATION	MAIN 117
C	SKIRT=10 ARMOR=20 TARGET=30	MAIN 118
C	-1,1-9,11-19,21-29,.....,91-99 SPACE CODES	MAIN 119
C		MAIN 120

40	LIRFO=NDQ-NRMAX-10	MAIN 121
	IF(LIRFO.GT.LEGEOM)GOTO 41	MAIN 122
	WRITE(6,913)LEGEOM,LIRFO	MAIN 123
	STOP	MAIN 124
41	WRITE(6,910)LIRFO	MAIN 125
	MASTER(LIRFO-1)=115+1	MAIN 126
C		MAIN 127
42	READ(5,911)IRN,ICODE,IDENT,(A(I),I=1,6)	MAIN 128
	IF(IRN.LE.0)GOTO 50	MAIN 129
	WRITE(6,912)IRN,ICODE,IDENT,(A(I),I=1,6)	MAIN 130
	IDENT=IDENT+1	MAIN 131
	K=LIRFO+IRN-1	MAIN 132
	MASTER(K)=ICODE*115+IDENT	MAIN 133
	GOTO 42	MAIN 134
C		MAIN 135
C	NOAA = NUM OF ASPECT ANGLES FOR GRID	MAIN 136
C	ITAPE8 IS THE SUPPRESS PRINTER OPTION	MAIN 137
C	IWOT IS WRITE OPTION FOR TAPE 1	MAIN 138
C	NAREA = NUM OF ASPECT ANGLES FOR AREA	MAIN 139
C		MAIN 140
50	READ(5,927)NOAA,IWOT,ITAPE8,NAREA	MAIN 141
	IF(IWOT.NE.0)IWOT=1YES	MAIN 142
	IF(ITAPE8.EQ.0)GOTO 51	MAIN 143
	ITAPE8=NO	MAIN 144
	GOTO 52	MAIN 145
51	ITAPE8=1YES	MAIN 146
52	IF(IWOT.EQ.NO)GOTO 60	MAIN 147
	REWIND 1	MAIN 148
	WRITE(6,914)	MAIN 149
	WRITE(1,915)NOAA,(IT(I),I=1,10)	MAIN 150
C		MAIN 151
C	GRID	MAIN 152
C		MAIN 153
60	IF(NOAA.LE.0)GOTO 70	MAIN 154
	WRITE(6,925)NOAA	MAIN 155
C		MAIN 156
DO 61 I=1,NOAA		MAIN 157
CALL GRID		MAIN 158
IF(IWOT.EQ.1YES)WRITE(1,918)		MAIN 159
WRITE(6,919)I		MAIN 160
WRITE(6,929)IERR		MAIN 161
WRITE(6,930)IERR0		MAIN 162
IERR=0		MAIN 163
IERR0=0		MAIN 164
61 CONTINUE		MAIN 165
C		MAIN 166
C	AREA	MAIN 167
C		MAIN 168
70	IF(NAREA.LE.0)GOTO 99	MAIN 169
	WRITE(6,928)NAREA	MAIN 170
C		MAIN 171
DO 71 I=1,NAREA		MAIN 172
CALL AREA		MAIN 173
WRITE(6,919)I		MAIN 174
IERR=0		MAIN 175
71 CONTINUE		MAIN 176
C		MAIN 177
99	WRITE(6,999)	MAIN 178
	STOP	MAIN 179
	END	MAIN 180

C		MAIN 181
C		MAIN 182
	SUBROUTINE UN2(L,J1,J2)	**** 1
	UNPACKS 2 ITEMS FROM THE MASTER-ASTER ARRAY	UN2 2
	COMMON MASTER(30000)	UN2 3
	I3=MASTER(L)	UN2 4
	J1=I3/32768	UN2 5
	J2=I3-J1*32768	UN2 6
	RETURN	UN2 7
	END	UN2 8
C		UN2 9
C		UN2 10
	SUBROUTINE UN3(L,J1,J2,J3)	**** 2
	UNPACKS 3 ITEMS FROM G1 STORAGE	UN3 2
	COMMON MASTER(30000)	UN3 3
	I3=MASTER(L)	UN3 4
	I2=I3/32768	UN3 5
	J1=I2/64	UN3 6
	J2=I2-J1*64	UN3 7
	J3=I3-I2*32768	UN3 8
	RETURN	UN3 9
	END	UN3 10
C		UN3 11
C		UN3 12
	SUBROUTINE OPENK(L,J1,J2,J3)	**** 3
	COMMON/GTRACK/D1,D2,KHIT,LMAX,TR(200),XBS(3),IRSTRT,IENC,	OPENK 2
	I ITR(200),CA,CE,SA,SE	OPENK 3
		OPENK 4
C	UNPACKS 3 ITEMS FROM COMPONENT LINE OF SIGHT STORAGE ITR	OPENK 5
C	/ SURFACE NUM / BODY NUM / NEXT REGION /	OPENK 6
C		OPENK 7
	I3=ITR(L)	OPENK 8
	I2=I3/4096	OPENK 9
	J1=I2/4096	OPENK 10
	J2=I2-J1*4096	OPENK 11
	J3=I3-I2*4096	OPENK 12
	RETURN	OPENK 13
	END	OPENK 14
C		OPENK 15
C		OPENK 16
	FUNCTION RAN(M)	**** 4
	COMMON/RANDM/IRN	RAN 2
	GENERATES RANDOM NUMBERS	RAN 3
	RAN=URAN31(IRN)	RAN 4
	RETURN	RAN 5
	END	RAN 6
C		RAN 7
C		RAN 8
	FUNCTION URAN31(I)	**** 5
	IF(I)20,10,20	URAN31 2
10	I=11111111	URAN31 3
20	J=I	URAN31 4
	J=J*25	URAN31 5
	J=J-(J/67108864)*67108864	URAN31 6
	J=J*25	URAN31 7
	J=J-(J/67108864)*67108864	URAN31 8
	J=J*5	URAN31 9
	J=J-(J/67108864)*67108864	URAN3110
	A1=J	URAN3111
	I=J	URAN3112

```

URAN31=A1/67108864.
RETURN
END
C
C
SUBROUTINE CROSS(ANSWER,FIRST,SECOND)
DIMENSION ANSWER(3),FIRST(3),SECOND(3)
C     COMPUTES CROSS PRODUCT ANSWER = FIRST X SECOND
ANSWER(1) = FIRST(2)*SECOND(3) - FIRST(3)*SECOND(2)
ANSWER(2) = FIRST(3)*SECOND(1) - FIRST(1)*SECOND(3)
ANSWER(3) = FIRST(1)*SECOND(2) - FIRST(2)*SECOND(1)
RETURN
END
C
C
FUNCTION DOT(FIRST,SECOND)
DIMENSION FIRST(3),SECOND(3)
C     COMPUTES DOT PRODUCT DOT = FIRST . SECOND
DOT = FIRST(1)*SECOND(1)+FIRST(2)*SECOND(2)+FIRST(3)*SECOND(3)
RETURN
END
C
C
SUBROUTINE UNIT(V)
DIMENSION V(3)
C     COMPUTES UNIT VECTOR
TEMP = SQRT(DOT(V,V))
V(1)=V(1)/TEMP
V(2)=V(2)/TEMP
V(3)=V(3)/TEMP
RETURN
END
C
C
SUBROUTINE QRTIC(C,R,NRE)
C     SOLVES A POLYNOMIAL EQUATION OF THE TYPE
C     X**4 + C(1)*X**3 + C(2)*X**2 + C(3)*X + C(4) = 0
C     THE COEFFICIENT OF X**4 IS ASSUMED TO BE 1
C     R CONTAINS THE ROOTS
C     NRE CONTAINS THE NUMBER OF REAL ROOTS
C     IF THERE ARE TWO REAL ROOTS THEY WILL BE IN R(1) AND R(2),
C     WITH THE COMPLEX ROOTS R(3) +/- R(4)*I
C     IF THERE ARE NO REAL ROOTS, THE COMPLEX ROOTS ARE
C     R(1) +/- R(2)*I AND R(3) +/- R(4)*I
C
DIMENSION C(4),R(4),CP(3),Y(3)
C1SQ=C(1)**2
CP(1)=-C(2)
CP(2)=C(1)*C(3)-4.*C(4)
CP(3)=(4.*C(2)-C1SQ)*C(4)-C(3)**2
CALL CUBIC(CP,Y,NRE)
A=C1SQ/4.-C(2)+Y(1)
B=.5*C(1)*Y(1)-C(3)
D=.25*Y(1)**2-C(4)
IF(A.GT.0.)GOTO 10
E=0.
GOTO 20
10 E=SQRT(A)
20 IF(D.GT.0.)GOTO 30

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URAN3113
URAN3114
URAN3115
URAN3116
URAN3117
**** 6
CROSS 2
CROSS 3
CROSS 4
CROSS 5
CROSS 6
CROSS 7
CROSS 8
CROSS 9
CROSS 10
**** 7
DOT 2
DOT 3
DOT 4
DOT 5
DOT 6
DOT 7
DOT 8
**** 8
UNIT 2
UNIT 3
UNIT 4
UNIT 5
UNIT 6
UNIT 7
UNIT 8
UNIT 9
UNIT 10
UNIT 11
**** 9
QRTIC 2
QRTIC 3
QRTIC 4
QRTIC 5
QRTIC 6
QRTIC 7
QRTIC 8
QRTIC 9
QRTIC 10
QRTIC 11
QRTIC 12
QRTIC 13
QRTIC 14
QRTIC 15
QRTIC 16
QRTIC 17
QRTIC 18
QRTIC 19
QRTIC 20
QRTIC 21
QRTIC 22
QRTIC 23
QRTIC 24
QRTIC 25
QRTIC 26

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F=0.	QRTIC 27
GOTO 50	QRTIC 28
30 F=SIGN(SQRT(D),B)	QRTIC 29
50 NKF=0	QRTIC 30
REAL=-.25*C(1)+.5*L	QRTIC 31
DSCR=REAL**2-.5*Y(1)+F	QRTIC 32
RAD=SQRT(ABS(DSCR))	QRTIC 33
IF(DSCR.LT.0.)GOTO 60	QRTIC 34
NRE=2	QRTIC 35
R(1)=REAL+RAD	QRTIC 36
R(2)=REAL-RAD	QRTIC 37
GOTO 65	QRTIC 38
60 R(3)=REAL	QRTIC 39
R(4)=RAD	QRTIC 40
65 REAL=REAL-F	QRTIC 41
DSCR=REAL**2-.5*Y(1)-F	QRTIC 42
RAD=SQRT(ABS(DSCR))	QRTIC 43
IF(DSCR.LT.0.)GOTO 80	QRTIC 44
NRE=NRE+2	QRTIC 45
R(NRE)=REAL-RAD	QRTIC 46
R(NRE-1)=REAL+RAD	QRTIC 47
RETURN	QRTIC 48
80 R(NRE+1)=REAL	QRTIC 49
R(NRE+2)=RAD	QRTIC 50
RETURN	QRTIC 51
END	QRTIC 52
C	QRTIC 53
C	QRTIC 54
SUBROUTINE CUBIC(C,R,NRE)	**** 10
C	CUBIC 2
C	CUBIC 3
C	CUBIC 4
C	CUBIC 5
C	CUBIC 6
C	CUBIC 7
C	CUBIC 8
C	CUBIC 9
C	CUBIC 10
C	CUBIC 11
C	CUBIC 12
C	CUBIC 13
C	CUBIC 14
C	CUBIC 15
C	CUBIC 16
C	CUBIC 17
C	CUBIC 18
C	CUBIC 19
C	CUBIC 20
C	CUBIC 21
C	CUBIC 22
C	CUBIC 23
C	CUBIC 24
C	CUBIC 25
C	CUBIC 26
C	CUBIC 27
C	CUBIC 28
C	CUBIC 29
C	CUBIC 30
C	CUBIC 31
C	CUBIC 32
DIMENSION C(3),R(3)	
C1SQ=C(1)**2	
P=C(2)-C1SQ/3.	
Q=C(3)-C(1)*(C(2)/3.-2.*C1SQ/27.)	
DEL=4.*P**3+27.*Q**2.	
T=C(1)/3.	
IF(DEL.LT.0.)GOTO 10	
SQ=SQRT(DEL/108.)	
HQ=.5*Q	
A=-HQ+SQ	
B=-HQ-SQ	
CRTA=SIGN(ABS(A)**.3333333333333333,A)	
CRTB=SIGN(ABS(B)**.3333333333333333,B)	
Y=CRTA+CRTB	
R(1)=Y-T	
R(2)=-.5*Y-T	
R(3)=.866025404*(CRTA-CRTB)	
NRE=1	
RETURN	
10 PHI3=ATAN2(SQRT(-DEL/27.),-Q)/3.	
CON=2.*SQRT(-P/3.)	
R(1)=CON*COS(PHI3)-T	

	R(2)=-CON*COS(1.04719755-PHI3)-T	CUBIC 33
	R(3)=-CON*COS(1.04719755+PHI3)-T	CUBIC 34
	NRE=3	CUBIC 35
	RETURN	CUBIC 36
	END	CUBIC 37
C		CUBIC 38
C		CUBIC 39
	FUNCTION XDIST(XA,XB)	**** 11
	COMPUTES THE DISTANCE BETWEEN XA AND XB	XDIST 2
	DIMENSION XA(3),XB(3)	XDIST 3
	XSUM=0.	XDIST 4
	DO 10 I=1,3	XDIST 5
	XSUM=XSUM+(XA(I)-XB(I))**2	XDIST 6
10	CONTINUE	XDIST 7
	XDIST=SQRT(XSUM)	XDIST 8
	RETURN	XDIST 9
	END	XDIST 10
C		XDIST 11
C		XDIST 12
	SUBROUTINE DCOSP(XA,XB,WA)	**** 12
	COMPUTES DIRECTION COSINES FROM POINT XA TO POINT XB	DCOSP 2
	AND STORES DIRECTION COSINES IN WA	DCOSP 3
	DIMENSION XA(3),XB(3),WA(3)	DCOSP 4
	DIS=XDIST(XA,XB)	DCOSP 5
	DO 10 I=1,3	DCOSP 6
	WA(I)=(XB(I)-XA(I))/DIS	DCOSP 7
10	CONTINUE	DCOSP 8
	RETURN	DCOSP 9
	END	DCOSP 10
C		DCOSP 11
C		DCOSP 12
	SUBROUTINE TROPIC(WP)	**** 13
	GENERATES RANDOM DIRECTION COSINES FROM AN	TROPIC 2
	ISOTROPIC DISTRIBUTION	TROPIC 3
	DIMENSION WP(3)	TROPIC 4
10	X1=RAN (-1)	TROPIC 5
	X2=RAN (-1)	TROPIC 6
	X1S=X1**2	TROPIC 7
	X2S=X2**2	TROPIC 8
	T=X1S+X2S	TROPIC 9
	IF(T.GE.1.)GOTO 10	TROPIC10
	CALC SIN AND COS OF A RANDOM ANGLE PHI	TROPIC11
	CSPHI=(X1S-X2S)/T	TROPIC12
	SNPHI=(2.*X1*X2)/T	TROPIC13
	X1=RAN (-1)	TROPIC14
	IF(X1.LE..5)SNPHI=-SNPHI	TROPIC15
	CALC COS AND SIN OF RANDOM ANGLE THT	TROPIC16
	CSTHT=2.*RAN (-1)-1.	TROPIC17
	SNHTT=SQRT(1.-CSTHT**2)	TROPIC18
	CALC DIRECTION COSINES	TROPIC19
	WP(1)=SNHTT*SNPHI	TROPIC20
	WP(2)=SNHTT*CSPHI	TROPIC21
	WP(3)=CSTHT	TROPIC22
	RETURN	TROPIC23
	END	TROPIC24
C		TROPIC25
C		TROPIC26
C		TROPIC27
C		TROPIC28
	SUBROUTINE GFNI	**** 14

DIMENSION MASTER(30000),ITY(11),IAN(8),IAA(8),FX(20),	GENI	2
1 NOC(3),NO1(3),NO2(3),O4(3),TT(3),TT1(3),TT2(3),NBOD(11)	GENI	3
COMMON ASTER(30000)	GENI	4
COMMON/GFOM/LBASE,LRIN,LRGT,LRJ,LRQ,PINF,IERR,DIST	GENI	5
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	GENI	6
1 LDATA,LRIN,LRGT,LIO,LUODA,I15,I30,LBODY,NASC,KLOOP	GENI	7
COMMON/TEMPOR/XS(6),X(6),IX(8),IT(10),IA(9),IN(9)	GENI	8
COMMON/CONTRL/ITESTG,IRAYSK,IENLV,IVOLUM,IWOT,ITAPE8,NO,IYES	GENI	9
COMMON/SIZE/NGQ	GENI	10
COMMON/UNCLE/MN,IC(4)	GENI	11
COMMON/RRPP/LRPPD,LABUT	GENI	12
EQUIVALLNCE(ASTER,MASTER)	GENI	13
901 FORMAT(1H0,24HSTART READING SOLID DATA)	GENI	14
902 FORMAT(10A6)	GENI	15
903 FORMAT(1H0,10A6/)	GENI	16
904 FORMAT(7I10)	GENI	17
905 FORMAT(4X,34HNO. OF RECTANGULAR PARALLELEPIPEDS,I10/	GENI	18
1 4X,34HNO. OF TRIPLETS ,I10/	GENI	19
2 4X,34HNO. OF SCALERS ,I10/	GENI	20
3 4X,34HNO. OF SOLIDS ,I10/	GENI	21
4 4X,34HMAX NO. OF REGIONS ,I10)	GENI	22
906 FORMAT(1H0,45X,32HRECTANGULAR PARALLELEPIPED INPUT)	GENI	23
907 FORMAT(1H0,37X,12HTRIPLET DATA)	GENI	24
908 FJRMAT(6E12.6)	GENI	25
909 FORMAT(18,17X,3F12.5)	GENI	26
910 FORMAT(1H0,25X,12HSCALAR DATA)	GENI	27
911 FORMAT(1H0,50X,22HDESCRIPTION OF SOLIDS)	GENI	28
912 FORMAT(3A1,A3,A4,6F10.5)	GENI	29
913 FORMAT(1H0,6HITYPE ,A3,27H DOES NOT MATCH WITH AN ITY)	GENI	30
914 FORMAT(19,1X,3A1,3X,A3,A4,3X,8I5)	GENI	31
915 FORMAT(18,1X,3A1,2X,A3,A4,4X,6F12.5)	GENI	32
916 FORMAT(25X,6F12.5)	GENI	33
917 FORMAT(1H0,38HNO MORE ROOM FOR SOLID DATA LDATA=,I10,	GENI	34
1 5X,5HLBOT=,I10,5X,4HNDQ=,I10)	GENI	35
918 FORMAT(1H0,25HFINISH READING SOLID DATA)	GENI	36
919 FORMAT(1H0, 5HLREGD,7H LREGL,7H LENLV,7H LRIN,7H LROT,	GENI	37
1 7H LIO,7H LECEOM/I5,6I7)	GENI	38
920 FORMAT(1H1,36X,23HREGION COMBINATION DATA)	GENI	39
921 FORMAT(15,1X,9(A2,I5))	GENI	40
922 FORMAT(1H0,30HEKRRR IN DESCRIPTION OF REGION,I5,	GENI	41
19H IN FIELD,I2,5X,24HBODY NUM.GT.NRPP + NBODY)	GENI	42
923 FORMAT(10X,9(1H(,A2,I5,1H),1X))	GENI	43
924 FORMAT(18,2X,9(1H(,A2,I5,1H),1X))	GENI	44
925 FORMAT(1H0,30HILLEGAL OPERATOR IN ABOVE CARD,5X,A2,	GENI	45
1 9H IN FIELD,I2)	GENI	46
926 FORMAT(1H0,29HEKRRR IN REGION INPUT IR=,I5,14H OR N.GT.NRMAX)	GENI	47
927 FORMAT(1H0,39HNO MORE ROOM FOR REGION DATA LDATA=,I10,	GENI	48
1 5X,4HNDQ=,I10)	GENI	49
928 FORMAT(1H0,26HFINISH READING REGION DATA)	GENI	50
929 FORMAT(14H ERROR, REGION,I10,18H IS PART OF REGION,I10)	GENI	51
930 FORMAT(24H FINISH CHECKING REGION ,I5)	GENI	52
931 FORMAT(1H0,34HNO MORE ROOM FOR ENTER LEAVE TABLE,5X,	GENI	53
1 6HLDATA=,I10,5X,4HNDQ=I10,5X,4HPASS,I2,5X,3HIR=,I10)	GENI	54
932 FORMAT(1H0,28HTOTAL ROOM FOR GEOMETRY DATA,5X,7HLECEOM=,I6)	GENI	55
933 FORMAT(1H0,5HENTER,18I6/(23X,15I6))	GENI	56
934 FORMAT(1H ,5HLEAVE,18I6/(23X,15I6))	GENI	57
935 FORMAT(1H1,50X,18HBEGIN ARRAY OUTPUT/)	GENI	58
936 FORMAT(3(3I6,1X,E11.4,3H \$))	GENI	59
937 FORMAT(/)	GENI	60
	GENI	61

938	FORMAT(1H0,34HFINISH A PASS OF ENTER LEAVE TABLE,I5)	GENI	62
939	FORMAT(1H0,14HERROR IN INPUT,5X,A3,23H DOES NOT ALLOW TRIPLET, 1 22H AND SCALAR TYPE INPUT)	GENI	63
940	FJRMAT(10X,6F10.5)	GENI	64
941	FORMAT(1H0,37HTERMINATION ON BAD REGION DESCRIPTION)	GENI	65
942	FORMAT(1H0,32HERROR IN DESCRIPTION OF BODY NUM,I6/ 1 7H VECTOR,3F12.5,24H IS NOT PERPENDICULAR TO / 2 7H VECTOR,3F12.5/)	GENI	66
943	FORMAT(1H0,27HERROR IN DESCRIPTION OF TOR,5X,8HR2.GT.R1/)	GENI	67
944	FORMAT(1H0,27HERROR IN DESCRIPTION OF TRC,5X,7HR1 = R2/)	GENI	68
945	FORMAT(1H0,5HLBASE,7H LRPPD, 1 7H LABUT,7H LBODY,7H LBOU,7H LDATA,7H LBOT,7H LSCAL, 2 7H LTRIP,7H NDQ/15,9I7)	GENI	69
946	FORMAT(1H1,17HENTER-LEAVE TABLE)	GENI	70
947	FORMAT(1H0,11(2X,A3)/11I5)	GENI	71
948	FORMAT(1H0,27HERROR IN DESCRIPTION OF TEC,5X, 1 41HHEIGHT VECTOR IS PARALLEL TO BASE ELLIPSE)	GENI	72
C		GENI	73
		GENI	74
		GENI	75
		GENI	76
		GENI	77
		GENI	78
		GENI	79
		GENI	80
		GENI	81
	INTEGER HHBOX, HHSPH, HHRCC, HHREC, HHTRC, HHELL, HHRAW, HHARB, HHTEC, 1 HHTOR, HHARS, HHOR, HHBR, HHR, HHRA, HHAR, HHBA, HHA, HHB	GENI	82
C		GENI	83
	DATA HHBOX, HHSPH, HHRCC, HHREC, HHTRC, HHELL, HHRAW, HHARB, 1 HHTEC, HHTOR, HHARS, HHBOX, 3HSPH, 3HRCC, 3HREC, 3HTRC, 23HELL, 3HRAW, 3HARB, 3HTEC, 3HTOR, 3HARS/ DATA HHOR, HHBR, HHR, HHRA, HHAR, HHBA, HHA, HHB 1/2HOR, 2HRR, 1HR, 2HRA, 2HAR, 2H A, 2HA, 2H /	GENI	84
	IY(1)=HHBOX	GENI	85
	IY(2)=HHSPH	GENI	86
	IY(3)=HHRCC	GENI	87
	IY(4)=HHREC	GENI	88
	IY(5)=HHTRC	GENI	89
	IY(6)=HHELL	GENI	90
	IY(7)=HHRAW	GENI	91
	IY(8)=HHARB	GENI	92
	IY(9)=HHTEC	GENI	93
	IY(10)=HHTOR	GENI	94
	IY(11)=HHARS	GENI	95
	IAN(1)=1	GENI	96
	IAN(2)=1	GENI	97
	IAN(3)=1	GENI	98
	IAN(4)=2	GENI	99
	IAN(5)=2	GENI	100
	IAN(6)=3	GENI	101
	IAN(7)=3	GENI	102
	IAN(8)=4	GENI	103
	IAA(1)=HHOR	GENI	104
	IAA(2)=HHBR	GENI	105
	IAA(3)=HHR	GENI	106
	IAA(4)=HHRA	GENI	107
	IAA(5)=HHAR	GENI	108
	IAA(6)=HHBA	GENI	109
	IAA(7)=HHA	GENI	110
	IAA(8)=HHB	GENI	111
	IBL=HHB	GENI	112
C		GENI	113
	WRITE (6,901)	GENI	114
	READ(5,902)(IT(I),I=1,10)	GENI	115
	WRITE (6,903)(IT(I),I=1,10)	GENI	116
		GENI	117
		GENI	118
		GENI	119
		GENI	120
		GENI	121

	READ(5,904)NRPP,NTRIP,NSCAL,NBODY,NRMAX,IPRIN,IRCHEK	GENI 122
	WRITE (6,905)NRPP,NTRIP,NSCAL,NBODY,NRMAX	GENI 123
C		GENI 124
C	RPP	GENI 125
C		GENI 126
	WRITE (6,906)	GENI 127
	LAR=1	GENI 128
	IF(NRPP.LE.0)GOTO 20	GENI 129
	CALL RPPIN(LAR)	GENI 130
	IF(I+RR.GT.0)RETURN	GENI 131
C		GENI 132
C	LBODY STORAGE RESERVE 3*(NRPP+NBODY) WORDS	GENI 133
C	/ ITYPE / LDATA /	GENI 134
C	/ LOC ENTER LIST / LOC LEAVE LIST /	GENI 135
C	/ NUM ENTER / NUM LEAVE /	GENI 136
C		GENI 137
C	LDATA POINTS TO BODY POINTERS STORED AT LBOD	GENI 138
C		GENI 139
	20 LTRIP=NDU-3*NTRIP+1	GENI 140
	LSCAL=LTRIP-NSCAL	GENI 141
	LBOT=LSCAL	GENI 142
	L=LAR	GENI 143
	LBODY=L+1	GENI 144
	LDATA=LBODY+3*(NBODY+NRPP)	GENI 145
	LBOD=LDATA	GENI 146
C		GENI 147
C	TRIPLETS	GENI 148
C		GENI 149
	IF(NTRIP.EQ.0)GOTO 30	GENI 150
	WRITE (6,907)	GENI 151
	DO 21 I=1,NTRIP	GENI 152
	I1=LTRIP+3*(I-1)	GENI 153
	I2=I1+2	GENI 154
	READ(5,908)(ASTER(K),K=I1,I2)	GENI 155
	WRITE (6,909)(I,(ASTER(K),K=I1,I2))	GENI 156
	21 CONTINUE	GENI 157
C		GENI 158
C	SCALARS	GENI 159
C		GENI 160
	30 IF(NSCAL.EQ.0)GOTO 50	GENI 161
	I1=LSCAL	GENI 162
	I2=I1+NSCAL-1	GENI 163
	WRITE (6,910)	GENI 164
	DO 31 I=I1,I2	GENI 165
	J=I-I1+1	GENI 166
	READ(5,908)ASTER(I)	GENI 167
	WRITE (6,909)J,ASTER(I)	GENI 168
	31 CONTINUE	GENI 169
C		GENI 170
C	READ AND PROCESS BODIES	GENI 171
C		GENI 172
	50 WRITE (6,911)	GENI 173
C		GENI 174
C	LOOP TO PROCESS SOLIDS	GENI 175
C		GENI 176
	DO 37C N=1,NBODY	GENI 177
	NN=N+NRPP	GENI 178
	LS1=0	GENI 179
	READ(5,912) IC(1),IC(2),IC(3),ITYPE,IC(4),(FX(K),K=1,6)	GENI 180
	DO 51 I=1,11	GENI 181

	IF(IITYPE.EQ.ITY(1))GOTO 52	GENI 182
51	CONTINUE	GENI 183
	WRITE (6,913)IITYPE	GENI 184
	STOP	GENI 185
52	IITYPE=I	GENI 186
	NBOD(I)=NBOD(I)+1	GENI 187
	K=LBODY+3*(NRPP+N-1)	GENI 188
	MASTER(K)=IITYPE*I15+LDATA	GENI 189
	IF(IC(1).NE.IBL)GOTO 200	GENI 190
C		GENI 191
C	BOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	GENI 192
	GOTO(101,103,102,101,101,102,101,100,104,101,100),IITYPE	GENI 193
100	WRITE (6,939)ITY(IITYPE)	GENI 194
	STOP	GENI 195
101	LL=4	GENI 196
	GOTO 110	GENI 197
102	LE=3	GENI 198
	GOTO 110	GENI 199
103	LE=2	GENI 200
	GOTO 110	GENI 201
104	LE=7	GENI 202
110	CALL CONVRT(FX,IX,LE)	GENI 203
	WRITE (6,914)NN,IC(1),IC(2),IC(3),ITY(IITYPE),IC(4),(IX(J),J=1,LE)	GENI 204
	LT=LTRIP-3	GENI 205
	J1=IX(1)	GENI 206
	J2=IX(2)	GENI 207
	J3=IX(3)	GENI 208
	J4=IX(4)	GENI 209
	J5=IX(5)	GENI 210
	J6=IX(6)	GENI 211
	J7=IX(7)	GENI 212
C	BOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	GENI 213
	GOTO(120,130,140,120,150,160,120,100,170,150,100),IITYPE	GENI 214
C	BOX REC RAW	GENI 215
120	MASTER(LDATA)=(LT+3*J1)*I30+(LT+3*J2)*I15+LT+3*J3	GENI 216
	MASTER(LDATA+1)=LT+3*J4	GENI 217
	LDATA=LDATA+2	GENI 218
	GOTO 360	GENI 219
C	SPH	GENI 220
130	MASTER(LDATA)=(LT+3*J1)*I15+LSCAL+J2-1+I30	GENI 221
	LDATA=LDATA+1	GENI 222
	GOTO 360	GENI 223
C	RCC	GENI 224
140	MASTER(LDATA)=(LT+3*J1)*I30+(LT+3*J2)*I15+LSCAL+J3-1	GENI 225
	LDATA=LDATA+1	GENI 226
	GOTO 360	GENI 227
C	TRC TOR	GENI 228
150	MASTER(LDATA)=(LT+3*J1)*I30+(LT+3*J2)*I15+LSCAL+J3-1	GENI 229
	MASTER(LDATA+1)=LSCAL+J4-1	GENI 230
	LDATA=LDATA+2	GENI 231
	GOTO 360	GENI 232
C	ELL	GENI 233
160	MASTER(LDATA)=(LT+3*J1)*I30+(LT+3*J2)*I15+LSCAL+J3-1	GENI 234
	LDATA=LDATA+1	GENI 235
	GOTO 360	GENI 236
C	TEC	GENI 237
170	MASTER(LDATA)=(LT+3*J1)*I30+(LT+3*J2)*I15+LT+3*J3	GENI 238
	MASTER(LDATA+1)=(LT+3*J4)*I30+(LSCAL+J5-1)*I15+LSCAL+J6-1	GENI 239
	MASTER(LDATA+2)=LSCAL+J7-1	GENI 240
	LDATA=LDATA+3	GENI 241

	GOTO 360	GENI 242
C		GENI 243
C	NOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	GENI 244
200	GOTO(201,220,202,201,203,202,201,230,204,203,240), ITYPE	GENI 245
201	LE=12	GENI 246
	GOTO 210	GENI 247
202	LL=7	GENI 248
	GOTO 210	GENI 249
203	LE=8	GENI 250
	GOTO 210	GENI 251
204	LL=13	GENI 252
210	WRITE (6,915)NN, IC(1), IC(2), IC(3), ITY(ITYPE), IC(4), (FX(J), J=1,6)	GENI 253
	RLAB(5,940)(FX(J), J=7, LE)	GENI 254
	WRITE (6,916)(FX(J), J=7, LE)	GENI 255
C	NOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	GENI 256
	GOTO(290,300,300,290,285,270,290,300,260,250,300), ITYPE	GENI 257
C	SPH	GENI 258
220	WRITE (6,915)NN, IC(1), IC(2), IC(3), ITY(ITYPE), IC(4), (FX(J), J=1,4)	GENI 259
	GOTO 300	GENI 260
C	ARB / RI / VI / 6 PER ARB	GENI 261
230	WRITE (6,915)NN, IC(1), IC(2), IC(3), ITY(ITYPE), IC(4), (FX(J), J=1,6)	GENI 262
	CALL ALBERT(FX, LBOT, NDU, LSI)	GENI 263
	GOTO 360	GENI 264
C	ARS / / LDATA /	GENI 265
240	CALL ARIN(LBOT, LDATA, MASTER, ASTER, IWH)	GENI 266
	GOTO 360	GENI 267
C	TOR CONVERT TO UNIT VECTOR	GENI 268
250	TI(1)=FX(4)	GENI 269
	TI(2)=FX(5)	GENI 270
	TI(3)=FX(6)	GENI 271
	CALL UNIT(TI)	GENI 272
	FX(4)=TI(1)	GENI 273
	FX(5)=TI(2)	GENI 274
	FX(6)=TI(3)	GENI 275
	IF(FX(7).GE.FX(8))GOTO 280	GENI 276
	WRITE (6,943)	GENI 277
	IERR=IERR+1	GENI 278
	GOTO 290	GENI 279
C	TEC	GENI 280
260	FX(10)=FX(13)	GENI 281
	LE=15	GENI 282
	TT1(1)=FX(7)	GENI 283
	TT1(2)=FX(8)	GENI 284
	TT1(3)=FX(9)	GENI 285
	TT2(1)=FX(10)	GENI 286
	TT2(2)=FX(11)	GENI 287
	TT2(3)=FX(12)	GENI 288
	IF(ABS(DOT(TT1,TT2)).LE.0.01) GOTO 265	GENI 289
	WRITE (6,942)NN, TT1, TT2	GENI 290
	IERR=IERR+1	GENI 291
C	SEMI MAJOR AXIS FX(13)	GENI 292
265	FX(13)=SQRT(DOT(TT1,TT1))	GENI 293
	CALL UNIT(TT1)	GENI 294
	FX(10)=TT1(1)	GENI 295
	FX(11)=TT1(2)	GENI 296
	FX(12)=TT1(3)	GENI 297
C	SEMI MINOR AXIS FX(14)	GENI 298
	FX(14)=SQRT(DOT(TT2,TT2))	GENI 299
C	NORMAL HEIGHT VECTOR	GENI 300
	CALL CROSS(TT, TT1, TT2)	GENI 301

	CALL UNIT(TT)	GENI 302
	HON=FX(4)*TT(1)+FX(5)*TT(2)+FX(6)*TT(3)	GENI 303
	IF(HON)267,266,268	GENI 304
266	WRITE(6,948)	GENI 305
	IERR=IERR+1	GENI 306
	GOTO 268	GENI 307
267	TT(1)=-TT(1)	GENI 308
	TT(2)=-TT(2)	GENI 309
	TT(3)=-TT(3)	GENI 310
268	FX(7)=TT(1)	GENI 311
	FX(8)=TT(2)	GENI 312
	FX(9)=TT(3)	GENI 313
	GOTO 280	GENI 314
C	FLL COMPUTE FOCI	GENI 315
270	IF(IC(4).EQ.1BL)GOTO 300	GENI 316
	ASQ=FX(4)*FX(4)+FX(5)*FX(5)+FX(6)*FX(6)	GENI 317
	C=SQRT(ASQ-FX(7)*FX(7))	GENI 318
	A=SQRT(ASQ)	GENI 319
	FX(7)=A+A	GENI 320
C	X,Y,Z COMPONENTS OF FOCI	GENI 321
	CX=C*FX(4)/A	GENI 322
	CY=C*FX(5)/A	GENI 323
	CZ=C*FX(6)/A	GENI 324
C	VERTEX + AND - X,Y,Z COMPONENTS GIVE THE 2 FOCI	GENI 325
	FX(4)=FX(1)+CX	GENI 326
	FX(5)=FX(2)+CY	GENI 327
	FX(6)=FX(3)+CZ	GENI 328
	FX(1)=FX(1)-CX	GENI 329
	FX(2)=FX(2)-CY	GENI 330
	FX(3)=FX(3)-CZ	GENI 331
C	PRINT NEW INPUT	GENI 332
280	WRITE(6,915)NN,IC(1),IC(2),IC(3),ITY(ITYPE),IC(4),(FX(J),J=1,6)	GENI 333
	WRITE(6,916)(FX(J),J=7,LE)	GENI 334
	GOTO 300	GENI 335
C	TRC CHECK R1.NE.R2	GENI 336
285	IF(FX(7).NE.FX(8))GOTO 300	GENI 337
	WRITE(6,944)	GENI 338
	IERR=IERR+1	GENI 339
	GOTO 300	GENI 340
C	BOX RAW REC CHECK IF VECTORS ARE PERPENDICULAR	GENI 341
290	IF(ABS(FX(4)*FX(7)+FX(5)*FX(8)+FX(6)*FX(9)).LE.0.01)GOTO 291	GENI 342
	WRITE(6,942)NN,(FX(J),J=4,9)	GENI 343
	IERR=IFRR+1	GENI 344
291	IF(ABS(FX(4)*FX(10)+FX(5)*FX(11)+FX(6)*FX(12)).LE.0.01)GOTO 292	GENI 345
	WRITE(6,942)NN,FX(4),FX(5),FX(6),FX(10),FX(11),FX(12)	GENI 346
	IERR=IERR+1	GENI 347
292	IF(ABS(FX(7)*FX(10)+FX(8)*FX(11)+FX(9)*FX(12)).LE.0.01)GOTO 300	GENI 348
	WRITE(6,942)NN,(FX(J),J=7,12)	GENI 349
	IERR=IERR+1	GENI 350
C		GENI 351
C	BOX SPH RCC RLC TRC ELL RAW ARB TEC TOR ARS	GENI 352
300	GOTO(310,320,330,310,340,330,310,230,350,340,240),ITYPE	GENI 353
C	BOX REC RAW / V1 / V2 /	GENI 354
C	/ V2 / V3 /	GENI 355
310	CALL SEE3(IWH,ASTER,MASTER,FX(1),FX(2),FX(3),LBOT,LDATA,NDQ,LS1)	GENI 356
	MASTR(LDATA)=IWH*115	GENI 357
	CALL SEE3(IWH,ASTER,MASTER,FX(4),FX(5),FX(6),LBOT,LDATA,NDQ,LS1)	GENI 358
	MASTR(LDATA)=MASTR(LDATA)+IWH	GENI 359
	CALL SEE3(IWH,ASTER,MASTER,FX(7),FX(8),FX(9),LBOT,LDATA,NDQ,LS1)	GENI 360
	MASTR(LDATA+1)=IWH*115	GENI 361

	CALL SEE3(IWH,ASTER,MASTER,FX(10),FX(11),FX(12),	GENI 362
	1 LBOT,LDATA,NDQ,LS1)	GENI 363
	MASTER(LDATA+1)=MASTER(LDATA+1)+IWH	GENI 364
	LDATA=LDATA+2	GENI 365
	GO TO 360	GENI 366
C	SPH / V1 / R1 /	GENI 367
320	CALL SEE3(IWH,ASTER,MASTER,FX(1),FX(2),FX(3),LBOT,LDATA,NDQ,LS1)	GENI 368
	MASTER(LDATA)=IWH*115	GENI 369
	LS1=1	GENI 370
	CALL SEE3(IWH,ASTER,MASTER,FX(4),FX(4),FX(4),LBOT,LDATA,NDQ,LS1)	GENI 371
	LS1=0	GENI 372
	MASTER(LDATA)=MASTER(LDATA)+IWH	GENI 373
	LDATA=LDATA+1	GENI 374
	GO TO 360	GENI 375
C	RCC FLL / V1 / V2 /	GENI 376
C	/ / R1 /	GENI 377
330	CALL SEE3(IWH,ASTER,MASTER,FX(1),FX(2),FX(3),LBOT,LDATA,NDQ,LS1)	GENI 378
	MASTER(LDATA)=IWH*115	GENI 379
	CALL SEE3(IWH,ASTER,MASTER,FX(4),FX(5),FX(6),LBOT,LDATA,NDQ,LS1)	GENI 380
	MASTER(LDATA)=MASTER(LDATA)+IWH	GENI 381
	LS1=1	GENI 382
	CALL SEE3(IWH,ASTER,MASTER,FX(7),FX(7),FX(7),LBOT,LDATA,NDQ,LS1)	GENI 383
	LS1=0	GENI 384
	MASTER(LDATA+1)=IWH	GENI 385
	LDATA=LDATA+2	GENI 386
	GO TO 360	GENI 387
C	IRC TOR / V1 / V2 /	GENI 388
C	/ R1 / R2 /	GENI 389
340	CALL SEE3(IWH,ASTER,MASTER,FX(1),FX(2),FX(3),LBOT,LDATA,NDQ,LS1)	GENI 390
	MASTER(LDATA)=IWH*115	GENI 391
	CALL SEE3(IWH,ASTER,MASTER,FX(4),FX(5),FX(6),LBOT,LDATA,NDQ,LS1)	GENI 392
	MASTER(LDATA)=MASTER(LDATA)+IWH	GENI 393
	LS1=1	GENI 394
	CALL SEE3(IWH,ASTER,MASTER,FX(7),FX(7),FX(7),LBOT,LDATA,NDQ,LS1)	GENI 395
	MASTER(LDATA+1)=IWH*115	GENI 396
	CALL SEE3(IWH,ASTER,MASTER,FX(8),FX(8),FX(8),LBOT,LDATA,NDQ,LS1)	GENI 397
	LS1=0	GENI 398
	MASTER(LDATA+1)=MASTER(LDATA+1)+IWH	GENI 399
	LDATA=LDATA+2	GENI 400
	GO TO 360	GENI 401
C	TEC / V1 / V2 /	GENI 402
C	/ V3 / V4 /	GENI 403
C	/ R1 / R2 /	GENI 404
C	/ / R3 /	GENI 405
350	CALL SEE3(IWH,ASTER,MASTER,FX(1),FX(2),FX(3),LBOT,LDATA,NDQ,LS1)	GENI 406
	MASTER(LDATA)=IWH*115	GENI 407
	CALL SEE3(IWH,ASTER,MASTER,FX(4),FX(5),FX(6),LBOT,LDATA,NDQ,LS1)	GENI 408
	MASTER(LDATA)=MASTER(LDATA)+IWH	GENI 409
	CALL SEE3(IWH,ASTER,MASTER,FX(7),FX(8),FX(9),LBOT,LDATA,NDQ,LS1)	GENI 410
	MASTER(LDATA+1)=IWH*115	GENI 411
	CALL SEE3(IWH,ASTER,MASTER,FX(10),FX(11),FX(12),	GENI 412
	1 LBOT,LDATA,NDQ,LS1)	GENI 413
	MASTER(LDATA+1)=MASTER(LDATA+1)+IWH	GENI 414
	LS1=1	GENI 415
	CALL SEE3(IWH,ASTER,MASTER,FX(13),FX(13),FX(13),	GENI 416
	1 LBOT,LDATA,NDQ,LS1)	GENI 417
	MASTER(LDATA+2)=IWH*115	GENI 418
	CALL SEE3(IWH,ASTER,MASTER,FX(14),FX(14),FX(14),	GENI 419
	1 LBOT,LDATA,NDQ,LS1)	GENI 420
	MASTER(LDATA+2)=MASTER(LDATA+2)+IWH	GENI 421

	CALL SEE3(IWH,ASTER,MASTER,FX(15),FX(15),FX(15),	GENI 422
	1 LBOT,LDATA,NDQ,LS1)	GENI 423
	LS1=0	GENI 424
	MASTER(LDATA+3)=IWH	GENI 425
	LDATA=LDATA+4	GENI 426
C	CHECK IF ANY MORE ROOM FOR SOLID DATA	GENI 427
	360 IF(LDATA.LT.NDQ)GOTO 370	GENI 428
	WRITE (6,917)LDATA,LBOT,NDQ	GENI 429
	STOP	GENI 430
	370 CONTINUE	GENI 431
	WRITE (6,918)	GENI 432
	WRITE(6,947)IIFY,NBOD	GENI 433
	WRITE (6,945)LBASE,LRPPD,LABUT,LBODY,LBOD,LDATA,LBOT,LSCAL,LTRIP,NGENI	GENI 434
	ADD	GENI 435
C		GENI 436
C	TRANSFER ASTER(LBOT - NDQ) TO ASTER(LDATA - LDATA+LSUB)	GENI 437
C		GENI 438
	LD=LDATA-1	GENI 439
	LSUB=LBOT-LD-1	GENI 440
	DO 375 I=LBOT,NDQ	GENI 441
	ASTER(LDATA)=ASTER(I)	GENI 442
	LDATA=LDATA+1	GENI 443
	375 CONTINUE	GENI 444
C	UNPACK POINTERS AND ADJUST FOR TRANSFER	GENI 445
	K=LBCDY+3*(NRPP+NBODY)	GENI 446
	DO 390 I=K,LD	GENI 447
	CALL UN2(I,I1,I2)	GENI 448
	IF(I1.NE.0)I1=I1-LSUB	GENI 449
	IF(I2.NE.0)I2=I2-LSUB	GENI 450
	MASTER(I)=I1*I15+I2	GENI 451
	390 CONTINUE	GENI 452
C		GENI 453
C	REGION STORAGE	GENI 454
C	LREGD / LOC BODY LIST / NUM OF BODIES /	GENI 455
C	LDATA / OPERATOR / BODY NUM /	GENI 456
C		GENI 457
C		GENI 458
	WRITE (6,920)	GENI 459
	N=0	GENI 460
	J=0	GENI 461
	LREGD=LDATA	GENI 462
	LDATA=LDATA+NRMAX	GENI 463
	LREGL=LDATA	GENI 464
C		GENI 465
C	READ REGION	GENI 466
C		GENI 467
	400 READ(5,921)IR,(IA(I),IN(I),I=1,9)	GENI 468
C	CHECK VALIDITY OF REGION DATA	GENI 469
	DO 410 I=1,9	GENI 470
	IF(IABS(IN(I)).LT.NBODY+NRPP)GOTO 410	GENI 471
	WRITE (6,922)IR,I	GENI 472
	J=J+1	GENI 473
	410 CONTINUE	GENI 474
C		GENI 475
C	STORE REGION DATA	GENI 476
C		GENI 477
	IF(IR)440,420,421	GENI 478
	420 WRITE (6,923)(IA(I),IN(I),I=1,9)	GENI 479
	GOTO 430	GENI 480
	421 N=N+1	GENI 481

	WRITE (6,924)IR,(IA(I),IN(I),I=1,9)	GENI 482
	M=LRFCD+N-1	GENI 483
	MASTER(M)=LDATA*115	GENI 484
C	CHECK OPERATOR	GENI 485
430	DO 435 I=1,9	GENI 486
	DO 431 K=1,8	GENI 487
	IF(IA(I).EQ.IAA(K))GOTO 432	GENI 488
431	CONTINUE	GENI 489
	WRITE (6,925)IA(I),I	GENI 490
	STOP	GENI 491
432	IA(I)=IAM(K)	GENI 492
	IF(IN(I))433,400,434	GENI 493
433	IA(I)=4+IA(I)	GENI 494
	IN(I)=-IN(I)	GENI 495
434	MASTER(LDATA)=IA(I)*115+IN(I)	GENI 496
	LDATA=LDATA+1	GENI 497
	MASTER(M)=MASTER(M)+1	GENI 498
	IF(LDATA.LT.NDC)GOTO 435	GENI 499
	WRITE (6,927)LDATA,NDC	GENI 500
	STOP	GENI 501
435	CONTINUE	GENI 502
	GOTO 400	GENI 503
L		GENI 504
C	END REGION READ	GENI 505
C		GENI 506
440	IF(N.GE.NRMAX)GOTO 441	GENI 507
	WRITE (6,926)IR	GENI 508
	STOP	GENI 509
441	IF(J.LF.C)GOTO 442	GENI 510
	WRITE (6,941)	GENI 511
	STOP	GENI 512
442	WRITE (6,928)	GENI 513
C		GENI 514
C	IF(IRCHEK.NE.C)TEST REGION DATA	GENI 515
C	(ERROR IF POINT CAN BE IN MORE THAN 1 REGION)	GENI 516
C		GENI 517
	IF(IRCHEK.EQ.NO)GOTO 500	GENI 518
	WRITE (6,937)	GENI 519
	LL=0	GENI 520
	MIS=0	GENI 521
C		GENI 522
	DO 456 I=1,NRMAX	GENI 523
	JJ=I+1	GENI 524
	DO 455 J=JJ,NRMAX	GENI 525
	KRI=LREGD+I-1	GENI 526
	CALL UN2(KRI,LOCI,NUMI)	GENI 527
	KRJ=LREGD+J-1	GENI 528
	CALL UN2(KRJ,LOCJ,NUMJ)	GENI 529
	IF(NUMI.GE.NUMJ)GOTO 450	GENI 530
	IO=NUMI	GENI 531
	II=NUMI	GENI 532
	GOTO 451	GENI 533
450	IO=NUMJ	GENI 534
	II=NUMI	GENI 535
	L=LOCI	GENI 536
	LOCJ=LOCJ	GENI 537
	LOCJ=L	GENI 538
C		GENI 539
451	DO 453 KO=1,IO	GENI 540
	KLK=LOCI+KO-1	GENI 541

CALL UN2(KLK,IOP0,NB0)	GENI 542
DO 452 KI=1,II	GENI 543
KLK=LOCJ+KI-1	GENI 544
CALL UN2(KLK,IOP1,NB1)	GENI 545
IF(IOP0.NE.IOP1)GOTO 452	GENI 546
IF(NB0.NE.NB1)GOTO 452	GENI 547
MIS=MIS+1	GENI 548
GOTO 453	GENI 549
452 CONTINUE	GENI 550
453 CONTINUE	GENI 551
IF(MIS.NE.II)GOTO 454	GENI 552
WRITE (6,929)J,I	GENI 553
LL=LL+1	GENI 554
454 MIS=0	GENI 555
455 CONTINUE	GENI 556
WRITE (6,930)I	GENI 557
456 CONTINUE	GENI 558
IF(LL.GE.0)STOP	GENI 559
WRITE (6,937)	GENI 560
C	GENI 561
C IS=+1 ENTERING TABLE STORED BY I15	GENI 562
C WHICH REGIONS (J) A RAY MIGHT BE IN IF IT	GENI 563
C ENTERS A GIVEN BODY (I)	GENI 564
C IS=-1 LEAVING TABLE STORED BY I	GENI 565
C WHICH REGIONS (J) A RAY MIGHT GO INTO IF IT	GENI 566
C LEAVES A GIVEN BODY (I)	GENI 567
C	GENI 568
500 IS=-1	GENI 569
NN=NBODY+NRPP	GENI 570
LENLV=LDATA	GENI 571
DO 590 MMM=1,2	GENI 572
DO 580 I=1,NN	GENI 573
M=LBODY+3*(I-1)	GENI 574
IF(IS.GE.0)GO TO 510	GENI 575
MASTER(M+1)=MASTER(M+1)+LDATA	GENI 576
GO TO 520	GENI 577
510 MASTER(M+1)=MASTER(M+1)+LCAIA*I15	GENI 578
C	GENI 579
520 DO 570 J=1,NRMAX	GENI 580
ITEMP=LREGD+J-1	GENI 581
CALL UN2(ITEMP,LOC,NC)	GENI 582
CALL UN2(LOC,IOP,DUM)	GENI 583
DO 560 N=1,NC	GENI 584
MM=LOC+N-1	GENI 585
CALL UN2(MM,IOPER,NUM)	GENI 586
IF(NUM.NE.I)GOTO 560	GENI 587
IF(IOP.EQ.1.OR.IOP.EQ.5)GOTO 540	GENI 588
IF(IOPER.GT.4)GOTO 530	GENI 589
IF(IS-1)560,550,560	GENI 590
530 IF(IS+1)560,551,560	GENI 591
540 IF(IS.LT.0)GOTO 551	GENI 592
550 MASTER(M+2)=MASTER(M+2)+I15	GENI 593
GO TO 552	GENI 594
551 MASTER(M+2)=MASTER(M+2)+1	GENI 595
552 MASTER(LDATA)=J	GENI 596
LDATA=LDATA+1	GENI 597
IF(LDATA.LT.NDQ)GOTO 570	GENI 598
WRITE (6,931)LDATA,NDQ,MMM,I	GENI 599
STOP	GENI 600
560 CONTINUE	GENI 601

570	CONTINUE	GENI 602
580	CONTINUE	GENI 603
	WRITE (6,938)MMM	GENI 604
	IS=IS+2	GENI 605
590	CONTINUE	GENI 606
C	RIN STORAGE ROUT STORAGE GI TEMP STORAGE	GENI 607
	L1=LDATA-1	GENI 608
	NN=NRPP+NBODY	GENI 609
	LKIN=LDATA+1	GENI 610
	LR0T=LRIN+NA	GENI 611
	L10=LR0T+NN	GENI 612
	LEGEOM=L10+NN	GENI 613
	WRITE (6,932)LEGEOM	GENI 614
	WRITE (6,919)LREGD,LREGL,LENLV,LRIN,LR0T,L10,LEGEOM	GENI 615
C		GENI 616
C	PRINT ENTERING AND LEAVING TABLE	GENI 617
C		GENI 618
	IF (IFNTLV.EQ.0) RETURN	GENI 619
	WRITE (6,946)	GENI 620
	NBNR=NBODY+NRPP	GENI 621
C		GENI 622
	DO 600 J=1,NBNR	GENI 623
	LOC=LBODY+3*(N-1)	GENI 624
	LOC=LOC+1	GENI 625
	CALL UN2(LOC,LENT,LEAV)	GENI 626
	LOC=LOC+1	GENI 627
	CALL UN2(LOC,NENT,NEAV)	GENI 628
	J1=LENT	GENI 629
	J2=LENT+NENT-1	GENI 630
	WRITE (6,933)N,J1,J2,(MASTER(K),K=J1,J2)	GENI 631
	J1=LEAV	GENI 632
	J2=LEAV+NEAV-1	GENI 633
	WRITE (6,934)N,J1,J2,(MASTER(K),K=J1,J2)	GENI 634
600	CONTINUE	GENI 635
C		GENI 636
C	MASTER-ASTER ARRAY OUTPUT	GENI 637
C		GENI 638
	IF (IPRIN.EQ.0) RETURN	GENI 639
	WRITE (6,935)	GENI 640
C		GENI 641
	DO 620 K=LBASE,L1,3	GENI 642
	IK=K	GENI 643
	IK2=K+2	GENI 644
	M=0	GENI 645
	DO 610 I=IK,IK2	GENI 646
	M=M+1	GENI 647
	CALL UN2(I,I1,I2)	GENI 648
	NO1(M)=I1	GENI 649
	NO2(M)=I2	GENI 650
	O4(M)=ASTER(I)	GENI 651
	NOO(M)=I	GENI 652
610	CONTINUE	GENI 653
	WRITE (6,936)(NOO(L),NO1(L),NO2(L),O4(L),L=1,3)	GENI 654
620	CONTINUE	GENI 655
	RETURN	GENI 656
	END	GENI 657
C		GENI 658
C		GENI 659
	SUBROUTINE RPPIN(LAR)	**** 15
	DIMENSION MASTER(30000),X(6)	RPPIN 2

COMMON ASTER(30000)	RPPIN 3
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERK,DIST	RPPIN 4
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	RPPIN 5
1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	RPPIN 6
COMMON/R&RPP/LRPPD,LABUT	RPPIN 7
EQUIVALENCE(MASTER,ASTER)	RPPIN 8
C	RPPIN 9
910 FORMAT(6F12.6)	RPPIN 10
920 FORMAT(18,17X,6F12.5)	RPPIN 11
930 FORMAT(1H0,27HERROR IN DESCRIPTION OF RPP,15,5X,10HMIN.GE.MAX)	RPPIN 12
940 FORMAT(1H0,27HERROR IN DESCRIPTION OF RPP,7X,110,10X,110)	RPPIN 13
950 FORMAT(10X,7HSURFACE,15,8X,2E20.6)	RPPIN 14
C	RPPIN 15
C N IS RPP NUMBER J IS SURFACE NUMBER	RPPIN 16
C	RPPIN 17
C MASTER-ASTER STORAGE FOR RPP	RPPIN 18
C	RPPIN 19
C LBASE - RPP POINTERS RESERVE 12 WORDS/RPP	RPPIN 20
C / I / J /	RPPIN 21
C / / K /	RPPIN 22
C I (POINTER TO LIST OF ABUTING RPP'S)	RPPIN 23
C J (NUM OF RPP'S THAT ABUT THIS SURFACE)	RPPIN 24
C K (POINTER TO MIN OR MAX CORRESPONDING	RPPIN 25
C TO THIS SURFACE)	RPPIN 26
C	RPPIN 27
C LRPPD - RPP DATA STARTING AT LBASE + 12 * NRPP	RPPIN 28
C MIN OR MAX K POINTS HERE	RPPIN 29
C	RPPIN 30
C LABUT TO LBODY-1	RPPIN 31
C LIST OF ABUTING RPP'S PACKED 1 OR 2/WORD	RPPIN 32
C I POINTS HERE / 1 / 2 /	RPPIN 33
C J CONTAINS NUMBER IN LIST	RPPIN 34
C	RPPIN 35
C IERR=0	RPPIN 36
C N=1	RPPIN 37
C I=LBASE+12*NRPP	RPPIN 38
C LRPPD=I	RPPIN 39
10 READ(5,910)(X(J),J=1,6)	RPPIN 40
WRITE (6,920)N,(X(J),J=1,6)	RPPIN 41
DO 20 J=1,6,2	RPPIN 42
IF(X(J).LT.X(J+1))GOTO 20	RPPIN 43
WRITE (6,930)N	RPPIN 44
STOP	RPPIN 45
20 CONTINUE	RPPIN 46
C	RPPIN 47
C STORE MIN AND MAX BEGINNING AT LBASE + 12 * NRPP	RPPIN 48
C	RPPIN 49
C DO 33 J=1,6	RPPIN 50
II=LBASE+12*NRPP	RPPIN 51
L=LBASE+12*(N-1)+2*(J-1)	RPPIN 52
30 IF(II.LT.I)GOTO 31	RPPIN 53
ASTER(II)=X(J)	RPPIN 54
MASTER(L+1)=I	RPPIN 55
I=I+1	RPPIN 56
GOTO 33	RPPIN 57
C CHECK FOR DUPLICATION	RPPIN 58
31 IF(X(J).EQ.ASTER(II))GOTO 32	RPPIN 59
II=II+1	RPPIN 60
GOTO 30	RPPIN 61
32 MASTER(L+1)=II	RPPIN 62

33	CONTINUE	RPPIN 63
	IF(N.GE.NRPP)GOTO 40	RPPIN 64
	N=N+1	RPPIN 65
	GOTO 10	RPPIN 66
C		RPPIN 67
40	LABUT=I	RPPIN 68
	LAST=I-1	RPPIN 69
	L=LAST	RPPIN 70
C		RPPIN 71
C	SEARCH FOR ABUTING RPP'S TO SURFACE	RPPIN 72
C		RPPIN 73
	DO 57 I=1,NRPP	RPPIN 74
	DO 57 N=1,6	RPPIN 75
	LL=0	RPPIN 76
	M=1	RPPIN 77
	K=LBASE+12*(I-1)+2*(N-1)	RPPIN 78
	MASTER(K)=(L+1)*115+MASTER(K)	RPPIN 79
	NC=3*N-1-4*(N/2)	RPPIN 80
	DO 56 J=1,NRPP	RPPIN 81
	IF(I.FQ.J)GOTO 56	RPPIN 82
	IF(S(I,I).NE.S(J,NC))GOTO 56	RPPIN 83
C		RPPIN 84
	DO 53 K=1,3	RPPIN 85
	NN=N+I*NC	RPPIN 86
	K41=4*K-1	RPPIN 87
	IF(NN.FQ.K41)GOTO 53	RPPIN 88
	K2=2*K	RPPIN 89
	K21=K2-1	RPPIN 90
	IF(S(I,K21).GT.S(J,K21))GOTO 50	RPPIN 91
	IF(S(J,K21).LT.S(I,K2))GOTO 53	RPPIN 92
50	IF(S(I,K21).GE.S(J,K2))GOTO 51	RPPIN 93
	IF(S(J,K2).LL.S(I,K2))GOTO 53	RPPIN 94
51	IF(S(I,K2).GT.S(J,K2))GOTO 56	RPPIN 95
	IF(S(I,K21).LT.S(J,K21))GOTO 56	RPPIN 96
53	CONTINUE	RPPIN 97
	M=-M	RPPIN 98
	IF(M.LT.0)GOTO 54	RPPIN 99
	MASTER(L)=MASTER(L)+J	RPPIN100
	GOTO 55	RPPIN101
54	L=L+1	RPPIN102
	MASTER(L)=J*115	RPPIN103
55	LL=LL+1	RPPIN104
56	CONTINUE	RPPIN105
	K=LBASE+12*(I-1)+2*(N-1)	RPPIN106
	MASTER(K)=MASTER(K)+LL	RPPIN107
57	CONTINUE	RPPIN108
C		RPPIN109
C	TEST VALIDITY OF RPP DATA	RPPIN110
C		RPPIN111
	IF(NRPP.LE.1)GOTO 63	RPPIN112
C		RPPIN113
	DO 62 J=1,6	RPPIN114
	NRPP1=NRPP-1	RPPIN115
	DO 61 I=1,NRPP1	RPPIN116
	JJ=LBASE+12*(I-1)+2*(J-1)	RPPIN117
	CALL UN2(JJ,I0UM,I2)	RPPIN118
	I3=MASTER(JJ+1)	RPPIN119
	IF(I2.NE.0)GOTO 61	RPPIN120
	II=I+1	RPPIN121
	DO 60 K=II,NRPP	RPPIN122

```

      *K=LBASE+12*(K-1)+2*(J-1)
      CALL UN2(KK, IDUM, I5)
      I6=MASTER(KK+1)
      IF(I5.NE.0)GOTO 60
      IF(I3.EQ.I6)GOTO 60
      IERR=IERR+1
      WRITE (6,940)I,K
      WRITE (6,950)J,ASTER(I3),ASTER(I6)
60  CONTINUE
      GOTO 62
61  CONTINUE
62  CONTINUE
63  LAR=L
      RETURN
      END

```

C
C

```

SUBROUTINE ALBERT(FX,LBOT,NDQ,LS1)
DIMENSION MASTER(30000),IA(6,4),AA(8,3),F(4),FX(6)
COMMON ASTER(30000)
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,TRIP,LSCAL,LREGD,
1 LDAIA,LRIN,LRUT,LIO,LOCCA,I15,I30,LBODY,NASC,KLOOP
COMMON/UCOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
EQUIVALENCE(ASTER,MASTER)

```

C

```

901 FORMAT(25X,6F12.5)
902 FORMAT(10X,6(1X,4I1))
903 FORMAT(10X,6E10.3)
904 FORMAT(25X,6(4X,4I2))
905 FORMAT(1H0,15HUNDEFINED PLANE)
906 FORMAT(15,10(E11.4))
907 FORMAT(1H0,26HFOUR POINTS NOT IN A PLANE)
908 FORMAT(1H0,25HERROR IN SIDE DESCRIPTION)
909 FORMAT(1H0,16HDEGENERATE PLANE,I5)

```

C

```

      K=1
      DO 10 I=1,2
      DO 10 J=1,3
      AA(I,J)=FX(K)
      K=K+1
10  CONTINUE
      READ(5,903)((AA(I,J),J=1,3),I=3,8)
      READ(5,902)((IA(I,J),J=1,4),I=1,6)
      WRITE (6,901)((AA(I,J),J=1,3),I=3,8)
      WRITE (6,904)((IA(I,J),J=1,4),I=1,6)

```

C

```

DO 70 I=1,6
IX=IA(I,1)
IY=IA(I,2)
IZ=IA(I,3)
X1=AA(IX,1)
Y1=AA(IX,2)
Z1=AA(IX,3)
X2=AA(IY,1)
Y2=AA(IY,2)
Z2=AA(IY,3)
X3=AA(IZ,1)
Y3=AA(IZ,2)
Z3=AA(IZ,3)
D=X1*(Y2*Z3-Z2*Y3)-X2*(Y1*Z3-Z1*Y3)+X3*(Y1*Z2-Z1*Y2)

```

```

RPPIN123
RPPIN124
RPPIN125
RPPIN126
RPPIN127
RPPIN128
RPPIN129
RPPIN130
RPPIN131
RPPIN132
RPPIN133
RPPIN134
RPPIN135
RPPIN136
RPPIN137
RPPIN138
RPPIN139
****1,16
ALBERT 2
ALBERT 3
ALBERT 4
ALBERT 5
ALBERT 6
ALBERT 7
ALBERT 8
ALBERT 9
ALBERT10
ALBERT11
ALBERT12
ALBERT13
ALBERT14
ALBERT15
ALBERT16
ALBERT17
ALBERT18
ALBERT19
ALBERT20
ALBERT21
ALBERT22
ALBERT23
ALBERT24
ALBERT25
ALBERT26
ALBERT27
ALBERT28
ALBERT29
ALBERT30
ALBERT31
ALBERT32
ALBERT33
ALBERT34
ALBERT35
ALBERT36
ALBERT37
ALBERT38
ALBERT39
ALBERT40
ALBERT41
ALBERT42
ALBERT43

```


A=(-Y2*Z3+Z2*Y3+Y1*Z3-Z1*Y3-Y1*Z2+Z1*Y2)	ALBERT44
B=(X2*Z3-Z2*X3-X1*Z3+X3*Z1+X1*Z2-Z1*X2)	ALBERT45
C=(Y2*X3-X2*Y3-Y1*X3+X1*Y3+Y1*X2-X1*Y2)	ALBERT46
D12=(X1-X3)**2+(Y1-Y3)**2+(Z1-Z3)**2	ALBERT47
A2B2C2=A*A+B*B+C*C	ALBERT48
IF(A2B2C2.NE.C.)GOTO 21	ALBERT49
WRITE (6,909)I	ALBERT50
U=ABS(D)	ALBERT51
GOTO 61	ALBERT52
21 D1210=D12*1.0E-12	ALBERT53
IF(A2B2C2.GT.D1210)GOTO 22	ALBERT54
WRITE (6,905)	ALBERT55
WRITE (6,906)I,A,B,C,D,D12	ALBERT56
IERR=IERR+1	ALBERT57
GOTO 70	ALBERT58
22 S=SQRT(A2B2C2)	ALBERT59
WX=A/S	ALBERT60
WY=B/S	ALBERT61
WZ=C/S	ALBERT62
IC=IA(1,4)	ALBERT63
X4=AA(IC,1)	ALBERT64
Y4=AA(IC,2)	ALBERT65
Z4=AA(IC,3)	ALBERT66
D2=(-D-(A*X4)-(B*Y4)-(C*Z4))/((A*WX)+(B*WY)+(C*WZ))	ALBERT67
U22=D2*U2	ALBERT68
C THE NEXT CARD BYPASSES THE 4TH POINT TEST	ALBERT69
IF(D22.LE.0.01)GOTO 30 & PRINT 907 & IERR=IERR+1	ALBERT70
IF(D22.LE.1.01)GOTO 30	ALBERT71
WRITE (6,907)	ALBERT72
IERR=IERR+1	ALBERT73
WRITE (6,906)I,A,B,C,D,D12,D2	ALBERT74
GOTO 70	ALBERT75
C	ALBERT76
30 DO 31 K=1,4	ALBERT77
F(K)=0.	ALBERT78
31 CONTINUE	ALBERT79
L=1	ALBERT80
DO 32 J=1,8	ALBERT81
IF(J.EQ.IX.OR.J.EQ.IY.OR.J.EQ.IZ.OR.J.EQ.IC)GOTO 32	ALBERT82
F(L)=A*AA(J,1)+B*AA(J,2)+C*AA(J,3)+D	ALBERT83
L=L+1	ALBERT84
32 CONTINUE	ALBERT85
M=0	ALBERT86
N=0	ALBERT87
J=0	ALBERT88
C	ALBERT89
DO 44 L=1,4	ALBERT90
IF(ABS(F(L)).LE.1.0E-6)GOTO 42	ALBERT91
IF(F(L))41,42,43	ALBERT92
41 M=M+1	ALBERT93
GOTO 44	ALBERT94
42 N=N+1	ALBERT95
GOTO 44	ALBERT96
43 J=J+1	ALBERT97
44 CONTINUE	ALBERT98
C	ALBERT99
IF(N.EQ.0)GOTO 51	ALBERT100
IF(M+N.EQ.4)GOTO 60	ALBERT101
IF(J+N.EQ.4)GOTO 61	ALBERT102
GOTO 52	ALBERT103

51	IF(M.EQ.4)GOTO 60	ALBER104
	IF(J.EQ.4)GOTO 61	ALBER105
52	WRITE (6,908)	ALBER106
	WRITE (6,906)I,A,B,C,D,D12,D2,(F(L),L=1,4)	ALBER107
	IERR=IERR+1	ALBER108
	GOTO 70	ALBER109
C		ALBER110
60	A=-A	ALBER111
	B=-B	ALBER112
	C=-C	ALBER113
	D=-D	ALBER114
61	CALL SEE3(IWH,ASTER,MASTER,A,B,C,LBOT,LDATA,NDQ,LS1)	ALBER115
	MASTER(LDATA)=IWH	ALBER116
	LS1=1	ALBER117
	CALL SEE3(IWH,ASTER,MASTER,D,D,D,LBOT,LDATA,NDQ,LS1)	ALBER118
	LS1=0	ALBER119
	MASTER(LDATA)=MASTER(LDATA)+IWH*115	ALBER120
	LDATA=LDATA+1	ALBER121
70	CONTINUE	ALBER122
	RETURN	ALBER123
	END	ALBER124
C		ALBER125
C		ALBER126
	SUBROUTINE ARIN(LBOT,LDATA,MASTER,ASTER,IWH)	**** 17
	DIMENSION MASTER(30000),ASTER(30000)	ARIN 2
	COMMON/UNCLE/NN,IC(4)	ARIN 3
C		ARIN 4
C	SEE ARS SUBROUTINE FOR STORAGE IN MASTER-ASTER ARRAY	ARIN 5
C		ARIN 6
901	FORMAT(10X,2I10)	ARIN 7
902	FORMAT(10X,6E10.3)	ARIN 8
903	FORMAT(I8,1X,3A1,2X,3HARS,2X,A4,6X,19HNUMBER OF CURVES IS,I6,	ARIN 9
	1 5X,29HNUMBER OF POINTS PER CURVE IS,I6/)	ARIN 10
904	FORMAT(25X,6F12.5)	ARIN 11
C		ARIN 12
C	MAX = NUM OF CURVES	ARIN 13
C	NAX = NUM OF POINTS/CURVE	ARIN 14
C		ARIN 15
	READ(5,901)MAX,NAX	ARIN 16
	WRITE (6,903)NN,(IC(I),I=1,4),MAX,NAX	ARIN 17
	LBOT=LBOT-4*MAX*NAX-92	ARIN 18
	IWH=LBOT	ARIN 19
	MASTER(LDATA)=IWH	ARIN 20
	LDATA=LDATA+1	ARIN 21
C		ARIN 22
	DO 50 M=1,MAX	ARIN 23
	L1=LBOT+92+4*NAX*(M-1)	ARIN 24
	L2=L1+4*NAX-1	ARIN 25
	READ(5,902)(ASTER(L),ASTER(L+1),ASTER(L+2),L=L1,L2,4)	ARIN 26
	WRITE (6,904)(ASTER(L),ASTER(L+1),ASTER(L+2),L=L1,L2,4)	ARIN 27
	WRITE (6,904)	ARIN 28
50	CONTINUE	ARIN 29
	MASTER(LBOT)=0	ARIN 30
	MASTER(LBOT+1)=MAX	ARIN 31
	MASTER(LBOT+2)=NAX	ARIN 32
	RETURN	ARIN 33
	END	ARIN 34
C		ARIN 35
C		ARIN 36
	SUBROUTINE SEE3(IWH,ASTER,MASTER,FX,FXX,FXXX,LBOT,LDATA,NDQ,LS1)	**** 18

C	DIMENSION ASTER(30000),MASTER(30000)	SEE3	2
C		SEE3	3
C	STOKES TRIPLETS AND SCALARS IN MASTER-ASTER ARRAY	SEE3	4
C		SEE3	5
C	IF(LSI.NE.0)GOTO 50	SEE3	6
C	TRIPLLS	SEE3	7
C	IF(LBOT.GT.NDQ)GOTO 20	SEE3	8
C	NDQ2=NDQ-2	SEE3	9
C	DO 10 I=LBOT,NDQ2	SEE3	10
C	IF(ASTER(I).NE.FX)GOTO 10	SEE3	11
C	IF(ASTER(I+1).NE.FXX)GOTO 10	SEE3	12
C	IF(ASTER(I+2).NE.FXXX)GOTO 10	SEE3	13
C	IWH=I	SEE3	14
C	RETURN	SEE3	15
C	10 CONTINUE	SEE3	16
C	20 ASTER(LBOT-1)=FXXX	SEE3	17
C	ASTER(LBOT-2)=FXX	SEE3	18
C	ASTER(LBOT-3)=FX	SEE3	19
C	LBOT=LBOT-3	SEE3	20
C	IWH=LBOT	SEE3	21
C	IF(LBOT.LE.LDATA)WRITE (6,30)LBOT,LDATA	SEE3	22
C	RETURN	SEE3	23
C	30 FORMAT(1H0,22HMEMORY OVERLAP IN SEE3,5X,5HLBOT=,110,	SEE3	24
C	1 5X,6HLDATA=,110)	SEE3	25
C		SEE3	26
C	SCALARS	SEE3	27
C	50 DO 60 I=LBOT,NDQ	SEE3	28
C	IF(ASTER(I).NE.FX)GOTO 60	SEE3	29
C	IWH=I	SEE3	30
C	RETURN	SEE3	31
C	60 CONTINUE	SEE3	32
C	ASTER(LBOT-1)=FX	SEE3	33
C	LBOT=LBOT-1	SEE3	34
C	IWH=LBOT	SEE3	35
C	RETURN	SEE3	36
C	END	SEE3	37
C		SEE3	38
C		SEE3	39
C	FUNCTION S(I,N)	****	19
C	DIMENSION MASTER(30000)	S	2
C	COMMON ASTER(30000)	S	3
C	COMMON/GEOM/LBASE,RIN,RDUT,LRI,LRO,PINF,IERR,DIST	S	4
C	EQUIVALENCE(MASTER,ASTER)	S	5
C		S	6
C	S RETRIEVES COORDINATES OF ANY OF THE 6 SIDES OF AN RPP	S	7
C	I IS RPP NUMBER N IS SURFACE NUMBER	S	8
C		S	9
C	L=LBASE+12*(I-1)+2*(N-1)	S	10
C	LL=MASTER(L+1)	S	11
C	S=ASTER(LL)	S	12
C	RETURN	S	13
C	END	S	14
C		S	15
C		S	16
C	SUBROUTINE CONVRT(FX,IX,LE)	****	20
C	DIMENSION FX(6),IX(6)	CONVRT	2
C	LE NUMBER OF REFERENCES TO SCALARS AND TRIPLETS	CONVRT	3
C	INTLGRAL PART OF FX CONVERTED TO FIXED POINT NUM IN IX(I)	CONVRT	4
C	FRACTIONAL PART OF FX CONVERTED TO FIXED POINT NUM IN IX(I1)	CONVRT	5
C	NFX=(LE+1)/2	CONVRT	6

```

DO 10 IFX=1,NFX
  I1=2*IFX
  I=I1-1
  IX(I)=FX(IFX)+.000001
  X=IX(I)
  IX(I1)=(FX(IFX)-X)*100000.+0.00001
10 CONTINUE
  RETURN
  END

```

```

CONVRT 7
CONVRT 8
CONVRT 9
CONVRT10
CONVRT11
CONVRT12
CONVRT13
CONVRT14
CONVRT15
CONVRT16
CONVRT17

```

C
C

```

SUBROUTINE GRID
DIMENSION WP(3)
COMMON/PAREM/XB(3),WB(3),IR
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
1  LDATA,LKIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP
COMMON/GTRACK/D1,D2,KHIT,LMAX,TR(200),XBS(3),IRSTRT,IENC,
1  ITR(200),CA,CE,SA,SE
COMMON/CAL/NIK,SIN,ANGLE,NTYPE,SSPACE,L,XS(3),WS(3),
1  TRAVEL,SN,V,H,IVIH
COMMON/WALT/LIRFO,NGIERR
COMMON/HOYT/VREF,HREF
COMMON/CELL/CELSIZ
COMMON/CONTRL/ITESTG,IRAYSK,IENLV,IVOLUM,IWOT,ITAPE8,NO,IYES

```

```

**** 21
GRID 2
GRID 3
GRID 4
GRID 5
GRID 6
GRID 7
GRID 8
GRID 9
GRID 10
GRID 11
GRID 12
GRID 13
GRID 14

```

C

```

901 FORMAT(8I10)
902 FORMAT(6E12.8)
903 FORMAT(1H0,2HNX,15,5X,2HNY,15,5X,7HIRSTART,15,5X,4HIENC,15,5X,
1  6HNSTART,16,5X,4HNEND,16,5X,9HCELL SIZE,F7.2//
2  17H DATUM LINE AT Z=,F10.3,27H WITH RESPECT TO THE ORIGIN/
3  17H GROUND IS AT Z=,F10.3,27H WITH RESPECT TO THE ORIGIN/
4  17H XSHIFT IS AT X=,F10.3,27H WITH RESPECT TO THE ORIGIN/
5  17H YSHIFT IS AT Y=,F10.3,27H WITH RESPECT TO THE ORIGIN/)
904 FORM(1H ,7HAZIMUTH,F12.5,5X,9HELEVATION,F12.5,5X,
1  13HBACK OFF DIST,F12.5)
905 FORMAT(2E20.8,4E10.3)
906 FORMAT(52HOTHIS RAY WAS SUPPRESSED BECAUSE IT WAS BELOW GROUND)
907 FORMAT(1H0,15,15H CELLS SKIPPED)

```

```

GRID 15
GRID 16
GRID 17
GRID 18
GRID 19
GRID 20
GRID 21
GRID 22
GRID 23
GRID 24
GRID 25
GRID 26
GRID 27
GRID 28

```

C

```

READ (5,901)NX,NY,IRSTRT, IENC,NGIERR,NSTART,NEND
READ (5,902)A,E,ENGTH,ZSHIFT,GROUND
READ (5,902)XSHIFT,YSHIFT,CELSIZ
IF(IRSTRT .LE.0)IRSTRT=1
IF(CELSIZ .LE.0.)CELSIZ=4.
IF(NSTART.LE.0)NSTART=1
IF(NEND.LE.NSTART)NEND=NX*NY
IF(NGIERR.LE.0)NGIERR=25

```

```

GRID 29
GRID 30
GRID 31
GRID 32
GRID 33
GRID 34
GRID 35
GRID 36
GRID 37

```

C

```

WRITE (6,903)NX,NY,IRSTRT, IENC,NSTART,NEND,CELSIZ,
1  ZSHIFT,GROUND,XSHIFT,YSHIFT
IF(IWOT.EQ.IYES)WRITE(1,905)A,E,XSHIFT,YSHIFT,ZSHIFT,CELSIZ
WRITE (6,904)A,E,ENGTH
RADIAN=.017453292519943
AR=A*RADIAN
ER=E*RADIAN
WRITE (6,904)AR,FK,ENGTH
SA=SIN(AR)
CA=COS(AR)
SE=SIN(ER)

```

```

GRID 38
GRID 39
GRID 40
GRID 41
GRID 42
GRID 43
GRID 44
GRID 45
GRID 46
GRID 47
GRID 48
GRID 49

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```

C          CE=CELS(ER)
C          PROCFS KL CELLS IN GRID
C          DO 40 KK=NSTART,NEND
C          WB(1)=-CL*CA
C          WB(2)=-CF*SA
C          WB(3)=-SE
C          II=((KK-1)/NX)+1
C          J=KK-(II-1)*NX
C          COMPUTE COORDINATES OF GRID CELL IN GRID PLANE
C          CELL2=.5*CELSIZ
C          V=FLOAT((MY/2)-II)*CELSIZ +CELL2
C          VREF=V+CELL2
C          H=FLOAT((NX/2)- J)*CELSIZ +CELL2
C          HREF=H+CELL2
C          IV=KAN(-1)*10.
C          IH=KAN(-1)*10.
C          IVIH=10*IH+IV
C          COMPUTE H,V AT RANDOM POINT IN GRID CELL
C          V=V+CELSIZ *FLOAT(IV)/10.+CELSIZ /20.
C          H=H+CELSIZ *FLOAT(IH)/10.+CELSIZ /20.
C          X,Y,Z IN COORDINATE SYSTEM OF VEHICLE
C          XBS(1)=XSHIFT-V*CA*SE-H*SA
C          XBS(2)=YSHIFT-V*SA*SE+H*CA
C          XBS(3)=ZSHIFT+V*CE
C          CALL TROPIC(WP)
C          XBS(1)=XBS(1)+WP(1)*1.0E-4
C          XBS(2)=XBS(2)+WP(2)*1.0E-4
C          XBS(3)=XBS(3)+WP(3)*1.0E-4
C          XB(1)=XBS(1)-ENGTH*WB(1)
C          XB(2)=XBS(2)-ENGTH*WB(2)
C          XB(3)=XBS(3)-ENGTH*WB(3)
C          IF(XB(3).GT.GROUND)GOTO 10
C          IF(ITAPE8.EQ.IYES)WRITE (6,906)
C          GOTO 40
10 DO 20 KK1=1,3
C          XS(KK1)=XB(KK1)
C          WS(KK1)=WB(KK1)
20 CONTINUE
C          CALL TRACK
C          IF(IERR.GE.NGIERR)RETURN
C          IF(IRAYSK.EQ.NO)GOTO 40
C          MSHIFT=KAN(-1)*25.
C          WRITE (6,907)MSHIFT
C          KK=KK+MSHIFT
40 CONTINUE
C          RETURN
C          END
C
C
C          SUBROUTINE TRACK
C          DIMENSION XP(3),ERROR(2)
C          COMMON/PAREM/XB(3),WB(3),IR
C          COMMON/GEOM/LBASEF,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
C          COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
1  LDATA,LRIN,LRJT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP
C          COMMON/GTRACK/D1,D2,KHIT,LMAX,TR(200),XBS(3),IRSTRT,IENC,
1  ITR(200),CA,CE,SA,SE

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GRID 50
GRID 51
GRID 52
GRID 53
GRID 54
GRID 55
GRID 56
GRID 57
GRID 58
GRID 59
GRID 60
GRID 61
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GRID 92
GRID 93
GRID 94
GRID 95
GRID 96
GRID 97
GRID 98
GRID 99
GRID 100
GRID 101
**** 22
TRACK 2
TRACK 3
TRACK 4
TRACK 5
TRACK 6
TRACK 7
TRACK 8

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COMMON/CAL/NIR,SIN,ANGLE,NTYPE,SSPACE,L,XS(3),WS(3),TRAVEL,	TRACK 9
1 SN,V,H,IVIH	TRACK 10
COMMON/CONTRL/ITESTG,IRAYSK,IENTLV,IVOLUM,IWOT,ITAPE8,NO,IYES	TRACK 11
COMMON/WALT/LIRFO,NGIERR	TRACK 12
COMMON/HOYT/VREF,HREF	TRACK 13
COMMON/LSU/LSURF	TRACK 14
COMMON/CELL/CELSIZ	TRACK 15
COMMON/ERR/IERRO	TRACK 16
C	TRACK 17
901 FORMAT(F6.1,1X,F6.1,1X,I2,1X,F7.2,1X,F7.2,4(1X,I1),I3,1X,2I3,	TRACK 18
1 1X,F8.3,1X,F8.3)	TRACK 19
902 FORMAT(2(I4,F7.2,F7.2,F6.1,I3,F7.2),1X,2I3,1X,I1,I1,I2,4X,A6)	TRACK 20
903 FORMAT(3IH NUMBER OF INTERSECTIONS.GT.200)	TRACK 21
904 FORMAT(//)	TRACK 22
905 FORMAT(1H0,16H0 ITEM IN CELL (,I4,1H,,I4,1H),5X,	TRACK 23
1 2HH=,F6.1,5X,2HV=,F6.1)	TRACK 24
C	TRACK 25
ERROR(2)= 6H0 ITEM	TRACK 26
DATA ERROR(1),ERROR(2)/4H ,4HITEM/	TRACK 27
I12=4096	TRACK 28
NASC=-1	TRACK 29
IR=IRSTRT	TRACK 30
L=1	TRACK 31
KHIT=0	TRACK 32
JCNT=0	TRACK 33
MSKHT=0	TRACK 34
MTARG=1	TRACK 35
MARMR=0	TRACK 36
MVOL =0	TRACK 37
C	TRACK 38
DO 10 I=1,200	TRACK 39
ITR(I)=0	TRACK 40
TR(I)=0.	TRACK 41
10 CONTINUE	TRACK 42
C	TRACK 43
C S1 IS DISTANCE THRU REGION IR	TRACK 44
C IRPRIM IS NEW REGION NUMBER	TRACK 45
C XP IS POINT OF CONTACT	TRACK 46
C	TRACK 47
20 CALL G1(S1,IRPRIM,XP)	TRACK 48
IF(IRPRIM.LT.0)RETURN	TRACK 49
TR(L)=S1	TRACK 50
KLSURF=LSURF+7	TRACK 51
LOC=LIRFO+IR-1	TRACK 52
CALL UN2(LOC,DUM,IDENT)	TRACK 53
IDENT=IDENT-1	TRACK 54
C / SURFACE NUM / BODY NUM / NEXT REGION /	TRACK 55
ITR(L)=(KLSURF*I12+NASC)*I12+IRPRIM	TRACK 56
IF(NASC.LE.NRPP)IRPRIM=0	TRACK 57
IF(IRPRIM.EQ.0)GOTO 100	TRACK 58
IR=IRPRIM	TRACK 59
KHIT=KHIT+1	TRACK 60
IF(L.GT.1)GOTO 40	TRACK 61
SUM=0.	TRACK 62
DO 30 I=1,3	TRACK 63
SUM=SUM+WS(I)*XP(I)	TRACK 64
30 CONTINUE	TRACK 65
DI=-SUM	TRACK 66
GOTO 60	TRACK 67
C	TRACK 68

C	CHECK IDENT CODE	0 NONE	TRACK 69	
C	10=SKIRT	20=ARMOR	30=TARGET	TRACK 70
C	SPACE CODES	1 EXTERIOR VOLUME	TRACK 71	
C		-1,2-9,11-19,21-29,.....,91-99 INTERIOR VOLUME	TRACK 72	
C			TRACK 73	
	40	IF(IDENT.EQ.0)GOTO 60	TRACK 74	
		IF(IDENT-(IDENT/10)*10.EQ.0)GOTO 50	TRACK 75	
		KHIT=KHIT-1	TRACK 76	
		IF(IDENT.NE.1)MVOL=1	TRACK 77	
		GOTO 60	TRACK 78	
C			TRACK 79	
	50	IF(IDENT.LQ.20)MARMR=1	TRACK 80	
		IF(IDENT.EQ.30)MTARG=1	TRACK 81	
		IF(IDENT.EQ.10)MSKRT=1	TRACK 82	
	60	L=L+1	TRACK 83	
		IF(L.LE.200)GOTO 20	TRACK 84	
		WRITE (6,903)	TRACK 85	
		STOP	TRACK 86	
C			TRACK 87	
C	END OF RAY	PRINT RESULTS	TRACK 88	
C			TRACK 89	
	100	IF(L.EQ.1)RETURN	TRACK 90	
		IF(IIAPLS.EQ.NO.AND.IWOT.EQ.NO)RETURN	TRACK 91	
		D2=XDIST(XBS,XP)-S1	TRACK 92	
		D2=-D2	TRACK 93	
		IF(KHIT.GT.0)GOTO 105	TRACK 94	
		KHIT=KHIT+1	TRACK 95	
		MTARG=0	TRACK 96	
	105	KHIT=KHIT-1	TRACK 97	
		IH=ABS(H/CELSIZ)+.5	TRACK 98	
		IF(H.LT.0.)IH=-IH	TRACK 99	
		IV=ABS(V/CELSIZ)+.5	TRACK 100	
		IF(V.LT.0.)IV=-IV	TRACK 101	
C		PRINT CARD NUM 1	TRACK 102	
		IF(IIAPE8.EQ.NO)GOTO 110	TRACK 103	
		WRITE (6,904)	TRACK 104	
		WRITE (6,901)HREF,VREF,IVIH,D1,D2,MSKRT,MTARG,MARMR,MVOL,	TRACK 105	
	1	KHIT,IH,IV,H,V	TRACK 106	
	110	IF(IWOT.EQ.IYES)WRITE(1,901)HREF,VREF,IVIH,D1,D2,MSKRT,MTARG,	TRACK 107	
	1	MARMR,MVOL,KHIT,IH,IV,H,V	TRACK 108	
C			TRACK 109	
C	PROCESS COMPONENT CARDS		TRACK 110	
C			TRACK 111	
		LMAX=L	TRACK 112	
		L=0	TRACK 113	
		TRAVEL=TR(1)	TRACK 114	
C			TRACK 115	
C	NIR	REGION IDENTIFICATION(VEHICLE COMPONENT)	TRACK 116	
C	SIN	LINE-OF-SIGHT DISTANCE	TRACK 117	
C	ANGLE	OBLIQUITY ANGLE	TRACK 118	
C	SN	NORMAL DISTANCE THRU REGION	TRACK 119	
C	NTYPE	TYPE OF SPACE AFTER NIR(NONE=0,END RAY=9)	TRACK 120	
C	SSPACE	LINE-OF-SIGHT DISTANCE THRU SPACE	TRACK 121	
C			TRACK 122	
	DO 200	KIK=1,LMAX,2	TRACK 123	
		JERQ=1	TRACK 124	
		L=L+1	TRACK 125	
		IF(L.GE.LMAX)RETURN	TRACK 126	
		CALL CALC	TRACK 127	
		IF(NIR.NE.0)GOTO 113	TRACK 128	

	JERRO=2	TRACK129
	IERR0=IERR0+1	TRACK130
113	IF(SSPACE.NE.0.)JCNT=JCNT+1	TRACK131
	NIR1=NIR	TRACK132
	SIN1=SIN	TRACK133
	ANGLE1=ANGLE	TRACK134
	SN1=SN	TRACK135
	NTYPE1=NTYPE	TRACK136
	SSPACE1=SSPACE	TRACK137
C	SECOND HALF OF CARD	TRACK138
	L=L+1	TRACK139
	IF(L.LT.LMAX)GOTO 115	TRACK140
	NIR=0	TRACK141
	SIN=0.	TRACK142
	ANGLE=0.	TRACK143
	SN=0.	TRACK144
	NTYPE=0	TRACK145
	SSPACE=0.	TRACK146
	GOTO 120	TRACK147
115	CALL CALC	TRACK148
	IF(NIR.NE.0)GOTO 117	TRACK149
	JERRO=2	TRACK150
	IERR0=IERR0+1	TRACK151
117	IF(SSPACE.EC.0.)GOTO 130	TRACK152
120	JCNT=JCNT+1	TRACK153
130	I1=0	TRACK154
	I2=0	TRACK155
	N=L-JCNT	TRACK156
C		TRACK157
C	TRACK FLAG 501 IS TRACK EDGE 502 IS TRACK FACE	TRACK158
C	10 IN. NORMAL THICKNESS IS CUTOFF	TRACK159
C		TRACK160
	IF(NIR1.NE.501)GOTO 140	TRACK161
	IF(SN1.LT.10.)NIR1=502	TRACK162
140	IF(NIR.NE.501)GOTO 150	TRACK163
	IF(SN.LT.10.)NIR=502	TRACK164
C		TRACK165
C	PRINT COMPONENT CARD	TRACK166
C		TRACK167
150	IF(IWOT.EQ.IYES)WRITE(1,902)NIR1,SIN1,SN1,ANGLE1,NTYPE1,SSPACE1,	TRACK168
1	NIR,SIN,SN,ANGLE,NTYPE,SSPACE,IH,IV,I1,I2,N	TRACK169
	IF(ITAPE8.EQ.IYES)WRITE(6,902)NIR1,SIN1,SN1,ANGLE1,NTYPE1,SSPACE1,	TRACK170
1	NIR,SIN,SN,ANGLE,NTYPE,SSPACE,IH,IV,I1,I2,N,ERROR(JERRO)	TRACK171
	IF(ITAPE8.EQ.NO.AND.JERRO.EQ.2)WRITE(6,905)IH,IV,HREF,VREF	TRACK172
C		TRACK173
	IF(L.GE.LMAX)RETURN	TRACK174
	IF(NTYPE.EQ.9)RETURN	TRACK175
200	CONTINUE	TRACK176
	RETURN	TRACK177
	END	TRACK178
C		TRACK179
C		TRACK180
	SUBROUTINE CALC	**** 23
	DIMENSION MASTER(30000),XP(3),TEMP(3),TEMP1(3),TEM(3),TEM1(3),	CALC 2
1	XMID(3),IEMP(4),WN(3),WI(3),WA(3),XI(3),AUN(3),HF(3),	CALC 3
2	VF(3),Q(3),DELTA(3),ARSTP(3)	CALC 4
	COMMON ASTER(30000)	CALC 5
	COMMON/PAREM/XB(3),WB(3),IR	CALC 6
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	CALC 7
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	CALC 8


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1  LDATA,LCIN,TRGT,LIO,LOCDA,IIS,I30,LBODY,NASC,KLOOP          CALC 9
COMMON/TRACK/DI,D2,KHIT,LMAX,TR(200),XBS(3),IRSTRT,IENC,        CALC 10
1  ITYPE=0,CA,CE,SA,SE                                          CALC 11
COMMON/CALZ/NIR,SIN,ANGLF,NTYPE,SPACE,L,XS(3),WS(3),TRAVEL,    CALC 12
1  S,V,IVIH                                                      CALC 13
COMMON/WALT/LIRFO,NUTERR                                        CALC 14
EQUIVALNCE(MASTER,ASTER)                                       CALC 15
REAL(DEF)                                                       CALC 16
C
901 FORMAT(10,15)THATS ALL FOLKS//                               CALC 17
902 FORMAT(10,17)HAI ITYPE IN CALC,5X,6HITYPE=,15,4HNBO=,15/  CALC 18
1  100 RETURN TO TRACK//                                         CALC 19
903 FORMAT(10,23)HARS DID NOT FIND NORMAL)                     CALC 20
904 FORMAT(10,23)NORM/5H NIR=,110,5X,6HITYPE=,110,5X,4HNBO=,110,5X,  CALC 21
1  6HNS=,110/4H NB=,3E20.10/4H WS=,3E20.10/4H XP=,3E20.8/    CALC 22
2  6H XS=,3E20.10/4H XI=,3E20.10/6H XNOS=,3E20.10)           CALC 23
905 FOR ATLESTH ERROR IN CALC A TRC HAS R1 = R2 )             CALC 24
906 FOR ATLESTH ERROR IN CALC BAD LSURF FOR BOX OR RAW )      CALC 25
C
/ BOX AC / NUP / BODY NUM / NEXT REGION /                       CALC 26
C
CALL OPNFK(L,LSURF,NIR,NIR)                                       CALC 27
IF(LN.GT.0)GOTO 10                                              CALC 28
WRITE (6,901)                                                    CALC 29
RETURN                                                            CALC 30
C
TRAVEL LINE-OF-SIGHT DIST TO THIS REGION                         CALC 31
XS STARTING POINT (XS=XD)                                       CALC 32
SIN LINE-OF-SIGHT DIST THRU THIS REGION                          CALC 33
C
10 SIN=TR(L+1)                                                    CALC 34
DO 20 I=1,3                                                       CALC 35
XI(I)=XS(I)+TRAVEL*WS(I)                                         CALC 36
20 CONTINUE                                                       CALC 37
TRAVEL=TRAVEL+SIN                                                CALC 38
LSURF=LSURF-7                                                    CALC 39
C
XNOS=1.                                                           CALC 40
IF(LSURF.LT.0)XNOS=-1.                                           CALC 41
LOC=LBODY+3*(NBO-1)                                              CALC 42
CALL UN2(LOC,ITYPE,LDATA)                                         CALC 43
LSURF=IALS(LSURF)                                                CALC 44
ITYPE=ITYPE+1                                                    CALC 45
IF(ITYPE.GE.1.AND.ITYPE.LE.12)GOTO 30                           CALC 46
WRITE (6,902)ITYPE,NBO                                          CALC 47
RETURN                                                            CALC 48
C
COMPUTE NORMAL DIST AND OBLIQUITY ANGLE                          CALC 49
C
RPP BOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS                CALC 50
30 GOTO(50,100,150,200,200,300,350,400,450,500,550,600),ITYPE  CALC 51
C
CHECK FOR SPACE CODES IDENT = -1,1-9,11-19,21-29,.....,91-99  CALC 52
C
40 CALL OPNFK(L+1,DUM,DUM,NEXREG)                                  CALC 53
ISPOT=LIRFO+NEXREG-1                                             CALC 54
CALL UN2(ISPOT,DUM,IDENT)                                         CALC 55
ISPOT=LIRFO+NIR-1                                                CALC 56
CALL UN2(ISPOT,NIR,DUM)                                           CALC 57
IDENT=IDENT-1                                                    CALC 58

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C	CHECK FOR SPACE CODES IDENT = -1,1-9,11-19,21-29,.....	CALC 69
	IF(IDENT-(IDENT/10)*10.NE.0)GOTO 41	CALC 70
	NTYPE=0	CALC 71
	SSPACE=0.	CALC 72
	RETURN	CALC 73
41	L=L+1	CALC 74
	IF(L+1.LT.LMAX)GOTO 42	CALC 75
	IDENT=9	CALC 76
	SSPACE=1.0E-4	CALC 77
	NTYPE=IDENT	CALC 78
	RETURN	CALC 79
42	NTYPE=IDENT	CALC 80
	SSPACE=TR(L+1)	CALC 81
	TRAVEL=TRAVEL+SSPACE	CALC 82
	RETURN	CALC 83
C		CALC 84
C	RPP	CALC 85
C		CALC 86
50	IF(LSURF-2)52,53,54	CALC 87
52	XNOS=-XNOS	CALC 88
53	I=1	CALC 89
	GOTO 60	CALC 90
54	IF(LSURF-4)55,56,57	CALC 91
55	XNOS=-XNOS	CALC 92
56	I=3	CALC 93
	GOTO 60	CALC 94
57	IF(LSURF.GE.6)GOTO 59	CALC 95
	XNOS=-XNOS	CALC 96
59	I=5	CALC 97
60	LKK=LBASF+2*I+1	CALC 98
	LV1=MASTER(LKK)	CALC 99
	LKK=LKK+2	CALC 100
	LV2=MASTER(LKK)	CALC 101
	DO 62 J=1,3	CALC 102
	M=J-1	CALC 103
	IJK=M+LV1	CALC 104
	TEMP(J)=ASTER(IJK)	CALC 105
	IJK=M+LV2	CALC 106
	TEMP1(J)=ASTER(IJK)	CALC 107
62	CONTINUE	CALC 108
	CALL DCOSP(TEMP,TEMP1,WB)	CALC 109
	DO 63 J=1,3	CALC 110
	WB(J)=XNOS*WB(J)	CALC 111
63	CONTINUE	CALC 112
	GOTO 1000	CALC 113
C		CALC 114
C	BOX	CALC 115
C		CALC 116
100	CONTINUE	CALC 117
	KCOM=LSURF-(LSURF/2)*2	CALC 118
	IF(KCOM.EQ.0)XNOS=-XNOS	CALC 119
	IF(LSURF-3)104,103,105	CALC 120
103	I=1	CALC 121
	GOTO 110	CALC 122
104	I=2	CALC 123
	GOTO 110	CALC 124
105	IF(LSURF.LT.5)GOTO 103	CALC 125
	I=3	CALC 126
110	CALL UN2(LDATA,IEMP(4),IEMP(1))	CALC 127
	LDATA=LDATA+1	CALC 128

CALL UN2(LDATA,TEMP(2),TEMP(3))	CALC 129
DO 115 J=1,3	CALC 130
LH=TEMP(1)	CALC 131
LV=TEMP(4)	CALC 132
M=J-1	CALC 133
IJK=LH+M	CALC 134
IJK1=LV+M	CALC 135
TEMP(J)=ASTER(IJK)+ASTER(IJK1)	CALC 136
MK=J-1+TEMP(4)	CALC 137
TEMP1(J)=ASTER(MK)	CALC 138
115 CONTINUE	CALC 139
CALL DCOSP(TEMP1,TEMP,WB)	CALC 140
DO 120 J=1,3	CALC 141
WB(J)=XNOS*WB(J)	CALC 142
120 CONTINUE	CALC 143
GOTO 1000	CALC 144
C	CALC 145
C	CALC 146
C	CALC 147
150 CALL UN2(LDATA,LV,DUM)	CALC 148
DO 160 I=1,3	CALC 149
M=I-1+LV	CALC 150
TEM(I)=ASTER(M)	CALC 151
160 CONTINUE	CALC 152
CALL DCOSP(XI,TEM,WB)	CALC 153
DO 170 I=1,3	CALC 154
WB(I)=XNOS*WB(I)	CALC 155
170 CONTINUE	CALC 156
GOTO 1000	CALC 157
C	CALC 158
C	CALC 159
C	CALC 160
200 IF(LSURF-2)202,201,210	CALC 161
201 XNOS=-XNOS	CALC 162
202 CALL UN2(LDATA,LV1,LV2)	CALC 163
DO 203 I=1,3	CALC 164
M=I-1	CALC 165
IJK1=M+LV1	CALC 166
IJK2=M+LV2	CALC 167
TEM(I)=ASTER(IJK1)	CALC 168
TEM1(I)=ASTER(IJK1)+ASTER(IJK2)	CALC 169
203 CONTINUE	CALC 170
CALL DCOSP(TEM,TEM1,WB)	CALC 171
DO 204 I=1,3	CALC 172
WB(I)=XNOS*WB(I)	CALC 173
204 CONTINUE	CALC 174
GOTO 1000	CALC 175
C	CALC 176
C	CALC 177
C	CALC 178
C	CALC 179
DIR COS FOR NORMAL TO SURFACE ONE OR TWO	CALC 180
NOW HAVE TO GET FROM A POINT TO THE HEIGHT VECTOR	CALC 181
210 CALL UN2(LDATA,LV,LH)	CALC 182
LRI=MASTER(LDATA+1)	CALC 183
DO 211 J=1,3	CALC 184
M=J-1	CALC 185
IJK=LV+M	CALC 186
TEM(J)=ASTER(IJK)	CALC 187
IJK1=LH+M	CALC 188
TEM1(J)=ASTER(IJK)+ASTER(IJK1)	
211 CONTINUE	

CALL DCOSP(TEM,XI,WN)	CALC 189
CALL DCOSP(TEM,TEM1,WI)	CALC 190
SUM=0.	CALC 191
DO 212 J=1,3	CALC 192
SUM=SUM+WN(J)*WI(J)	CALC 193
212 CONTINUE	CALC 194
DO 214 J=1,3	CALC 195
XP(J)=SUM*XDIST(TEM,XI)	CALC 196
XP(J)=XP(J)*WI(J)+TEM(J)	CALC 197
214 CONTINUE	CALC 198
IF(IITYPE.EQ.5)GOTO 250	CALC 199
CALL DCCSP(XI,XP,WB)	CALC 200
DO 220 J=1,3	CALC 201
WB(I)=XNOS*WB(J)	CALC 202
220 CONTINUE	CALC 203
GOTO 1000	CALC 204
C	CALC 205
C REC	CALC 206
C	CALC 207
C FOR SURFACE 1 AND 2 NORMAL IS SAME AS RCC	CALC 208
C FOR SURFACE 3 JUMP OUT WHEN XP(I)=POINT ON HEIGHT VECTOR	CALC 209
C	CALC 210
250 LDATA=LDATA+1	CALC 211
CALL UN2(LDATA,LR1,LR2)	CALC 212
DO 255 J=1,3	CALC 213
M=J-1	CALC 214
IJK1=M+LR1	CALC 215
TEMP(J)=ASTER(IJK1)+XP(J)	CALC 216
IJK2=M+LR2	CALC 217
TEMP1(J)=ASTER(IJK2)+XP(J)	CALC 218
255 CONTINUE	CALC 219
A1=XDIST(XP,TEMP)	CALC 220
A2=XDIST(XP,TEMP1)	CALC 221
IF(A1.GE.A2)GOTO 260	CALC 222
A1=A2	CALC 223
A3=A1	CALC 224
A2=A3	CALC 225
TEMP(1)=TEMP1(1)	CALC 226
TEMP(2)=TEMP1(2)	CALC 227
TEMP(3)=TEMP1(3)	CALC 228
260 C=SQRT(A1*A1-A2*A2)	CALC 229
CALL DCOSP(XP,TEMP,WN)	CALC 230
DO 265 J=1,3	CALC 231
TEM(J)=XP(J)+C*WN(J)	CALC 232
TEM1(J)=XP(J)-C*WN(J)	CALC 233
265 CONTINUE	CALC 234
CALL DCOSP(TEM,XI,WN)	CALC 235
DO 270 J=1,3	CALC 236
TEM(J)=2.*A1*WN(J)+TEM(J)	CALC 237
270 CONTINUE	CALC 238
CALL DCOSP(TEM,TEM1,WB)	CALC 239
DO 275 J=1,3	CALC 240
WB(J)=XNOS*WB(J)	CALC 241
275 CONTINUE	CALC 242
GOTO 1000	CALC 243
C	CALC 244
C TRC	CALC 245
C	CALC 246
300 IF(LSURF.LE.2)GO TO 320	CALC 247
CALL UN2(LDATA,LV,LH)	CALC 248

LUATA=LUATA+1	CALC 247
CALL UNZ(LDATA,LR1,LR2)	CALC 248
DIF=ASTER(LR1)-ASTER(LR2)	CALC 249
IF(DIF)302,301,303	CALC 250
301 WRITE(6,905)	CALC 251
STOP	CALC 252
302 TEMP(1)=LR1	CALC 253
LR1=LR2	CALC 254
LR2=TEMP(1)	CALC 255
DIF=ABS(DIF)	CALC 256
303 FACTR=ASTER(LR1)/DIF	CALC 257
DO 304 J=1,3	CALC 258
M=J-1	CALC 259
IJK=M+LV	CALC 260
IJK1=M+LH	CALC 261
TEMP1(J)=ASTER(IJK)	CALC 262
TEMP(J)=ASTER(IJK)+FACTR*ASTER(IJK1)	CALC 263
304 CONTINUE	CALC 264
QDIS=XDIS(XI,TEMP)	CALC 265
QDIS=XDIS(TEMP1,TEMP)	CALC 266
CALL DCOSP(TEMP,XI,WN)	CALC 267
CALL DCOSP(TEMP1,TEMP1,WA)	CALC 268
SUM=.	CALC 269
DO 310 J=1,3	CALC 270
SUM=WN(J)*WA(J)+SUM	CALC 271
310 CONTINUE	CALC 272
QSUM=QDIS/SUM	CALC 273
QPLS=QDIS-QSUM	CALC 274
DO 311 J=1,3	CALC 275
TEMP(J)=-QPLS*WA(J)+TEMP1(J)	CALC 276
311 CONTINUE	CALC 277
CALL DCOSP(XI,TEMP,WB)	CALC 278
DO 312 J=1,3	CALC 279
WB(J)=XNOS*WB(J)	CALC 280
312 CONTINUE	CALC 281
GOTO 1000	CALC 282
C	CALC 283
320 IF(LSURF.EQ.2)XNOS=-XNOS	CALC 284
CALL UNZ(LDATA,LV,LH)	CALC 285
DO 321 J=1,3	CALC 286
M=J-1	CALC 287
IJK=M+LV	CALC 288
TEMP(J)=ASTER(IJK)	CALC 289
IJK1=M+LH	CALC 290
TEMP1(J)=ASTER(IJK)+ASTER(IJK1)	CALC 291
321 CONTINUE	CALC 292
CALL DCOSP(TEMP,TEMP1,WB)	CALC 293
DO 322 J=1,3	CALC 294
WB(J)=XNOS*WB(J)	CALC 295
322 CONTINUE	CALC 296
GOTO 1000	CALC 297
C	CALC 298
C	CALC 299
ELL	CALC 300
C	CALC 301
350 CALL UNZ(LDATA,LR1,LR2)	CALC 302
LS=MASTER(LDATA+1)	CALC 303
DO 352 J=1,3	CALC 304
M=J-1	CALC 305
IJK1=M+LR1	CALC 306
IJK2=M+LR2	CALC 307
	CALC 308

TEM(J)=ASTER(IJK1)	CALC 309
TEM1(J)=ASTER(IJK2)	CALC 310
352 CONTINUE	CALC 311
A=ASTER(LS)	CALC 312
CALL DCOSP(TEM,XI,WN)	CALC 313
DO 353 J=1,3	CALC 314
TEM(J)=A*WN(J)+TEM(J)	CALC 315
353 CONTINUE	CALC 316
CALL DCOSP(TEM,TEM1,WB)	CALC 317
DO 354 J=1,3	CALC 318
WB(J)=XNOS*WB(J)	CALC 319
354 CONTINUE	CALC 320
GOTO 1000	CALC 321
C	CALC 322
C RAW	CALC 323
C	CALC 324
C THIS WILL SHAPE THE BOX FOR LSURF=1,3,5,6	CALC 325
C JUMPS TO 100 TO INDICATE BOX PORTION	CALC 326
C	CALC 327
400 IF(LSURF.EQ.2)GOTO 401	CALC 328
IF(LSURF.NE.4)GOTO 100	CALC 329
WRITE (6,906)	CALC 330
STOP	CALC 331
401 CALL UN2(LDATA,LV,LV1)	CALC 332
LDATA=LDATA+1	CALC 333
CALL UN2(LDATA,LV2,LV3)	CALC 334
DO 410 J=1,3	CALC 335
M=J-1	CALC 336
IJK1=M+LV1	CALC 337
IJK2=M+LV2	CALC 338
TEMP(J)=ASTER(IJK1)	CALC 339
XMID(J)=ASTER(IJK1)-ASTER(IJK2)	CALC 340
IJK3=M+LV3	CALC 341
TEM(J)=ASTER(IJK3)	CALC 342
410 CONTINUE	CALC 343
I=1	CALC 344
J=2	CALC 345
K=3	CALC 346
LK=0	CALC 347
DO 411 KK=1,3	CALC 348
TEM1(I)=XMID(J)*TEM(K)-XMID(K)*TEM(J)	CALC 349
LK=I	CALC 350
I=J	CALC 351
J=K	CALC 352
K=LK	CALC 353
411 CONTINUE	CALC 354
SUM=0.	CALC 355
DO 412 J=1,3	CALC 356
SUM=TEM1(J)*TEMP(J)+SUM	CALC 357
412 CONTINUE	CALC 358
SUM=-SUM/ABS(SUM)	CALC 359
TLK=TEM1(1)**2+TEM1(2)**2+TEM1(3)**2	CALC 360
TLK=SQRT(TLK)	CALC 361
DO 420 J=1,3	CALC 362
WB(J)=XNOS*SUM*TEM1(J)/TLK	CALC 363
420 CONTINUE	CALC 364
GOTO 1000	CALC 365
C	CALC 366
C ARB	CALC 367
C	CALC 368

T3=DOT(TEMP,AUN)/TAU	CALC 429
T4=DOT(TEMP,C)	CALC 430
GAMMA=ODN/HDN	CALC 431
EM=GAMMA*R4+(1.0-GAMMA)*R2	CALC 432
T5=HDA/HDN	CALC 433
T6=HDK/HDN	CALC 434
DO 510 I=1,3	CALC 435
WB(I)=XNOS*(T3*(AUN(I)-T5*NF(I))+	CALC 436
1 T4*(O(I)-T6*NF(I))-EM*(R4-R2)*NF(I)/HDN)	CALC 437
510 CONTINUE	CALC 438
CALL UNIT(WB)	CALC 439
GOTO 1000	CALC 440
C	CALC 441
520 IF(LSURF.EQ.2)XNOS=-XNOS	CALC 442
CALL UN2(LDATA,LV,LH)	CALC 443
LDATA=LDATA+1	CALC 444
CALL UN2(LDATA,LN,DUM)	CALC 445
DO 521 I=1,3	CALC 446
J=LN+I-1	CALC 447
WB(I)=XNOS*ASTER(J)	CALC 448
521 CONTINUE	CALC 449
GOTO 1000	CALC 450
C	CALC 451
C	CALC 452
C	CALC 453
550 CALL UN2(LDATA,LV,LN)	CALC 454
LDATA=LDATA+1	CALC 455
CALL UN2(LDATA,LR1,DUM)	CALC 456
DO 551 I=1,3	CALC 457
J=I-1	CALC 458
IJK=LV+J	CALC 459
TEMP(I)=XI(I)-ASTER(IJK)	CALC 460
IJK=LN+J	CALC 461
TEMP1(I)=ASTER(IJK)	CALC 462
551 CONTINUE	CALC 463
R1=ASTER(LR1)	CALC 464
CALL CROSS(TEM,TEMP1,TEMP)	CALC 465
CALL CROSS(TEM1,TEM,TEMP1)	CALC 466
CALL UNIT(TEMP1)	CALC 467
DO 552 I=1,3	CALC 468
J=I-1	CALC 469
IJK=LV+J	CALC 470
TEM(I)=ASTER(IJK)	CALC 471
TEMP1(I)=TEM(I)+R1*TEMP1(I)	CALC 472
552 CONTINUE	CALC 473
CALL DCOSP(TEMP1,XI,WB)	CALC 474
DO 553 I=1,3	CALC 475
WB(I)=XNOS*WB(I)	CALC 476
553 CONTINUE	CALC 477
GOTO 1000	CALC 478
C	CALC 479
C	CALC 480
C	CALC 481
600 NE=4	CALC 482
IWH=MASTER(LDATA)	CALC 483
INOW=IWH+8	CALC 484
IEND=IWH+8+20*NE	CALC 485
DO 610 I=1,3	CALC 486
IJK=IWH+I+4	CALC 487
ARSTP(I)=ASTER(IJK)	CALC 488

610	CONTINUE	CALC 489
	DTRAV=XDIST(ARSTP,XI)	CALC 490
620	IF(ABS(DTRAV-ASIER(INOW)).GT.1.0E-07)GOTO 640	CALC 491
	DO 630 I=1,3	CALC 492
	IJK=INOW+I	CALC 493
	WB(I)=ASIER(IJK)	CALC 494
630	CONTINUE	CALC 495
	CALL UNIT(WB)	CALC 496
	GOTO 1000	CALC 497
C		CALC 498
640	INOW=INOW+NE	CALC 499
	IF(IEND.GT.INOW)GOTO 620	CALC 500
	WRITE (6,903)	CALC 501
	STOP	CALC 502
C		CALC 503
C	COMPUTE OBLIQUITY ANGLE	CALC 504
C	COMPUT NORMAL DIST (SN)	CALC 505
C		CALC 506
1000	DO 1001 J=1,3	CALC 507
	XB(J)=XI(J)+WS(J)*1.0E-3	CALC 508
1001	CONTINUE	CALC 509
	ANGLE=0.	CALC 510
	DO 1002 J=1,3	CALC 511
	ANGLE=ANGLE+WB(J)*WS(J)	CALC 512
1002	CONTINUE	CALC 513
	IF(ABS(ANGLE).LE.1.)GOTO 1010	CALC 514
	ANGLE=0.	CALC 515
	SN=0.	CALC 516
	WRITE (6,904)NIR,ITYPE,NBO,LSURF,WB,WS,XP,XB,XI,XNOS	CALC 517
	IR=NIR	CALC 518
	GOTO 40	CALC 519
C		CALC 520
1010	ANGLE=ATAN2(SCRT(1.-ANGLE*ANGLE),ANGLE)*180./3.141592654	CALC 521
	IF(ANGLE.LE.90.)GOTO 1020	CALC 522
	DO 1011 J=1,3	CALC 523
	WB(J)=-WB(J)	CALC 524
1011	CONTINUE	CALC 525
	GOTO 1000	CALC 526
C		CALC 527
1020	NASC=-2	CALC 528
	IR=NIR	CALC 529
	CALL GI(SI,IRPRIM,XP)	CALC 530
	SN=SI	CALC 531
	GOTO 40	CALC 532
	END	CALC 533
C		CALC 534
C		CALC 535
C		CALC 536
C		CALC 537
C		CALC 538
	SUBROUTINE TESTG	**** 24
C		TESTG 2
C	TESTG OPTIONS	TESTG 3
C		TESTG 4
C	NRAYS 0 0 TRACE A RAY BETWEEN TWO GIVEN POINTS	TESTG 5
C	XBS TO XBF	TESTG 6
C		TESTG 7
	DIMENSION XP(3),XBF(3)	TESTG 8
	COMMON/PAREM/XB(3),WB(3),IR	TESTG 9
	COMMON/GEOM/LBASEF,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	TESTG 10

```

COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
1  LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP
COMMON/WALT/LIRFO,NGIERR

```

C

```

901 FORMAT(2I10)
902 FORMAT(1H0,22HNUMBER OF SPECIAL RAYS,I5)
903 FORMAT(3E15.7,3I15)
904 FORMAT(1H0,5HSTART,5X,4H XB=,3E15.7,8H IRSTRT=,I5/
1  4H END,7X,4HXBF=,3E15.7,8H IRFIN=,I5)
905 FORMAT(1H0,3HWB=,3E15.7,5X,6HRANGE=,E15.7)
906 FORMAT(1H0,8X,2HIR,4X,6HIRPRIM,12X,2HS1,13X,2HXP,13X,2HYP,
1  13X,2HZP,12X,4HDIST)
907 FORMAT(2I10,5X,5E15.7)
908 FORMAT(1H0,21HTROUBLE IN REGION IR=,I10)

```

C

```

READ (5,901)NRAYS,NGIERR
WRITE (6,902)NRAYS
IF(NGIERR.LE.0)NGIERR=25

```

C

```

DO 50 IRAY=1,NRAYS
READ (5,903)XB,IRSTRT
READ (5,903)XBF,IRFIN
WRITE (6,904)XB,IRSTRT,XBF,IRFIN
RANGE=XDIST(XB,XBF)
CALL DCOSP(XB,XBF,WB)
WRITE (6,905)WB,RANGE
IR=IRSTRT
NASC=-1
WRITE (6,906)

```

C

```

10 CALL G1(S1,IRPRIM,XP)
IF(IERR.GE.NGIERR)GOTO 60
WRITE (6,907)IR,IRPRIM,S1,XP,DIST
IF(DIST.GE.RANGE)GOTO 30
IF(IRPRIM.LE.0)GOTO 20
IR=IRPRIM
GOTO 10

```

C

```

20 WRITE (6,908)IR
GOTO 50
30 IF(IR.NE.IRFIN)GOTO 20
50 CONTINUE
60 IERR=0
RETURN
END.

```

C

C

C

C

```

SUBROUTINE VOLUM
DIMENSION VASTER(1000),WAB(3),WTB(3),WOB(3),DSP(3),
1  XV(3),XT(3),XA(3),XO(3),XP(3),XTEMP(3)
COMMON ASTER(30000)
COMMON/PAREM/XB(3),WB(3),IR
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
1  LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP
COMMON/WALT/LIRFO,NGIERR

```

C

```

901 FORMAT(3E20.8)

```

```

TESTG 11
TESTG 12
TESTG 13
TESTG 14
TESTG 15
TESTG 16
TESTG 17
TESTG 18
TESTG 19
TESTG 20
TESTG 21
TESTG 22
TESTG 23
TESTG 24
TESTG 25
TESTG 26
TESTG 27
TESTG 28
TESTG 29
TESTG 30
TESTG 31
TESTG 32
TESTG 33
TESTG 34
TESTG 35
TESTG 36
TESTG 37
TESTG 38
TESTG 39
TESTG 40
TESTG 41
TESTG 42
TESTG 43
TESTG 44
TESTG 45
TESTG 46
TESTG 47
TESTG 48
TESTG 49
TESTG 50
TESTG 51
TESTG 52
TESTG 53
TESTG 54
TESTG 55
TESTG 56
TESTG 57
TESTG 58
TESTG 59
**** 25
VOLUM 2
VOLUM 3
VOLUM 4
VOLUM 5
VOLUM 6
VOLUM 7
VOLUM 8
VOLUM 9
VOLUM 10
VOLUM 11

```

902	FORMAT(2E20.8)	VOLUM 12
903	FORMAT(1H0,10X,6HVERTEX,14X,6HTOP.PT,14X,6HBOT.PT,14X,7HSIDE.PT)	VOLUM 13
904	FORMAT(4E20.8)	VOLUM 14
905	FORMAT(1H0, 8X,12HDELTA ON TOP,E20.8,10X,10HSIDE DELTA,E20.8)	VOLUM 15
906	FORMAT(2I10)	VOLUM 16
908	FORMAT(1H0, 2X,1RHSTARTING REGION IS,15)	VOLUM 17
909	FORMAT(1H0,16HVASTER OVERWRITE,5X,6HNRMAX=,15)	VOLUM 18
910	FJRMAT(110,E20.8)	VOLUM 19
911	FJRMAT(110,8HBAD CARD/110,E20.8,14H NOT PROCESSED)	VOLUM 20
912	FORMAT(110,E20.8,5X,E20.8,5X,E9.2)	VOLUM 21
913	FORMAT(1H0,5HSUMV=,5X,E20.8)	VOLUM 22
		VOLUM 23
	READ (5,906)IR,NGIERR	VOLUM 24
	IF(NGIERR.LE.0)NGIERR=25	VOLUM 25
	READ (5,901)(XV(I),I=1,3)	VOLUM 26
	READ (5,901)(XT(I),I=1,3)	VOLUM 27
	RFAID (5,901)(XO(I),I=1,3)	VOLUM 28
	RFAID (5,901)(XA(I),I=1,3)	VOLUM 29
	READ (5,902)DOD,DT	VOLUM 30
	WRITE (6,903)	VOLUM 31
	WRITE (6,904)(XV(J),XT(J),XO(J),XA(J),J=1,3)	VOLUM 32
	WRITE (6,905)DOD,DT	VOLUM 33
	WRITE (6,908)IR	VOLUM 34
	IF(NRMAX.GT.2000)WRITE (6,909)NRMAX	VOLUM 35
	CALL DCOSP(XV,XT,WTB)	VOLUM 36
	CALL DCOSP(XV,XO,WOB)	VOLUM 37
	CALL DCOSP(XV,XA,WAB)	VOLUM 38
	XVDIS=XDIST(XV,XA)	VOLUM 39
	TESTDN=0.	VOLUM 40
	TESTOV=0.	VOLUM 41
	XTEMP(1)=0.	VOLUM 42
	DO 10 I=1,NRMAX	VOLUM 43
	VASTER(I)=0.	VOLUM 44
10	CONTINUE	VOLUM 45
	JIR=IR	VOLUM 46
	IRJ=IR	VOLUM 47
	N2=XDIST(XV,XO)/DOD+1.	VOLUM 48
	N1=XDIST(XV,XT)/DT+1.	VOLUM 49
		VOLUM 50
		VOLUM 51
	DO 300 J=1,N2	VOLUM 52
	DO 100 I=1,3	VOLUM 53
	DSP(I)=WTB(I)*DT	VOLUM 54
	XB(I)=XV(I)	VOLUM 55
	WB(I)=WAB(I)	VOLUM 56
100	CONTINUE	VOLUM 57
	S1=0.	VOLUM 58
	IR=JIR	VOLUM 59
	DO 200 I=1,N1	VOLUM 60
	NASC=-1	VOLUM 61
110	CALL G1(S1,IRPRIM,XP)	VOLUM 62
	IF(IERR.GF.NGIERR)GOTO 400	VOLUM 63
	VASTER(IR)=VASTER(IR)+S1	VOLUM 64
	IF(DIST.GE.XVDIS)GOTO 115	VOLUM 65
	IF(IRPRIM.LE.0)GOTO 120	VOLUM 66
	IR=IRPRIM	VOLUM 67
	GOTO 110	VOLUM 68
115	VASTER(IR)=VASTER(IR)-(DIST-XVDIS)	VOLUM 69
120	XTEMP(1)=WB(1)	VOLUM 70
	XTEMP(2)=WB(2)	VOLUM 71
	XTEMP(3)=WB(3)	

```

IR=JIR
TESTDN=TESTDN-DT
IF(TESTDN.GT.0.)GOTO 180
WB(1)=WTB(1)
WB(2)=WTB(2)
WB(3)=WTB(3)
NASC=-1
CALL G1(S1,IRPRIM,XP)
IF(IERR.GE.NG1ERR)GOTO 400
IF(S1-DT)130,160,170
130 IR=IRPRIM
JIR=IR
CALL G1(S1,IRPRIM,XP)
IF(IERR.GE.NG1ERR)GOTO 400
IF(DIST-DT)140,160,170
140 IF(IRPRIM)150,210,130
150 STOP
160 IR=IRPRIM
JIR=IR
170 TESTDN=S1
180 DO 190 JI=1,3
WB(JI)=XTEMP(JI)
XB(JI)=XB(JI)+DSP(JI)
190 CONTINUE
200 CONTINUE
C
C ONE PLANE DONE - MOVE IN FOR NEXT PLANE IN LINE
C
210 NASC=-1
DO 220 I=1,3
WB(I)=WOB(I)
XB(I)=XV(I)
220 CONTINUE
JIR=IRJ
IR=JIR
TESTDN=0.
TESTOV=TESTOV-DOD
IF(TESTOV)230,230,280
230 CALL G1(S1,IRPRIM,XP)
IF(IERR.GE.NG1ERR)GOTO 400
IF(S1-DOD)240,260,270
240 IR=IRPRIM
IRJ=IR
CALL G1(S1,IRPRIM,XP)
IF(IERR.GE.NG1ERR)GOTO 400
IF(DIST-DOD)250,260,270
250 IF(IRPRIM)150,400,230
260 IR=IRPRIM
IRJ=IR
270 TESTOV=S1
280 DO 290 I=1,3
XA(I)=XA(I)+WOB(I)*DOD
XV(I)=XV(I)+WOB(I)*DOD
XT(I)=XT(I)+WOB(I)*DOD
290 CONTINUE
JIR=IR
300 CONTINUE
C
C VOLUMES COMPUTED
C

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```

VOLUM 72
VOLUM 73
VOLUM 74
VOLUM 75
VOLUM 76
VOLUM 77
VOLUM 78
VOLUM 79
VOLUM 80
VOLUM 81
VOLUM 82
VOLUM 83
VOLUM 84
VOLUM 85
VOLUM 86
VOLUM 87
VOLUM 88
VOLUM 89
VOLUM 90
VOLUM 91
VOLUM 92
VOLUM 93
VOLUM 94
VOLUM 95
VOLUM 96
VOLUM 97
VOLUM 98
VOLUM 99
VOLUM100
VOLUM101
VOLUM102
VOLUM103
VOLUM104
VOLUM105
VOLUM106
VOLUM107
VOLUM108
VOLUM109
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VOLUM111
VOLUM112
VOLUM113
VOLUM114
VOLUM115
VOLUM116
VOLUM117
VOLUM118
VOLUM119
VOLUM120
VOLUM121
VOLUM122
VOLUM123
VOLUM124
VOLUM125
VOLUM126
VOLUM127
VOLUM128
VOLUM129
VOLUM130
VOLUM131

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400 READ (5,910)IR1,VR
IF(IERR.GE.NG1ERR)GOTO 500
IF(IR1.LE.0)IR1=NRMAX+1
SUMV=0.
C
LJ 450 I=1,NRMAX
VASTLR(I)=VASTER(I)*DOD*DT
IF(I-IR1)410,430,420
410 WRITE (6,910)I,VASTER(I)
GOTO 440
420 WRITE (6,911)IR1,VR
READ (5,910)IR1,VR
GOTO 410
C
VOLUME REPLACEMENT
430 XPERC=100.*(VASTER(I)/VR-1.)
WRITE (6,912)I,VASTER(I),VR,XPERC
VASTLR(I)=VR
READ (5,910)IR1,VR
440 SUMV=SUMV+VASTER(I)
450 CONTINUE
WRITE (6,913)SUMV
500 ILKK=L
RETURN
END
C
C
C
C
SUBROUTINE AREA
DIMENSION XP(3),WP(3),XBS(3),CONVRT(4,4),TYPEUN(4)
COMMON ASTER(3000)
COMMON/PAREN/XB(3),WB(3),IR
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
COMMON/UNCSEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
I LDATA,LRIN,LRJI,LIO,LJCCA,I15,I30,LBODY,NASC,KLOOP
COMMON/CAL/NIR,SIN,ANGLE,NTYPE,SSPACE,L,XS(3),WS(3),
I TRAVEL,SN,V,H,IVIH
COMMON/WALT/LIRFO,NG1ERR
COMMON/CELL/CELSIZ
COMMON/ENGEOM/LLGEOM
C
901 FORMAT(7I10,6X,2A2)
902 FORMAT(6E12.8)
908 FORMAT(1H0,22HMEMORY OVERLAP IN AREA,5X,7HLEGEOM=,I6,
I 5X,6HLAREA=,I6,5X,6HLIRFO=,I6)
909 FORMAT(1H0,13HERROR IN AREA,5X,9HICODE = '0')
910 FORMAT(1H0,8HAZIMUTH=,F10.3,5X,10HELEVATION=,F10.3)
911 FORMAT(1H0,12HCELL SIZE IS,F4.1,1X,1HX,F4.1,1X,A2,1H.,10X,
I 12HAREAS IN SQ.,1X,A2,1H.)
912 FORMAT(1H0,5HICODE,19X,4HAREA/)
913 FORMAT(15,15X,F12.5)
914 FORMAT(1H0,15HPRESENTED AREA=,F12.5)
915 FORMAT(1H0,18HNUMBER OF CELLS IS,I5,10X,
I 22HNUMBER OF CELLS HIT IS,I5)
C
IN=1 FT=2 CM=3 M=4
I SQ. M. = 39.37 * 39.37 SQ. IN.
C
DATA HHIN,HHFI,HHCM,HHMB,HHBB/2HIN,2HFT,2HCM,2HM ,2H /
TYPFUN(1)=HHIN

```

```

VOLUM132
VOLUM133
VOLUM134
VOLUM135
VOLUM136
VOLUM137
VOLUM138
VOLUM139
VOLUM140
VOLUM141
VOLUM142
VOLUM143
VOLUM144
VOLUM145
VOLUM146
VOLUM147
VOLUM148
VOLUM149
VOLUM150
VOLUM151
VOLUM152
VOLUM153
VOLUM154
VOLUM155
VOLUM156
VOLUM157
VOLUM158
VOLUM159
**** 26
AREA 2
AREA 3
AREA 4
AREA 5
AREA 6
AREA 7
AREA 8
AREA 9
AREA 10
AREA 11
AREA 12
AREA 13
AREA 14
AREA 15
AREA 16
AREA 17
AREA 18
AREA 19
AREA 20
AREA 21
AREA 22
AREA 23
AREA 24
AREA 25
AREA 26
AREA 27
AREA 28
AREA 29
AREA 30
AREA 31
AREA 32

```

TYPEUN(2)=HHFT	AREA 33
TYPEUN(3)=HHCM	AREA 34
TYPEUN(4)=HHMB	AREA 35
CONVRT(1,1)=1.	AREA 36
CONVRT(1,2)=.006944444444444444	AREA 37
CONVRT(1,3)=6.451625806	AREA 38
CONVRT(1,4)=.0006451625806	AREA 39
CONVRT(2,1)=144.	AREA 40
CONVRT(2,2)=1.	AREA 41
CONVRT(2,3)=929.0341161	AREA 42
CONVRT(2,4)=.09290341161	AREA 43
CONVRT(3,1)=.15499969	AREA 44
CONVRT(3,2)=.001076386736	AREA 45
CONVRT(3,3)=1.	AREA 46
CONVRT(3,4)=.0001	AREA 47
CONVRT(4,1)=1549.9969	AREA 48
CONVRT(4,2)=10.7636736	AREA 49
CONVRT(4,3)=10000.	AREA 50
CONVRT(4,4)=1.	AREA 51
BLANK=HHBB	AREA 52
C	AREA 53
LAREA=LIRFO-1000	AREA 54
IF(LAREA.GE.LEGEOM)GOTO 10	AREA 55
WRITE (6,908)LEGEOM,LAREA,LIRFO	AREA 56
STOP	AREA 57
10 LAREA1=LIRFO-1	AREA 58
DO 20 L=LAREA,LAREA1	AREA 59
ASTER(L)=0.	AREA 60
20 CONTINUE	AREA 61
C	AREA 62
READ (5,901)NX,NY,IRSTRT ,IENC,NGIERR,NSTART,NEND,CELLUN,AREAUN	AREA 63
READ (5,902)A,E,ENGTH,ZSHIFT,GROUND	AREA 64
READ (5,902)XSHIFT,YSHIFT,CELSIZ	AREA 65
IF(IRSTRT .LE.0)IRSTRT=1	AREA 66
IF(CELSIZ .LE.0.)CELSIZ=4.	AREA 67
IF(NSTART.LE.0)NSTART=1	AREA 68
IF(NGIERR.LE.0)NGIERR=25	AREA 69
IF(AREAUN.EQ.BLANK)AREAUN=HHIN	AREA 70
IF(CELLUN.EQ.BLANK)CELLUN=HHIN	AREA 71
DO 30 I=1,4	AREA 72
IF(CELLUN.EQ.TYPEUN(I))GOTO 40	AREA 73
30 CONTINUE	AREA 74
40 DO 50 J=1,4	AREA 75
IF(AREAUN.EQ.TYPEUN(J))GOTO 60	AREA 76
50 CONTINUE	AREA 77
60 AREA=CELSIZ *CELSIZ *CONVRT(I,J)	AREA 78
C	AREA 79
RADIAN=.017453292519943	AREA 80
AR=A*RADIAN	AREA 81
ER=E*RADIAN	AREA 82
SA=SIN(AR)	AREA 83
CA=COS(AR)	AREA 84
SE=SIN(ER)	AREA 85
CE=COS(ER)	AREA 86
KL=NX*NY	AREA 87
NHIT=0	AREA 88
C	AREA 89
C	AREA 90
C	AREA 91
PROCESS KL CELL'S IN GRID	AREA 92
DO 200 KK=NSTART,KL	

```

WB(1)=-CF*CA
WB(2)=-CF*SA
WB(3)=-SF
II=((KK-1)/NX)+1
J=KK-(II-1)*NX
C      COMPUTE COORDINATES OF GRID CELL IN GRID PLANE
CELLZ=.5*CELSIZ
V=FLOAT((NY/2)-(II)*CELSIZ)+CELLZ
VREF=V+CELLZ
H=FLOAT((NX/2)-(J)*CELSIZ)+CELLZ
HREF=H+CELLZ
IV=RAV(-1)*IC.
IH=RAV(-1)*IO.
IVIH=IO*IH+IV
C      COMPUTE H,V AT RANDOM POINT IN GRID CELL
V=V+CELSIZ*FLOAT(IV)/10.+CELSIZ/20.
H=H+CELSIZ*FLOAT(IH)/10.+CELSIZ/20.
C      X,Y,Z IN COORDINATE SYSTEM OF VEHICLE
XBS(1)=XSHIFT-V*CA*SE-H*SA
XBS(2)=YSHIFT-V*SA*SE+H*CA
XBS(3)=ZSHIFT+V*CL
CALL IRPIC(WP)
XBS(1)=XBS(1)+WP(1)*1.0E-4
XBS(2)=XBS(2)+WP(2)*1.0E-4
XBS(3)=XBS(3)+WP(3)*1.0E-4
XB(1)=XBS(1)-LENGTH*WB(1)
XB(2)=XBS(2)-LENGTH*WB(2)
XB(3)=XBS(3)-LENGTH*WB(3)
IF(XB(3).LE.GROUND)GOTO 200
C
C      TRACE RAY TO FIRST COMPONENT HIT
C
IR=IRSTRT
NASC=-1
110 CALL GI(SI,IRPRIM,XP)
IF(ICERR.GE.NGIERR)RETURN
IF(IRPRIM.LT.0)GOTO 200
IF(NASC.LE.NRPP)IRPRIM=0
IF(IRPRIM.EQ.0)GOTO 200
LOC=LIREF+IRPRIM-1
CALL UN2(LOC,ICODE,IDENT)
IDENT=IDENT-1
IF(IDENT-(IDENT/10)*10.EQ.0)GOTO 120
IR=IRPRIM
GOTO 110
120 IF(ICODE.NE.0)GOTO 130
WRITE(6,909)
GOTO 200
130 LOC=AREA+ICODE-1
ASTER(LOC)=ASTER(LOC)+AREA
NHIT=NHIT+1
200 CONTINUE
C
C      PRINT RESULTS
C
WRITE(6,910)A,E
WRITE(6,911)CELSIZ,CELSIZ,CELLUN,AREAUN
WRITE(6,912)
SUMA=0.
DO 250 I=1,999

```

- AREA 93
- AREA 94
- AREA 95
- AREA 96
- AREA 97
- AREA 98
- AREA 99
- AREA 100
- AREA 101
- AREA 102
- AREA 103
- AREA 104
- AREA 105
- AREA 106
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- AREA 124
- AREA 125
- AREA 126
- AREA 127
- AREA 128
- AREA 129
- AREA 130
- AREA 131
- AREA 132
- AREA 133
- AREA 134
- AREA 135
- AREA 136
- AREA 137
- AREA 138
- AREA 139
- AREA 140
- AREA 141
- AREA 142
- AREA 143
- AREA 144
- AREA 145
- AREA 146
- AREA 147
- AREA 148
- AREA 149
- AREA 150
- AREA 151
- AREA 152

```

LOC=LAREA+I-1
IF(ASTER(LOC).EQ.0.)GOTO 250
WRITE (6,913)I,ASTER(LOC)
SUMA=SUMA+ASTER(LOC)
250 CONTINUE
WRITE (6,914)SUMA
WRITE (6,915)KL,NHIT
RETURN
END

SUBROUTINE G1(S1,IRPRIM,XP)
MAIN RAY TRACKING ROUTINE
GIVEN A RAY IN REGION IR AT POINT XB WITH DIRECTION
COSINES WB; FIND THE DISTANCE (S1) TO THE NEXT REGION
AND THE NUMBER OF THAT REGION (IRPRIM)

NASC=-2      $$ CALL FROM CALC TO FIND NORMAL DIST
NASC=-1      $$ START NEW RAY
IVOLUM=1     $$ CALL FROM VOLUM
ITESTG=1     $$ CALL FROM TESTG
DIST         $$ TOTAL DIST TRAVELED BY RAY SO FAR

DIMENSION MASTER(30000),XP(3),XBD(3),LSURT(50),NASCF(50)
COMMON ASTER(30000)
COMMON/PAREM/XB(3),WB(3),IR
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,
1  LDATA,LRLN,LROT,LLO,LOCDA,I15,I30,LBODY,NASC,KLOOP
COMMON/CALL/NIR,SIN,ANGLE,NTYPE,SSPACE,L,XS(3),WS(3),TRAVEL,
1  SN,V,H,IVIII
COMMON/WALT/LIRFO,NGIERR
COMMON/LSU/LSURF
COMMON/CONTRL/ITESTG,IRAYSK,IENTLV,IVOLUM,IWOT,ITAPE8,NO,IYES
COMMON/DAVIS/IGRID,LOOP,INORM
COMMON/CFL/CFLSIZ
EQUIVALENCE (ASTER,MASTER)

901 FORMAT(1H0,32HERROR IN G1 AT 140      BAD ITYPE,5X,4HITY=,I5)
902 FORMAT(1H0,33HERROR IN G1 AT 510      SM 0= PINF,5X,3HIR=,I5)
903 FORMAT(4H XB=,3E20.8/4H WB=,3E20.8/10X,5HKL00P,12X,3HNBO,
1  12X,3HLRI,12X,3HLRO,11X,4HNHIT,11X,4HLOOP/6I15)
904 FORMAT(1H1,15(2H* ),3X, 9HERROR NO.,I5,3X,15(2H* )//)
905 FORMAT(34X,4HCELL,2I4)
906 FORMAT(19H ERROR IN G1 AT 640/4H J1=,I10,4H J2=,I10,7H LSURF=,
1  110,6H NASC=,I10,4H IR=,I10/4H SM=,E21.10/4H S1=,E17.10/
2  4H WB=,3E21.10/4H XB=,3E21.10)
907 FORMAT(50H THE (SOLID POSITION/DEPTH/POINT NOW AT) IS ONE OF,
1  6H THESE/6H XBD =,3E21.10/6H DIST=,E21.10//)
908 FORMAT(4X,3HRIN,12X,4HROUT,7X,8HENTERING,2X,7HLEAVING,3X,
1  8HBODY NO.,5X,3HRAY,/35X,8HSIDE NO.,2X,8HSIDE NO.//)
909 FORMAT(//16H TILT RIN=ROUT=,E20.10,30X,2HI=,I5//)
910 FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,7HSTARTED/)
911 FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,7HHAS HIT/)
912 FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,7HLEAVING/)
913 FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,7H IN /)
914 FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,7H IN /)

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AREA 153
AREA 154
AREA 155
AREA 156
AREA 157
AREA 158
AREA 159
AREA 160
AREA 161
AREA 162
AREA 163
AREA 164
AREA 165
**** 27
G1 2
G1 3
G1 4
G1 5
G1 6
G1 7
G1 8
G1 9
G1 10
G1 11
G1 12
G1 13
G1 14
G1 15
G1 16
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G1 38
G1 39
G1 40
G1 41
G1 42
G1 43
G1 44
G1 45
G1 46
G1 47

```


915	FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,8HENTERING/)	G1	48
916	FORMAT(2(2X,E15.8),4X,12,8X,12,6X,15,5X,8HWILL HIT/)	G1	49
917	FORMAT(//4(14H END ERROR NO.,14,3X)/)	G1	50
918	FORMAT(11H,15,21H ERRORS !N G1, RETURN)	G1	51
		G1	52
	INORM=0	G1	53
	IF(NASC.EQ.-2)INORM=1	G1	54
	S1=0.	G1	55
	IF(NASC.GT.0)GOTO 20	G1	56
	NEW RAY	G1	57
	DIST=0.	G1	58
	IF(KLOOP.LT.32000)GOTO 15	G1	59
	KLOOP=0	G1	60
	LION=LIO+NBODY+NRPP-1	G1	61
	DO 10 I=LIO,LION	G1	62
	MASTER(I)=0	G1	63
10	CONTINUE	G1	64
15	KLOOP=KLOOP+1	G1	65
		G1	66
	BEGIN TRACING RAY	G1	67
		G1	68
20	SM=PI*F	G1	69
	NHIT=0	G1	70
	LOC=LREGD+IR-1	G1	71
	CALL UN2(LOC,LOC,NC)	G1	72
	LOC=L1C-1	G1	73
		G1	74
	NC=NUM OF BODIES IN REGION DESCRIPTION	G1	75
	FIND RIN AND ROUT FOR EACH OF THESE BODIES	G1	76
	RIN IS DIST FROM XB TO POINT WHERE RAY ENTERS THE BODY	G1	77
	ROUT IS DIST FROM XB TO POINT WHERE RAY LEAVES THE BODY	G1	78
	IF ROUT = -PI*F RAY DOES NOT HIT BODY	G1	79
	G1 SELECTS SMALLEST OF RIN AND ROUT DISTANCES O DIST	G1	80
	1) UNIQUE RIN VALUE - NEXT BODY IN PATH OF RAY	G1	81
	2) 2 OR MORE RIN VALUES - 2 OR MORE BODIES HAVE	G1	82
	A COMMON SURFACE	G1	83
	3) ROUT FOR CURRENT BODY MEANS RAY WILL LEAVE	G1	84
	THIS BODY BEFORE ENCOUNTERING ANOTHER	G1	85
		G1	86
	DO 500 N=1,NC	G1	87
	LOC=L1C+1	G1	88
	CALL UN2(LOC,DUM,NBO)	G1	89
	ITEMP=LIO+NBO-1	G1	90
	CALL UN3(IITEMP,LRI,LRO,LOOP)	G1	91
	ITEMP=L1BODY+3*(NBO-1)	G1	92
	CALL UN2(IITEMP,ITYPF,LOCDA)	G1	93
	IF(LOOP.NE.KLOOP)GOTO 130	G1	94
	(CONTINUATION OF RAY	G1	95
	IF(ITYPE.GT.11)GOTO 140	G1	96
	IJK=LK1I+NBO-1	G1	97
	RIN=ASTER(IJK)	G1	98
	IJK=LROT+NBO-1	G1	99
	ROUT=ASTER(IJK)	G1	100
	IF(ITYPE.LT.10)GOTO 320	G1	101
	TOR AND ARS	G1	102
	IF DIST .GE. ROUT COMPUTE RIN / ROUT SET	G1	103
	IF(ROUT.LT.0.)GOTO 320	G1	104
	IF(DIST.LT.ROUT)GOTO 320	G1	105
	IF(NASC.EQ.NBO)NASC=0	G1	106
		G1	107

130	LRI=1	G1	108
	LRO=1	G1	109
	ITY=ITYE+1	G1	110
	IF(ITY.GE.1.AND.ITY.LE.12)GOTO 200	G1	111
140	IERR=IERR+1	G1	112
	WRITE (6,901)ITYE	G1	113
	GOTO 800	G1	114
C		G1	115
C	RPP BOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	G1	116
200	GOTO(205,210,215,220,225,230,235,240,245,250,255,260),ITY	G1	117
205	CALL RPP(NBO)	G1	118
	GOTO 300	G1	119
210	CALL ROX	G1	120
	GOTO 300	G1	121
215	CALL SPH	G1	122
	GOTO 300	G1	123
220	CALL RCC	G1	124
	GOTO 300	G1	125
225	CALL REC	G1	126
	GOTO 300	G1	127
230	CALL TRC	G1	128
	GOTO 300	G1	129
235	CALL ELL	G1	130
	GOTO 300	G1	131
240	CALL RAW	G1	132
	GOTO 300	G1	133
245	CALL ARB	G1	134
	GOTO 300	G1	135
250	CALL TEC	G1	136
	GOTO 300	G1	137
255	CALL TOR	G1	138
	GOTO 300	G1	139
260	CALL ARS	G1	140
C		G1	141
300	IJK=LRIN+NBO-1	G1	142
	ASTER(IJK)=RIN	G1	143
	IJK=LROT+NBO-1	G1	144
	ASTER(IJK)=ROUT	G1	145
	IJK=LIO+NBO-1	G1	146
	MASTER(IJK)=KLOOP+115*(LRO+64*LRI)	G1	147
C		G1	148
320	IF(NASC.NE.NBO)GOTO 330	G1	149
	IF(LSURF)500,500,340	G1	150
C		G1	151
330	IF(ROUT.LE.0.)GOTO 500	G1	152
	IF(RIN.GT.0.)GOTO 350	G1	153
C		G1	154
340	IF(ABS(ROUT-SM).GT.SM*1.0E-6)GOTO 341	G1	155
	ROUT=SM	G1	156
	IJK=LROT+NBO-1	G1	157
	ASTER(IJK)=ROUT	G1	158
	GOTO 345	G1	159
341	IF(ROUT-SM)342,345,500	G1	160
342	IF(DIST.GE.ROUT)GOTO 500	G1	161
	NHIT=0	G1	162
345	NHIT=NHIT+1	G1	163
	SM=ROUT	G1	164
	LSURT(NHIT)=-LRO	G1	165
	NASC1(NHIT)=NBO	G1	166
	GOTO 500	G1	167

C		G1	168
	350 IF(ABS(RIN-SM).GT.SM*1.0E-6)GOTO 351	G1	169
	RIN=SM	G1	170
	IJK=LRIN+NBO-1	G1	171
	ASTER(IJK)=RIN	G1	172
	GOTO 355	G1	173
	351 IF(RIN-SM)352,355,500	G1	174
	352 IF(DIST.GE.RIN)GOTO 340	G1	175
	NHIT=0	G1	176
	355 NHIT=NHIT+1	G1	177
	SM=RIN	G1	178
	LSURT(NHIT)=LRI	G1	179
	NASCT(NHIT)=NBO	G1	180
C		G1	181
	500 CONTINUE	G1	182
C		G1	183
C	SM.GE.PINF ERROR AT 510 IN G1	G1	184
C		G1	185
	IF(SM.LT.PINF)GOTO 530	G1	186
	WRITE (6,902)IR	G1	187
	WRITE (6,903)XB,WB,KLOOP,NBO,LRI,LRO,NHIT,LOOP	G1	188
	GOTO 700	G1	189
C		G1	190
	530 S1=S1+SM-DIST	G1	191
	DIST=SM	G1	192
	XP(1)=XB(1)+SM*WB(1)	G1	193
	XP(2)=XB(2)+SM*WB(2)	G1	194
	XP(3)=XB(3)+SM*WB(3)	G1	195
C		G1	196
	IF(NASC.EQ.-2)RETURN	G1	197
C		G1	198
C	FIND NEXT REGION (IRPRIM)	G1	199
C		G1	200
	DO 640 NN=1,NHIT	G1	201
	NASC =NASCT(NN)	G1	202
	LSURF=LSURT(NN)	G1	203
	LTRUE=0	G1	204
	LOC=LBODY+3*(NASC-1)	G1	205
	LOC=LOC+1	G1	206
	CALL UN2(LOC,LENT,LEAV)	G1	207
	LOC=LOC+1	G1	208
	CALL UN2(LOC,NENT,NEAV)	G1	209
	IF(LSURF.LE.0)GOTO 600	G1	210
	J1=LENT	G1	211
	J2=LENT+NENT-1	G1	212
	GOTO 610	G1	213
	600 J1=LEAV	G1	214
	J2=LEAV+NEAV-1	G1	215
C		G1	216
	610 IRPRIM=MASTER(J2)	G1	217
	IF(J1.LE.J2)GOTO 620	G1	218
	IF(NASC.GT.ARPP)GOTO 700	G1	219
	IF(LSURF)630,700,700	G1	220
C		G1	221
	620 DO 625 J=J1,J2	G1	222
	IRPRIM=MASTER(J)	G1	223
	CALL WOWI(IRPRIM,LSURF,NASC,LTRUE)	G1	224
	IF(LTRUE.GT.0)GOTO 650	G1	225
	625 CONTINUE	G1	226
C		G1	227

C	RPP CHECK	G1	228
C		G1	229
	IF(NASC.GT.NRPP)GOTO 640	G1	230
	IF(LSURF)630,700,640	G1	231
630	CALL RPP2(LSURF,XP,IRP)	G1	232
	IF(IRP.GT.0)GOTO 631	G1	233
	IRPRIM=0	G1	234
	RETURN	G1	235
C		G1	236
631	LTRUE=0	G1	237
	LOC=LBODY+3*(IRP-1)	G1	238
	LOC=LCC+1	G1	239
	CALL UN2(LOC,LENT,LEAV)	G1	240
	LCC=LCC+1	G1	241
	CALL UN2(LOC,NENT,NEAV)	G1	242
	J1=LENT	G1	243
	J2=LENT+NFNT-1	G1	244
	IF(J1.GT.J2)GOTO 700	G1	245
C		G1	246
	DO 632 J=J1,J2	G1	247
	IRPRIM=MASTER(J)	G1	248
	CALL WOWI(IRPRIM,LSURF,IRP,LTRUE)	G1	249
	IF(LTRUE.GT.0)GOTO 650	G1	250
632	CONTINUE	G1	251
C		G1	252
640	CONTINUE	G1	253
	GOTO 700	G1	254
C		G1	255
C	NEXT REGION (IRPRIM) HAS BEEN DETERMINED	G1	256
C		G1	257
650	IF(IR.EQ.IRPRIM)GOTO 660	G1	258
	IF(S1.EQ.0.)GOTO 660	G1	259
	IF(S1.LT.0.)GOTO 700	G1	260
	IF(ABS(S1).LE.1.0E-6)GOTO 660	G1	261
	IF(IVOLUM.EQ.IYES)RETURN	G1	262
	IF(ITESTG.EQ.IYES)RETURN	G1	263
	LOC=LIRFO+IR-1	G1	264
	CALL UN2(LOC,ICODE,IDENT)	G1	265
	LOC=LIRFO+IRPRIM-1	G1	266
	CALL UN2(LOC,ICODE1,IDENT1)	G1	267
	IF(IDENT.EQ.1)GOTO 655	G1	268
	IF(IDENT.EQ.IDENT1)GOTO 660	G1	269
	RETURN	G1	270
655	IF(ICODE.NE.ICODE1)RETURN	G1	271
660	IR=IRPRIM	G1	272
	GOTO 20	G1	273
C		G1	274
C	DIAGNOSTIC ERROR PRINT	G1	275
C		G1	276
700	IERR=IERR+1	G1	277
	WRITE (6,904)IERR	G1	278
	IF(IVOLUM.EQ.IYES.OR.ITESTG.EQ.IYES)GOTO 705	G1	279
	IH=ABS(H/CELSIZ)+.5	G1	280
	IF(H.LT.0.)IH=-IH	G1	281
	IV=ABS(V/CELSIZ)+.5	G1	282
	IF(V.LT.0.)IV=-IV	G1	283
	WRITE (6,905)IH,IV	G1	284
705	WRITE (6,906)J1,J2,LSURF,NASC,IR,SM,S1,WB,XB	G1	285
	XBD(1)=XB(1)-DIST	G1	286
	XBD(2)=XB(2)-DIST	G1	287

	XBD(3)=XB(3)-DIST	G1	288
	WRITE (6,907)XBD,DIST	G1	289
	WRITE (6,908)	G1	290
	NN=NBODY+NRPP	G1	291
C		G1	292
	DO 750 I=1,NN	G1	293
	LOC=L10+I-1	G1	294
	CALL UN3(LOC,I1,I2,I3)	G1	295
	IF(KLOOP.NE.I3)GOTO 750	G1	296
	IJK=LRIN+I-1	G1	297
	RIN=ASTER(IJK)	G1	298
	IJK=LROT+I-1	G1	299
	ROUT=ASTER(IJK)	G1	300
	IF(RIN.NE.ROUT)GOTO 710	G1	301
	WRITE (6,910)RIN,I	G1	302
	GOTO 750	G1	303
C		G1	304
	710 IF(ABS(RIN).NE.PINF)GOTO 720	G1	305
	IF(ABS(ROUT)-PINF)740,750,740	G1	306
	720 IF(RIN-DIST)730,744,745	G1	307
	730 IF(ROUT-DIST)741,742,743	G1	308
C		G1	309
	740 WRITE (6,911)RIN,ROUT,I1,I2,I	G1	310
	GOTO 750	G1	311
	741 WRITE (6,912)RIN,ROUT,I1,I2,I	G1	312
	GOTO 750	G1	313
	742 WRITE (6,913)RIN,ROUT,I1,I2,I	G1	314
	GOTO 750	G1	315
	743 WRITE (6,914)RIN,ROUT,I1,I2,I	G1	316
	GOTO 750	G1	317
	744 WRITE (6,915)RIN,ROUT,I1,I2,I	G1	318
	GOTO 750	G1	319
	745 WRITE (6,916)RIN,ROUT,I1,I2,I	G1	320
C		G1	321
	750 CONTINUE	G1	322
	WRITE (6,917)IERR,IERR,IERR,IERR	G1	323
	IRPRIM=-1	G1	324
C		G1	325
	800 IF(IERR.GE.NGIERR)WRITE (6,918)NGIERR	G1	326
	RETURN	G1	327
	END	G1	328
C		G1	329
C		G1	330
	SUBROUTINE WOWI(JREG,LSURF,NEX,LTRUE)	****	28
C		WOWI	2
C	GIVEN A POINT (XB) AND A REGION (JREG), DOES XB	WOWI	3
C	LIE WITHIN JREG	WOWI	4
C		WOWI	5
C	SUFFICIENT CONDITION FOR POINT XB TO BE IN REGION	WOWI	6
C	JREG, IS THAT REGION DESCRIPTION OF JREG BE	WOWI	7
C	SATISFIED. TWO REGIONS CANNOT BE SATISFIED FOR	WOWI	8
C	THE SAME POINT	WOWI	9
C		WOWI	10
C	+ OPERATOR VALID IF ROUT.GT.0 AND RIN.LE.DIST.LT.ROUT	WOWI	11
C	- OPERATOR VALID IF ROUT.LE.0 OR DIST.LT.RIN OR DIST.GE.ROUT	WOWI	12
C	OR OPERATOR VALID IF ALL (+) AND (-) IN (OR) STATEMENT VALID	WOWI	13
C		WOWI	14
C	REGION DESCRIPTION WITH 1 OR MORE (OR) STATEMENTS VALID	WOWI	15
C	IF ANY ONE OF (OR) STATEMENTS IS VALID	WOWI	16
C	REGION DESCRIPTION WITH NO (OR) STATEMENTS IS VALID ONLY	WOWI	17

C	IF EVERY (+) AND (-) OPERATOR IS VALID	WOWI	18
C		WOWI	19
	DIMENSION MASTER(30000)	WOWI	20
	COMMON ASTER(30000)	WOWI	21
	COMMON/PAREM/XB(3),WB(3),IR	WOWI	22
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	WOWI	23
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	WOWI	24
	1 LDATA,LRIN,LROT,LIO,LCDA,I15,I30,LBODY,NASC,KLOOP	WOWI	25
	EQUIVALENCE(ASTER,MASTER)	WOWI	26
C		WOWI	27
	901 FORMAT(1H0,32HERROR IN G1 AT 140 BAD ITYPE,5X,4HITY=,15)	WOWI	28
C		WOWI	29
	LOC=LREGD+JREG-1	WOWI	30
	CALL UN2(LOC,LOCDA,NC)	WOWI	31
	CALL UN2(LOCDA,IOP,NBO)	WOWI	32
	N=1	WOWI	33
	IOPER=IOP	WOWI	34
C		WOWI	35
C	EXAMINE NC CHOICES N=1,NC	WOWI	36
C		WOWI	37
	10 ITEMP=LIO+NBO-1	WOWI	38
	CALL UN3(ITEMP,LRI,LRO,LOOP)	WOWI	39
	ITEMP=LBODY+3*(NBO-1)	WOWI	40
	CALL UN2(ITEMP,ITYPE,LOCDA)	WOWI	41
	IF(LOOP.NE.KLOOP)GOTO 30	WOWI	42
C	CONTINUATION OF RAY	WOWI	43
	IF(ITYPE.GT.11)GOTO 40	WOWI	44
	IJK=LRIN+NBO-1	WOWI	45
	RIN=ASTER(IJK)	WOWI	46
	IJK=LRO1+NBO-1	WOWI	47
	ROUT=ASTER(IJK)	WOWI	48
	IF(ITYPE.LT.10)GOTO 310	WOWI	49
C	TOR AND ARS	WOWI	50
C	IF DIST 0 ROUT COMPUT RIN/ROUT SET	WOWI	51
	IF(ROUT.LT.0.)GOTO 400	WOWI	52
	IF(DIST.LE.ROUT)GOTO 310	WOWI	53
C		WOWI	54
	30 LRI=1	WOWI	55
	LRO=1	WOWI	56
	ITY=ITYPE+1	WOWI	57
	IF(ITY.GE.1.AND.ITY.LE.12)GOTO 100	WOWI	58
	40 IERR=IERR+1	WOWI	59
	WRITE (6,901)ITYPE	WOWI	60
	RETURN	WOWI	61
C	RPP BOX SPH RCC REC TRC ELL RAW ARB TEC TOR ARS	WOWI	62
	100 GOTO(110,120,130,140,150,160,170,180,190,200,210,220),ITY	WOWI	63
	110 CALL RPP(NBO)	WOWI	64
	GOTO 300	WOWI	65
	120 CALL BOX	WOWI	66
	GOTO 300	WOWI	67
	130 CALL SPH	WOWI	68
	GOTO 300	WOWI	69
	140 CALL RCC	WOWI	70
	GOTO 300	WOWI	71
	150 CALL REC	WOWI	72
	GOTO 300	WOWI	73
	160 CALL TRC	WOWI	74
	GOTO 300	WOWI	75
	170 CALL ELL	WOWI	76
	GOTO 300	WOWI	77

180	CALL RAW	WOWI	78
	GOTO 300	WOWI	79
190	CALL ARR	WOWI	80
	GOTO 300	WOWI	81
200	CALL TEC	WOWI	82
	GOTO 300	WOWI	83
210	CALL TOR	WOWI	84
	GOTO 300	WOWI	85
220	CALL ARS	WOWI	86
C		WOWI	87
300	IJK=LIO+NBO-1	WOWI	88
	MASTER(IJK)=KLOOP+I15*(LRO+64*LR1)	WOWI	89
C		WOWI	90
310	IF(ROUT.LL.0.)GOTO 330	WOWI	91
	IF(ABS(RIN-DIST).GT.DIST*1.0E-6)GOTO 320	WOWI	92
	RIN=DIST	WOWI	93
	GOTO 330	WOWI	94
C		WOWI	95
320	IF(ABS(ROUT-DIST).LE.DIST*1.0E-6)ROUT=DIST	WOWI	96
C		WOWI	97
330	IJK=LXIN+NBO-1	WOWI	98
	ASTER(IJK)=RIN	WOWI	99
	IJK=LROT+NBO-1	WOWI	100
	ASTER(IJK)=ROUT	WOWI	101
C		WOWI	102
C	TEST CONDITIONS FOR XB IN JREG (LTRUE SET=1)	WOWI	103
C		WOWI	104
400	IF(IOPER.GT.4)GOTO 500	WOWI	105
C	(+) OPERATOR TEST FOR INSIDE RIN.LE.DIST.LT.ROUT	WOWI	106
	IF(RIN.GT.DIST)GOTO 700	WOWI	107
	IF(DIST-ROUT)600,700,700	WOWI	108
C	(-) OPERATOR TEST FOR OUTSIDE DIST.LT.RIN DIST.GE.ROUT	WOWI	109
500	IF(ROUT.LE.0.)GOTO 600	WOWI	110
	IF(DIST.LT.RIN)GOTO 600	WOWI	111
	IF(DIST.EQ.RIN)GOTO 700	WOWI	112
	IF(DIST.LT.ROUT)GOTO 700	WOWI	113
C	CHECK NEXT BODY IN DESCRIPTION	WOWI	114
600	IF(N.GE.NC)GOTO 800	WOWI	115
	N=N+1	WOWI	116
	LOCD=LOCD+1	WOWI	117
	CALL UN2(LOCD,IOPER,NBO)	WOWI	118
	IF(IOPER.EQ.1.OR.IOPER.EQ.5)GOTO 800	WOWI	119
	GOTO 10	WOWI	120
C	OR OPERATOR	WOWI	121
700	IF(1OP.NE.1.AND.1OP.NE.5) RETURN	WOWI	122
	IF(N.GE.NC)RETURN	WOWI	123
	N=N+1	WOWI	124
	DO 710 NN=N,NC	WOWI	125
	LOCD=LOCD+1	WOWI	126
	CALL UN2(LOCD,IOPER,NBO)	WOWI	127
	IF(1OPER.NE.1.AND.1OPER.NE.5)GOTO 710	WOWI	128
	N=NN	WOWI	129
	GOTO 10	WOWI	130
710	CONTINUE	WOWI	131
	RETURN	WOWI	132
C		WOWI	133
800	LTRUE=LTRUE+1	WOWI	134
	RETURN	WOWI	135
	END	WOWI	136
C		WOWI	137

C	SUBROUTINE ARB	WOWI 138
	DIMENSION AA(6,4),XP(3)	*** 29
	COMMON ASTER(30000)	ARB 2
	COMMON/PAREM/XB(3),WB(3),IR	ARB 3
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	ARB 4
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	ARB 5
	1 LDATA,LRAIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	ARB 6
C	LOC=LOCDA-1	ARB 7
	DO 10 I=1,6	ARB 8
	LOC=LOC+1	ARB 9
	CALL UN2(LOC,LD,LC)	ARB 10
	AA(I,1)=ASTER(LC)	ARB 11
	AA(I,2)=ASTER(LC+1)	ARB 12
	AA(I,3)=ASTER(LC+2)	ARB 13
	AA(I,4)=ASTER(LD)	ARB 14
10	CONTINUE	ARB 15
	RIN=-PINF	ARB 16
	ROUT=PINF	ARB 17
	LRO=0	ARB 18
	LRI=0	ARB 19
	S1=0.	ARB 20
	S2=0.	ARB 21
	L1=0	ARB 22
	L2=0	ARB 23
	DO 70 I=1,6	ARB 24
	D=AA(I,4)	ARB 25
	SNUM=-D-AA(I,1)*XB(1)-AA(I,2)*XB(2)-AA(I,3)*XB(3)	ARB 26
	SDEN=AA(I,1)*WB(1)+AA(I,2)*WB(2)+AA(I,3)*WB(3)	ARB 27
	IF(SDEN)20,70,30	ARB 28
20	IF(SNUM)40,70,70	ARB 29
30	IF(SNUM)70,70,40	ARB 30
40	S=SNUM/SDEN	ARB 31
	DO 50 K=1,3	ARB 32
	XP(K)=XB(K)+S*WB(K)	ARB 33
50	CONTINUE	ARB 34
	DO 60 J=1,6	ARB 35
	IF(I.EQ.J)GOTO 60	ARB 36
	T=AA(J,1)*XP(1)+AA(J,2)*XP(2)+AA(J,3)*XP(3)+AA(J,4)	ARB 37
	IF(ABS(T).LE.1.0E-6)T=0.	ARB 38
	IF(T.LT.0.)GOTO 70	ARB 39
60	CONTINUE	ARB 40
	IF(L1.GT.0)GOTO 65	ARB 41
	L1=I	ARB 42
	S1=S	ARB 43
	GOTO 70	ARB 44
65	IF(ABS(S1-S).GT.1.0E-6)GOTO 100	ARB 45
70	CONTINUE	ARB 46
C		ARB 47
	IF(L1)200,200,150	ARB 48
100	S2=S	ARB 49
	L2=I	ARB 50
	IF(ABS(S1-S2).LE.S1*1.0E-5)GOTO 200	ARB 51
	IF(S1-S2)110,200,120	ARB 52
110	RIN=S1	ARB 53
	ROUT=S2	ARB 54
	LRI=L1	ARB 55
	LRO=L2	ARB 56
	RETURN	ARB 57
		ARB 58
		ARB 59

120 RIN=S2	ARB	60			
LRI=L2	ARB	61			
130 ROUT=S1	ARB	62			
LRO=L1	ARB	63			
RETURN	ARB	64			
150 DO 160 J=1,6	ARB	65			
IF(L1.EQ.J)GOTO 160	ARB	66			
T1=AA(J,1)*XB(1)+AA(J,2)*XB(2)+AA(J,3)*XB(3)+AA(J,4)	ARB	67			
IF(ABS(T1).LE.1.0E-6)T1=0.	ARB	68			
IF(T1.LI.0.)GOTO 200	ARB	69			
160 CONTINUE	ARB	70			
GOTO 130	ARB	71			
C	ARB	72			
200 RIN=PINF	ARB	73			
ROUT=-PINF	ARB	74			
LRI=0	ARB	75			
LRO=0	ARB	76			
RETURN	ARB	77			
END	ARB	78			
C	ARB	79			
C	ARB	80			
SUBROUTINE ARS	****	30			
DIMENSION MASTER(30000),COL1(3),COL2(3),COL3(3),COL4(3),	ARS	2			
1 U(3),V(3),W(3),SAVE(84)	ARS	3			
COMMON/PADEM/XB(3),WB(3),IR	ARS	4			
COMMON/GFCM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	ARS	5			
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	ARS	6			
1 LDATA,LKIN,LROI,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	ARS	7			
COMMON/DAVIS/IGRID,LOOP,INORM	ARS	8			
EQUIVALENCE(COL11,COL1(1)),(COL12,COL1(2)),(COL13,COL1(3))	ARS	9			
EQUIVALENCE(COL21,COL2(1)),(COL22,COL2(2)),(COL23,COL2(3))	ARS	10			
EQUIVALENCE(COL31,COL3(1)),(COL32,COL3(2)),(COL33,COL3(3))	ARS	11			
EQUIVALENCE(COL41,COL4(1)),(COL42,COL4(2)),(COL43,COL4(3))	ARS	12			
EQUIVALENCE(ASTER,MASTER)	ARS	13			
C	ARS	14			
901 FORMAT(1H0,21HTRGUBLE IN ARS AT 150)	ARS	15			
902 FORMAT(1H0,48HPOSSIBLE ERROR IN ARBITRARY SURFACE, CHECK INPUT,15)	ARS	16			
C	ARS	17			
C	ARS	18			
C	ARS	19			
LOCDA+0	T	TEMPORARY STORAGE	ARS	20	
C	+1	M	NO. CURVES	ARS	21
C	+2	N	NO. POINTS/CURVE	ARS	22
C	+3	IGDTL	GRID TOLERANCE	ARS	23
C	+4	BIAS	NO. OF NEGATIVE OR ZERO HITS	ARS	24
C	+5	XB(X)		ARS	25
C	+6	XB(Y)		ARS	26
C	+7	XB(Z)		ARS	27
C	+8	(84 WORDS)	RESERVED FOR HITS	ARS	28
C	.	.		ARS	29
C	.	.		ARS	30
C	.	.		ARS	31
C	+91	.		ARS	32
C	+92	X)		ARS	33
C	.	Y)N=1)	M SETS OF N POINTS	ARS	34
C	.	Z)		ARS	35
C	.	K)		ARS	36
C	.	.)		ARS	37
C	.	.)N=2)		ARS	38
C	.	.)		ARS	39

C		ARS	40
C		ARS	41
C	M = THE NUMBER OF CURVES INPUT	ARS	42
C	N = THE NUMBER POINTS/CURVE	ARS	43
C	IGDTL = THE NUMBER OF GRID SQUARES TO ALLOW AROUND EACH POINT	ARS	44
C	IBIAS = THE INDEX INTO MASTER TO THE NUMBER OF DISCARDED HITS	ARS	45
C		ARS	46
C	LOCHTS IS THE LOCATION OF THE AREA IN MASTER-ASTER	ARS	47
C	RESERVED FOR STORING HITS	ARS	48
C		AKS	49
C	LOCARY IS THE LOCATION IN MASTER-ASTER OF THE DATA POINTS	ARS	50
C	THEMSELVES IN FORMAT(X , Y , Z , GRID SQUARE)	ARS	51
C		ARS	52
C		ARS	53
	NE=4	ARS	54
	IWH=MASTER(LOCDA)	ARS	55
	IBIAS=IWH+4	ARS	56
	LOCHTS=IBIAS+4	ARS	57
	IF(INORM.EQ.0)GOTO 20	ARS	58
	DO 10 I=1,84	ARS	59
	IJK=LOCHTS+I-1	ARS	60
	SAVE(I)=ASTER(IJK)	ARS	61
10	CONTINUE	ARS	62
	GOTO 30	ARS	63
20	ASTER(IWH+5)=XB(1)	AKS	64
	ASTER(IWH+6)=XB(2)	ARS	65
	ASTER(IWH+7)=XB(3)	ARS	66
30	IF(KLOOP.EQ.LOOP)GOTO 400	AKS	67
C		ARS	68
	LRI=1	AKS	69
	LRO=1	ARS	70
	M=MASTER(IWH+1)	ARS	71
	N=MASTER(IWH+2)	ARS	72
	IGDTL=MASTER(IWH+3)	ARS	73
	LOCARY=LOCHTS+21*NE	ARS	74
	NHITS=0	ARS	75
	ASTER(LOCHTS)=PINF	ARS	76
	MASTER(IBIAS)=0	ARS	77
	KAPPA=M-1	ARS	78
C		ARS	79
C		ARS	80
C	IN THE EVEN CASE, THE TRIANGLES ARE -	ARS	81
C		ARS	82
C	(1) (I,J) (I+1,J) (I,J+1)	ARS	83
C	(2) (I,J) (I,J-1)	ARS	84
C	(3) (I-1,J) (I,J+1)	ARS	85
C	(4) (I,J) (I,J-1)	ARS	86
C		ARS	87
C		ARS	88
C	IN THE ODD CASE, THE TRIANGLES ARE -	ARS	89
C		ARS	90
C	(1) (I,J) (I+1,J) (I+1,J+1)	ARS	91
C	(2) (I,J) (I+1,J-1)	ARS	92
C	(3) (I-1,J) (I+1,J+1)	ARS	93
C	(4) (I,J) (I+1,J-1)	ARS	94
C		ARS	95
C	NOTE THAT THE ONLY DIFFERENCE IS THE ROW DESIGNATION OF W	ARS	96
C		ARS	97
C	BECAUSE OF THE INCREMENTATION OF I AND J, WE NEED	ARS	98
C	CONSIDER ONLY CASES (1) AND (2)	ARS	99

C	DO 200 I=1,KAPPA	ARS 100
	DO 200 J=1,N	ARS 101
	ITRY=0	ARS 102
	K=(I+J)/2	ARS 103
	IODD=I+J-2*K	ARS 104
C	IWI=4*((I-1+IODD)*N+J)+LOCARY	ARS 105
	IF(N.LE.J)GOTO 190	ARS 106
100	IV1=4*(I*N+(J-1))+LOCARY	ARS 107
	IU1=4*((I-1)*N+(J-1))+LOCARY	ARS 108
	IF(INORM.EQ.0)GOTO 110	ARS 109
	IF(IABS(IGRID-MASTER(IU1+3)).GT.IGDTL)GOTO 200	ARS 110
	IF(IABS(IGRID-MASTER(IV1+3)).GT.IGDTL)GOTO 200	ARS 111
	IF(IABS(IGRID-MASTER(IWI+3)).GT.IGDTL)GOTO 180	ARS 112
110	DO 115 K=1,3	ARS 113
	IJK=IU1+K-1	ARS 114
	U(K)=ASTER(IJK)	ARS 115
	IJK=IV1+K-1	ARS 116
	V(K)=ASTER(IJK)	ARS 117
	IJK=IWI+K-1	ARS 118
	W(K)=ASTER(IJK)	ARS 119
115	CONTINUE	ARS 120
C		ARS 121
C	AT THIS TIME WE HAVE U,V,W SIDES OF TRIANGLE	ARS 122
C		ARS 123
	DO 120 K=1,3	ARS 124
	COL1(K)=U(K)-W(K)	ARS 125
	COL2(K)=V(K)-W(K)	ARS 126
	COL3(K)=-WB(K)	ARS 127
	COL4(K)=XR(K)-W(K)	ARS 128
120	CONTINUE	ARS 129
	D = COL11*(COL22*COL33-COL23*COL32)	ARS 130
	1 -COL12*(COL21*COL33-COL23*COL31)	ARS 131
	2 +COL13*(COL21*COL32-COL22*COL31)	ARS 132
	IF(ABS(D).LE.1.0E-6)GOTO 180	ARS 133
C		ARS 134
	DALPHA= COL41*(COL22*COL33-COL23*COL32)	ARS 135
	1 -COL42*(COL21*COL33-COL23*COL31)	ARS 136
	2 +COL43*(COL21*COL32-COL22*COL31)	ARS 137
	ALPHA=DALPHA/D	ARS 138
	IF(ALPHA*(1.-ALPHA).LT.0.)GOTO 180	ARS 139
C		ARS 140
	DBETA = COL11*(COL42*COL33-COL43*COL32)	ARS 141
	1 -COL12*(COL41*COL33-COL43*COL31)	ARS 142
	2 +COL13*(COL41*COL32-COL42*COL31)	ARS 143
	BETA=DBETA/D	ARS 144
	IF(BETA*(1.-BETA).LT.0.)GOTO 180	ARS 145
	TP=ALPHA+BETA	ARS 146
	IF(TP*(1.-TP).LT.0.)GOTO 180	ARS 147
C		ARS 148
	DS = COL11*(COL22*COL43-COL23*COL42)	ARS 149
	1 -COL12*(COL21*COL43-COL23*COL41)	ARS 150
	2 +COL13*(COL21*COL42-COL22*COL41)	ARS 151
	S=DS/D	ARS 152
C		ARS 153
	IF(NHITS.GT.20)GOTO 400	ARS 154
	LIMIT=NHITS+1	ARS 155
	LIMIT1=LOCHTS+20*NE-1	ARS 156
	TRY=1-ITRY-ITRY	ARS 157
		ARS 158
		ARS 159

CALL CROSS(COL3,COL1,COL2)	ARS	160
DO 140 L=1,3	ARS	161
COL3(L)=TRY*COL3(L)	ARS	162
140 CONTINUE	ARS	163
DO 150 L=1,LIMIT	ARS	164
INDEX=LOCHTS+(L-1)*NE	ARS	165
IF(S.LE.ASTER(INDEX))GOTO 160	ARS	166
150 CONTINUE	ARS	167
WRITE (6,901)	ARS	168
GOTO 180	ARS	169
C	ARS	170
C	ARS	171
160 DO 165 L=INDEX,LIMIT1	ARS	172
IJK=LIMIT1+INDEX-L	ARS	173
IJK1=IJK+NE	ARS	174
ASTER(IJK1)=ASTER(IJK)	ARS	175
165 CONTINUE	ARS	176
ASTER(INDEX)=S	ARS	177
DO 170 L=1,3	ARS	178
IJK=INDEX+L	ARS	179
ASTER(IJK)=COL3(L)	ARS	180
170 CONTINUE	ARS	181
NHITS=NHITS+1	ARS	182
180 IF(!TRY.GT.0)GOTO 200	ARS	183
190 IW1=IW1-8	ARS	184
ITRY=1	ARS	185
IF(J.GT.1)GOTO 100	ARS	186
200 CONTINUE	ARS	187
C	ARS	188
C THIS SECTION CHECKS FOR PROPER ENTER-LEAVE SEQUENCE IN HITS TABLE	ARS	189
C	ARS	190
IF(NHITS-1)800,210,220	ARS	191
210 ASTER(LOCHTS)=PINF	ARS	192
IJK=LOCHTS+NE	ARS	193
ASTER(IJK)=PINF	ARS	194
GOTO 800	ARS	195
220 ILEAVE=1	ARS	196
SLAST=-PINF	ARS	197
C	ARS	198
C ILEAVE = -1 IMPLIES AN ENTRY	ARS	199
C ILEAVE = +1 IMPLIES AN EXIT	ARS	200
C ENTRIES AND EXITS SHOULD ALTERNATE IN TABLE	ARS	201
C	ARS	202
DO 300 L=1,NHITS	ARS	203
INDEX=LJCHTS+(L-1)*NE	ARS	204
DO 230 L1=1,3	ARS	205
IJK=INDEX+L1	ARS	206
COL4(L1)=ASTER(IJK)	ARS	207
230 CONTINUE	ARS	208
TEMP=DOT(WR,COL4)	ARS	209
INEXT=SIGN(1.0,TEMP)	ARS	210
IF(ABS(SLAST-ASTER(INDEX)).GT.1.0E-7)GOTO 235	ARS	211
IF(ILEAVE*INEXT.GE.0)GOTO 260	ARS	212
LTRY=L	ARS	213
INDEX=INDEX-NE	ARS	214
GOTO 270	ARS	215
235 IJK=INDEX+NE	ARS	216
IF(ABS(ASTER(INDEX)-ASTER(IJK)).GT.1.0E-7)GOTO 240	ARS	217
IF(ILEAVE*INEXT)290,250,250	ARS	218
240 IF(ILEAVE*INEXT)290,280,280	ARS	219

C		ARS	220
C	BAD START OF A NEW S SET - TRY TO FIND AN ALTERNATING MEMBER	ARS	221
C		ARS	222
	250 LTRY=L	ARS	223
	251 LTRY=LTRY+1	ARS	224
	IF(LTRY.GT.NHITS)GOTO 280	ARS	225
	INDEX1=LOCHTS+(LTRY-1)*NE	ARS	226
	IF(ABS(ASTER(INDEX)-ASTER(INDEX1)).GT.1.0E-7)GOTO 280	ARS	227
	DO 252 L1=1,3	ARS	228
	IJK=INDEX1+L1	ARS	229
	COL4(L1)=ASTER(IJK)	ARS	230
	252 CONTINUE	ARS	231
	TEMP=DOT(WB,COL4)	ARS	232
	INEXT=SIGN(1.0,TEMP)	ARS	233
	IF(ILEAVE*INEXT.GE.0)GOTO 251	ARS	234
	LTRY=L+1	ARS	235
	GOTO 270	ARS	236
C		ARS	237
C	AT THIS POINT WE HAVE DETECTED TWO CONSECUTIVE ENTRIES OR EXITS	ARS	238
C	TRY TO RESOLVE BY DELETING ITEMS WITH EQUAL S ENTRIES	ARS	239
C		ARS	240
	260 LTRY=L	ARS	241
	261 LTRY=LTRY+1	ARS	242
	IF(LTRY.LE.NHITS)GOTO 262	ARS	243
	LTRY=L+1	ARS	244
	GOTO 270	ARS	245
	262 INDEX1=LOCHTS+(LTRY-1)*NE	ARS	246
	IF(ABS(ASTER(INDEX)-ASTER(INDEX1)).LE.1.0E-7)GOTO 263	ARS	247
	LTRY=L+1	ARS	248
	GOTO 270	ARS	249
	263 DO 264 L1=1,3	ARS	250
	IJK=INDEX1+L1	ARS	251
	COL4(L1)=ASTER(IJK)	ARS	252
	264 CONTINUE	ARS	253
	TEMP=DOT(WB,COL4)	ARS	254
	INEXT=SIGN(1.0,TEMP)	ARS	255
	IF(ILEAVE*INEXT.GE.0)GOTO 261	ARS	256
	LTRY=L	ARS	257
	INDEX=INDEX-NE	ARS	258
	GOTO 270	ARS	259
C		ARS	260
C	PROCEED TO FORGET FROM INDEX THRU NEXT ENTRY WITH DIFFERENT S	ARS	261
C	COMMENCING TO CHECK WITH THE L TH ENTRY	ARS	262
C		ARS	263
	273 INDEX1=LOCHTS+(LTRY-1)*NE	ARS	264
	IF(ABS(ASTER(INDEX1)-ASTER(INDEX)).GT.0.)GOTO 271	ARS	265
	LTRY=LTRY+1	ARS	266
	270 NHITS=NHITS-1	ARS	267
	IF(NHITS-1)800,210,273	ARS	268
	271 DO 272 LTRY=INDEX,LIMIT1	ARS	269
	IJK=LTRY+INDEX1-INDEX	ARS	270
	ASTER(LTRY)=ASTER(IJK)	ARS	271
	272 CONTINUE	ARS	272
	GOTO 220	ARS	273
C		ARS	274
	280 WRITE (6,902)INDEX	ARS	275
	290 SLAST=ASTER(INDEX)	ARS	276
	ILEAVE=INEXT	ARS	277
	300 CONTINUE	ARS	278
C		ARS	279

C	NOW CHOOSE THE HIT (THIS SECTION ALSO ENTERED FOR REENTRY)	ARS	280
C		ARS	281
	400 DO 420 I=1,20	ARS	282
	I1ST=LOCHTS+(I-1)*NE	ARS	283
	I2ND=LOCHTS+I*NE	ARS	284
	IF(ASTER(I2ND).GE.PINF)GOTO 800	ARS	285
	IF(ASTER(I1ST).GE.PINF)GOTO 800	ARS	286
	IF(ABS(ASTER(I1ST)-ASTER(I2ND)).LE.1.0E-7)GOTO 420	ARS	287
	IF(DIST.LT.ASTER(I1ST))GOTO 410	ARS	288
	IF(DIST.GT.ASTER(I2ND))GOTO 420	ARS	289
	410 K=(MASTER(IBIAS)+I)/2	ARS	290
	IF(2*K-I-MASTER(IBIAS))500,510,510	ARS	291
	420 CONTINUE	ARS	292
C		ARS	293
	500 RIN=ASTER(I1ST)	ARS	294
	ROUT=ASTER(I2ND)	ARS	295
	GOTO 810	ARS	296
	510 RIN=ASTER(I2ND)	ARS	297
	IJK=I2ND+NE	ARS	298
	ROUT=ASTER(IJK)	ARS	299
	GOTO 810	ARS	300
	800 RIN=-PINF	ARS	301
	ROUT=0.	ARS	302
	810 IF(NASC.GT.-2)RETURN	ARS	303
	DO 820 I=1,84	ARS	304
	IJK=LOCHTS+I-1	ARS	305
	ASTER(IJK)=SAVE(I)	ARS	306
	820 CONTINUE	ARS	307
	RETURN	ARS	308
	END	ARS	309
C		ARS	310
C		ARS	311
	SUBROUTINE BOX	****	31
	DIMENSION MASTER(30000)	BOX	2
	COMMON ASTER(30000)	BOX	3
	COMMON/PAREM/XB(3),WB(3),IR	BOX	4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	BOX	5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	BOX	6
	1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	BOX	7
	EQUIVALENCE (MASTER,ASTER)	BOX	8
C		BOX	9
	CALL UN2(LOCDA,IV,IH1)	BOX	10
	LOC=LOCDA+1	BOX	11
	CALL UN2(LOC,IH2,IH3)	BOX	12
	RIN=-PINF	BOX	13
	ROUT=PINF	BOX	14
	DO 105 I=1,3	BOX	15
	IF(I-2)11,12,13	BOX	16
	11 II=2	BOX	17
	GOTO 14	BOX	18
	12 II=1	BOX	19
	GOTO 14	BOX	20
	13 II=3	BOX	21
	14 A=0.	BOX	22
	VP=0.	BOX	23
	W=0.	BOX	24
	DO 15 J=1,3	BOX	25
	JV=IV+J	BOX	26
	JA=IH1+J	BOX	27
	VP=VP+(ASTER(JV-1)-XB(J))*ASTER(JA-1)	BOX	28

W=WB(J)*ASTER(JA-1)	BOX	29
A=A+ASTER(JA-1)**2	BOX	30
15 CONTINUE	BOX	31
IF(W)30,20,40	BOX	32
20 IF(-VP.LT.0.)GOTO 200	BOX	33
IF(-VP-A)100,100,200	BOX	34
30 CP=VP/W	BOX	35
LO=2*II-1	BOX	36
IF(CP.LE.0.)GOTO 200	BOX	37
CM=(VP+A)/W	BOX	38
LI=LO+1	BOX	39
GOTO 60	BOX	40
40 CP=(VP+A)/W	BOX	41
LO=2*II	BOX	42
IF(CP.LE.0.)GOTO 200	BOX	43
CM=VP/W	BOX	44
LI=LO-1	BOX	45
60 IF(ROUT.LE.CP)GOTO 80	BOX	46
ROUT=CP	BOX	47
LRO=LO	BOX	48
80 IF(RIN.GE.CM)GOTO 100	BOX	49
RIN=CM	BOX	50
LRI=LI	BOX	51
100 IH1=IH2	BOX	52
IH2=IH3	BOX	53
105 CONTINUE	BOX	54
IF(ABS(RIN-ROUT).LE.ROUT*1.0E-6)GOTO 200	BOX	55
IF(RIN.LT.ROUT)RETURN	BOX	56
200 RIN=PINF	BOX	57
ROUT=-PINF	BOX	58
RETURN	BOX	59
END	BOX	60
C	BOX	61
C	BOX	62
SUBROUTINE ELL	****	32
DIMENSION FOCIA(3),FOCIB(3),MASTER(30000)	ELL	2
COMMON ASTER(30000)	ELL	3
COMMON/PAREM/XB(3),WB(3),IR	ELL	4
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	ELL	5
COMMON/UNCGEH/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	ELL	6
1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	ELL	7
EQUIVALENCE (ASTER,MASTER).	ELL	8
C	ELL	9
CALL UN2(LOCDA,IV1,IV2)	ELL	10
IRR=MASTER(LOCDA+1)	ELL	11
FOCIA(1)=ASTER(IV1)	ELL	12
FOCIA(2)=ASTER(IV1+1)	ELL	13
FOCIA(3)=ASTER(IV1+2)	ELL	14
FOCIB(1)=ASTER(IV2)	ELL	15
FOCIB(2)=ASTER(IV2+1)	ELL	16
FOCIB(3)=ASTER(IV2+2)	ELL	17
C=ASTER(IRR)	ELL	18
RIN=PINF	ELL	19
ROUT=-PINF	ELL	20
D1X=XB(1)-FOCIA(1)	ELL	21
D1Y=XB(2)-FOCIA(2)	ELL	22
D1Z=XB(3)-FOCIA(3)	ELL	23
D2X=XB(1)-FOCIB(1)	ELL	24
D2Y=XB(2)-FOCIB(2)	ELL	25
D2Z=XB(3)-FOCIB(3)	ELL	26

	A1=2.*(D1X*WB(1)+D1Y*WB(2)+D1Z*WB(3))	ELL	27
	A2=2.*(D2X*WB(1)+D2Y*WB(2)+D2Z*WB(3))	ELL	28
	B1=D1X*D1X+D1Y*D1Y+D1Z*D1Z	ELL	29
	B2=D2X*D2X+D2Y*D2Y+D2Z*D2Z	ELL	30
	AA=(A2-A1)/(2.*C)	ELL	31
	BB=(C*C+B2-B1)/(2.*C)	ELL	32
	ALAMD=AA*AA-1.	ELL	33
	ALAMI=(AA*BB-.5*A2)/ALAMD	ELL	34
	U=(BB*BB-B2)/ALAMD	ELL	35
	DISCRM=ALAMI*ALAMI-U	ELL	36
	IF(DISC RM.LE.O.)RETURN	ELL	37
	SQRTDI=SQRT(DISC RM)	ELL	38
	RIN=-ALAMI-SQRTDI	ELL	39
	ROUT=-ALAMI+SQRTDI	ELL	40
	RETURN	ELL	41
	END	ELL	42
		ELL	43
		ELL	44
		***	33
C	SUBROUTINE RAW	RAW	2
	DIMENSION H1(3),H2(3),H3(3),V(3),ASQ(3),PV(4),G(3)	RAW	3
	COMMON ASTER(3000)	RAW	4
	COMMON/PAREM/XB(3),WB(3),IR	RAW	5
	COMMON/GEOM/LBASE,KIN,ROUT,LRI,LRO,PINF,IERR,DIST	RAW	6
	COMMON/UNCSEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	RAW	7
	1 LDATA,LRI,N,LR0T,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	RAW	8
C		RAW	9
	CALL UN2(LOCDA,IV,IH1)	RAW	10
	LOC=LOCDA+1	RAW	11
	CALL UN2(LOC,IH2,IH3)	RAW	12
	H1(1)=ASTER(IH1)	RAW	13
	H1(2)=ASTER(IH1+1)	RAW	14
	H1(3)=ASTER(IH1+2)	RAW	15
	H2(1)=ASTER(IH2)	RAW	16
	H2(2)=ASTER(IH2+1)	RAW	17
	H2(3)=ASTER(IH2+2)	RAW	18
	H3(1)=ASTER(IH3)	RAW	19
	H3(2)=ASTER(IH3+1)	RAW	20
	H3(3)=ASTER(IH3+2)	RAW	21
	V(1)=ASTER(IV)	RAW	22
	V(2)=ASTER(IV+1)	RAW	23
	V(3)=ASTER(IV+2)	RAW	24
	RIN=-PINF	RAW	25
	ROUT=PINF	RAW	26
	CM=-PINF	RAW	27
	CP=PINF	RAW	28
	L=0	RAW	29
	L1=0	RAW	30
	K=0	RAW	31
	LRI=0	RAW	32
	LRO=0	RAW	33
	ASQ(1)=H1(1)*H1(1)+H1(2)*H1(2)+H1(3)*H1(3)	RAW	34
	ASQ(2)=H2(1)*H2(1)+H2(2)*H2(2)+H2(3)*H2(3)	RAW	35
	ASQ(3)=H3(1)*H3(1)+H3(2)*H3(2)+H3(3)*H3(3)	RAW	36
	XB1V1=XB(1)-V(1)	RAW	37
	XB2V2=XB(2)-V(2)	RAW	38
	XB3V3=XB(3)-V(3)	RAW	39
	PV(1)=XB1V1*H1(1)+XB2V2*H1(2)+XB3V3*H1(3)	RAW	40
	PV(2)=XB1V1*H2(1)+XB2V2*H2(2)+XB3V3*H2(3)	RAW	41
	PV(3)=XB1V1*H3(1)+XB2V2*H3(2)+XB3V3*H3(3)	RAW	42
	G(1)=WB(1)*H1(1)+WB(2)*H1(2)+WB(3)*H1(3)	RAW	42

	G(2)=WB(1)*H2(1)+WB(2)*H2(2)+WB(3)*H2(3)	RAW	43
	G(3)=WB(1)*H3(1)+WB(2)*H3(2)+WB(3)*H3(3)	RAW	44
C		RAW	45
	DO 140 I=1,2	RAW	46
	IF(G(I))10,110,60	RAW	47
C		RAW	48
10	IF(-PV(I))20,400,400	RAW	49
20	TEMP=-PV(I)/G(I)	RAW	50
	IF(TEMP-CP)30,130,130	RAW	51
30	CP=TEMP	RAW	52
	L=I	RAW	53
	GOTO(40,50),I	RAW	54
40	LRO=3	RAW	55
	GOTO 130	RAW	56
50	LRO=1	RAW	57
	GOTO 130	RAW	58
C		RAW	59
60	IF(-PV(I).LE.0.)GOTO 130	RAW	60
	TEMP=-PV(I)/G(I)	RAW	61
	IF(TEMP.LE.CM)GOTO 130	RAW	62
	CM=TEMP	RAW	63
	K=I	RAW	64
	GOTO(90,100),I	RAW	65
90	LRI=3	RAW	66
	GOTO 130	RAW	67
100	LRI=1	RAW	68
	GOTO 130	RAW	69
C		RAW	70
110	IF(PV(I).LE.0.)GOTO 810	RAW	71
	IF(PV(I).GE.ASQ(I))GOTO 810	RAW	72
130	L1=L1+I	RAW	73
140	CONTINUE	RAW	74
C		RAW	75
	IF(G(3))150,210,230	RAW	76
150	TEMP=ASQ(3)-PV(3)	RAW	77
	IF(TEMP.GE.0.)GOTO 180	RAW	78
	TEMP=TEMP/G(3)	RAW	79
	IF(TEMP.LE.CM)GOTO 190	RAW	80
	CM=TEMP	RAW	81
	K=3	RAW	82
	LRI=6	RAW	83
180	IF(-PV(3))190,400,400	RAW	84
190	TEMP=-PV(3)/G(3)	RAW	85
	IF(TEMP.GE.CP)GOTO 290	RAW	86
	CP=TEMP	RAW	87
	L=3	RAW	88
	LRO=5	RAW	89
	GOTO 290	RAW	90
C		RAW	91
210	IF(PV(3).LE.0.)GOTO 400	RAW	92
	IF(PV(3)-ASQ(3))290,290,400	RAW	93
C		RAW	94
230	IF(-PV(3).LE.0.)GOTO 260	RAW	95
	TEMP=-PV(3)/G(3)	RAW	96
	IF(TEMP.LE.CM)GOTO 260	RAW	97
	CM=TEMP	RAW	98
	K=3	RAW	99
	LRI=5	RAW	100
260	TEMP=ASQ(3)-PV(3)	RAW	101
	IF(TEMP.LE.0.)GOTO 400	RAW	102

TEMP=TEMP/G(3)	RAW 103
IF(TEMP.GE.CP)GOTO 290	RAW 104
CP=TEMP	RAW 105
L=3	RAW 106
LRO=6	RAW 107
290 AG=ASQ(2)*G(1)+ASQ(1)*G(2)	RAW 108
PV(4)=PV(1)*ASQ(2)+PV(2)*ASQ(1)	RAW 109
TOP=ASQ(1)*ASQ(2)-PV(4)	RAW 110
IF(AG)310,350,330	RAW 111
310 TEMP=TOP/AG	RAW 112
IF(TEMP.LE.CM)GOTO 380	RAW 113
CM=TEMP	RAW 114
K=4	RAW 115
LRI=2	RAW 116
GOTO 380	RAW 117
C	RAW 118
330 IF(TOP.LT.0.)GOTO 400	RAW 119
TEMP=TOP/AG	RAW 120
IF(TEMP-CP)370,380,380	RAW 121
C	RAW 122
350 IF(PV(4).LE.0.)GOTO 400	RAW 123
IF(-TOP)380,400,400	RAW 124
370 CP=TEMP	RAW 125
L=4	RAW 126
LKO=2	RAW 127
380 IF(L+K.LE.0)GOTO 400	RAW 128
ROUT=CP	RAW 129
RIN=CM	RAW 130
C	RAW 131
400 IF(ROUT.GE.PINF)GOTO 810	RAW 132
IF(ROUT.LE.0.)GOTO 810	RAW 133
IF(RIN.GE.ROUT)GOTO 810	RAW 134
IF(ABS(RIN-ROUT).GT.ROUT*1.0E-5)GOTO 820	RAW 135
C	RAW 136
810 ROUT=-PINF	RAW 137
RIN=PINF	RAW 138
LRO=0	RAW 139
LRI=0	RAW 140
820 RETURN	RAW 141
END	RAW 142
C	RAW 143
C	RAW 144
SUBROUTINE RCC	**** 34
DIMENSION V(3),H(3),MASTER(30000)	RCC 2
COMMON ASTER(30000)	RCC 3
COMMON/PAREM/XB(3),WB(3),IR	RCC 4
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	RCC 5
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	RCC 6
1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	RCC 7
EQUIVALENCE (ASTER,MASTER)	RCC 8
C	RCC 9
CALL UN2(LOCDA,IV,IH)	RCC 10
IRR=MASTER(LOCDA+1)	RCC 11
H(1)=ASTER(IH)	RCC 12
H(2)=ASTER(IH+1)	RCC 13
H(3)=ASTER(IH+2)	RCC 14
V(1)=ASTER(IV)	RCC 15
V(2)=ASTER(IV+1)	RCC 16
V(3)=ASTER(IV+2)	RCC 17
R=ASTER(IRR)	RCC 18

RIN=-PINF	RCC	19
ROUT=PINF	RCC	20
RSQ=R*R	RCC	21
LRO=0	RCC	22
LRI=0	RCC	23
TOP=0.	RCC	24
POT=0.	RCC	25
HH=H(1)*H(1)+H(2)*H(2)+H(3)*H(3)	RCC	26
VPH=H(1)*(V(1)-XB(1))+H(2)*(V(2)-XB(2))+H(3)*(V(3)-XB(3))	RCC	27
WH=WB(1)*H(1)+WB(2)*H(2)+WB(3)*H(3)	RCC	28
DEN=HH-WH*WH	RCC	29
DO 10 I=1,3	RCC	30
TOP=TOP+WB(I)*(XB(I)-V(I))	RCC	31
POT=POT+(XB(I)-V(I))**2	RCC	32
10 CONTINUE	RCC	33
AMBD=-HH*TOP-WH*VPH	RCC	34
UM=(POT-RSQ)*HH-VPH**2	RCC	35
IF(WH)40,70,50	RCC	36
40 CP=VPH/WH	RCC	37
CM=(VPH+HH)/WH	RCC	38
LCP=1	RCC	39
LCM=2	RCC	40
GOTO 60	RCC	41
50 CP=(VPH+HH)/WH	RCC	42
CM=VPH/WH	RCC	43
LCM=1	RCC	44
LCP=2	RCC	45
60 IF(CP)300,80,80	RCC	46
70 CP=PINF	RCC	47
CM=-CP	RCC	48
IF(VPH.GT.0.)GOTO 300	RCC	49
IF(HH+VPH)300,90,90	RCC	50
80 IF(ABS(DEN).GE.1.0E-6)GOTO 90	RCC	51
R1=-PINF	RCC	52
R2=PINF	RCC	53
GOTO 100	RCC	54
90 R1=0.	RCC	55
R2=0.	RCC	56
AMBDA=AMBD/DEN	RCC	57
UMU=UM/DEN	RCC	58
DISC=AMBDA**2-UMU	RCC	59
IF(DISC.LE.0.)GOTO 300	RCC	60
SD=SQRT(DISC)	RCC	61
R1=AMBDA-SD	RCC	62
R2=AMBDA+SD	RCC	63
100 IF(CM.GT.R1)GOTO 110	RCC	64
RIN=R1	RCC	65
LRI=3	RCC	66
GOTO 120	RCC	67
110 RIN=CM	RCC	68
LRI=LCM	RCC	69
120 IF(CP.LE.R2)GOTO 130	RCC	70
ROUT=R2	RCC	71
LRO=3	RCC	72
GOTO 200	RCC	73
130 ROUT=CP	RCC	74
LRO=LCP	RCC	75
200 IF(ABS(ROUT-RIN).LE.ROUT*1.0E-5)GOTO 300	RCC	76
GOTO(210,210,220),LRO	RCC	77
210 F1=DEN*ROUT**2-2.*AMBD*ROUT+UM	RCC	78

	IF(F1)250,250,300	RCC	79
220	F1=ROUT*WH-VPH	RCC	80
	IF(F1)300,250,230	RCC	81
	GOTO 230	RCC	82
230	IF(F1.GI.HH) GOTO 300	RCC	83
250	GOTO(260,260,270),LRI	RCC	84
260	F1=DEN*RIN**2-2.*AMB*D*RIN+UM	RCC	85
	IF(F1)310,310,300	RCC	86
270	F1=RIN*WH-VPH	RCC	87
	IF(F1)300,310,280	RCC	88
	GOTO 280	RCC	89
280	IF(F1.LF.HH)GOTO 310	RCC	90
300	RIN=PINF	RCC	91
	ROUT=-PINF	RCC	92
	LRO=0	RCC	93
	LRI=0	RCC	94
310	RETURN	RCC	95
	END	RCC	96
C		RCC	97
C		RCC	98
	SUBROUTINE REC	****	35
	DIMENSION V(3),H(3),A(3),B(3)	REC	2
	COMMON ASTER(30000)	REC	3
	COMMON/PAREM/XB(3),WB(3),IR	REC	4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	REC	5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LIRIP,LSCAL,LREGD,	REC	6
1	LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	REC	7
C		REC	8
	CALL UN2(LOCDA,IV,IH)	REC	9
	LOC=LOCDA+1	REC	10
	CALL UN2(LOC,IA,IB)	REC	11
	V(1)=ASTER(IV)	REC	12
	V(2)=ASTER(IV+1)	REC	13
	V(3)=ASTER(IV+2)	REC	14
	H(1)=ASTER(IH)	REC	15
	H(2)=ASTER(IH+1)	REC	16
	H(3)=ASTER(IH+2)	REC	17
	A(1)=ASTER(IA)	REC	18
	A(2)=ASTER(IA+1)	REC	19
	A(3)=ASTER(IA+2)	REC	20
	B(1)=ASTER(IB)	REC	21
	B(2)=ASTER(IB+1)	REC	22
	B(3)=ASTER(IB+2)	REC	23
	RIN=-PINF	REC	24
	ROUT=PINF	REC	25
	LRO=0	REC	26
	LRI=0	REC	27
	AA=A(1)*A(1)+A(2)*A(2)+A(3)*A(3)	REC	28
	BB=B(1)*B(1)+B(2)*B(2)+B(3)*B(3)	REC	29
	V1XB1=V(1)-XB(1)	REC	30
	V2XB2=V(2)-XB(2)	REC	31
	V3XB3=V(3)-XB(3)	REC	32
	VPA=V1XB1*A(1)+V2XB2*A(2)+V3XB3*A(3)	REC	33
	VPB=V1XB1*B(1)+V2XB2*B(2)+V3XB3*B(3)	REC	34
	WBA=WB(1)*A(1)+WB(2)*A(2)+WB(3)*A(3)	REC	35
	WBB=WB(1)*B(1)+WB(2)*B(2)+WB(3)*B(3)	REC	36
	WBAWBA=WBA*WBA	REC	37
	WBBWBB=WBB*WBB	REC	38
	AAAA=AA*AA	REC	39
	BBBB=BB*BB	REC	40

AMBD=WBA*VPA*BBBB+WB*VPB*AAAA	REC	41
UM=BBBB*VPA*VPA+AAAA*VPR*VPB-AAAA*BBBB	REC	42
DEN=WRWBA*BBBB+WBWB*AAAA	REC	43
IF(ABS(DEN).LE.1.0E-6)GOTO 10	REC	44
AMBD=AMBD/DEN	REC	45
UMU=UM/DEN	REC	46
DISC=AMBD**2-UMU	REC	47
IF(DISC.LE.0.)GOTO 300	REC	48
SD=SQRT(DISC)	REC	49
R1=AMBD-SD	REC	50
R2=AMBD+SD	REC	51
GOTO 20	REC	52
10 R1=-PINF	REC	53
R2=PINF	REC	54
20 HH=H(1)*H(1)+H(2)*H(2)+H(3)*H(3)	REC	55
WH=WB(1)*H(1)+WB(2)*H(2)+WB(3)*H(3)	REC	56
VPH=V1XB1*H(1)+V2XB2*H(2)+V3XB3*H(3)	REC	57
IF(WH)40,70,50	REC	58
40 IF(VPH.GE.0.)GOTO 300	REC	59
CP=VPH/WH	REC	60
CM=(VPH+HH)/WH	REC	61
LCP=1	REC	62
LCM=2	REC	63
GOTO 100	REC	64
50 VPHHH=VPH+HH	REC	65
IF(VPHHH.LE.0.)GOTO 300	REC	66
CP=VPHHH/WH	REC	67
CM=VPH/WH	REC	68
LCM=1	REC	69
LCP=2	REC	70
GOTO 100	REC	71
70 CP=PINF	REC	72
CM=-CP	REC	73
100 IF(CM.GI.R1)GOTO 110	REC	74
RIN=R1	REC	75
LRI=3	REC	76
GOTO 120	REC	77
110 RIN=CM	REC	78
LRI=LCM	REC	79
120 IF(CP.LE.R2)GOTO 130	REC	80
ROUT=R2	REC	81
LRO=3	REC	82
GOTO 200	REC	83
130 ROUT=CP	REC	84
LRO=LCP	REC	85
200 IF(ABS(ROUT-RIN).LE.ROUT*1.0E-5)GOTO 300	REC	86
GOTO(210,210,220),LRO	REC	87
210 F1=DEN*ROUT**2-2.*AMBD*ROUT+UM	REC	88
IF(F1)250,250,300	REC	89
220 F1=ROUT*WH-VPH	REC	90
IF(F1)300,250,230	REC	91
GOTO 230	REC	92
230 IF(F1.GT.HH)GOTO 300	REC	93
250 GOTO(260,260,270),LRI	REC	94
260 F1=DEN*RIN**2-2.*AMBD*RIN+UM	REC	95
IF(F1)310,310,300	REC	96
270 F1=RIN*WH-VPH	REC	97
IF(F1)300,310,280	REC	98
GOTO 280	REC	99
280 IF(F1.LE.HH)GOTO 310	REC	100

300	KIN=PINF	RPL	101
	ROUT=-PINF	RPL	102
	LRI=0	RPL	103
	LRO=0	RPL	104
310	RETURN	RPL	105
	END	RPL	106
C		RPL	107
C		RPL	108
	SUBROUTINE RPP(NBO)	***	36
	DIMENSION MASTER(30000),PR(6),LR(6),XS(6),LST(6)	RPP	2
	COMMON ASTER(30000)	RPP	3
	COMMON/PAREM/XB(3),WB(3),IR	RPP	4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	RPP	5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	RPP	6
	1 LUATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	RPP	7
	EQUIVALENCE (MASTER,ASTER)	RPP	8
C		RPP	9
901	FORMAT(1H0,12HERROR IN RPP/4H L =,110,5X,4HNBO=,110,5X,3HIR=,	RPP	10
	1 110/4H XB=,3E20.10/4H WB=,3E20.10/4H PR=,6E20.10/4H LR=,6I10)	RPP	11
C		RPP	12
	LST(1)=1	RPP	13
	LST(2)=1	RPP	14
	LST(3)=2	RPP	15
	LST(4)=2	RPP	16
	LST(5)=3	RPP	17
	LST(6)=3	RPP	18
	L=0	RPP	19
	PR(1)=0.	RPP	20
	PR(2)=0.	RPP	21
	DO 10 I=1,6	RPP	22
	XS(I)=S(NBO,I)	RPP	23
10	CONTINUE	RPP	24
C		RPP	25
	DO 100 I=1,6	RPP	26
	II=LST(I)	RPP	27
	TEMP=XS(I)-XB(II)	RPP	28
	IF(WB(II)) 20,100,30	RPP	29
20	IF(TEMP)40,100,100	RPP	30
30	IF(TEMP.LE.0.)GOTO 100	RPP	31
40	TRY=TEMP/WB(II)	RPP	32
	DO 60 J=1,3	RPP	33
	IF(J.EQ.II)GOTO 60	RPP	34
	XRY=XB(J)+TRY*WB(J)	RPP	35
	IF((XS(2*J-1)-XRY)*(XRY-XS(2*J)).LT.0.)GOTO 100	RPP	36
60	CONTINUE	RPP	37
	L=L+1	RPP	38
	PR(L)=TRY	RPP	39
	LR(L)=I	RPP	40
	IF(L.EQ.2)GOTO 130	RPP	41
	IF(L.LT.2)GOTO 100	RPP	42
	WRITE (6,901)L,NBO,IR,XB,WB,PR,LR	RPP	43
	ROUT=-PINF	RPP	44
	RETURN	RPP	45
100	CONTINUE	RPP	46
	GOTO 160	RPP	47
C		RPP	48
130	IF(ABS(PR(1)-PR(2)).LE.PR(1)*1.0E-6)GOTO 200	RPP	49
	IF(PR(1)-PR(2))140,180,150	RPP	50
140	RIN=PR(1)	RPP	51
	LR1=LR(1)	RPP	52

ROUT=PR(2)	RPP	53
LRO=LR(2)	RPP	54
RETURN	RPP	55
150 RIN=PR(2)	RPP	56
LRI=LR(2)	RPP	57
ROUT=PR(1)	RPP	58
LRO=LR(1)	RPP	59
RETURN	RPP	60
C	RPP	61
160 IF(L.GE.1)GOTO 180	RPP	62
170 ROUT=-PINF	RPP	63
RETURN	RPP	64
180 RIN=-PINF	RPP	65
LRI=0	RPP	66
ROUT=PR(1)	RPP	67
LRO=LR(1)	RPP	68
RETURN	RPP	69
C	RPP	70
200 DO 220 J=1,3	RPP	71
IF(XB(J).LT.XS(2*J-1))GOTO 170	RPP	72
IF(XB(J).GT.XS(2*J))GOTO 170	RPP	73
220 CONTINUE	RPP	74
GOTO 180	RPP	75
END	RPP	76
C	RPP	77
C	RPP	78
SUBROUTINE RPP2(LSURF,XP,IRP)	****	37
FINDS ABUTING RPP	RPP2	2
DIMENSION XP(3)	RPP2	3
COMMON ASTER(30000)	RPP2	4
COMMON/PAREM/XB(3),WB(3),IR	RPP2	5
COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	RPP2	6
COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	RPP2	7
I LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	RPP2	8
C	RPP2	9
LOC=LBASE+12*(NASC-1)-2*(LSURF+1)	RPP2	10
CALL UN2(LOC,LOCAT,NC)	RPP2	11
IF(NC-1)10,20,30	RPP2	12
10 IRP=0	RPP2	13
RETURN	RPP2	14
20 CALL UN2(LOCAT,IRP,DUM)	RPP2	15
RETURN	RPP2	16
30 M=1	RPP2	17
C	RPP2	18
DO 90 I=1,NC	RPP2	19
M=-M	RPP2	20
IF(M.GT.0)GOTO 50	RPP2	21
CALL UN2(LOCAT,I1,I2)	RPP2	22
LOCAT=LOCAT+1	RPP2	23
IRP=I1	RPP2	24
GOTO 70	RPP2	25
50 IRP=I2	RPP2	26
70 LS=(1-LSURF)/2	RPP2	27
DO 80 J=1,3	RPP2	28
IF(J.EQ.LS)GOTO 80	RPP2	29
IF((S(IRP,2*J-1)-XP(J))*(XP(J)-S(IRP,2*J)).LT.0.)GOTO 90	RPP2	30
80 CONTINUE	RPP2	31
RETURN	RPP2	32
90 CONTINUE	RPP2	33
IRP=0	RPP2	34

	RETURN	RPP2	35
	END	RPP2	36
C		RPP2	37
C		RPP2	38
	SUBROUTINE SPH	****	38
	COMMON ASTER(30000)	SPH	2
	COMMON/PAREM/XB(3),WB(3),IR	SPH	3
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	SPH	4
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	SPH	5
	1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	SPH	6
C		SPH	7
	CALL UN2(LOCDA,ITEMP,I2)	SPH	8
	R=ASTER(I2)	SPH	9
	ITEMP=ITEMP+1	SPH	10
	DX=XB(1)-ASTER(ITEMP-1)	SPH	11
	DY=XB(2)-ASTER(ITEMP)	SPH	12
	DZ=XB(3)-ASTER(ITEMP+1)	SPH	13
	B=DX*WB(1)+DY*WB(2)+DZ*WB(3)	SPH	14
	C=DX*DX+DY*DY+DZ*DZ-R*R	SPH	15
	DIS=B*B-C	SPH	16
	IF(C.GT.0.)GOTO 10	SPH	17
	RIN=-PINF	SPH	18
	ROUT=SQRT(DIS)-B	SPH	19
	RETURN	SPH	20
	10 IF(DIS.GT.0.)GOTO 20	SPH	21
	RIN=PINF	SPH	22
	ROUT=-PINF	SPH	23
	RETURN	SPH	24
	20 DIS=SQRT(DIS)	SPH	25
	RIN=-B-DIS	SPH	26
	ROUT=-B+DIS	SPH	27
	RETURN	SPH	28
	END	SPH	29
C		SPH	30
C		SPH	31
	SUBROUTINE TEC	****	39
	DIMENSION MASTER(30000),DELTA(3),HF(3),AUN(3)	TEC	2
	COMMON ASTER(30000)	TEC	3
	COMMON/PAREM/XB(3),WB(3),IR	TEC	4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	TEC	5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	TEC	6
	1 LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	TEC	7
	EQUIVALENCE (MASTER,ASTER),(GAMMA,SIGMA)	TEC	8
	REAL NF(3),K(3),M,M2,MM,MM2	TEC	9
C		TEC	10
	CALL UN2(LOCDA,IV,IH)	TEC	11
	LOC=LOCDA+1	TEC	12
	CALL UN2(LOC,IN,IA)	TEC	13
	LOC=LOC+1	TEC	14
	CALL UN2(LOC,IR1,IR2)	TEC	15
	IRC=MASTER(LOC+1)	TEC	16
	R1=ASTER(IR1)	TEC	17
	R2=ASTER(IR2)	TEC	18
	R3=R1/ASTER(IRC)	TEC	19
	R4=R2/ASTER(IRC)	TEC	20
	DDN=0.	TEC	21
	WDA=0.	TEC	22
	DDA=0.	TEC	23
	HDA=0.	TEC	24
	HDN=0.	TEC	25

WDN=0.	TEC	26
DO 100 I=1,3	TEC	27
I1=I-1	TEC	28
J1=IV+I1	TEC	29
J2=IH+I1	TEC	30
J3=IN+I1	TEC	31
J4=IA+I1	TEC	32
DELTA(I)=ASTER(J1)-XB(I)	TEC	33
HF(I)=ASTER(J2)	TEC	34
NF(I)=ASTER(J3)	TEC	35
AUN(I)=ASTER(J4)	TEC	36
DDN=DELTA(I)*NF(I)+DDN	TEC	37
WDA=WB(I)*AUN(I)+WDA	TEC	38
DDA=DELTA(I)*AUN(I)+DDA	TEC	39
HDA=HF(I)*AUN(I)+HDA	TEC	40
HON=HF(I)*NF(I)+HON	TEC	41
WDN=WB(I)*NF(I)+WDN	TEC	42
100 CONTINUE	TEC	43
CALL CROSS(K,AUN,NF)	TEC	44
WDK=DOT(WB,K)	TEC	45
DDK=DOT(DELTA,K)	TEC	46
HDK=DOT(HF,K)	TEC	47
IF(ABS(WDN).GT.1.0E-7)GOTO 300	TEC	48
GAMMA=-DDN/HON	TEC	49
IF(GAMMA.LT.0.)GOTO 900	TEC	50
RTP=GAMMA-1.	TEC	51
IF(RTP.GT.0.)GOTO 900	TEC	52
M=GAMMA*R3+R1*(1.-GAMMA)	TEC	53
MM=GAMMA*R4+R2*(1.-GAMMA)	TEC	54
M2=M*M	TEC	55
MM2=MM*MM	TEC	56
T=SIGMA*HDA+DDA	TEC	57
TT=SIGMA*HDK+DDK	TEC	58
A=MM2*WDA**2+M2*WDK**2	TEC	59
B=- (MM2*WDA*T+M2*WDK*TT)	TEC	60
C=MM2*T**2+M2*TT**2-M2*MM2	TEC	61
DISC=B*B-A*C	TEC	62
IF(DISC.LT.0.)GOTO 900	TEC	63
IF(DISC.GT.0.)DISC=SQRT(DISC)	TEC	64
RIN=(-B-DISC)/A	TEC	65
ROUT=(-B+DISC)/A	TEC	66
LRI=3	TEC	67
LRO=3	TEC	68
GOTO 950	TEC	69
C	TEC	70
300 FLIPD=1.	TEC	71
IF(WDN.LT.0.)GOTO 310	TEC	72
FLIPD=-1.	TEC	73
WDA=-WDA	TEC	74
WDN=-WDN	TEC	75
WDK=-WDK	TEC	76
310 ALPHA=HON/WDN	TEC	77
BETA=DDN/WDN	TEC	78
TAU=(R3/R4)**2	TEC	79
A=(ALPHA*WDA-HDA)**2+TAU*(ALPHA*WDK-HDK)**2-TAU*(R4-R2)**2	TEC	80
B=- (-ALPHA*BETA*WDA**2+ALPHA*WDA*DDA+BETA*WDA*HDA-DDA*HDA	TEC	81
1 +TAU*(-ALPHA*BETA*WDK**2+ALPHA*WDK*DDK+BETA*WDK*HDK-DDK*HDK	TEC	82
2 +R2*R4-R2*R2))	TEC	83
C=(DDA-BETA*WDA)**2+TAU*((DDK-BETA*WDK)**2-R2**2)	TEC	84
DISC=B*B-A*C	TEC	85

IF(DISC.LT.0.)GOTO 900	TEC 86
IF(DISC.GT.0.)DISC=SQRT(DISC)	TEC 87
IF(ABS(A).LE.1.0E-7)GOTO 330	TEC 88
IF(A)320,330,340	TEC 89
320 SIGMA1=(-B-DISC)/A	TEC 90
SIGMA2=(-B+DISC)/A	TEC 91
GOTO 350	TEC 92
330 SIGMA1=-C/(2.*B)	TEC 93
SIGMA2=-PINF	TEC 94
IF(SIGMA1)900,350,350	TEC 95
340 SIGMA1=(-B+DISC)/A	TEC 96
SIGMA2=(-B-DISC)/A	TEC 97
350 SIGMAP=-R1/(R3-R1)	TEC 98
IF(SIGMA2.GT.1.)GOTO 900	TEC 99
IF(SIGMA1.LT.0.)GOTO 900	TEC 100
IF(SIGMA1.GT.1.)GOTO 410	TEC 101
IF(SIGMA2.GT.0.)GOTO 400	TEC 102
RIN=ALPHA*SIGMA1+BETA	TEC 103
LRI=3	TEC 104
ROUT=BETA	TEC 105
LRO=1	TEC 106
GOTO 490	TEC 107
400 RIN=ALPHA*SIGMA1+BETA	TEC 108
LRI=3	TEC 109
ROUT=ALPHA*SIGMA2+BETA	TEC 110
LRO=3	TEC 111
GOTO 490	TEC 112
410 IF(SIGMA2.GT.0.)GOTO 440	TEC 113
IF(SIGMA1.GT.SIGMAP)GOTO 900	TEC 114
RIN=ALPHA+BETA	TEC 115
LRI=2	TEC 116
ROUT=BETA	TEC 117
LRO=1	TEC 118
GOTO 490	TEC 119
440 IF(SIGMA1.GT.SIGMAP)GOTO 460	TEC 120
RIN=ALPHA+BETA	TEC 121
LRI=2	TEC 122
ROUT=ALPHA*SIGMA2+BETA	TEC 123
LRO=3	TEC 124
GOTO 490	TEC 125
460 RIN=ALPHA*SIGMA2+BETA	TEC 126
LRI=3	TEC 127
ROUT=BETA	TEC 128
LRO=1	TEC 129
C	TEC 130
490 IF(FLIPD.GE.0.)GOTO 950	TEC 131
RTP=RIN	TEC 132
ITP=LRI	TEC 133
RIN=-ROUT	TEC 134
LRI=LRO	TEC 135
ROUT=-RTP	TEC 136
LRO=ITP	TEC 137
GOTO 950	TEC 138
900 RIN=PINF	TEC 139
ROUT=-PINF	TEC 140
950 IF(ROUT.GT.0.)GOTO 1000	TEC 141
RIN=PINF	TEC 142
ROUT=-PINF	TEC 143
RETURN	TEC 144
1000 IF(ABS(ROUT-RIN).LE.RIN*1.0E-6)GOTO 900	TEC 145

	RLTURN	TEC 146
	END	TEC 147
C		TEC 148
C		TEC 149
	SUBROUTINE TOR	**** 40
	DIMENSION MASTER(30000),XMCV(3),C(4),RT(4),RTS(4),XAW(3),XTRY(3)	TOR 2
	COMMON ASTER(30000)	TOR 3
	COMMON/PAREM/XB(3),WB(3),IR	TOR 4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	TOR 5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	TOR 6
	! LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	TOR 7
	EQUIVALENCE (MASTER,ASTER),(DIST,STHUS)	TOR 8
	REAL NF(3)	TOR 9
C		TOR 10
	CALL UN2(LOCDA,IV,IN)	TOR 11
	LOC=LOCDA+1	TOR 12
	CALL UN2(LOC,IR1,IR2)	TOR 13
	R1=ASTER(IR1)	TOR 14
	R2=ASTER(IR2)	TOR 15
	WDN=0.	TOR 16
	XMC2=0.	TOR 17
	AW=SQRT(DOT(WB,WB))	TOR 18
	DO 10 I=1,3	TOR 19
	J1=IV+I-1	TOR 20
	XAW(I)=ASTER(J1)-XB(I)	TOR 21
10	CONTINUE	TOR 22
	RSAVE=ABS(DOT(XAW,WB)/AW)-R1-R2-R2	TOR 23
	IF(NASC.EQ.-2)RSAVE=0.	TOR 24
	DO 20 I=1,3	TOR 25
	XTRY(I)=XB(I)+RSAVE*WB(I)	TOR 26
20	CONTINUE	TOR 27
	DO 100 I=1,3	TOR 28
	J1=IV+I-1	TOR 29
	J2=IN+I-1	TOR 30
	NF(I)=ASTER(J2)	TOR 31
	XMCV(I)=XTRY(I)-ASTER(J1)	TOR 32
	XMC2=XMCV(I)**2+XMC2	TOR 33
	WDN=WB(I)*ASTER(J2)+WDN	TOR 34
100	CONTINUE	TOR 35
	WDXMC=DOT(WB,XMCV)	TOR 36
	XMCDN=DOT(XMCV,NF)	TOR 37
	R12=R1*R1	TOR 38
	R22=R2*R2	TOR 39
	TERM=R12+R22-XMC2	TOR 40
	C(1)=4.*WDXMC	TOR 41
	TEMP=4.*WDXMC**2	TOR 42
	C(2)=4.*R12*WDN**2-2.*TERM+TEMP	TOR 43
	C(3)=8.*R12*WDN*XMCDN-4.*WDXMC*TERM	TOR 44
	C(4)=4.*R12*(XMCDN**2-R22)+TERM**2	TOR 45
	CALL QRTIC(C,RT,NR)	TOR 46
	IF(NR-2)110,120,140	TOR 47
C	TOR NOT HIT	TOR 48
110	RIN=0.	TOR 49
	ROUT=-PINF	TOR 50
	RETURN	TOR 51
C	2 ROOTS	TOR 52
120	IF(RT(1).GE.RT(2))GOTO 130	TOR 53
	RIN=RT(1)	TOR 54
	ROUT=RT(2)	TOR 55
	GOTO 900	TOR 56

130	RIN=RT(2)	TOR	57
	ROUT=RT(1)	TOR	58
	GOTO 900	TOR	59
C	4 ROOTS SELECT FIRST PAIR .GE. DIST AS RIN AND ROUT	TOR	60
140	RTS(1)=RT(1)	TOR	61
	IF(RT(2).LT.RTS(1))GOTO 150	TOR	62
	RTS(2)=RT(2)	TOR	63
	GOTO 160	TOR	64
150	RTS(2)=RTS(1)	TOR	65
	RTS(1)=RT(2)	TOR	66
160	IF(RT(3).LT.RTS(2))GOTO 170	TOR	67
	RTS(3)=RT(3)	TOR	68
	GOTO 190	TOR	69
170	RTS(3)=RTS(2)	TOR	70
	IF(RT(3).LT.RTS(1))GOTO 180	TOR	71
	RTS(2)=RT(3)	TOR	72
	GOTO 190	TOR	73
180	RTS(2)=RTS(1)	TOR	74
	RTS(1)=RT(3)	TOR	75
190	IF(RT(4).LT.RTS(3))GOTO 200	TOR	76
	RTS(4)=RT(4)	TOR	77
	GOTO 300	TOR	78
200	RTS(4)=RTS(3)	TOR	79
	IF(RT(4).LT.RTS(2))GOTO 210	TOR	80
	RTS(3)=RT(4)	TOR	81
	GOTO 300	TOR	82
210	RTS(3)=RTS(2)	TOR	83
	IF(RT(4).LT.RTS(1))GOTO 220	TOR	84
	RTS(2)=RT(4)	TOR	85
	GOTO 300	TOR	86
220	RTS(2)=RTS(1)	TOR	87
	RTS(1)=RT(4)	TOR	88
C	STHUS=DIST	TOR	89
300	IF(ABS(STHUS-RTS(2)).LE.1.0E-7)GOTO 310	TOR	90
	IF(STHUS.GE.RTS(2))GOTO 310	TOR	91
	RIN=RTS(1)	TOR	92
	ROUT=RTS(2)	TOR	93
	GOTO 900	TOR	94
310	RIN=RTS(3)	TOR	95
	ROUT=RTS(4)	TOR	96
C		TOR	97
900	LRI=1	TOR	98
	LRO=1	TOR	99
	RIN=RIN+RSAVE	TOR	100
	ROUT=ROUT+RSAVE	TOR	101
	IF(ROUT.GE.0.0)GOTO 920	TOR	102
910	RIN=PINF	TOR	103
	ROUT=-PINF	TOR	104
	RETURN	TOR	105
920	IF(ABS(ROUT-RIN).LE.RIN*1.0E-6)GOTO 910	TOR	106
	RETURN	TOR	107
	END	TOR	108
C		TOR	109
C		TOR	110
	SUBROUTINE TRC	****	41
	DIMENSION MASTER(30000),V(3),H(3)	TRC	2
	COMMON ASTER(30000)	TRC	3
	COMMON/PAREM/XB(3),WB(3),IR	TRC	4
	COMMON/GEOM/LBASE,RIN,ROUT,LRI,LRO,PINF,IERR,DIST	TRC	5
	COMMON/UNCGEM/NRPP,NTRIP,NSCAL,NBODY,NRMAX,LTRIP,LSCAL,LREGD,	TRC	6

	I	LDATA,LRIN,LROT,LIO,LOCDA,I15,I30,LBODY,NASC,KLOOP	TRC	7
		EQUIVALENCE(MASTER,ASTER)	TRC	8
C		CALL UN2(LOCDA,IV,IH)	TRC	9
		LOC=LOCDA+1	TRC	10
		CALL UN2(LOC,IRB,IRTOP)	TRC	11
		V(1)=ASTER(IV)	TRC	12
		V(2)=ASTER(IV+1)	TRC	13
		V(3)=ASTER(IV+2)	TRC	14
		H(1)=ASTER(IH)	TRC	15
		H(2)=ASTER(IH+1)	TRC	16
		H(3)=ASTER(IH+2)	TRC	17
		RB=ASTER(IRB)	TRC	18
		RT=ASTER(IRTOP)	TRC	19
		RIN=-PINF	TRC	20
		ROUT=PINF	TRC	21
		LRO=0	TRC	22
		LRI=0	TRC	23
		INTSEC=0	TRC	24
		INTR1=0	TRC	25
		INTR2=0	TRC	26
		V1XB1=V(1)-XB(1)	TRC	27
		V2XB2=V(2)-XB(2)	TRC	28
		V3XB3=V(3)-XB(3)	TRC	29
		PVPV=V1XB1*V1XB1+V2XB2*V2XB2+V3XB3*V3XB3	TRC	30
		VPW=V1XB1*WB(1)+V2XB2*WB(2)+V3XB3*WB(3)	TRC	31
		WH=WB(1)*H(1)+WB(2)*H(2)+WB(3)*H(3)	TRC	32
		VPH=V1XB1*H(1)+V2XB2*H(2)+V3XB3*H(3)	TRC	33
		HH=H(1)*H(1)+H(2)*H(2)+H(3)*H(3)	TRC	34
		RTRB=RT-RB	TRC	35
		RBRTVP=RB-VPH*RTRB/HH	TRC	36
		VPHHH=VPH*HH	TRC	37
		UM=HH*(PVPV-RBRTVP**2)-VPH*VPH	TRC	38
		AMBD=HH*VPW-WH*(VPH-RTRB*RBRTVP)	TRC	39
		DEN=HH-WH**2*(1.+RTRB**2/HH)	TRC	40
		IF(ABS(DEN).GT.1.0E-6)GOTO 40	TRC	41
		IF(RTRB.EQ.0.)GOTO 200	TRC	42
		R2=UM/(2.*AMBD)	TRC	43
		F1=R2*WH-VPH	TRC	44
		IF(F1.LT.0.)GOTO 200	TRC	45
		IF(F1.GT.HH)GOTO 200	TRC	46
		INTSEC=INTSEC+1	TRC	47
		IF(WH.LE.0.)GOTO 10	TRC	48
		IF(RTRB)20,20,30	TRC	49
	10	IF(RTRB)30,30,20	TRC	50
	20	LRO=3	TRC	51
		ROUT=R2	TRC	52
		GOTO 250	TRC	53
	30	LRI=3	TRC	54
		RIN=R2	TRC	55
		INTSEC=INTSEC+1	TRC	56
		GOTO 210	TRC	57
			TRC	58
			TRC	59
	40	AMBDA=AMBD/DEN	TRC	60
		UMU=UM/DEN	TRC	61
		DISC=AMBDA**2-UMU	TRC	62
		IF(DISC)350,200,50	TRC	63
		GOTO 50	TRC	64
	50	SD=SQRT(DISC)	TRC	65
		R1=AMBDA-SD	TRC	66

R2=AMBDA+SD	TRC	67
F1=R2*WH-VPH	TRC	68
IF(F1.LT.0.)GOTO 60	TRC	69
IF(F1.LE.HH)INTR2=INTR2+1	TRC	70
60 F1=R1*WH-VPH	TRC	71
IF(F1.LT.0.)GOTO 70	TRC	72
IF(F1.LE.HH)GOTO 80	TRC	73
70 IF(INTR2.LT.1)GOTO 200	TRC	74
ROUT=R2	TRC	75
RIN=R2	TRC	76
LRO=3	TRC	77
LRI=3	TRC	78
INTSEC=INTSEC+1	TRC	79
GOTO 200	TRC	80
80 INTR1=INTR1+1	TRC	81
IF(INTR2.GE.1)GOTO 90	TRC	82
ROUT=R1	TRC	83
RIN=R1	TRC	84
LRO=3	TRC	85
LRI=3	TRC	86
INTSEC=INTSEC+1	TRC	87
GOTO 200	TRC	88
90 IF(R1-R2)100,350,110	TRC	89
100 RIN=R1	TRC	90
ROUT=R2	TRC	91
LRO=3	TRC	92
LRI=3	TRC	93
GOTO 300	TRC	94
110 RIN=R2	TRC	95
ROUT=R1	TRC	96
LRO=3	TRC	97
LRI=3	TRC	98
GOTO 300	TRC	99
C	TRC	100
200 IF(WH)210,350,250	TRC	101
210 IF(VPH.GE.0.)GOTO 350	TRC	102
CP=VPH/WH	TRC	103
F1=CP*CP-2.*CP*VPW+PVPV-RB*RB	TRC	104
IF(F1.GT.0.)GOTO 220	TRC	105
INTSEC=INTSEC+1	TRC	106
ROUT=CP	TRC	107
LRO=1	TRC	108
IF(INTSEC.GE.2)GOTO 300	TRC	109
220 CM=VPHHH/WH	TRC	110
F1=CM*CM-2.*((VPW+WH)*CM-VPH)+HH+PVPV-RT*RT	TRC	111
IF(F1.GT.0.)GOTO 350	TRC	112
RIN=CM	TRC	113
LRI=2	TRC	114
GOTO 300	TRC	115
250 IF(VPHHH.LT.0.)GOTO 350	TRC	116
CP=VPHHH/WH	TRC	117
F1=CP*CP-2.*((VPW+WH)*CP-VPH)+HH+PVPV-RT*RT	TRC	118
IF(F1.GT.0.)GOTO 260	TRC	119
INTSEC=INTSEC+1	TRC	120
ROUT=CP	TRC	121
LRO=2	TRC	122
260 IF(INTSEC.GE.2)GOTO 300	TRC	123
CM=VPH/WH	TRC	124
F1=CM*CM-2.*CP*VPW+PVPV-RB*RB	TRC	125
IF(F1.GT.0.)GOTO 350	TRC	126

```
      RIN=CM
      LRI=1
C
300 IF (ABS(ROUT-RIN)-ROUT*1.0E-5)350,350,360
350 RIN=PINF
      ROUT=-PINF
      LRI=0
      LRO=0
360 RETURN
      END
L
C
END
```

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TRC 127
TRC 128
TRC 129
TRC 130
TRC 131
TRC 132
TRC 133
TRC 134
TRC 135
TRC 136
TRC 137
TRC 138
TRC 139
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