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SAN/1109-8/3

**SOLAR PILOT PLANT, PHASE 1
PRELIMINARY DESIGN REPORT**

Volume 2, Book 2

Central Receiver Optical Model Users Manual (CDRL Item 2)

May 1, 1977

Work Performed Under Contract No. EY-76-C-03-1109

**Honeywell, Incorporated
Energy Resources Center
Minneapolis, Minnesota**

MASTER

U.S. Department of Energy

Solar Energy

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ERDA Contract No. E(04-3)-1109

1 MAY 1977

SOLAR PILOT PLANT
PHASE I

PRELIMINARY DESIGN REPORT

VOLUME II - BOOK 2

CENTRAL RECEIVER OPTICAL MODEL
USERS MANUAL

CDRL Item 2

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FOREWORD

This is the initial submittal of the Solar Pilot Plant Preliminary Design Report per Contract Data Requirement List Item 2 of ERDA Contract E(04-3)-1109. The report is submitted for review and approval by ERDA. This is Volume II-Book 2 of seven volumes.

Readers of this report and users of the Central Receiver Optical/Thermal Model program, HELIAK1, should be cautioned that, although the program has been used considerably and appears to be relatively error free, some "bugs" may well remain. Further, since this program evolved over a period of time in a step-by-step updating of the model, some unused variables may also remain. Needless to say, the authors cannot take responsibility for any versions of the program which do not correspond exactly to the program listing in this report.

10 MEGAWATT SOLAR PILOT PLANT
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

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SECTION 1

INTRODUCTION

HELIAKI is a FORTRAN computer program which simulates the optical/thermal performance of a central receiver solar thermal power plant for the dynamic conversion of solar-generated heat to electricity. The solar power plant which this program simulates consists of a field of individual sun tracking mirror units, or heliostats, redirecting sunlight into a cavity, called the receiver, mounted atop a tower. The program calculates the power retained by that cavity receiver at any point in time or the energy into the receiver over a year's time using a Monte Carlo ray trace technique to solve the multiple integral equations. An artist's concept of this plant is shown in Figure 1-1.

Heliostats are arranged in the field around the tower in concentric circles. The ground cover, ratio of mirror area to field area, is varied by changing the spacing between heliostats in either or both the radial or azimuthal directions. Figure 1-2 shows the heliostat modeled in this program.

The receiver is modeled as an upright circular cylinder mounted atop a tower and held in place by three corbels. Sun rays from various parts of the field (redirected by the heliostats) enter the receiver cavity through the aperture and impinge on the interior surface of the receiver. Some heliostats close to the tower cutout perimeter may reflect, for part of day, the power onto the receiver roof, whereas the power from some heliostats farther away may whistle-through the aperture. The methodology of the program accounts for these phenomena as well as many more subtle phenomena. These are described in the methodology section of this manual.

Figure 1-1. Solar Pilot Plant

Figure 1-2. Experimental Heliostat Assembly

Although the Monte Carlo ray trace code described in this manual is quite design specific, the general program methodology and structure has been applied to a wide variety of designs. In the area of central receivers, the program has been used to model a number of receiver types, including an exposed surface sphere, cylinder, half cylinder, star or cone shape. A variety of aiming strategies has been used for each of these possible configurations. In addition, a planar target has been used for the tower top aperture opening when a cavity-type receiver is used.

For the heliostat, both Az-El and tilt-tilt gimbal sequences have been modeled. A single mirror facet per heliostat or multiple-mirror facets can be analyzed with either gimbal sequence. The code described in this manual has the tilt-tilt heliostat model which is restricted to a four-mirror facet configuration by the modeling of the frame structure. If the specific frame structure were eliminated, the code can be applied to any number of mirror facets, including a single facet design. The field layout of the heliostats has also been varied with past program versions. Rectilinear, both uniform and nonuniform, heliostat spacing has been modeled as well as hexagon packing. The version used in the present code orients each heliostat such that the outer tracking axis is normal to a line of sight to the tower. Both uniform and nonuniform field packing densities can be analyzed with the present code.

Other code versions have included options to perform flux mapping on a cavity aperture, a variety of mirror-focusing strategies, plant costing algorithms, reflectance analysis by wavelength and incidence angle and several techniques for analyzing design change impacts on performance. This program, however, is limited to the specific design described in this document.

Even though users of this program may not necessarily be acquainted with Monte Carlo methods, only an elementary explanation of the method is made. Further, no attempt is made at a rigorous derivation or mathematical justification of the vector identities or algebra. It is assumed any users are familiar with vector algebra techniques.

It is quite possible to obtain misleading results of the power or energy into the cavity by inappropriate choice of heliostat tracking errors and mirror surface errors or by selecting too few sun rays to be traced through the optical part of the model. However, repeated use of the program results in experience which is often the only helpful clue to the proper choice of magnitude of tracking and surface errors and number of rays.

Simulations are initiated by card input using the FORTRAN NAMELIST feature in a subroutine called INITCOL. All variables in the NAMELIST table are defaulted to a specific central receiver baseline model. Only those portions of the model which change from the baseline need be input by card.

It should be noted that units are mixed. English units are used for all dimensions and geometric descriptions while the SI system of units is used for the flux and energy descriptions.

HELIAKI, as listed in this report, is operational on the Control Data Corporation 6600 Computer.

SECTION 2

BASIC FORMULATION

Given a position of a heliostat relative to the receiver, the amount of energy carried from any point on the sun's surface monochromatically at any given instant depends on the exact path of the ray through the optical interfaces of the system. These interfaces are the mirrors on the heliostats and the actual surface of the receiver.

The angle made by any ray with respect to each mirror surface is a function only of the angular position on the solar disk whence the ray came and the impact point on the particular mirror.

Thus, for any wavelength and perfect optics, the energy carried from the sun to the receiver surface can be found by specifying the four coordinates of the ray, independent of the number of optical elements in the optics train.

If the sun's disk coordinates are δ_1 and δ_2 and the impact point coordinates are X_1 and X_2 , then the total thermal power absorbed in a wavelength interval $d\lambda$ is

$$E_{d\lambda} = \int_{X_1} \int_{X_2} \int_{\delta_1} \int_{\delta_2} E(X_1, X_2, \delta_1, \delta_2) dX_1 dX_2 d\delta_1 d\delta_2 \quad (1)$$

where X_1 and X_2 are bounded by the actual surface extent of the mirror. To obtain the energy from the entire solar spectrum, integration over all wavelengths is required. This yields

$$E_p = \underbrace{\int_{\lambda}}_{\text{total spectrum}} \underbrace{\int_{X_1} \int_{X_2}}_{\text{mirror surface}} \underbrace{\int_{\delta_1} \int_{\delta_2}}_{\text{sun disk}} E(X_1, X_2, \delta_1, \delta_2, \lambda) dX_1 dX_2 d\delta_1 d\delta_2 d\lambda \quad (2)$$

Introducing finite quality optics into the model introduces uncertainty in tracking accuracy and mirror quality.

There are four uncertain optical parameters that are known only statistically. The first two parameters are uncertainties in the angular position of the two gimbaled tracking drives (θ_1, θ_2). The second two parameters are the angular uncertainties in the mirror surface normal at any point on the mirror surface (ϕ_1, ϕ_2). We assume that each of these four parameters is statistically independent of each other or any other design parameter. For example, a given error in the mirror normal is equally likely anywhere on the mirror surface. The mirror is not known as a continuous surface with smooth waves or ripples but rather as a probability distribution of mirror normals perturbed from the mathematically correct shape by an assumed probability distribution. For each statistically known variable, the distribution is understood to be a "normal" or "standard error" distribution.

Now consider a random-variable Z defined by the normalized probability distribution $P(Z)$. If we wished to calculate the mean value of $Z (= \bar{Z})$ or its expected value, we would form the integral of the product of $P_Z(Z)$ times Z over all allowed values of Z , i. e.,

$$\bar{Z} = \int_{-\infty}^{\infty} P_Z(Z) Z dZ \quad (3)$$

To simulate a specific error set $(\theta_1, \theta_2, \phi_1, \phi_2)$, one would have to evaluate

$$E_p(\theta_1, \theta_2, \phi_1, \phi_2) = \int_{\lambda} \int_{X_1} \int_{X_2} \int_{\delta_1} \int_{\delta_2} E(X_1, X_2, \delta_1, \delta_2, \lambda, \theta_1, \theta_2, \phi_1, \phi_2) dX_1 dX_2 d\delta_1 d\delta_2 d\lambda \quad (4)$$

Then the expected value of the thermal power absorbed ($\bar{E}_p$) is given by:

$$\bar{E}_p = \int_{\theta_1} \int_{\theta_2} \int_{\phi_1} \int_{\phi_2} P_{\theta_1}(\theta_1) P_{\theta_2}(\theta_2) P_{\phi_1}(\phi_1) P_{\phi_2}(\phi_2) E_p(\theta_1, \theta_2, \phi_1, \phi_2) d\theta_1 d\theta_2 d\phi_1 d\phi_2 \quad (5)$$

because each distribution is statistically independent. The above expression is:

$$\bar{E}_p = \underbrace{\int_{\theta_1} \int_{\theta_2} \int_{\phi_1} \int_{\phi_2}}_{\substack{\text{tracking} \\ \text{errors}}} \underbrace{P_{\theta_1} P_{\theta_2} P_{\phi_1} P_{\phi_2}}_{\substack{\text{mirror} \\ \text{imper-} \\ \text{fections}}} \underbrace{\int_{\lambda} \int_{X_1} \int_{X_2} \int_{\delta_1} \int_{\delta_2}}_{\substack{\text{total} \\ \text{spectrum} \\ \text{mirror} \\ \text{area}}} \underbrace{E d\delta_2 d\delta_1 dX_2 d\lambda d\phi_2 d\phi_1 d\theta_2 d\theta_1}_{\text{sun disk}} \quad (6)$$

To calculate the total thermal power redirected from the field of heliostats onto the receiver, one sums over the total number of heliostats

$$E_T = \sum_{i=1}^{\text{number of mirrors}} \bar{E}_{p_i} \quad (7)$$

Furthermore, integration over the total number of hours of sunlight during any given time period results in the expression

$$W_T = \int_{\text{time period}} E_T dt \quad (8)$$

The stochastic nature of four of the independent variables in the ten-integrals of Equation (8) and the prime objective of performing a parametric study of the performance of the system led to the decision that the experimental Monte Carlo approach was more suitable to the problem.

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SECTION 3 METHODOLOGY

Basically, the premise of the method used to solve Equations (7) and (8) of the previous section is a Monte Carlo technique. Any Monte Carlo computation that yields quantitative results may be considered as estimating the value of a multiple integral. The simplest Monte Carlo approach is to observe random numbers, selected in such a way that they directly simulate the physical random processes of the problem at hand, and to deduce the required solution from the behavior of these numbers. In this program, that process involves the incident flux on the receiver over the direct solar flux on the heliostat field being equal to the convergent ratio of randomly drawn rays which reach the receiver divided by the total number of rays drawn uniformly over the heliostat field. Appropriate scaling of each ray value for reflectance and absorptance losses, tracking and reflective surface errors, etc., is included in the Monte Carlo simulation.

The simulation is accomplished by randomly selecting a sufficient number of sun rays to statistically represent the sun's intensity pattern as seen from the earth's surface. Solar limb darkening and atmospheric losses are accounted for. These same rays are allowed to impinge upon the entire heliostat field randomly and are reflected to the receiver should they strike a properly aligned reflecting surface. The rays drawn must represent the sun's power at that time so each ray is given a relative weighted value as a function of the time and the number of rays drawn. If annual energy is being calculated then each ray carries the appropriate amount of energy.

The general program flow to follow the physics of each interaction of individual rays through the optics train is shown in Figure 3-1. All executive-level tests are shown in the flow chart, from the mirror hit test to the receiver hit test. A number of check points along the ray path are not shown

Figure 3-1. Optical Model Software Logic Flow

in this figure but are documented in Appendix A where detailed subroutine flow charts are presented. The interested reader is directed to these flow charts for a thorough understanding of the program. Each test of a specific ray interaction is accomplished using ray trace techniques. Given any one randomly determined individual ray start point, the ray may be traced to the ground or to a mirror or frame surface. If a mirror hit is found the individual ray is traced to its final destination.

The ray trace technique uses vector algebra to track each ray along its optical path. The following subsections describe the primary steps in the vector derivations, as well as the basic modeling philosophy. The sections are ordered to follow the actual program flow.

BASE VECTORS

The basic reference vectors in the ray trace code describe local vertical ($\vec{N}$), local north ($\vec{UN}$) and local east ($\vec{UE}$). Each of these vectors is a unit vector and the set ($\vec{N}$, $\vec{UN}$, $\vec{UE}$) is an orthonormal triad which can be thought of as originating at the tower center. Variations in the direction of these vectors with respect to position on the field are not considered. Thus, the heliostat field is assumed to be a flat plane tangent to the surface of the earth at the tower base. Figure 3-2 shows the field and reference vectors as well as a sun vector ($\vec{UR}$).

The sun vector is simply a unit vector along the ray path from the sun's center to the point on the earth's surface at which the tower is located. The sun vector is considered to be the same over the entire plane of the heliostat field. This introduces an error of less than 1 minute of arc per mile of distance from the tower base.

Figure 3-2. Field, Reference and Sun Vectors

Each of the reference vectors and the sun vector is calculated in subroutine VECTS. The vectors are calculated based on an initial vector triad located at the earth's center. However, the construction of all other vectors required in the ray trace analysis depends only on the ($\vec{N}$, $\vec{UN}$, $\vec{UE}$) triad and the earth center triad can be ignored.

HELIOSTAT FIELD MODEL

One of the first steps in the Monte Carlo simulation is the uniform draw of ray start points over the heliostat field. Specifically, points are drawn uniformly over an imaginary surface which covers the field of heliostats called the test plane. If the mirrors were allowed to assume all possible rotational attitudes, they could occupy all points within a cylinder centered around the heliostat center. If all such cylinders were bounded by planes tangent to the top and bottom of each cylinder, the test plane would be the upper plane and the ground plane would be the lower plane. Figure 3-3 shows an edge view of this. Once a ray start point is drawn, the trace of the ray from its start point on the test plane to its terminus on the ground plane can be found. The ray start points are drawn in subroutine MONTE or MONTE2.

Figure 3-4 shows that only those heliostats which are "close" or "along" the ray trace from the test plane to the ground plane could be involved in redirecting the ray. It is important to limit the number of "hit tests" (subroutine INHIT) to be numerically performed on each ray to those heliostats which lie along the ray path. Clearly, if all heliostats were tested for a hit for each ray drawn, the run time would be prohibitive. A simple algorithm performs the identification of the few (nominally 10) heliostats which can interact with the ray.

The identification algorithm (subroutine FINDIT) is based on two facts:

- The cylinders of influence of the individual heliostats do not overlap each other.
- The heliostat center locations can be uniquely and quickly identified.

Consider a top view of the test plane with a typical ray path drawn (see Figure 3-5). In this example, the heliostat boundaries on the field are shown as portions of circle arcs and radii. For our purposes the heliostats are simply numbered from 0 to 8. Heliostat number 1 is bounded by radii r_i and r_{i+1} as well as a boundary equidistant between heliostat number 0 and 1 and 1 to 2. The top view of the ray path shows that only heliostat number 4 can actually intercept the ray and redirect it toward the tower. The ray trace program uses a simple search along the ray path to identify the center of all closest heliostats from ray start to end. The search for closest centers is based on the zone boundaries and not the cylinders of influence. For the example in Figure 3-5, this implies that heliostats 1, 2, 4 and 6 will be included in the list for possible hits.

The method used to develop the list of heliostats is to first find the closest heliostat to the start point. Then the closest heliostat to the end point is found. If the closest heliostat to both the start and end point is the same, then the list is complete. We also have the case, as shown in Figure 3-4, where start and end points are close to different heliostats. The program will then divide the ray path into many points and find the closest heliostat at each of these points along the ray path. The spacing of the test points along the line is not critical as long as it is less than one heliostat boundary dimension. When this test sweep is complete, the code has found a list of one, two or perhaps many different heliostats which could redirect the ray. The requirement that the heliostats cannot overlap guarantees that there are

Figure 3-3. Test and Ground Planes

Figure 3-4. Heliostats Along Ray Path

Figure 3-5. Top View of Ray Path and Cylinders of Influence

no other heliostats which could redirect the ray. This list of closest adjacent heliostats is more heliostats than could physically be involved with the ray.

It would be possible to further reduce the list of heliostats to be tested by using the distance formula to rule out any heliostats for which the closest ray approach lies outside the cylinder of influence. This was not done in the program because the distance formula requires as much computation time to execute as does the hit test itself and would add more complexity to the code.

HELIOSTAT HIT TEST

The next step in the process is to test all heliostats on the list of possibilities for a mirror hit. To establish a mirror hit or miss, the mirror normal must be constructed. This is done with knowledge of the sun vector, UR , and the mirror position and aim point relative to the tower base. As shown in Figure 3-6, a heliostat to be tested is at a position defined by the center coordinates X_c , Y_c , where the X axis lies along local east and Y is positive along local north. A vector from the heliostat center to the aim point on the aperture opening can be written as

$$\vec{T} = -X_c \vec{UE} - Y_c \vec{UN} + (TH - D_{col}/2) \vec{N} + \vec{\delta} \quad (9)$$

where $\vec{\delta}$ is a small vector from the tower top center out to the aim points (calculated in subroutine AIMPP). A unit vector pointing from the heliostat center to the aim point is

$$\vec{UT} = \vec{T}/|\vec{T}| \quad (10)$$

Using $\vec{UT}$ and $\vec{UR}$ the heliostat normal must be formed to redirect incoming rays along $\vec{UR}$ on the path to the aim point $\vec{UT}$. This is shown in Figure 3-7. The mirror normal, $\vec{UMN}$, is simply

$$\vec{UMN} = (\vec{UT} - \vec{UR}) / |\vec{UT} - \vec{UR}| \quad (11)$$

as calculated in subroutine MIRRNR.

The heliostat geometry used for all hit and blockage tests is shown in Figure 3-8. Honeywell's baseline heliostat consists of four mirror facets mounted on a single frame. The frame can be rotated about an outer axis to provide one tilt of the mirrors and an inner axis drive for each facet provides the other tilt function. The inner axis drive for all facets is provided by one motor such that the inner rotations are the same for all facets. However, the program does have an option to independently drive each inner axis (a separate motor for each facet).

The nominal mirror normal, $\vec{UMN}$ shown in Figure 3-7, is constructed as described above for the heliostat center position. This mirror normal is later rotated for a specified toe-in strategy (explained later) but, for the purpose of establishing a mirror hit the nominal mirror normal is assumed to be the normal for each facet. In addition to the mirror normal, a vector along the heliostat outer axis can be specified from knowledge of the heliostat center coordinates. The tilt-tilt baseline heliostat is oriented such that the outer axis is normal to the line of sight to the tower. This orientation is shown in Figure 3-9 and is considered advantageous with regard to mirror blockage losses and off-axis facet misalignment. Using this orientation rule, a unit vector along the outer axis is given by

$$\vec{UHV} = (Y_c \vec{UE} - X_c \vec{UN}) / \sqrt{Y_c^2 + X_c^2} \quad (12)$$

Figure 3-6. Construction of Tower Vector ($\vec{T}$)

Figure 3-7. Unit Normal ($\vec{UMN}$)

Figure 3-8. Helio-stat Geometry
(not to scale)

Figure 3-9. Helio-stat Orientation

The remainder of the vectors needed to describe the heliostat frame and nominal facet orientations are found from $\overrightarrow{UMN}$ and $\overrightarrow{UHV}$ (as calculated in subroutine TRIADS). Referring to Figure 3-8, the vector along the inner axis of each facet is $\overrightarrow{UAXV}$, which is constructed by

$$\overrightarrow{UAXV} = \overrightarrow{UMN} \times \overrightarrow{UHV} / |\overrightarrow{UMN} \times \overrightarrow{UHV}| \quad (13)$$

The vector normal to the inner axis of each facet, and lying in the plane of the facet is $\overrightarrow{UXV2}$, which is simply

$$\overrightarrow{UXV2} = \overrightarrow{UAXV} \times \overrightarrow{UMN} \quad (14)$$

The last vector needed to define the frame orientation is $\overrightarrow{UBEDN}$, the normal to the top plane of the heliostat frame as found by

$$\overrightarrow{UBEDN} = \overrightarrow{UAXV} \times \overrightarrow{UHV} \quad (15)$$

Finally, the heliostat hit test can be most easily thought of as a series of four individual mirror facet hit tests. The geometry for each mirror hit test is shown in Figure 3-10, where r_{col} is the diameter of the cylinder of influence, (X_p, Y_p) are the east and north coordinates of the ray start point and $\overrightarrow{UR}$ is the sun vector.

Figure 3-10. HIT Test Geometry

The vector from the start point to the hit point on the plane of the heliostat is given by

$$\vec{VR} = \vec{UR} L \quad (16)$$

where L is an unknown length from the start point to the hit point on the plane.

Recall that any line not parallel to a plane must intersect the plane (not necessarily within the heliostat mirror boundary) at one and only one point. Thus, there will always be a real value of L . We can also write a vector from the ray start point to the center of the test facet (to be called $\vec{VC}$), which is given by

$$\vec{VC} = \vec{UE}(x_c - x_p) + \vec{UN}(y_c - y_p) + \vec{N} D_{col}/2 - D_{test} \vec{UHV} \quad (17)$$

where $(\vec{UE})$ is a unit vector along the local east direction (positive east), $(\vec{UN})$ is a unit vector along local north (positive north) and $(\vec{N})$ is the unit normal to the earth surface (vertical up positive). The D_{test} term is the distance from the heliostat center to the test facet center.

Since both $\vec{VC}$ and $\vec{UR}$ go from the same point in space to the surface of a plane normal to $\vec{UMN}$ they must have the same projected length along $\vec{UMN}$ even though they do not enter the $\vec{UMN}$ plane at the same point. Thus, we can write the identity

$$\vec{VC} \cdot \vec{UMN} = \vec{VR} \cdot \vec{UMN} \quad (18)$$

and substituting Equation (16) into Equation (18) we have

$$\vec{VC} \cdot \vec{UMN} = L \vec{UR} \cdot \vec{UMN} \quad (19)$$

which is a scalar equation for the unknown L . Now that we know the vector $\vec{VR}$ we can calculate where $\vec{VR}$ touches the plane relative to the mirror facet center.

The vector in the mirror surface plane from the center of the facet out to the point where the ray hits the plane is given by

$$\begin{aligned}\vec{RRIF} &= \vec{VR} - \vec{VC} \\ &= L \vec{UR} - \vec{SC}\end{aligned}\tag{20}$$

The hit test is completed by simply comparing the hit point coordinates, as calculated from $\vec{RRIF}$, to the facet boundaries on the $\vec{UMN}$ plane. The order of heliostats tested in this way is from the ray start point to the end point. Thus the first time a hit is found the ray is redirected. Succeeding facets and heliostats (if any) are also tested and any hits are added to the shadow count.

Since the mirror facets are held in place by a frame structure as previously shown, it is possible that the frame may shadow the mirror surface. For any ray which is found to hit a mirror surface, the program will check for a prior hit on the frame structure. The frame modeled in the ray trace code consists of two "I" beam side supports, three "I" beam cross members and angle iron braces in the top frame plane. Figure 3-11 shows a sketch of the frame without mirror facets and some of the vectors required to test for a frame shadow. The " $\vec{VS}$ " vectors start at the ray start point on the test plane and extend to a point on the frame corresponding to the middle of one of the seven different planes defined by the "I" beam structure. For example, the vector $\vec{VS5}$ goes from the ray start point (X_p, Y_p) to the middle of the plane defined by the vertical member of the first "I" beam cross member. Similarly, the $\vec{VS1}$ vector goes from the start point to the middle of the top plane as defined by the top piece of all "I" beams and the angle iron braces. The construction of the " $\vec{VS}$ " vectors required for the frame shadow test is given below:

Figure 3-11. Heliostat Frame Model

$$\vec{VS1} = (X_c - X_p)\vec{UE} + (Y_c - Y_p)\vec{UN} - \frac{DCOL}{2} \vec{N} - HTMIR \vec{UBEDN} \quad (21)$$

$$\vec{VS2} = \vec{VS1} + \left(\frac{WD+CAP+WLONG}{2}\right) \vec{UAXV} - \frac{WSIDE}{2} \vec{UBEDN} \quad (22)$$

$$\vec{VS3} = \vec{VS1} - \left(\frac{WD+CAP+WLONG}{2}\right) \vec{UAXV} - \frac{WSIDE}{2} \vec{UBEDN} \quad (23)$$

$$\vec{VS4} = \vec{VS1} - \frac{HTCROS}{2} \vec{UBEDN} \quad (24)$$

$$\vec{VS5} = \vec{VS4} - XDF \vec{UHV} \quad (25)$$

$$\vec{VS6} = \vec{VS4} + XDF \vec{UHV} \quad (26)$$

$$\vec{VS7} = \vec{VS1} - HTCROS \vec{UBEDN} \quad (27)$$

Where the definition of the scalar dimensional quantities may be found in Appendix C.

A frame hit test follows the logic of the mirror hit test very closely. Each plane of the frame structure is defined by a plane normal vector already constructed by our definition of the heliostat orientation vectors. For the top and bottom planes, $\overrightarrow{UBEDN}$ is the plane normal. For the vertical members of the "I" beam cross braces, the plane normal is defined by $\overrightarrow{UHV}$ and the side structures vertical member's plane normal is $\overrightarrow{UAXV}$.

As an example of the hit test, consider the frame top plane. A vector from the start point to the sun ray hit point on the plane is $L \cdot \overrightarrow{UR}$. As in the mirror hit test we have two vectors, $L \cdot \overrightarrow{UR}$ and $\overrightarrow{VS1}$, which start at a single location in space and end on a plane with known surface normal, in this case $\overrightarrow{UBEDN}$. The length L from the start point to the hit point along the sun vector $\overrightarrow{UR}$ is found by

$$L \cdot \overrightarrow{UR} \cdot \overrightarrow{UBEDN} = \overrightarrow{VS1} \cdot \overrightarrow{UBEDN} \quad (28)$$

which is a scalar equation for L . The vector from the plane center point (1) to the hit point is

$$\overrightarrow{RHIT} = -\overrightarrow{VS1} + L \cdot \overrightarrow{UR} \quad (29)$$

Then for an x, y coordinate system centered at point 1 of Figure 3-11, the coordinates of the hit point are:

$$XHIT = \overrightarrow{RHIT} \cdot \overrightarrow{UHV} \quad (30)$$

and

$$YHIT = \overrightarrow{RHIT} \cdot \overrightarrow{UAXV} \quad (31)$$

where $\overrightarrow{UAXV}$ is a unit vector along the facet axle and $\overrightarrow{UHV}$ is a unit vector along the heliostat outer axle. A simple check is made to determine if the ray hit a frame by comparing the values of $XHIT$ and $YHIT$ to the dimensions of that portion of the frame. Again the order of the heliostats tested in this way is from ray start to hit point. Thus, the first time a frame hit is found it is compared to the mirror hit to determine which came first along the ray path. If a frame hit is found prior to the mirror hit, then a frame shadow exists. If no frame shadow exists the ray will be reflected from the mirror surface.

REFLECTED RAY

To this point, the analysis has not involved the finite size of the sun or the tracking uncertainties of the heliostats. This simply means that the ray has been traced from its uniform draw start point to the mirror or the ground. Physically this means that we have ignored the finite size of the sun and the tracking errors in the shadow analysis. The finite sun and finite tracking errors tend to "blur" the edges of the mirrors and the edges of the shadows somewhat when taken on average over the whole field.

If at this point in the flow, one of the heliostats on the list of possibilities has in fact tested out to have a hit, we proceed to perturb $\overrightarrow{UR}$ and $\overrightarrow{UMN}$ for the finite sun size, the tracking errors and the mirror surface slope uncertainty. To begin the perturbation process a ray start point is drawn over the sun's face. The simplest case of this is the assumption that the sun is a "flat" disk of brightness in the sky. The plot of this is shown in Figure 3-12. The uniform draw over a disk is simply a uniform draw over the polar coordinate (θ) and a weighted draw over ρ (see Figure 3-13).

The weighted draw over ρ comes from the fact that more rays must be drawn in the annulus ρ to $\rho + d\rho$ at large values of ρ than at small values of ρ . Another

way to consider this is to plot the sun's energy from 0 out to ρ versus ρ (see Figure 3-14). The formula for this curve is simply

$$E = E_T (\rho/\rho_{\max})^2 \quad (32)$$

where E_T is the total energy from the sun's disk and $\rho_{\max}$ is the maximum angular extent of the sun.

Thus, if we want to draw uniformly over the area of the disk, we simply draw uniformly over the abscissa (energy axis) of Figure 3-14 and Equation (32) is inverted to find the ordinate value (ρ) which we want. Thus, if we draw the random number x_1 uniformly from 0 to 1 then the value of ρ for each x_1 is given by the inverse of Equation (32) or

$$\rho = \rho_{\max} \sqrt{x_1} \quad (33)$$

The (θ) coordinate is found from another (independent) uniform number x_2 drawn from 0 to 1 by

$$\theta = 2\pi x_2 \quad (34)$$

If we arbitrarily define two axes in the sun face ($\overrightarrow{UX_1}$, $\overrightarrow{UX_2}$) then the rotation angles of $\overrightarrow{UR}$ about these axis ($\Delta\theta_1$, $\Delta\theta_2$) are shown in Figure 3-15, which are given by

$$\Delta\theta_1 = \rho \sin \theta \quad (35)$$

$$\Delta\theta_2 = \rho \cos \theta \quad (36)$$

Thus, we can perturb $\vec{UR}$ into $\vec{UR}'$ with

$$\vec{UR}' = \frac{(\vec{UR} - \tan \Delta\theta_2 \vec{UX1} - \tan \Delta\theta_1 \vec{UX2})}{\sqrt{1 + \tan^2 \Delta\theta_2 + \tan^2 \Delta\theta_1}} \quad (37)$$

The three-space drawing from which this can be derived is shown in Figure 3-16. Notice that $(\vec{UR}, \vec{UX1}, \vec{UX2})$ form an orthonormal triad.

This is all the vector algebra necessary to incorporate the finite sun size into the analysis. The computer code includes a limb-darkening option and an option with limb darkening and scattering outside the geometric sun perimeter.

The process we have outlined here is the same for both of these options except that the weighted draw of ρ is weighted in such a way that the draw is again uniform over the new solar disk energy distribution. This involves plotting brightness versus angular distance from the sun's center and integrating energy as before. Then, the integrated energy curve is curve-fit and the fit function is inverted. This inverse function (analogous to Equation (33) is then the basis for the draw.

The next step in the trace process is to perturb the unit mirror normal $\vec{UMN}$ for the uncertainties in heliostat tracking (subroutine PERT3). This involves a first rotation of $\vec{UMN}$ about an axis (the outer axis) which is not normal to it. The essential vectors were previously described as the heliostat orientation vectors as shown in Figure 3-17. The rotation for outer axis tracking errors is a rotation about the $\vec{UHV}$ vector. The triad used for this rotation is $(\vec{UBEDN}, \vec{UAXV}, \vec{UHV})$ as shown in Figure 3-18. The rotation (tracking error) is shown as $\Delta\phi_1$ and the rotated heliostat orientation vectors are shown as dashed vectors $\vec{UBEDN}'$ and $\vec{UAXV}'$. The vectors are constructed by

Figure 3-12. Ray Start Point Plot

Figure 3-13. Uniform and Weighted Draw

Figure 3-14. Energy Plot

Figure 3-15. Rotation Angles

Figure 3-16. Three-Space Drawing

Figure 3-17. Heliostat Orientation Vectors

$$\overrightarrow{UBEDN'} = \cos \Delta\phi_1 \overrightarrow{UBEDN} + \sin \Delta\phi_1 \overrightarrow{UAXV} \quad (38)$$

$$\overrightarrow{UAXV'} = \cos \Delta\phi_1 \overrightarrow{UAXV} - \sin \Delta\phi_1 \overrightarrow{UBEDN} \quad (39)$$

Next, the effect of this rotation on the nominal mirror normal must be developed. Referring to Figure 3-18, the $\overrightarrow{UMN}$ and $\overrightarrow{UXV2}$ vectors must rotate around $\overrightarrow{UHV}$. With the rotation about $\overrightarrow{UHV}$ the components of $\overrightarrow{UMN}$ and $\overrightarrow{UXV2}$ along $\overrightarrow{UHV}$ are unchanged. The magnitude of the projections of $\overrightarrow{UMN}$ and $\overrightarrow{UXV2}$ onto $\overrightarrow{UBEDN}$ and $\overrightarrow{UAXV}$ are the same as the projections onto the rotated frame normal and inner axis vectors, $\overrightarrow{UBEDN'}$ and $\overrightarrow{UAXV'}$.

Reference back to Figure 3-17 may aid in clarifying this fact. Therefore, the rotated vectors can be written as

$$\overrightarrow{UMN}' = (\overrightarrow{UMN} \cdot \overrightarrow{UHV}) \overrightarrow{UHV} + (\overrightarrow{UMN} \cdot \overrightarrow{UBEDN}) \overrightarrow{UBEDN}' \quad (40)$$

$$\overrightarrow{UXV2}' = (\overrightarrow{UXV2} \cdot \overrightarrow{UHV}) \overrightarrow{UHV} + (\overrightarrow{UXV2} \cdot \overrightarrow{UBEDN}) \overrightarrow{UBEDN}' \quad (41)$$

The second rotation is for tracking errors about the inner axis. The angular error is denoted as $\Delta\phi_2$. The rotation in this case is about the vector $\overrightarrow{UAXV}'$. Only the vectors associated with the mirror facet must be rotated. These vectors ($\overrightarrow{UMN}'$ and $\overrightarrow{UXV2}'$) and the rotation are shown in Figure 3-19. The fully rotated vectors are

$$\overrightarrow{UMN}'' = \cos \Delta\phi_2 \overrightarrow{UMN}' + \sin \Delta\phi_2 \overrightarrow{UXV2}' \quad (42)$$

$$\overrightarrow{UXV2}'' = \cos \Delta\phi_2 \overrightarrow{UXV2}' - \sin \Delta\phi_2 \overrightarrow{UMN}' \quad (43)$$

The error angles ($\Delta\phi_1$, $\Delta\phi_2$) are drawn at random with a normal distribution (standard error distribution) having a mean and variance specified by the user of the program. If the details of the heliostat drive mechanism can be more accurately modeled a distribution of error angles which more nearly matches the reality of the system could be substituted easily for the normal distribution.

Recall that the derived $\overrightarrow{UMN}''$ vector is the nominal mirror normal at the optical axis of the heliostat. In other words, it describes the position of an imaginary mirror facet located at the heliostat geometric center. The actual normal for any one of the individual heliostat facets differs slightly from this normal in that each facet may be toed-in, or canted slightly toward the heliostat center to improve the total heliostat focusing ability. A possible toe-in alignment is shown for a side view in Figure 3-20. The program may develop a toe-in angle, θ_t , for each facet of each heliostat in the field (subroutine TOEIN). The toe-in angle is specified by a reference sun position for which all mirror facets in the field are aligned to redirect incoming rays as nearly as possible to a single focal point. Given the toe-in angle for a specific mirror facet, the facet center normal and tangent vectors are constructed by

Figure 3-18. Rotated Heliostat Orientation Vector

Figure 3-19. $\vec{UMN}$ and $\vec{UXV2}$ Rotation

$$\overrightarrow{UMN}_i'' = \cos \theta_t \overrightarrow{UMN}'' + \sin \theta_t \overrightarrow{UXVZ}'' \quad (44)$$

$$\overrightarrow{UXVZ}_i'' = \cos \theta_t \overrightarrow{UXVZ}'' - \sin \theta_t \overrightarrow{UMN}'' \quad (45)$$

This represents a simple rotation of the mirror facet orientation vectors about the inner axis and is quite similar to the rotation for tracking errors on the inner axis.

The mirror normal at the hit point on the facet surface is found from knowledge of the facet shape. For the baseline tilt-tilt heliostat, each facet has a spherical surface which focuses at a distance F_s such that the radius of curvature is $2F_s$. The facet surface and required vectors are shown in Figure 3-21. Recall that the vector from the facet center to the hit point, $\overrightarrow{RHS}$, was found in the mirror hit test derivation and was previously called $\overrightarrow{RRIF}$. By ignoring the small displacement between the hit point indicated by $\overrightarrow{RHS}$ and the actual mirror surface location, the mirror normal at the hit point ($\overrightarrow{UNN}''$) can be found by

$$\overrightarrow{UNN}'' = (-\overrightarrow{RHS} + 2F_s \overrightarrow{UMN}_i'') / (\overrightarrow{RHS} + 2F_s \overrightarrow{UMN}_i'') \quad (46)$$

Neglecting the small displacement can be thought of as modeling the facet surface as a fresnel mirror so that each element in the mirror is approximately in a single plane normal to the nominal mirror normal.

A local facet tangent vector is constructed as follows:

$$\overrightarrow{TT} = \overrightarrow{RHS} - (\overrightarrow{RHS} \cdot \overrightarrow{UNN}'') \overrightarrow{UNN}'' \quad (47)$$

and a unit vector tangent to the mirror surface at the hit point is

$$\overrightarrow{UTT}'' = \overrightarrow{TT} / |\overrightarrow{TT}| \quad (48)$$

Figure 3-20. HelioStat Optical Model

Figure 3-21. HelioStat Facet Vector

To complete a triad at the hit point, a second tangent vector is found by

$$\overrightarrow{UT2''} = \overrightarrow{UTT''} \times \overrightarrow{UNN''} \quad (49)$$

The next and final perturbation of the heliostat mirror normal is the angular rotation which represents mirror surface irregularity. The sketch of this perturbation is shown in Figure 3-22. The final, fully perturbed mirror normal vector is called $\overrightarrow{UNNP}$ and is given by

$$\overrightarrow{UNNP} = \cos \delta_1 \overrightarrow{UNN''} + \sin \delta_1 (\cos \delta_2 \overrightarrow{UTT''} + \sin \delta_2 \overrightarrow{UT2''}) \quad (50)$$

where δ_2 is drawn uniformly from 0 to 360 degrees and δ_1 is drawn with a normal distribution having a specified mean and variance. Physically, what this last perturbation means is that the mirror surface normal is locally out of alignment with the average normal by an amount δ_1 . The plane in which the δ_1 rotation occurs is equally likely to occur in any direction around the local azimuth. Recall that at this point in the ray trace we can find the position on the heliostat of the ray being traced from the vector $\overrightarrow{RRIF}$. With this we could include a perturbation of the normal which was a function of position on the heliostat surface. Such a position-dependent variation could be a gravity or wind load deflection. If the wind forces and deflections were known only stochastically, this also could be included in the analysis. The code, to date, has not been modified for these types of local errors.

The reflected ray vector can now be calculated from the mirror normal $\overrightarrow{UNNP}$ and the sun vector $\overrightarrow{URP}$. The vector algebra simply obeys Snell's Law as shown in Figure 3-23. The reflected ray unit vector $\overrightarrow{US1}$ is

$$\overrightarrow{US1} = -2(\overrightarrow{UR'} \cdot \overrightarrow{UNNP}) \overrightarrow{UNNP} + \overrightarrow{UR'} \quad (51)$$

Thus, the $\overrightarrow{US1}$ vector represents a ray path which includes the effects of a finite sun size, imperfect tracking drives, a facet toe-in strategy, and mirror surface imperfections.

Figure 3-22. Mirror Normal Perturbation

Figure 3-23. Reflected Ray Vector

BLOCKAGE

The next check point along the ray path is to determine whether or not the reflected ray ($\overrightarrow{US1}$) passes cleanly out of the mirror field. The first step in this process checks for a block by another mirror facet on the same heliostat as the hit facet, or by the frame structure which supports the facets.

The blockage test for mirror facet is much the same as the mirror hit test already described. The test consists of finding the intersection of the reflected ray $\overrightarrow{US1}$ with the plane of another mirror facet with normal $\overrightarrow{UMN}$. For the purposes of deciding whether or not $\overrightarrow{US1}$ is blocked, we ignore the effect of the small error rotations on the mirror normal vectors. This results in translations on the order of inches while pertinent facet dimensions are on the order of many feet.

The geometry for a mirror blockage test is shown in Figure 3-24. The vector $\overrightarrow{XC}$ starts at the middle of the hit facet and goes to the middle of the test facet. If the unknown length of the vector from the incoming ray hit point to the outgoing ray ($\overrightarrow{US1}$) blockage point is called L , then our basic hit test formulation for L is

$$L \overrightarrow{US1} \cdot \overrightarrow{UMN} = (\overrightarrow{XC} - \overrightarrow{RHS}) \cdot \overrightarrow{UMN} \quad (52)$$

from which we can easily solve for the length L . The vector from the test facet center to the blockage point is $\overrightarrow{RRB}$, which, by simple vector addition is

$$\overrightarrow{RRB} = -\overrightarrow{XC} + \overrightarrow{RHS} + L \overrightarrow{US1} \quad (53)$$

The blockage test is completed by comparing the blockage point coordinates as defined by $\overrightarrow{RRB}$ to the test facet mirror boundaries. If a block is found, the blockage test is completed. If no block is found on any test facet then we proceed to check for frame blocks.

Figure 3-24. Mirror Blockage Test

The frame block test is again similar to the frame hit test and the method will not be repeated here. If a frame block is not found the program will go on to check for blockage by neighboring heliostat mirror facets or frames. These tests logically follow the procedures already discussed. The first step in the procedure is to find the list of all neighboring heliostats which could block the ray. The closest heliostats are found for a ray path extending from the mirror hit point to the test plane along $\overrightarrow{US1}$. As for incoming rays, the list of closest heliostats is developed by checking first the start and end point of the closest heliostats. For the blockage list, the first heliostat is the hit heliostat. If the last heliostat is the same as the first then no blockage by adjacent heliostats is possible and the procedure is terminated.

When other heliostats are in the outgoing ray path, the code checks one by one for blocks, with mirrors blocks checked first and frame blocks second. Tests for hit points are by now familiar to the reader. One brief example here should sufficiently describe the blockage test for adjacent heliostats. For instance, a block by the frame of a neighboring heliostat is shown in Figure 3-25. On this example, the incoming ray ($\overrightarrow{UR}$) hits the facet on the far left of the first heliostat and the reflected ray ($\overrightarrow{US1}$) is shown to strike the adjacent heliostat frame on the vertical plane of the near side "I" beam.

Figure 3-25. Frame Block by Neighboring Frame

The " $\overrightarrow{VS}$ " vector from the hit point to the center of the test frame plane is $\overrightarrow{VS2}$. The length of the vector along $\overrightarrow{US1}$ from the hit point to the blockage point is L such that

$$L \overrightarrow{US1} \cdot \overrightarrow{UAXV} = \overrightarrow{VS2} \cdot \overrightarrow{UAXV} \quad (54)$$

where $\overrightarrow{UAXV}$ is normal to the test plane in this example. The above equation is solved for L and the vector from the test plane center to the blockage point ($\overrightarrow{RHIT}$) is

$$\overrightarrow{RHIT} = -\overrightarrow{VS2} + L \overrightarrow{US1} \quad (55)$$

By checking the end point of $\overrightarrow{RHIT}$ against the dimensions of the frame side member a block or no block is determined. If the blockage tests are completed and no blocks are found, then the redirected ray has cleared the test plane and can be checked for receiver hits.

RECEIVER HITS

Two routines, CONE and PIPE, are used to determine whether or not the ray hit the receiver and if it hit, where on the receiver the hit occurred. If the ray misses, another is drawn and the process starts over. If it hits, the hit total is incremented and sorted out by location on the receiver to obtain flux maps of the receiver surface. The ray trace code keeps track of the final ray disposition at the receiver by aperture misses high, misses wide or misses low, corbel hits, rays going through and cavity wall or receiver hits.

The cavity aperture is defined as a portion of a cone of angle θ_c , and a cone radius, R_{cone} , at a set height up the aperture ($HTOT/2$). The nomenclature is shown below.

The cone can be located anywhere in space as defined by an orthonormal triad ($\vec{UN}$, $\vec{UE}$, $\vec{N}$) and vector $\vec{D}$ from the origin of the ray to be tested to the center of the lower disc of a cone frustum. Figure 3-26 shows the cone extended infinitely, and the test ray. The cone vertex is defined to be at height z_o where z is the distance along the cone axis such that $z = 0$ at the lower aperture disc. Then z_o is calculated as

$$z_o = \frac{HTOT}{2} - \frac{R_{\text{cone}}}{\tan \theta_c} \quad (56)$$

Figure 3-26. Cavity Aperture Cone

The ray to be tested for a hit is $\overrightarrow{US1}$ and unit vector $\vec{N}$ is required to be along the cone axis.

The vector algebra for the cone hit test needs the formulation of two other vectors which define a hit plane normal to the cone axis at a height z_{hit} , the distance from $z = 0$ to the test ray entry or exit point. The vector from the lower aperture disc center to the hit plane along the cone axis is simply $z_{hit} \vec{N}$ and the vector from the hit plane center to the actual test ray hit point is defined as $\overrightarrow{RHIT}$. From simple vector addition $\overrightarrow{RHIT}$ is,

$$\overrightarrow{RHIT} = -AL \overrightarrow{US1} + \vec{D} + z_{hit} \vec{N} \quad (57)$$

where AL is the distance from the test ray origin to the hit point on the cone. There are two hit points and thus two hit planes and hit vectors which will be solved for in the algebra. For now, only one hit point, defined by one set of $\overrightarrow{RHIT}$, AL and z_{hit} is carried.

Vector $\overrightarrow{RHIT}$ has a magnitude defined by the height of the hit plane from the cone vertex,

$$|\overrightarrow{RHIT}| = (z_{hit} - z_o) \tan \theta_c \quad (58)$$

or since the magnitude of $\overrightarrow{RHIT}$ is defined by $\overrightarrow{RHIT} \cdot \overrightarrow{RHIT}$;

$$\begin{aligned} |\overrightarrow{RHIT}|^2 &= \overrightarrow{RHIT} \cdot \overrightarrow{RHIT} \\ &= (z_{hit} - z_o)^2 \tan^2 \theta_c \end{aligned} \quad (59)$$

Using Equation (57) for the vector $\overrightarrow{RHIT}$ leaves one equation with two unknowns: z_{hit} and AL. This distance AL can be calculated since both AL $\overrightarrow{US1}$ and $(\vec{D} + z_{hit} \vec{N})$ extend from the same point in space to the surface of the hit plane with unit normal $\vec{N}$. Therefore, both AL $\overrightarrow{US1}$ and $\vec{D} + z_{hit} \vec{N}$ must have the same projected length along N. Expressed algebraically,

$$(\vec{D} + Z_{\text{hit}} \vec{N}) \cdot \vec{N} = AL \vec{US1} \cdot \vec{N} \quad (60)$$

Equations (57), (59), and (60) can be combined to yield a quadratic in Z_{hit} or AL . Substituting for AL gives:

$$\begin{aligned} & Z_{\text{hit}}^2 \{1/(\vec{US1} \cdot \vec{N})^2 - 1 - \tan^2 \theta_c\} \\ & + Z_{\text{hit}} \{2(\vec{D} \cdot \vec{N})/(\vec{US1} \cdot \vec{N})^2 - 2(\vec{US1} \cdot \vec{D})/(\vec{US1} \cdot \vec{N}) + 2 Z_o \tan \theta_c\} \\ & + \left\{ -2 \frac{(\vec{D} \cdot \vec{N})(\vec{US1} \cdot \vec{D})}{\vec{US1} \cdot \vec{N}} + \frac{(\vec{D} \cdot \vec{N})^2}{(\vec{US1} \cdot \vec{N})^2} + (\vec{D} \cdot \vec{D}) - Z_o^2 \tan^2 \theta_c \right\} = 0 \end{aligned} \quad (61)$$

The solution of the quadratic gives the two piercing points (entry and exit) of the test ray with the cone. Imaginary roots indicate that the test ray failed to hit the cone. The entry and exit heights of the test ray are all that is required to determine if the incoming ray hit a corbel, went through the aperture, missed the aperture opening high or low or is a valid ray entering the cavity opening.

The subroutine PIPE is used to determine the hit point of rays entering the cavity, which is a right circular cylinder. When a hit is established, the two piercing points on the cylinder are computed and this information is used in the cavity wall flux mapping routines. The general method for finding the hit points is established below.

A right circular cylinder of radius R_{CYL} can be located anywhere in space as defined by the orthogonal triad set $(\vec{UN}, \vec{UE}, \vec{N})$ and vector $\vec{D}$ from the origin of the ray to be tested. Figure 3-27 shows the cylinder and test ray nomenclature. Unit vector $\vec{N}$ is along the cylinder axis and $\vec{US1}$ is the ray to be tested for hits on the cylinder. The vector $\vec{D}$ must go from the test ray origin to the center of the cylinder. The plane defined by $(\vec{UN}, \vec{UE})$ at the terminal point of $\vec{D}$ is the reference height along the cylinder ($z = 0$).

Figure 3-27. Cylinder and Test Ray Nomenclature

The vector algebra for the hit test requires that two other vectors be defined. First, a vector from the center of the reference plane to the center of a hit plane is defined as $\overrightarrow{VUP}$. Figure 3-27 shows the vector for one of the hit planes. There are two hit planes, one at height z_1 for the ray entry point and another at height z_2 for the ray exit point. For the ray entry test plane,

$$\overrightarrow{VUP} = z_1 \vec{N} \quad (62)$$

The second vector required is from the test plane center to the hit point on the cylinder. This vector is

$$\overrightarrow{RHC} = L_1 \vec{US1} - (z_1 \vec{N} + \vec{D}) \quad (63)$$

where the test ray ($\overrightarrow{US1}$) must be a vector of unit magnitude. The distance from the test ray origin to the hit point on the cylinder is defined as L_1 . This distance can be calculated since both $L \overrightarrow{US1}$ and $(\vec{D} + \overrightarrow{VUP})$ extend from the same point in space to the surface of the test plane with normal $\vec{N}$. Under these conditions both $L \overrightarrow{US1}$ and $(\vec{D} + \overrightarrow{VUP})$ must have the same projected length along $\vec{N}$, therefore:

$$L_1 \overrightarrow{US1} \cdot \vec{N} = (\vec{D} + \overrightarrow{VUP}) \cdot \vec{N} \quad (64)$$

or

$$L_1 = \frac{(\vec{D} + Z_1 \vec{N}) \cdot \vec{N}}{\overrightarrow{US1} \cdot \vec{N}} \quad (65)$$

By substituting L_1 from Equation (65) into Equation (63) we obtain

$$\overrightarrow{RHC} = \left(\frac{\vec{D} \cdot \vec{N} + Z_1}{\overrightarrow{US1} \cdot \vec{N}} \right) \overrightarrow{US1} = (Z_1 \vec{N} + \vec{D}) \quad (66)$$

Since $\overrightarrow{RHC}$ goes from the axis of the cylinder to the hit point, it must have a magnitude equal to the radius of the cylinder.

$$\overrightarrow{RHC} \cdot \overrightarrow{RHC} = R_{cyl}^2$$

Substituting $\overrightarrow{RHC}$ from Equation (66) into Equation (67) yields a quadratic in Z

$$\begin{aligned} & Z^2 \left[\frac{1}{(\overrightarrow{US1} \cdot \vec{N})^2} - 1 \right] + Z \left[\frac{2(\vec{D} \cdot \vec{N})}{(\overrightarrow{US1} \cdot \vec{N})^2} - \frac{2(\vec{D} \cdot \overrightarrow{US1})}{\overrightarrow{US1} \cdot \vec{N}} \right] \\ & + \left[\frac{(\vec{D} \cdot \vec{N})^2}{(\overrightarrow{US1} \cdot \vec{N})^2} - \frac{2(\vec{D} \cdot \vec{N})(\vec{D} \cdot \overrightarrow{US1})}{\overrightarrow{US1} \cdot \vec{N}} + \vec{D} \cdot \vec{D} - R_{cyl}^2 \right] = 0 \end{aligned} \quad (67)$$

The solution of the quadratic yields the heights Z_1 and Z_2 of two piercing points of the test ray. Imaginary roots indicate that the ray failed to hit the cylinder. The distances L_1 and L_2 may be found from Equation (65) and the $\overrightarrow{RHC}$ vectors from Equation (63). For cavity wall flux maps it is necessary to determine the location of the hit points in terms of local coordinates on the test plane. A scalar x and y may be found by

$$x = \overrightarrow{RHC} \cdot \overrightarrow{UE}$$

$$y = \overrightarrow{RHC} \cdot \overrightarrow{UN}$$

This x, y system is shown in Figure 3-28, the x axis being along UE and y along UN . The zoning of the cylinder is more commonly done in polar coordinates so the FORTRAN passes the angles θ_1 and θ_2 from the y axis to the hit points.

Figure 3-28. Test Plan Coordinate System

APPENDIX A
SUBROUTINE DESCRIPTIONS AND FLOWCHARTS

This appendix includes a description of all subroutines in the program with an associated program logic flowchart. The description of each subroutine is given on the same page as the flowchart to aid in understanding the logic flow of each.

AIMPP calculates a vector from the heliostat to the receiver aperture opening such that the heliostat will redirect the sun image to miss the corbels.

Figure A-1. AIMPP Program Flow

CHECK R tests ortho-
normality of a vector triad

Figure A-2. CHECK R Program Flow

CONE determines the hit point of a re-directed ray with the cavity aperture modeled as a portion of a cone. The piercing points (entry and exits) on the cone are found by solving a quadratic. Imaginary roots indicate that the ray missed cone.

Figure A-3. CONE Program Flow

Figure A-4. DOTER Program Flow

FDRIVE sets up the hit facets vector triad for heliostats with independent facet drives. The facet inner drive axis is rotated to a position such that the redirected beam is as close as possible (ignoring tracking errors) to the desired aim point.

Figure A-5. FDRIVE Program Flow

FINDIT generates a list of mirrors that lie along an incoming or outgoing ray path. It performs this function by calculating which mirrors could intersect the incoming or outgoing ray between a test plane and the ground plane.

Figure A-6. FINDIT Program Flow

Figure A-6. (Continued)

Figure A-6. (Continued)

Figure A-6. (Concluded)

Figure A-7. FRAME Program Flow

HELIAKI is the controlling program. Depending on the program options selected, HELIAKI calls the appropriate routine to perform:

- a. A time point simulation
- b. A time integration simulation
- c. Both a time point and time integration

Figure A-8. HELIAKI Program Flow

HITFAC keeps track of which facet a ray hits on a given heliostat. It performs this function for initial hits, as well as for shadowing and blockage counting.

HITFAC can be called in one of three modes:

- Initializations
- Calculation and summation
- Output

Figure A-9. HITFAC Program Flow

Figure A-10. INHIT Program Flow

INITCOL performs the following functions:

- a. Initializations of variables
- b. Initialization of the random number generator
- c. Input of program options
- d. Output summary of program options

Figure A-11. INITCOL Program Flow

INTEN calculates the direct normal intensity for a given month, day and hour of the year. The intensity is based on a clear air model using ASHRAE data for exoatmospheric intensity.

Figure A-12. INTEN Program Flow.

LIMDR calculates the Intensity distribution of energy across the face of the sun. There are three options:

- a. Flat sun
- b. Sun with limb darkening and solar radiations
- c. Sun with limb darkening

Figure A-13. LIMDR Program Flow

MIRRN Calculates a mirror normal given the sun vector the heliostat location and an aim point.

Figure A-14. MIRRN Program Flow

MOON checks for receiver hits for any ray which gets clearly away from the field. It checks for entry into the aperture, support hits, diffuser hits, cylinder hits, and whistle throughs. It maps all flux which hits the cylinder wall or roof.

Figure A-15. MOON Program Flow

Figure A-15. (Concluded)

MONTE is the monte carlo driver routine for a yearly, time integration run.

Its major functions are:

- Initialization calls for mapping and counting routines
- Calls to the random number generator
- Calls to the mapping and counting routines
- Calls PTOWER, the controlling routine for the hit tests
- Prints ray trace summary
- Output calls for mapping and counting routines

Functions b, c and d are performed for each ray traced.

Figure A-16. MONTE Program Flow

Figure A-16. (Continued)

Figure A-16. (Continued)

Figure A-16. (Concluded)

Figure A-17. MONTE2 Program Flow

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Figure A-17. (Continued)

Figure A-27. (Continued)

Figure A-17. (Concluded)

OFFBLOC checks to see if a ray reflected by a given facet of a heliostat is blocked by another facet of a different (neighboring) heliostat.

Figure A-18. OFFBLOC Program Flow

Figure A-19. ONBLOCK Program Flow

Figure A-20. PERT3 Program Flow

PIPE tests a reflected ray vector to determine its points of interaction (hit points) with a right circular cylinder (the receiver walls). Hits points are found by solving a quadratic. Imaginary roots indicate that the ray missed the cylinder.

Figure A-21. PIPE Program Flow

POLMAP sorts and sums energy totals and hits according to their origin on the mirror field. For each field zone, the following quantities are calculated:

- a. mirror hits - rays that hit cavity walls or roof
- b. reflected energy - rays that hit cavity walls or roof
- c. energy lost to shadowing
- d. energy lost to blockage
- e. energy lost to heliostat to heliostat shading
- f. corbel hits
- g. whistle throughs
- h. number of misses across the front
- i. number of misses high
- j. number of misses low

The routine can be called in one of three ways:

- a. initialization
- b. summation
- c. output

Figure A-22. POLMAP Program Flow

Figure A-22. (Concluded)

POLSP2 sets up the field for a non-uniform polar arrangement of the heliostats.

It calculates the radial spacing of every row and the number of heliostats in each zone.

Figure A-23. POLSP2 Program Flow

Figure A-23. (Concluded)

PTOWER controls the calls for all of the hit tests. The purpose of the hit tests is to determine the path taken by the ray. A ray (vector) and its hit point on the mirror field (as determined in one of the MONTE routine) are major inputs.

Figure A-24. PTOWER Program Flow

Figure A-25. RINDX Program Flow

RNORM generates pairs of independent normal random deviates (mean = 0, standard deviation = 1). They are normally distributed on the interval $(-\infty \text{ to } +\infty)$. Required input is a uniform random number generator.

Figure A-26. RNORM Program Flow

ROOF sorts the ray hits on the cavity ceiling by zone. These zones are concentric donuts divided further into azimuth zones. All zones are of equal area.

Figure A-27. ROOF Program Flow

TMAP details the yearly performance of various segments of the field around the year. TMAP is called only for time integration runs. It produces four maps: two are hit summaries, two are energy summaries.

TMAP can be called in one of three modes:

- a. Initializations
- b. Summations
- c. Outputs

Figure A-28. TMAP Program Flow

Calculates the angle of toe-in of the hit facet. The toe-in angle is the rotational angle which the net facet is moved from the horizontal frame top plane to focus at one point for a specified sum position. The sum position for the toe-in is a required input.

Figure A-29. TOEIN Program Flow

TSHAD determines if an incident ray is blocked by the tower. It performs this function by working backwards from the hit point on the field to the sun.

Figure A-30. TSHAD Program Flow

VECTS calculates the base orthonormal triad set ($\vec{N}$, $\vec{UN}$, $\vec{UE}$) located at the tower center. The sum vector ($\vec{UR}$) is also calculated for the desired month, day and hour of the year.

Figure A-31. VECTS Program Flow

WALLMP prints the cavity wall flux map. It does this by dividing the wall in zones according to height and azimuth. (Where 0° azimuth is North and 90° is east etc.)

Figure A-32. WALLMP Program Flow

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1	PROGRAM HELIAKI(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)	HELIAKI	2
	DIMENSION XM(9)	HELIAKI	3
	COMMON/RANDOM/NRUN,IRANC,IJUMP,MODE,ISRN,IRAYS	HELIAKI	4
	1 ,IT1,UDNI,LIMC,DINTV,YFRAC	HELIAKI	5
5	C** THIS IS THE CONTROLLING PROGRAM. FROM IT INITCOL IS CALLED. THEN	HELIAKI	6
	C ONE OF THE MONTE DRIVER ROUTINES. DEPENDING ON THE RESULTS DESIRED.	HELIAKI	7
	MODE=1	HELIAKI	8
	IRANC=0	HELIAKI	9
	1 CALL INITCOL	HELIAKI	10
10	C	HELIAKI	11
	C IJUMP CONTROLS THE MONTE CARLO SIMULATION	HELIAKI	12
	C IJUMP=0 TIME POINT ONLY	HELIAKI	13
	C IJUMP=1 TIME INTEGRATION ONLY	HELIAKI	14
	C IJUMP=2 TIME POINT PLUS TIME INTEGRATION	HELIAKI	15
15	IF(IJUMP.EQ.1) GO TO 5	HELIAKI	16
	CALL MONTE2(XM)	HELIAKI	17
	IF(IJUMP.EQ.0) GO TO 10	HELIAKI	18
	5 CALL MONTE(XM,=OURS)	HELIAKI	19
	10 IF(IT1.LT.3) GO TO 1	HELIAKI	20
20	STOP	HELIAKI	21
	END	HELIAKI	22

```

1      SUBROUTINE INITCOL                                HELIAKI    23
      REAL N                                              INITCOL    2
      DIMENSION AIMP(3)                                  INITCOL    3
      INTEGER CILAT                                       INITCOL    4
5      COMMON/DARKLE/DDTOP,DBASE                          INITCOL    5
      COMMON/CAVITY/SEP,DD1,DD2,RDIF,HDIF,HCAV,HSWTC(2),RSWTC(2), INITCOL    6
      1 CILAT(2),CAVLAT(2,21),AIMHGT                     INITCOL    7
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH, INITCOL    8
      1 ICSH,IFC,INIT,ICSH2,NCOL,IHOUR,MIN,ELZ,T,TDISX,TDISY, INITCOL    9
10      2 DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT, INITCOL   10
      3 NLONG,ILONG,NLATC,RCO,NPACK,ENHM                 INITCOL   11
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WVU,NHF,XDF,W02,WVU2, INITCOL   12
      1 RMS(3),DELX,DELY,W0,IFV,RRB(3),UAXVP(3),UXV2PP(3), INITCOL   13
      2 UTT(3),UNNP(3),UXV2P(3)                          INITCOL   14
15      3 UMNPP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE  INITCOL   15
      COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),        INITCOL   16
      1 UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ INITCOL   17
      COMMON/JOKER/URP(3),US1(3),THSL,PK,THSR,THSU,COUNT,WAVL(20),DRAD INITCOL   18
      COMMON /STATS/TPB,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B INITCOL   19
20      COMMON /RALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3) INITCOL   20
      COMMON/RANDOM/NRUN,IRANC,IJUMP,MODE,ISRAN,IRAYS    INITCOL   21
      1 IT1,UDNI,LIMC,DINTV,YFRAC                        INITCOL   22
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLOUM,WCELL,ICELL,JCELL, INITCOL   23
25      1 XCSAV,YCSAV,XCM,YCM,ICELM,JCELM               INITCOL   24
      COMMON/SUPPT/DELT,THES,KSEG,APH,SW,NSUP,RCONE,TMECON,HTOT INITCOL   25
      COMMON/CEILING/NAZZ,NRZ,DTAZ(21),DRZ(10),DD3,IZR,IAZ INITCOL   26
      COMMON/MAPS/NRZF,NAZZF,NC(250,8),SRAD(250,8),NPRAD(8),DEG INITCOL   27
      COMMON/TILTED/TILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET INITCOL   28
30      COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,B1,B2,WACROSS,W0UM,IFRAM INITCOL   29
      *,HTMIR,HTCROS,WJCROS                              INITCOL   30
      COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT,UTARG(3),DTARG(3) INITCOL   31
C      INITCOL   32
C *****NAMLIST DICTIONARY                             INITCOL   33
35      C NAMLIST /CHANGE/ RFIELD,TH,NSTOPS,TDISX,TDISY,IRAYS,TPB,TSB,PHB, INITCOL   34
      1 TPV,TSV,PHV,THETA,MON,IDAY,T,IJUMP,IT1,NRUN,ISRAN, INITCOL   35
      2 PAX1V,PAX2V,SCDELT,NLONG,NLATC,GCOVER,RCO,RCONE,HCAV, INITCOL   36
      3 SW,NSUP,DD3,NRZ,NRZF,NAZZF,W0,WVU,XDF,NPACK,SPACEF, INITCOL   37
      4 IDRIVE,NVU,WAPMAX,WAPMIN,OFFSET,WLONG,WACROSS,WTRI,GAP, INITCOL   38
40      5 XLTRI,HTMIR,HTCROSS,WJCROS,ITOE,IFOCUS,TAZT,TELT, INITCOL   39
      6 MONT,IDAYT,TIMET                                  INITCOL   40
      DATA WAVL/.39,.44,.48,.51,.54,.57,.60,.63,.66,.70,.74,.78,.82,.87, INITCOL   41
      1.96,1.02,1.08,1.22,1.48,1.68/                   INITCOL   42
C      IT1=3 END OF RUN                                  INITCOL   43
45      C MODE=1 AT FIRST ROUND                          INITCOL   44
      C MODE=2 AFTER THAT                                INITCOL   45
C      THIS IS THE INITIALIZING ROUTINE. IT INITIALIZES ALL OF THE INITCOL   46
C VALUES IN THE ENTIRE PROGRAM.                       INITCOL   47
C VARIABLE LIST IN INITCOL.                             INITCOL   48
50      C SEP=DISTANCE BETWEEN LOWER AND UPPER DISK    INITCOL   49
      C SW=SUPPORT WIDTH                                INITCOL   50
      C NSUP=NUMBER OF SUPPORTS                         INITCOL   51
      C DD3=INNER CAVITY DIAMETER                      INITCOL   52
      C W0=FACET LENGTH                                 INITCOL   53
55      C WVU=FACET WIDTH                                INITCOL   54
      C XDF=DISTANCE BETWEEN FACET AXES                INITCOL   55
      C AIMHGT=AIM CIRCLE HEIGHT UP CONE AXIS          INITCOL   56
C      INITCOL   57

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	C	WAPMAX=MAXIMUM APERTURE WIDTH	INITCOL	58
	C	WAPMIN=MINIMUM APERTURE WIDTH	INITCOL	59
60	C	IFOCUS=MIRROR FOCUSING OPTION	INITCOL	60
	C	0 MEANS INDIVIDUAL FOCUSING	INITCOL	61
	C	1-10 ARE NUMBER OF FOCUSING ZONES FOR CONSTANT FOCUSING	INITCOL	62
	C	11 MEANS FLAT MIRRORS	INITCOL	63
			INITCOL	64
65	C	HTCROSS IS THE VERTICAL DIMENSION OF A CROSS PIECE ON THE FRAME	INITCOL	65
	C	WJCROSS IS THE WIDTH OF THE CENTER CROSS PIECE OF THE FRAME	INITCOL	66
	C	MON = MONTH	INITCOL	67
	C	T=TIME OF DAY	INITCOL	68
	C	IDAY=DAY OF THE MONTH	INITCOL	69
70	C	RFIELD=OUTER RADIUS OF THE FIELD IN FEET	INITCOL	70
	C	TH=HEIGHT OF THE TOWER UP TO THE LOWER DISK	INITCOL	71
	C	HCAV=CAVITY HEIGHT IN FEET	INITCOL	72
	C	NLATC=NUMBER OF HEIGHT ZONES ON THE CAVITY WALLS	INITCOL	73
	C	NLONG=NUMBER OF AZIMUTH ZONES ON THE CAVITY WALL	INITCOL	74
75	C	NSTOPS IS NUMBER OF CHECK POINTS ALONG RAY PATH FROM TEST PLANE	INITCOL	75
	C	TO GROUND	INITCOL	76
			INITCOL	77
	C	NRZF=NUMBER OF RADIAL ZONES IN THE FIELD	INITCOL	78
	C	NAZZF=NUMBER OF AZIMUTH ZONES IN THE FIELD	INITCOL	79
80	C	ISRAN=INITIAL RANDOM SEED	INITCOL	80
	C	TDISY=TOWER OFFSET FROM THE CENTER OF THE FIELD. IT MUST BE ZERO	INITCOL	81
	C	FOR A DONUT FIELD, IN A NORTH-SOUTH DIRECTION	INITCOL	82
	C	TDISX=TOWER OFFSET FROM THE CENTER OF THE FIELD. IT MUST BE ZERO	INITCOL	83
	C	FOR A DONUT FIELD, IN A EAST-WEST DIRECTION	INITCOL	84
85	C	NRUN=NUMBER OF RUNS (10)	INITCOL	85
	C	IRAYS=NUMBER OF RAYS IN 1 RUN	INITCOL	86
	C	DINTV=INTERVAL OF HOURS THAT WE ARE INTEGRATING OVER FOR THE TIME	INITCOL	87
	C	INTEGRATION	INITCOL	88
	C	YFRAC=NUMBER OF DAYS IN A YEAR	INITCOL	89
90	C	GCOVER=GROUND COVER RATIO (AREA MIRRORS/GROUND AREA)	INITCOL	90
	C	ITI=CONTROL VARIABLE. THE PROGRAM TERMINATES WHEN ITI IS GREATER	INITCOL	91
	C	THAN OR EQUAL TO 3	INITCOL	92
	C	DRAD =CONVERSION FACTOR FROM DEGREES TO RADIAN	INITCOL	93
	C	THETA=LATITUDE ANGLE OF THE SITE TESTED	INITCOL	94
95	C	TPB,TSB,PHB,TPV,TSV,PHV,PAXIV,PAX2V = HELIOSTAT OPTICAL PROPERTIES	INITCOL	95
	C	AND TRACKING DRIVE PROPERTIES FOR A NORMAL DISTRIBUTION.	INITCOL	96
	C	(B=MEAN,V=VARIANCE)	INITCOL	97
	C	NPACK DEFINES FIELD PACKING GEOMETRY	INITCOL	98
	C	4 POLAR PACKING	INITCOL	99
100	C	5 POLAR NON-UNIFORM	INITCOL	100
	C	IDRIE CONTROLS FACET DRIVES	INITCOL	101
	C	1 GANGED.	INITCOL	102
	C	2 INDEPENDENT IN ONE AXIS.	INITCOL	103
	C	** NNU IS FOR NONUNIFORM POLAR PACKING OF	INITCOL	104
105	C	** TILT-TILT HELIOSTATS. IT IS THE NUMBER OF NONUNIFORM	INITCOL	105
	C	** AZIMUTH ZONES. THIS CAN BE 1 OR 8.	INITCOL	106
	C	***NLONG IS THE WIDTH OF THE LONG PIECES ON THE FRAME	INITCOL	107
	C	***WCROSS IS THE WIDTH OF THE CROSS PIECES ON THE FRAME	INITCOL	108
	C	***GAP IS THE SPACE BETWEEN THE LONG PIECES MINUS WD	INITCOL	109
110	C	***WTRI IS THE WIDTH OF THE CROSS BRACES	INITCOL	110
	C	***XLTRI IS THE LONGER EDGE OF THE CROSS BRACES	INITCOL	111
	C	** TAZT=TOEIN AZIMUTH ANGLE (RADIAN)	INITCOL	112
	C	** TELT=TOEIN ELEVATION ANGLE (RADIAN)	INITCOL	113
	C	** TAZT AND TELT DEFAULT TO 3/21 NOON AT 33 DEGREES LATITUDE	INITCOL	114

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115      C      HTMIR IS THE DISTANCE OF THE FACET AXIS ABOVE THE TOP FRAME PLANE INITCOL 115
      C      HXCROSS IS THE VERTICAL DIMENSION OF A CROSS PIECE ON THE FRAME INITCOL 116
      C      WJCROSS IS THE WIDTH OF THE CENTER CROSS PIECE OF THE FRAME INITCOL 117
      MON=6 INITCOL 118
      DO 1953 IO=1,3 INITCOL 119
120      1953 SCDELT(IO)=0.0 INITCOL 120
      T=12. INITCOL 121
      IDAY=21 INITCOL 122
      AMAX=1.3 INITCOL 123
      LIMC=3 INITCOL 124
125      ISRAN=27641 INITCOL 125
      DINTV=14. INITCOL 126
      YFRAC=365. INITCOL 127
      IT1=2 INITCOL 128
      DRAD=.01745 INITCOL 129
130      CAPR=149.5*10.**6 INITCOL 130
      SMALR= 6357.0 INITCOL 131
      THETA=33. INITCOL 132
      NRUN=10 INITCOL 133
      IF (IRANC.NE.0) GO TO 1800 INITCOL 134
135      WRITE(6,7002) INITCOL 135
      WRITE(6,1811) ISRAN,NRUN INITCOL 136
1811  FORMAT(5X,20HINITIAL RANDOM SEED=,I10,3X,19HNUMBER OF RUNS PER , INITCOL 137
      16HBTCH=,I5,/) INITCOL 138
      DJEF=FLOAT(ISRAN) INITCOL 139
140      DJEF=RANF(DJEF) INITCOL 140
      IRANC=1 INITCOL 141
1800  CONTINUE INITCOL 142
      TPH=0. INITCOL 143
      TSR=0. INITCOL 144
145      PHH=0. INITCOL 145
      TPV=.05 INITCOL 146
      TSV=.05 INITCOL 147
      PHV=.05 INITCOL 148
      NSTOPS=11 INITCOL 149
150      DO 3460 I=1,3 INITCOL 150
      3460 SCDELT(I)=0. INITCOL 151
      TDISX=0. INITCOL 152
      PAX1B=0. INITCOL 153
      PAX2B=0. INITCOL 154
155      C SIDERIAL EARTH RATE INITCOL 155
      OME= 0.2625159 INITCOL 156
      OMS=360./(365.25*57.3) INITCOL 157
      XTH=THETA*DRAD INITCOL 158
      STH=SIN(XTH) INITCOL 159
160      CTH=COS(XTH) INITCOL 160
      XSEQ=23.5*DRAD INITCOL 161
      SEQ=SIN(XSEQ) INITCOL 162
      CEQ=COS(XSEQ) INITCOL 163
      UA(1)=SEQ INITCOL 164
165      UA(2)=0. INITCOL 165
      UA(3)=CEQ INITCOL 166
      IF(MODE.GT.1) GO TO 4000 INITCOL 167
      IDRIVE=1 INITCOL 168
      PAX1V=.05 INITCOL 169
170      PAX2V=.05 INITCOL 170
      WAPMAX=24. INITCOL 171

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	WAPMIN=18.	INITCOL 172
	AIMHGT=SEP/2.0	INITCOL 173
	GCOVER=.3	INITCOL 174
175	RFIELD=826.	INITCOL 175
	TH=392.	INITCOL 176
	RCO=120.	INITCOL 177
	HCAV=46.1	INITCOL 178
	XDF=16.	INITCOL 179
180	NHF=4	INITCOL 180
	IRAYS=2	INITCOL 181
	RCONE=20.0	INITCOL 182
	NCONHT=5	INITCOL 183
	NCONAZ=3	INITCOL 184
185	TDISY=0.0	INITCOL 185
	NLATC=5	INITCOL 186
	F=1050.	INITCOL 187
	NLONG=8	INITCOL 188
	WFV=10.	INITCOL 189
190	WD=10.	INITCOL 190
	IJUMP=1	INITCOL 191
	OD3=42.	INITCOL 192
	NSUP=3	INITCOL 193
	SPACEF=1.1	INITCOL 194
195	NRZ=5	INITCOL 195
	NRZF = 7	INITCOL 196
	NPACK=5	INITCOL 197
	NNU=8	INITCOL 198
	NAZZF = 8	INITCOL 199
200	SV = 2.	INITCOL 200
	GAP=0.25	INITCOL 201
	XLTRI=4.681	INITCOL 202
	WLONG=0.48	INITCOL 203
	WCROSS=0.385	INITCOL 204
205	WTRI=0.177	INITCOL 205
	WSIDE=0.84	INITCOL 206
	HTMIR=0.833	INITCOL 207
	HTCROS=0.833	INITCOL 208
	WJCROS=0.224	INITCOL 209
210	TAZT=3.14159	INITCOL 210
	TELT=0.9948	INITCOL 211
	MONT=3	INITCOL 212
	IDAYT=21	INITCOL 213
	TIMET=12.	INITCOL 214
215	IFOCUS=0	INITCOL 215
	4000 READ(S,CHANGE)	INITCOL 216
	IF(MODE.LI.2) MODE=2	INITCOL 217
	WRITE(G,7002)	INITCOL 218
	7002 FORMAT(1H1)	INITCOL 219
220	CALL VECTS	INITCOL 220
	IF(C.GT.0.0005) GO TO 6	INITCOL 221
	WRITE(F,7)	INITCOL 222
	7 FORMAT(//,10X,50HDAWN IS YET TO COME-NO TIME POINT CAN BE PERFORM	INITCOL 223
	IED)	INITCOL 224
225	IF(IJUMP.EQ.2) IJUMP=1	INITCOL 225
	GO TO 16	INITCOL 226
	6 DENOM=SQRT(A*A+B*B)	INITCOL 227
	ELZ=ATAN2(C,DENOM)	INITCOL 228

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230      CALL INTEN(MON, IDAY, ELZ, UDNI)
      UDNI=.0015*UDNI*0
      INITIALIZE CONE AND TILT ANGLES FOR FIELD GEOMETRY INPUT
      16 RN=RFIELD*TDISY
      RS=RFIELD*TDISY
      XN=SQRT(RN*RN*0.5*RCO*RCO*0.5)
      XS=SQRT(RS*RS*0.5*RCO*RCO*0.5)
235      TAPE1=ATAN(TH/XN)
      TAPE2=ATAN(TH/XS)
      THECON=(TAPE1+TAPE2)*0.5
      TTILT=TAPE2-THECON
240      C TO UNTILT APERTURE SIMPLY SETS WHAT IS BEST THETA CONE
      TTILT=0.0
      THECON=27.0/57.3
      HTOT=(WAPMAX*WAFMIN)*0.5*COS(THECON)
      SEP=HTOT
      AIMHGT=SEP*0.5
      DELRC=(HTOT*0.5)*TAN(THECON)
      DD1=(RCONE-DELRC)*2.
      DD2=(RCONE+DELRC)*2.
      NAZZ = NLONG
245      CALL MOON(0,9)
      C INITIALIZATION OF AIM POINT SUBROUTINE
      HSWTC(1)=H0IF
      HSWTC(2)=HCAV
      RSWTC(1)=R0IF
      RSWTC(2)=.5*DD3
255      XDUM=(WD*GAP-WCROSS)*0.5
      WDUM=(WD*GAP+WLCNG)*0.5
      B1=XDUM-XLTRI*0.70711
      B2=XDUM-XLTRI*0.70711+WTRI/0.70711
260      CTAZT=COS(TAZT)
      STAZT=SIN(TAZT)
      CTELT=COS(TELT)
      STELT=SIN(TELT)
      DDTOP=DD1
265      DDBASE=DD1*20.0
      WD2=WD/2.
      WFW2=WFW/2.
      ALEN=(NHF-1)*XDF
      DCOL=WFW
      CXLAT=HCAV/FLOAT(NLATC)
270      DO 9622 I=1,NLATC
      DO 9622 I=1,NLATC
      9622 CAVLAT(2,I)=HCAV-CXLAT*FLOAT(I)
      WCELL=.2*RFIELD
      AFIELD=3.14159*(RFIELD*RFIELD-RCO*RCO)
275      ACOL=(NHF*WD*WFW)
      GCMIR=ACOL/(WD*(ALEN+WFW))
      IF(GCOVER.GT.GCMIR) WRITE(6,1901)
      1901 FORMAT(/10X,48H***** GROUND COVER FACTOR,GCOVER,TOO LARGE *****)
      CALL POLSP2(ACOL,NNU,SPACEF,NTOTAL,GCOVER)
      AFIELD=3.14159*(RFIELD*RFIELD-RCO*RCO)
280      NCOL=NTOTAL
      WRITE(6,7002)
      WRITE(6,1945) NSTOPS,NCOL,RFIELD,TH,GCOVER
      1945 FORMAT(/20X,51HHELIAXI VERSION 13, TIME POINT AND/OR ANNUAL ENERGY
285      1/20X,39HROUND FIELD WITH LOW PROFILE HELIOSTATS//16X,

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INITCOL 229
INITCOL 230
INITCOL 231
INITCOL 232
INITCOL 233
INITCOL 234
INITCOL 235
INITCOL 236
INITCOL 237
INITCOL 238
INITCOL 239
INITCOL 240
INITCOL 241
INITCOL 242
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INITCOL 285

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26HNSSTOPS,6X,4HNCOL,9X,6HRCFIELD,8X,7HTOWER H,
3 9X,6HGCORVER,/,10X,2I10,4F15.3,/)
WRITE(6,1946) NHF,WFFV,WD,XDF,ALEN,SPACEF
1946 FORMAT(/,16X,3HNNHF,12X,3HWFV,13X,2HWD,12X,3HXDF,11X,4HALEN,
290 1 10X,6HSPACEF,/,9X,I10,5,5X,F10.2),/)
WRITE(6,1949) GAP,WLONG,WCRSS,WTRI,XLTRI,WSIDE,WJCROS,HTMIR,
* HTCROS
1949 FORMAT(/,11X,3HGAP,9X,5HWWLONG,8X,6HWCROSS,10X,4HWTRI,9X,
* 5HXLTRI,9X,5HWSIDE,8X,6HWCROS,9X,5HHTMIR,8X,6HHTCROS,
295 * /,9(4X,F10.3),/)
WRITE(6,1111) (WAVL(ILOP1,ILOP=1,20)
1111 FORMAT(///,32X,43HTHE CENTER WAVELENGTHS OF THE TWENTY EQUAL ,
112HENERGY BANDS,/,2(20X,10F10.5,/,/),/)
WRITE(6,1948) TDISX,TDISY,AFIELD,RCO
300 1948 FORMAT(/,20X,5HTDISX,10X,5HTDISY,9X,6HAFIELD,12X,3HRCO,/,10X,
14F15.3,/)
IHOURL=INT(T)
AMIN=60.*(T-FLOAT(IHOURL))
MIN=INT(AMIN)
305 WRITE(6,5) MON,IDAY,THETA,IHOURL,MIN
5 FORMAT( ///,50X,I2,1H/,I2,3H/80,/,10X,9HLATITUDE=,F7.2,
1 10X,4HHDUR,I5,5X,3HMIN,I5,/)
CALL AIMPP(XC,YC,1,AIMP)
WRITE(6,879) RCONE,THECON,HTOT,TTILT
310 879 FORMAT(/,22X,5HRCONE,14X,6HTHECON,14X,4HHTOT,15X,5HTTILT,/,
2 15X,F10.2,10X,F10.2,9X,F10.2,12X,F10.2)
WRITE(6,1515) WAPMAX,WAPMIN,OFFSET
315 1515 FORMAT(/,19X,6HWAPMAX,14X,6HWAPMIN,14X,6HOFFSET,/,15X,
2 3(F10.1,10X))
WRITE(6,21)
21 FORMAT(/,5X,20HPROGRAM OPTIONS USED)
IF (IFOCUS.EQ.0) WRITE(6,410)
IF (IFOCUS.GT.0.AND.IFOCUS.LE.10) WRITE(6,420) IFOCUS
IF (IFOCUS.GT.10) WRITE(6,430)
320 WRITE(6,440)
WRITE(6,450) MONT,IDAYT,TIMET
450 FORMAT(10X,19HTOEIN STRATEGY FOR ,I2,1H/,I2,4H AT ,F4.1)
410 FORMAT(10X,19HINDIVIDUAL FOCUSING)
420 FORMAT(10X,I2,15H FOCUSING ZONES)
325 430 FORMAT(10X,12HFLAT MIRRORS)
440 FORMAT(10X,17HINDIVIDUAL TOE-IN)
IF (IDRIVE.EQ.1) WRITE(6,518)
IF (IDRIVE.EQ.2) WRITE(6,519)
518 FORMAT(10X,13HFACEIS GANGED)
330 519 FORMAT(10X,23HINDEPENDENT FACET DRIVE)
RETURN
END

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INITCOL 332

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1  SUBROUTINE AIMPP(XC,YC,INIT,AIMP)
C** THIS ROUTINE DRAWS A VECTOR FROM THE CENTER OF THE ANNULUS
C OUT TO THE AIM POINT.
    INTEGER CILAT
5    REAL N
    COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
    1 UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEO
    COMMON/CAVITY/SEP,DD1,DD2,RDIF,HDIF,HCAV,HSWTC(2),RSWTC(2),
10    1 CILAT(2),CAVLAT(2,21),AIMHGT
    COMMON/SUPPT/DELT,THES,KSEG,APH,SW,NSUP,RCONE,THECON,HTOT
    COMMON/TILT/TTILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET
    DIMENSION UPLAN(3),AIMP(3),UCON(3)
C THIS FUNCTION RETURNS THE ITH COMPONENT OF THE AIM POINT ASSOCIATED
C WITH HELIOSTATS LOCATED AT (XC,YC) RELATIVE TO THE RECEIVER CENTER
15    IF (INIT.GT.1) GO TO 100
    SEP2=AIMHGT
    RDC=DD1/2.0*AIMHGT*(DD2-DD1)/(2.0*SEP)
    THES=2.*3.14159/NSJP
    XDUM=(DD2-DD1)/2.
20    APH=SQRT(SEP**2-XDUM**2)
    AMD=SW/2.+APH/2.
    THEMIS=ATAN(AMD/RDC)
    FRACTN=(THES-2.*THEMIS)/THES
    DD3=RSWTC(2)*2.
25    WRITE (6,20) SEP,DD1,DD2,RDIF,HCAV,DD3,AIMHGT
20    FORMAT (///,30X,21HCAVITY RECEIVER SPECS,/,17X,3HSEP,7X,3HDD1,
    1 7X,3HDD2,6X,4HRDIF,6X,4MHCAV,6X,4H DD3,5X,6HAIMHGT,/,10X,
    * 7F10.1,/)
    CTCON=COS(THECON)
30    STCON=SIN(THECON)
    CTL=COS(TTILT)
    STL=SIN(TTILT)
    DO 25 I=1,3
    UVT(I)=CTL*N(I)-STL*UN(I)
35    U1(I)=CTL*UN(I)+STL*N(I)
25    U2(I)=UE(I)
    RETURN
100 YCP=YC+CTL
    THEAZ=ATAN2(XC,YCP)+3.14159/3.0
40    IF (THEAZ.LT.0.0) THEAZ=THEAZ+2.*3.14159
    IF (THEAZ.GT.6.283185) THEAZ=THEAZ-6.283185
    KSEG=INT(THEAZ/THES)+1
    THEMID=THES*(KSEG-1)+THES/2
    DELTM=THEAZ-THEMID
45    THEAIM=THEMID+DELT*FRACTN-3.14159/3.0
    IF (THEAIM.LT.0.0) THEAIM=THEAIM+6.283185
    CAIM=COS(THEAIM)
    SAIM=SIN(THEAIM)
    IF (THEAIM.GT.3.14159) THEAIM=2*3.14159-THEAIM
50    WAP=WAPMIN
    IF (THEAIM.LT.2.0944) WAP=WAP+(WAPMAX-WAPMIN)*(1.0-THEAIM*0.4775)
    WDNW=SEP2/CTCON-WAP*0.5
    IF (THEAIM.LT.2.0944) WDNW=SEP2/CTCON-WAP*0.53
    DO 45 I=1,3
55    UPLAN(I)=CAIM*U1(I)+SAIM*U2(I)
    UCON(I)=-CTCON*UVT(I)-STCON*UPLAN(I)
45    AIMP(I)=SEP2*UVT(I)+RDC*UPLAN(I)+WDNW*UCON(I)

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SUBROUTINE AIMPP 74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE 2

RETURN
END

AIMPP 59
AIMPP 60

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B-10

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1      SUBROUTINE MONTE2(XM)
C** THIS IS THE MONTE CARLO DRIVER ROUTINE FOR A FIXED TIME AND DAY
C OF THE YEAR. FROM IT INTEN, RNORM, LIMDR, AND PTOWER ARE CALLED.
      REAL N
5      DIMENSION TOP(15)
      INTEGER CILAT
      COMMON/CAVITY/SEP,OC1,DO2,RDIF,HDIF,HCAV,HSWTC(2),RSWTC(2),
1      CILAT(2),CAVLAT(2,21),AIMHGT
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XDF,WD2,WV2,
10     1      RHS(3),DELX,DELY,WD,IFV,RRB(3),UAXVP(3),UXV2PP(3),
2      UTT(3),UMNP(3),UXV2P(3)
3      ,UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
      COMMON /STATS/TPB,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B
15
      COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
      COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
1      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
      COMMON/RANDOM/NRUN,IRANC,IJUMP,MODE,ISRN,IRAYS
20
1      , IT1,UDNT,LINC,DINTV,YFRAC
      COMMON/SUPPT/DELT,THES,KSEG,APH,SW,NSUP,RCONE,THECON,HTOT
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      ICSH,IFC,IHIT,ICSH2,NCOL,IMOUR,MIN,ELZ,T,TDISX,TDISY,
2      DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
25     3      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLDUM,WCELL,ICELL,JCELL,
1      XCSAV,YCSAV,XCM,YCM,ICELM,JCELM
      COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,B1,B2,W,CROSS,WDUM,IFRAM
30     ,HTMIR,HTCROS,WJCROS
      COMMON/PLANE/IPLAN(7)
      COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT,UTARG(3),DTARG(3)
      DIMENSION FRSHAD(4)
      DIMENSION XDFPR(9,15),XM(9),ITT(21)
      DIMENSION FLMAPC(21,36)
35     DIMENSION AEBOTN(2,10),AFLUX(2),FIELD(12,12)
      DIMENSION ETA(7),EPN(8)
      DIMENSION NDM(12),IO(36),SL(15)
      DATA NDM/31,28,31,30,31,30,31,31,30,31,30,31/
40     IF(C.LT.0.0005) GO TO 52
      WRITE(6,7532)
7532 FORMAT(1H1,/,39X,28HHELIOSTAT OPTICAL PARAMETERS,/)
      WRITE(6,7001) PAX1B,PAX2B,TSB,PHB,PAX1V,PAX2V,TSV,PHV
7001 FORMAT(15X,5HPAX1B,5X,5HPAX2B,7X,3HTSB,7X,3HPHB,5X,5HPAX1V,5X,
15HPAX2V,7X,3HTSV,7X,3HPHV,/,10X,10F10.5,/)
45     NN1=NLATC
      DO 8011 I=1,7
8011 IPLAN(I)=0
      DO 412 I=1,4
412 FRSHAD(I)=0.0
50     DO 3010 I=1,20
3010 ITT(I)=0
      XKNT=0.0
      CALL ROOF(1,0.)
      DO 6101 I=1,NN1
      DO 6101 J=1,NLONG
55     6101 FLMAPC(I,J)=0.
      TOPC=0.

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	CALL POLMAP (0.,0.,0.,1,0)	MONTE2	59
	DO 8101 I=1,12	MONTE2	60
60	DO 8101 J=1,12	MONTE2	61
	8101 FIELD(I,J)=0.	MONTE2	62
	CALL HITFAC(0,0,0,1,0)	MONTE2	63
	SPPT = 0.0	MONTE2	64
	SHADL=0.0	MONTE2	65
65	IDFL=2	MONTE2	66
	DO 7009 MAC=1,IDFL	MONTE2	67
	7009 AFLUX(MAC)=0.	MONTE2	68
	DO 3611 I=1,7	MONTE2	69
	3611 XM(I)=0.	MONTE2	70
70	DAY=FLOAT(IDAY)	MONTE2	71
	DENOM=SQRT(A*A+B*B)	MONTE2	72
	ELZ=ATAN2(C,DENOM)	MONTE2	73
	CALL INTEN(MON,IDAY,ELZ,UDNI)	MONTE2	74
	XKWNI=.00315*UDNI	MONTE2	75
75	THETAZ=ATAN2(B,A)*360.0/(2.0*3.14159)	MONTE2	76
	IF (THETAZ .LT. .0001) THETAZ=THETAZ+360.0	MONTE2	77
	TELZ=ELZ*360.0/(2.0*3.14159)	MONTE2	78
	WRITE (6,22) TELZ,THETAZ,XKWNI	MONTE2	79
	XMDNI=XKWNI	MONTE2	80
80	22 FORMAT (/,'7X,3HELZ,4X,5HTHETAZ,5X,5HXKWNI,/,3F10.5,/)	MONTE2	81
	UDNI=.00315*UDNI*C.	MONTE2	82
	AVE=0.0	MONTE2	83
	ICOL0=0	MONTE2	84
	ICOLS=0	MONTE2	85
85	ICOLH=0	MONTE2	86
	COL0=0.0	MONTE2	87
	COLH=0.0	MONTE2	88
	C FOR POLAR PACKING THE DRAW RANGE IS EXTENDED FROM RCO/2 TO RFIELD.	MONTE2	89
	RFIELD=RFIELD*0.1*TH	MONTE2	90
90	RCO=RCO/2.	MONTE2	91
	AREA=3.14159*(RFIELD*RFIELD-RCO*RCO)	MONTE2	92
	CONV=.0929*AREA*UDNI	MONTE2	93
	RCO2 = -RCO*RCO	MONTE2	94
	DELRAD = RFIELD**2 - RCO2	MONTE2	95
95	RFIELD=RFIELD-0.1*TH	MONTE2	96
	RCO=RCO*2.	MONTE2	97
	C THIS IS BECAUSE Q IS IN LANGLY/MIN.	MONTE2	98
	WRITE(6,1001) CONV	MONTE2	99
	1001 FORMAT (/,'20X,10H*****20H CONVERSION FACTOR =,E20.10,	MONTE2	100
100	1 11H *****,,/)	MONTE2	101
	DO 297 I=1,3	MONTE2	102
	297 UHV(I)=UF(I)	MONTE2	103
	DO 1004 NX=1,NRUN	MONTE2	104
	DO 7010 MAC=1,IDFL	MONTE2	105
105	7010 AEDOTN(MAC,NX)=0.	MONTE2	106
	TOPCAV=0.	MONTE2	107
	DO 200 JJ=1,IRAYS	MONTE2	108
	ICELM=0	MONTE2	109
	JCELM=0	MONTE2	110
110	XCM=0.	MONTE2	111
	YCM=0.	MONTE2	112
	CALL RNORM(R6,R7)	MONTE2	113
	THSL=TSV*R6*TSB	MONTE2	114
	PH=360.*RANF(0.0)	MONTE2	115

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115	CALL RNORM(R3,R4)	MONTE2	116
	PAX1=PAX1V*P3+PAX1B	MONTE2	117
	PAX2=PAX2V*R4+PAX2B	MONTE2	118
	R2=RANF(0.)	MONTE2	119
	R3=RANF(0.)	MONTE2	120
120	CSRA=COS(6.28318*R2)	MONTE2	121
	SNRA=SIN(6.28318*R2)	MONTE2	122
	CALL LIMDR(R3,LIMC,ROERN)	MONTE2	123
	THSR=ROERN*CSRA	MONTE2	124
	THSU=ROERN*SNRA	MONTE2	125
125	708 R6=RANF(0.)	MONTE2	126
	R7=RANF(0.)	MONTE2	127
	ND1=2	MONTE2	128
	COUNT=1.	MONTE2	129
	IAC=0	MONTE2	130
130	CDUM1=COS(6.28318*R6)	MONTE2	131
	CDUM2=SIN(6.28318*R6)	MONTE2	132
	CDUM3=SQRT((RFIELD*0.1*TH)**2*R7)	MONTE2	133
	XP=CDUM1*CDUM3-TDISX	MONTE2	134
	YP=CDUM2*CDUM3-TDISY	MONTE2	135
135	IF (SQRT(XP*XP+YP*YP) .LT. RCO/2.) GO TO 708	MONTE2	136
	CALL TSHAD(DDBASE,ODTOP,ICOD)	MONTE2	137
	IF (ICOD.EQ.0) GO TO 8000	MONTE2	138
	ITT(14)=ITT(14)+1	MONTE2	139
	GO TO 200	MONTE2	140
140	8000 CALL PTOWER(ND1,IAC,ARATIO)	MONTE2	141
	ITT(ND1+1)=ITT(ND1+1)+1	MONTE2	142
	ICOLH=ICOLH+ICMH	MONTE2	143
	ICOLS=ICOLS+ICSH	MONTE2	144
	ICOL0=ICOL0+IOHIT	MONTE2	145
145	COLH=COLH+COUNT*ICMH	MONTE2	146
	COL0=COL0+COUNT*IOHIT	MONTE2	147
	C ENERGY LOST IN MIRROR SHADOWS	MONTE2	148
	SHADL=SHADL+COUNT*ICSH	MONTE2	149
	IF (IFRAM.GT.0) FRSHAD(IFRAM)=FRSHAD(IFRAM)+COUNT	MONTE2	150
150	IF (ND1.GE. 4) CALL POLMAP(COUNT,CONV,NPP,2,ND1)	MONTE2	151
	IF (ND1.EQ.12) SPPT=SPPT+COUNT	MONTE2	152
	IF (IAC.EQ.0) GO TO 200	MONTE2	153
	EDOTN=COUNT	MONTE2	154
	AVE=AVE+EDOTN	MONTE2	155
155	AEDOTN(IAC,NX)=AEDOTN(IAC,NX)+EDOTN	MONTE2	156
	FIELD(ICELM,JCELM)=FIELD(ICELM,JCELM)+COUNT	MONTE2	157
	IF (IAC.EQ.3) TOPCAV=TOPCAV+COUNT	MONTE2	158
	IF (IAC.EQ.3) CALL ROOF(2,DCONM)	MONTE2	159
	IF (IAC.EQ.2) FLMAPC(CILAT(2),ILONG)=FLMAPC(CILAT(2),ILONG)+COUNT	MONTE2	160
160	200 CONTINUE	MONTE2	161
	DNM=1./FLOAT(IRAYS)	MONTE2	162
	XDFPR(1,NX)=FLOAT(ICOLH)*DNM	MONTE2	163
	DNM2=FLOAT(ICOLS)	MONTE2	164
	DNM3=1./FLOAT(IRAYS+ICOLS)	MONTE2	165
165	XDFPR(2,NX)=DNM2*DNM3	MONTE2	166
	DNM4=FLOAT(ICOL0)	MONTE2	167
	XDFPR(3,NX)=DNM4*DNM	MONTE2	168
	XDFPR(4,NX)=AVE*DNM	MONTE2	169
	TOP(NX)=TOPCAV*DNM	MONTE2	170
170	DO 7004 MAC=1,IDFL	MONTE2	171
	7004 AEDOTN(MAC,NX)=AEDOTN(MAC,NX)+DNM	MONTE2	172

1004 CONTINUE
 DO 1802 I=1,NRUN
 TOPC=TOPC+TOP(I)
 175 DO 7005 MAC=1,IDFL
 7005 AFLUX(MAC)=AFLUX(MAC)+AEDOTN*MAC*I
 1802 CONTINUE
 DCCNM=.001*CONV/FLOAT(NRUN*IRAYS)
 SPFT = SOPT*DCCNM*1000.
 180 DO 6106 I=1,NN1
 DO 6106 J=1,NLONG
 6106 FL*APC(I,J) = FL*APC(I,J)*DCCNM
 XXR=1./FLOAT(NRUN*IRAYS)
 DO 8102 I=1,12
 185 DO 8102 J=1,12
 8102 FIELD(I,J)=FIELD(I,J)*XXR
 TOPC=TOPC/FLOAT(NRUN)
 DO 7006 MAC=1,IDFL
 7006 AFLUX(MAC)=AFLUX(MAC)/NRJN
 190 WRITE(6,1820) NRUN,IRAYS
 1820 FORMAT(25X,15HSTATISTICS FOR ,I4,8H RUNS AT,I6,13H RAYS PER RUN,/)
 WRITE(6,1821)
 1821 FORMAT(/,40X,10H*****J1=OUTPUT CODE,10H*****//,10X,
 144HETA1=FRACTION OF FIELD FLX THAT HIT MIRRORS,/,10X,
 195 216HETA2=REFLECTANCE,/,10X,
 349HETA3=FRACTION OF FLUX NOT OBSCURED ON THE WAY OUT,/,10X,
 536HETA4=FRACTION OF FLUX THAT HIT TOWER,/,10X,
 652HETA5=FRACTION OF FIELD FLX THAT HIT CAVITY ,/,10X,
 753HETA6=FRACTION OF FIELD FLX THAT HIT THE CAVITY WALLS,/,10X,
 200 852HETA7=FRACTION OF FIELD FLX THAT WAS IN TOWER SHADOW,/)
 WRITE(6,9001)
 9001 FORMAT(/,10X,34HEFLUX1=TOTAL FLUX ON FIELD IN KW ,/,10X,
 140HEFLUX2=TOTAL FLUX ON MIRRORS IN KW ,/,10X,
 242HEFLUX3=TOTAL FLUX LEAVING MIRRORS IN KW ,/,10X,
 205 355HEFLUX4=TOTAL FLUX CLEARLY AWAY FROM FIELD IN KW ,/,10X,
 139HEFLUX5=TOTAL FLUX ON POWER TOWER IN KW ,/,10X,
 237HEFLUX6=FLUX ON CAVITY DIFFUSER IN KW ,/,10X,
 734HEFLUX7=FLUX ON CAVITY WALLS IN KW ,/,10X,
 837HEFLUX8=FLUX ON CAVITY CEILING IN KW ,/)
 WRITE(6,2799)
 2799 FOPMAT(10X,28HN1=RAYS DRAWN BEFORE SUMRISE,/,10X,
 138HN2=RAYS DRAWN WHEN THE SUN WAS TOO LOW,/,10X,
 237HN3=RAYS DRAWN THAT HIT THE OPEN FIELD,/,10X,
 347HN4=RAYS WHICH HIT MIRROR BUT WERE LOST IN SPACE,/,10X,
 215 443HN5=RAYS DRAWN THAT WERE BLOCKED IN OMBLOCKS,/,10X,
 538HN6=RAYS THAT WERE OBSCURED IN OFFBLOCK,/,10X,
 633HN7=RAYS WHICH HIT CAVITY DIFFUSER,/,10X,
 723HN8=RAYS WHICH HIT WALLS,/,10X,
 822HN9=RAYS WHICH HIT ROOF,/,10X,
 220 926HN10=RAYS WHICH MISSED HIGH,/,10X,
 138HN11=RAYS WHICH MISSED ACROSS THE FRONT,/,10X,
 125HN12=RAYS WHICH MISSED LOW,/,10X,
 227HN13=RAYS WHICH HIT SUPPORTS,/,10X,
 339HN14=RAYS WHICH WERE IN THE TOWER SHADOW,/,10X,
 225 *28HN15=RAYS WHICH WHISTLED T-RU,/,10X,
 443HN16=RAYS WHICH FRAME SHADOWED ON SAME HELIO,/,10X,
 544HN17=RAYS WHICH FRAME SHADOWED ON OTHER HELIO,/,10X,
 642HN18=RAYS WHICH FRAME BLOCXED ON SAME HELIO,/,10X,

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230 743HN19=RAYS WHICH FRAME BLOCKED ON OTHER HELIO)
 TOPC=TOPC*CONV
 NTOT=NRUN*IRAYS
 XM(1)=CONV
 XM(2)=ICOLH*CONV/NTOT
 XM(3)=COLH*CONV/NTOT
 235 XMRLC=COLD*CONV/NTOT
 XMSHAD=SHADL*CONV/FLCAT(NTOT)
 XM(5)=AVE/NTOT*CONV
 XM(6)=AFLUX(1)*CONV
 XM(7)=AFLUX(2)*CONV
 240 XM(8)=TOPC
 FRSHAD(1)=FRSHAD(1)*CONV/FLOAT(NTOT)
 FRSHAD(2)=FRSHAD(2)*CONV/FLOAT(NTOT)
 FRSHAD(3)=FRSHAD(3)*CONV/FLOAT(NTOT)
 FRSHAD(4)=FRSHAD(4)*CONV/FLOAT(NTOT)
 245 C
 C*****FRSHAD(1)=ENERGY LOST FROM FRAME SHADOWS
 C*****ON THE SAME HELIOSTAT WHICH CONTAINS THE HIT FACET
 C
 C*****FRSHAD(2)=ENERGY LOST FROM FRAME SHADOWS ON HELIOSTATS
 250 C OTHER THAN THE ONE WHICH CONTAINS THE HIT FACET
 C
 C*****FRSHAD(3)=ENERGY LOST FROM FRAME BLOCKS ON THE SAME
 C HELIOSTAT WHICH CONTAINS THE HIT FACET
 C
 255 C*****FRSHAD(4)=ENERGY LOST FROM FRAME BLOCKS ON HELIOSTATS
 C OTHER THAN THE ONE WHICH CONTAINS THE HIT FACET
 C
 XM(4)=XM(3)-XMBLOC
 XMABBE=XM(4)-XM(5)
 260 XMREFL=XM(2)-XM(3)
 ETA(1)=XM(2)/XM(1)
 ETA(2)=1.0-XMREFL/XM(2)
 ETA(3)=1.0-XMBLOC/XM(3)
 ETA(4)=1.0-XMABBE/XM(4)
 265 ETA(5)=XM(5)/XM(1)
 ETA(6)=XM(7)/XM(1)
 ETA(7)=FLOAT(ITT(14))/FLOAT(NRUN*IRAYS)
 DDUM=1./ETA(1)
 XXR=CONV/(.0929*WCELL*WCELL)
 270 DO 8103 I=1,12
 DO 8103 J=1,12
 8103 FIELD(I,J)=FIELD(I,J)*XXR
 WRITE(6,1005) (I,I=1,7)
 1005 FORMAT(/,10X,7(4X,3HETA,I1))
 275 WRITE(6,1006) (ETA(I),I=1,7)
 1006 FORMAT(10X,14F8.5)
 KI=1
 WRITE(6,1007) (J,J=1,3)
 1007 FORMAT(/,8(9X,5HEFLUX,I1))
 280 WRITE(6,1008) (XM(I),I=1,8)
 1008 FORMAT(9F15.6)
 2001 FORMAT(/,10X,9(3X,1HN,I1),10(3X,1HN,I2))
 WRITE(6,2001) (I,I=1,19)
 WRITE(6,2002) (ITT(I),I=1,19)
 285 2002 FORMAT(10X,9I5,10I6,/)

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7002 FORMAT(1H1)
WRITE(6,20)
20  FORMAT(//,20X,14HTIME POINT FUN)
AFIELD=DELRAD*3.14159
AREAM=NCOL*NHF*WD*WV*0.0929
EPM(1)=(XM(2)*XMSHAD+FRSHAD(1)+FRSHAD(2))/AREAM
DO 21 I=2,5
21  EPM(I)=XM(I)/AREAM
EPM(6)=EPM(5)*0.9
TE1=EPM(1)/XMDNI
TE2=EPM(4)/XMDNI
WRITE(6,27) AREAM,XMDNI
27  FORMAT(/,9X,18HACTUAL MIRROR AREA,10X,20HDIRECT NORMAL ENERGY,
* /,15X,F12.4,18X,F12.4)
WRITE(6,23) (EPM(I),I=1,6)
23  FORMAT(/,23X,26HENERGY (KWH) PER SQ. METER,
1/,20X,10HUNSHADOWED,10X,F12.4,
2/,20X,8HSHADOWED,12X,F12.4,
3/,20X,14HLEAVING MIRROR,6X,F12.4,
4/,20X,12HCLEANLY AWAY,8X,F12.4,
5/,20X,13HTHRU APERTURE,7X,F12.4,
6/,20X,8HABSORBED,12X,F12.4)
WRITE(6,24) TE1,TE2
24  FORMAT(/,15X,19HTRACKING EFFICIENCY,2X,12H(UNSHADOWED),7X,
*F10.4,/,16X,14H(CLEANLY AWAY),5X,F10.4)
WRITE(6,5)
5  FORMAT(//,11X,9HNUMBER OF,5X,7HSUPPORT,7X,6HKWH ON,/,12X,8HSUPP
PORTS,7X,5HWIDTH,4X,8HSUPPORTS)
WRITE(6,10) NSUP,SW,SPRT
10  FORMAT(/,10X,110,F12.1,F12.1,/)
WRITE(6,4010) (IPAN(IP),IP=1,7)
8010 FORMAT(//,36X,20HHELIOSTAT FRAME HITS,/,20X,9HTOP FRAME,4X,
2 11HSIDE FRAMES,4X,12HCROSS FRAMES,4X,12HBOTTOM FRAME,/,22X,
3 13,9X,13,3X,13,5X,3(13,2X),6X,13)
WRITE(6,3150) FRSHAD(1),FRSHAD(2),FRSHAD(3),FRSHAD(4)
3150 FORMAT(//,40X,27HENERGY LOST ON FRAME IN KWH,/,28X,12HFRAME SHAD
*W,28X,11HFRAME BLOCK,/,16X,13HON SAME HELIO,7X,
113HON DIFF HELIO,7X,13HON SAME HELIO,7X,13HON DIFF HELIO,/,
215X,F12.1,8X,F12.1,8X,F12.1,8X,F12.1)
WRITE(6,7002)
CALL HITFAC(0,0,0,3,NHF)
XZONE=6.283185*RSWTC(2)*HCAV*0.0929/FLDAT(NLONG*NLATC)
PZONE=1./XZONE
DO 6402 I=1,NN1
DO 6402 J=1,NLONG
6402 FLMAPC(I,J)=FLMAPC(I,J)*PZONE
CALL WALLMP(FLMAPC,NLONG,NLATC,HCAV)
CALL ROOF(3,DCONM)
WRITE(6,8104)
8104 FORMAT(20X,44HKW/SQ.M FLUX MAP OF POWER TOWER MIRROR FIELD,/)
DO 8105 J=1,10
8105 WRITE(6,8106) (FIELD(I,J),I=1,10)
8106 FORMAT(10X,12F10.6)
CALL POLMAP(COUNT,CONV,NTOT,3,NO1)
STEST=10.E+30
NMX=110
IS=NMX/10

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MONTE2 327
FINAL 2
FINAL 3
FINAL 4
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FINAL 6
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SUBROUTINE MONTE2 74/74 OPT=1

FTN 4.5+410A

03/21/77 21.51.16

PAGE 7

	K=0	MONTE2	339
	ISTOP=IS	MONTE2	340
345	DO 3050 NN=1,NMX	MONTE2	341
	SMAX=0.0	MONTE2	342
	DO 3040 I=1,11	MONTE2	343
	DO 3040 J=1,10	MONTE2	344
3040	IF (FIELD(I,J).GT.SMAX.AND.FIELD(I,J).LT.STEST) SMAX=FIELD(I,J)	MONTE2	345
350	STEST=SMAX	MONTE2	346
	IF (NN.LT.ISTOP) GO TO 3050	MONTE2	347
	ISTOP=ISTOP+IS	MONTE2	348
	K=K+1	MONTE2	349
	SL(K)=SMAX	MONTE2	350
355	3050 CONTINUE	MONTE2	351
	KK=K-1	MONTE2	352
	WRITE (6,3180) (SL(I),I=1,10)	MONTE2	353
3180	FORMAT(1H1,///,10X,8HSL ARRAY,10F10.6,///)	MONTE2	354
	DO 61 J=1,10	MONTE2	355
360	DO 73 I=1,11	MONTE2	356
73	IO(I)=0	MONTE2	357
	DO 70 I=1,11	MONTE2	358
	DO 60 KL=1,KK	MONTE2	359
	KLX=KK-KL+1	MONTE2	360
365	IF (FIELD(I,J).GT.SL(KLX)) GO TO 43	MONTE2	361
	GO TO 70	MONTE2	362
43	IO(I)=KLX	MONTE2	363
60	CONTINUE	MONTE2	364
70	CONTINUE	MONTE2	365
370	WRITE(6,65) (IO(II),II=1,11)	MONTE2	366
	65 FCPMAT(20X,20I4,///)	MONTE2	367
	61 CONTINUE	MONTE2	368
	62 CONTINUE	MONTE2	369
	RETURN	MONTE2	370
375	END	MONTE2	371

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1      SJROUTINE MONTE(XM,HOURS)
      C** THIS IS THE TIME INTEGRATION ROUTINE. IT RANDOMLY CHOOSES A TIME
      C AND DAY OVER THE ENTIRE YEAR, AND USES THE RESULTS TO INTEGRATE
      C YEAPLY ENERGY. FROM IT, VECTS, INTEN, RNORP AND PTOWER ARE CALLED.
5      REAL N
      DIMENSION TOP(15)
      INTEGER CILAT
      COMMON/CAVITY/SEP,DD1,DD2,RDIF,HDIF,HCAV,HSWTC(2),RSWTC(2),
10     CILAT(2),CAVLAT(2,21),AIMHGT
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XDF,W02,WV2,
1     RNS(3),DELX,DELY,W0,IFY,RRB(3),UA,VP(3),UXV2PP(3),
2     UTT(3),UNNP(3),UXV2P(3),
3     UMNPP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),ORAD
15     COMMON /STATS/TPB,TSB,PHB,TPY,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B

      COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
      COMMON/BABA/STH,CTH,SEQ,OME,DMS,N(3),UE(3),
20     UN(3),US(3),UA(3),UR(3),THETA,MON,ICAY,SMALR,CAPR,CEQ
      COMMON/RANDOM/NRUN,IRANC,IJUMP,MODE,ISRAN,IRAYS
1     IT1,UDNI,LINC,DINTV,YFRAC
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1     ICSH,IFC,IHIT,ICSH2,WCOL,IHOUR,FIN,ELZ,T,TOISX,TOISY,
2     DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
25     NLONG,ILONG,NLATC,RCO,UPACK,ENMH
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLDUM,WCELL,ICELL,JCELL,
1     XCSAV,YCSAV,XCM,YCM,ICFLM,JCELM
      COMMON/SUPPT/DELT,THES,KSEG,APH,SW,NSUF,RCONE,THECON,HTOT
      COMMON/TILTED/TILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET
30     COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,B1,B2,WCCROSS,WUM,IFRAM
      COMMON/HTHIR,HTCROS,WJCROS
      COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT,UTARG(3),DTARG(3)
      DIMENSION FRSHAD(4)
      COMMON/PLANE/IPLAN(7)
35     DIMENSION XDFPR(9,15),XM(9),ITT(21)
      DIMENSION FLMAPC(21,36)
      DIMENSION AEDOTN(2,10),AFLUX(2),FIELD(12,12)
      DIMENSION ETA(7),EPH(8)
      DIMENSION NDM(12),IO(36),SL(15)
40     DATA NDM/31,59,90,120,151,181,212,243,273,304,334,365/
      WRITE(6,7532)
7532  FORMAT(141,/,39X,28HHELIOSTAT OPTICAL PARAMETERS,/)
      WRITE(6,7001) PAX1B,PAX2B,TSB,PHB,PAX1V,PAX2V,TSV,PHV
7001  FORMAT(15X,5HPAX1B,5X,5HPAX2B,7X,3HTSB,7X,3HPHB,5X,5HPAX1V,5X,
45  15HPAX2V,7X,3HTSV,7X,3HPHV,/,10X,10F10.5,/)
      NNI=NLATC
      DO 8011 I=1,7
      8011  IPLAN(I)=0
      DO 412 I=1,4
      412  FRSHAD(I)=0.0
50     DO 3010 I=1,20
      3010  ITT(I)=0
      CALL HITFAC(0.0,0.0,1.0)
      CALL TMAP(0.0,0.0,1.0,0.0,1)
      CALL POLMAP(0.0,0.0,0.0,1.0)
55     CALL ROOF(1.0)
      DO 6102 I=1,NNI

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FINAL 7
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	DO 6102 J= 1,NLONG	MONTE	59
60	6102 FLWAPC(I,J) = 0.	MONTE	60
	TOPC=0.	MONTE	61
	TOTEN=0.0	MONTE	62
	TOTONI=0.	MONTE	63
	COLH=0.0	MONTE	64
	COLO=0.0	MONTE	65
65	ENHM=0.0	MONTE	66
	FOPY=0.0	MONTE	67
	SHADL=0.0	MONTE	68
	NTOT=NRUN*IRAYS	MONTE	69
	XKNT=0.0	MONTE	70
70	C POINT D	MONTE	71
	DO 8101 I=1,12	MONTE	72
	DO 8101 J=1,12	MONTE	73
	8101 FIELD(I,J)=0.	MONTE	74
	IDFL=2	MONTE	75
75	CTILT=COS(TTILT)	MONTE	76
	STILT=SIN(TTILT)	MONTE	77
	SPOT = 0.0	MONTE	78
	DO 7009 MAC=1,IDFL	MONTE	79
	7009 AFLUX(MAC)=0.	MONTE	80
80	DO 3611 I=1,7	MONTE	81
	3611 XM(I)=0.	MONTE	82
	MON=6	MONTE	83
	IDAY=21	MONTE	84
	T=12.	MONTE	85
85	CALL VECTS	MONTE	86
	DENOM=SQRT(A*A*B*B)	MONTE	87
	EL7=ATAN2(C,DENOM)	MONTE	88
	CALL INTEN(MON, IDAY, ELZ, UDNI)	MONTE	89
	UDNI=.00315*UDNI*C	MONTE	90
90	C FOR POLAR PACKING THE DRAW RANGE IS EXTENDED FROM RCO/2 TO RFIELD.	MONTE	91
	RFIELD=RFIELD*0.1*TH	MONTE	92
	RCO=RCO/2.	MONTE	93
	AREA=3.14159*(RFIELD*RFIELD-RCO*RCO)	MONTE	94
	CONV=.0929*UDNI*AREA*DINTV*YFRAC	MONTE	95
95	RCO2 = RCO*RCO	MONTE	96
	DELRAD = RFIELD**2 - RCO2	MONTE	97
	RFIELD=RFIELD*0.1*TH	MONTE	98
	RCO=RCO*2.	MONTE	99
	C THIS IS BECAUSE Q IS IN LANGLEY/MIN.	MONTE	100
100	WRITE(6,1001) CONV	MONTE	101
	1001 FORMAT(/ ,20X,10H***** ,20H CONVERSION FACTOR =,E20.10,	MONTE	102
	1 11H *****/,)	MONTE	103
	DO 1004 NX=1,NRUN	MONTE	104
	AVF=0.	MONTE	105
105	ICOL0=0	MONTE	106
	ICOLS=0	MONTE	107
	ICOLH=0	MONTE	108
	TOPCAV=0.	MONTE	109
	DO 7010 MAC=1,IDFL	MONTE	110
110	7010 AEDOTN(MAC,NX)=0.	MONTE	111
	DO 200 JJ=1,IRAYS	MONTE	112
	ICELM=0	MONTE	113
	JCELM=0	MONTE	114
	XCM=0.	MONTE	115

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115	YCM=0.	MONTE 116
	ND1=0	MONTE 117
	CALL RNORM(R6,R7)	MONTE 118
	THSL=TSV*R6*TSB	MONTE 119
	PH=360.*RANF(0.)	MONTE 120
120	CALL RNORM(R3,R4)	MONTE 121
	PAX1=PAX1V*R3*PAX1B	MONTE 122
	PAX2=PAX2V*R4*PAX2B	MONTE 123
	XR2=RANF(0.)	MONTE 124
	XR3=RANF(0.)	MONTE 125
125	NDAY=INT(XR2*365.)*1	MONTE 126
	DO 5195 I=1,12	MONTE 127
	IF(NDAY.LE.NDM(I)) GO TO 5101	MONTE 128
	5195 CONTINUE	MONTE 129
	GO TO 5102	MONTE 130
130	5101 MON=I	MONTE 131
	5102 IF(MON.LE.1) GO TO 5196	MONTE 132
	IDAY=NDAY-NDM(MON-1)	MONTE 133
	GO TO 5197	MONTE 134
	5196 IDAY=NDAY	MONTE 135
135	5197 CONTINUE	MONTE 136
	T=XR3*14.*5.	MONTE 137
	CALL VECTS	MONTE 138
	IF (C.GT. 0.0) GO TO 8950	MONTE 139
	COUNT=0.	MONTE 140
140	ITT(1)=ITT(1)+1	MONTE 141
	GO TO 200	MONTE 142
	8950 DENOM=SQRT(B*B-A*A)	MONTE 143
	ELZ=ATAN2(C*DENOM)	MONTE 144
	IF (C.GE. .065) GO TO 5198	MONTE 145
145	ITT(2)=ITT(2)+1	MONTE 146
	COUNT=0.	MONTE 147
	GO TO 200	MONTE 148
	5198 CALL INTEN(MCN,IDAY,ELZ,DNI)	MONTE 149
	DNI=.00315*DNI*C	MONTE 150
150	COUNT=DNI/UDNI	MONTE 151
	DO 297 I=1,3	MONTE 152
	UVI(I)=CTILT*U(I)-STILT*UNI(I)	MONTE 153
	UI(I)=CTILT*U(I)+STILT*UNI(I)	MONTE 154
	U2(I)=UE(I)	MONTE 155
155	297 UHV(I)=UE(I)	MONTE 156
	ND1=2	MONTE 157
	C TOTAL ENERGY FALLING ON FIELD	MONTE 158
	TOTEN=TOTEN+COUNT	MONTE 159
	C TOTAL DIRECT NORMAL ENERGY	MONTE 160
160	TOTDNI=TOTDNI+DNI/C	MONTE 161
	R2=RANF(0.)	MONTE 162
	R3=RANF(0.)	MONTE 163
	CSRA=COS(6.28318*R2)	MONTE 164
	SNRA=SIN(6.28318*R2)	MONTE 165
165	CALL LJMOR(R3,LINC,ROERN)	MONTE 166
	THSR=ROERN*CSRA	MONTE 167
	THSU=ROERN*SNRA	MONTE 168
	708 R6=RANF(0.)	MONTE 169
	R7=RANF(0.)	MONTE 170
170	IAC=0	MONTE 171
	CDUM1=COS(6.28318*R6)	MONTE 172

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CDUM2=SIN(6.28318*R6)
 CDUM3=SQRT((RFIELD*.1*TH)**2*R7)
 XP=CDUM1*CDUM3
 YP=CDUM2*CDUM3
 XP=XP-TDJSX
 YP=YP-TDJSY
 IF (SQRT(XP*XP+YP*YP) .LT. RCO/2.) GO TO 708
 CALL TSHAD(DDBASE,DDTOP,ICOD)
 IF (ICOD.EQ.0) GO TO 8000
 ITT(14)=ITT(14)+1
 GO TO 200
 8000 CALL PTOWER(ND1,IAC,ARATIO)
 ITT(ND1+1)=ITT(ND1+1)+1
 ICOLH=ICOLH+ICMH
 ICOLS=ICOLS+ICSH
 ICOL0=ICOL0+IOHIT
 C ENERGY AWAY FROM MIRRORS (REFLECTANCE INCLUDED)
 COLH=COLH+COUNT*ICMH
 C ENERGY OBSCURED BY MIRROR BACKS
 COL0=COL0+COUNT*IOHIT
 SHADL=SHADL+COUNT*ICSH
 IF (IFRAM.GT.0) FRSHAD(IFRAM)=FRSHAD(IFRAM)+COUNT
 IF (ND1 .GE. 4) CALL POLMAP(COUNT,CONV,NPP,2,ND1)
 IF (ND1.EQ.12) SPPT=SPPT+COUNT
 IF (IAC.EQ.0) GO TO 200
 EDOTN=COUNT
 FOPT=FOPT+EDOTN
 AVE=AVE+EDOTN
 AEDOTN(IAC,NX)=AEDOTN(IAC,NX)+EDOTN
 CALL TMAP(XCM,YCM,MON,COUNT,NTOT,CONV,2)
 FIELD(ICELM,JCELM)=FIELD(ICELM,JCELM)+COUNT
 IF (IAC.EQ.3) TOPCAV=TOPCAV+COUNT
 IF (IAC.EQ.3) CALL ROOF(2,DCONM)
 IF (IAC.EQ.2) FLMAPC(CILAT(2),ILONG)=FLMAPC(CILAT(2),ILONG)+COUNT
 200 CONTINUE
 DNM=1./FLOAT(IRAYS)
 XDFPR(1,NX)=FLOAT(ICOLH)*DNM
 DNM2=FLOAT(ICOLS)
 DDDS=1./FLOAT(IRAYS+ICOLS)
 XDFPR(2,NX)=DNM2*DDDS
 DNM4=FLOAT(ICOL0)
 XDFPR(3,NX)=DNM4*DNM
 XDFPR(4,NX)=AVE*DNM
 TOP(NX)=TOPCAV*DNM
 DO 7004 MAC=1,IDFL
 7004 AEDOTN(MAC,NX)=AEDOTN(MAC,NX)*DNM
 1004 CONTINUE
 DO 1802 J=1,NRUN
 TOPC=TOPC+TOP(I)
 DO 7005 MAC=1,IDFL
 7005 AFLUX(MAC)=AFLUX(MAC)+AEDOTN(MAC,I)
 DO 1802 J=1,4
 1802 XM(J)=XM(J)+XDFPR(J,I)
 DCONM=.001*CONV/FLOAT(NRUN*IRAYS)
 DO 6004 J=1,NN1
 DO 6004 J=1,NLONG
 6004 FLMAPC(I,J)=FLMAPC(I,J)*DCONM

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230 SPPT = SPPT*DCONM*1000. MONTE 230
 XXP=1./FLOAT(NRUN*IRAYS) MONTE 231
 DO 8102 I=1,12 MONTE 232
 DO 8102 J=1,12 MONTE 233
 8102 FIELD(I,J)=FIELD(I,J)*XXR MONTE 234
 TOPC=TOPC*CONV/FLOAT(NRUN) MONTE 235
 235 DO 7006 MAC=1,10FL MONTE 236
 7006 AFLUX(MAC)=AFLUX(MAC)/NRUN MONTE 237
 WRITE(6,1820) NRUN,IRAYS MONTE 238
 1820 FORMAT(/,25X,15HSTATISTICS FOR ,14.8H RUNS AT,16,13H RAYS PER RUN, MONTE 239
 1/) MONTE 240
 240 WRITE(6,1821) MONTE 241
 1821 FORMAT(/,40X,10H*****,11HOUTPUT CODE,10H*****,//,10X, MONTE 242
 144HETA1=FRACTION OF FIELD FLUX THAT HIT MIRRORS,//,10X, MONTE 243
 216HETA2=REFLECTANCE,//,10X, MONTE 244
 349HETA3=FRACTION OF FLUX NOT OBSCURED ON THE WAY OUT,//,10X, MONTE 245
 245 536HETA4=FRACTION OF FLUX THAT HIT TOWER,//,10X, MONTE 246
 652HETA5=FRACTION OF FIELD FLUX THAT HIT CAVITY //,10X, MONTE 247
 753HETA6=FRACTION OF FIELD FLUX THAT HIT THE CAVITY WALLS,//,10X, MONTE 248
 852HETA7=FRACTION OF FIELD FLUX THAT WAS IN TOWER SHADOW.// MONTE 249
 WRITE(6,9001) MONTE 250
 250 9001 FORMAT(/,10X,34HEFLUX1=TOTAL FLUX ON FIELD IN KWH //,10X, MONTE 251
 140HEFLUX2=TOTAL FLUX ON MIRRORS IN KWH //,10X, MONTE 252
 242HEFLUX3=TOTAL FLUX LEAVING MIRRORS IN KWH //,10X, MONTE 253
 355HEFLUX4=TOTAL FLUX CLEARLY AWAY FROM FIELD IN KWH //,10X, MONTE 254
 139HEFLUX5=TOTAL FLUX ON POWER TOWER IN KWH//,10X, MONTE 255
 255 237HEFLUX6=FLUX ON CAVITY DIFFUSER IN KWH//,10X, MONTE 256
 734HEFLUX7=FLUX ON CAVITY WALLS IN KWH//,10X, MONTE 257
 837HEFLUX8=FLUX ON CAVITY CEILING IN KWH.// MONTE 258
 WRITE(6,2799) MONTE 259
 2799 FORMAT(/,10X,28HNI=RAYS DRAWN BEFORE SUNRISE,//,10X, MONTE 260
 138HN2=RAYS DRAWN WHEN THE SUN WAS TOO LOW,//,10X, MONTE 261
 237HN3=RAYS DRAWN THAT HIT THE OPEN FIELD,//,10X, MONTE 262
 347HN4=RAYS WHICH HIT MIRROR BUT WERE LOST IN SPACE,//,10X, MONTE 263
 443HN5=RAYS DRAWN THAT WERE BLOCKED IN OMBLOCKS,//,10X, MONTE 264
 538HN6=RAYS THAT WERE OBSCURED IN OFFBLOCKS,//,10X, MONTE 265
 265 633HN7=RAYS WHICH HIT CAVITY DIFFUSER,//,10X, MONTE 266
 723HN8=RAYS WHICH HIT WALLS,//,10X, MONTE 267
 822HN9=RAYS WHICH HIT ROOF,//,10X, MONTE 268
 926HN10=RAYS WHICH MISSED HIGH,//,10X, MONTE 269
 138HN11=RAYS WHICH MISSED ACROSS THE FRONT,//,10X, MONTE 270
 270 125HN12=RAYS WHICH MISSED LOW,//,10X, MONTE 271
 227HN13=RAYS WHICH HIT SUPPORTS,//,10X, MONTE 272
 335HN14=RAYS WHICH WERE IN THE TOWER SHADOW,//,10X, MONTE 273
 431HN15=RAYS WHICH WHISTLED THROUGH,//,10X, MONTE 274
 443HN16=RAYS WHICH FRAME SHADOWED ON SAME HELIO,//,10X, MONTE 275
 275 544HN17=RAYS WHICH FRAME SHADOWED ON OTHER HELIO,//,10X, MONTE 276
 642HN18=RAYS WHICH FRAME BLOCKED ON SAME HELIO,//,10X, MONTE 277
 743HN19=RAYS WHICH FRAME BLOCKED ON OTHER HELIO MONTE 278
 ETA(7)=FLOAT(ITT(14))/FLOAT(NRUN*IRAYS-ITT(1)-ITT(2)) MONTE 279
 C HIT RECEIVER MONTE 280
 280 XM(6)=AFLUX(1)*CONV MONTE 281
 XM(7)=AFLUX(2)*CONV MONTE 282
 ENORTH = 0.0 MONTE 283
 ESOUTH = 0.0 MONTE 284
 XM(8)=TOTDNI*0.01*NTV*YFRAC/NTOT MONTE 285
 285 XM(8)=TOPC MONTE 286

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290      XM(1)=TOTEN*CONV/NTOT
      XM(2)=EN*H*CONV/NTOT
      XM(3)=COL*H*CONV/NTOT
      XMBLOC=COL*H*CONV/NTOT
      XMSHAD=SHADL*CONV/FLOAT(NTOT)
      XM(5)=FOPT*CONV/NTOT
      FRSHAD(1)=FRSHAD(1)*CONV/FLOAT(NTOT)
      FRSHAD(2)=FRSHAD(2)*CONV/FLOAT(NTOT)
      FRSHAD(3)=FRSHAD(3)*CONV/FLOAT(NTOT)
295      FRSHAD(4)=FRSHAD(4)*CONV/FLOAT(NTOT)
      C
      C*****FRSHAD(1)=ENERGY LOST FROM FRAME SHADOWS
      C*****ON THE SAME HELIOSTAT WHICH CONTAINS THE HIT FACET
      C
300      C*****FRSHAD(2)=ENERGY LOST FROM FRAME SHADOWS ON HELIOSTATS
      C      OTHER THAN THE ONE WHICH CONTAINS THE HIT FACET
      C
      C*****FRSHAD(3)=ENERGY LOST FROM FRAME BLOCKS ON THE SAME
      C      HELIOSTAT WHICH CONTAINS THE HIT FACET
305      C
      C*****FRSHAD(4)=ENERGY LOST FROM FRAME BLOCKS ON HELIOSTATS
      C      OTHER THAN THE ONE WHICH CONTAINS THE HIT FACET
      C
      XM(4)=XM(3)-XMBLOC
310      XMABBE=XM(4)-XM(5)
      XMREFL=XM(2)-XM(3)
      ETA(1)=XM(2)/XM(1)
      ETA(2)=1.0-XMREFL/XM(2)
      ETA(3)=1.0-XMBLOC/XM(3)
315      ETA(4)=1.0-XMABBE/XM(4)
      ETA(5)=XM(5)/XM(1)
      ETA(6)=XM(7)/XM(1)
      DO 8202 I=1,10
      DO 8200 J=1,5
320      8200 ENORTH = ENORTH + FIELD(I,J)
      DO 8201 J=6,10
      8201 ESOUTH = ESOUTH + FIELD(I,J)
      8202 CONTINUE
      ENORTH = ENORTH*0.001*CONV
      ESOUTH = ESOUTH*0.001*CONV
325      XXR=.001*CONV/(.0929*WCELL*WCELL)
      DO 8103 I=1,12
      DO 8103 J=1,12
      8103 FIELD(I,J)=FIELD(I,J)*XXR
330      WRITE(6,1005) (I,I=1,7)
      1005 FORMAT(/,10X,7(4X,5HETA,11))
      WRITE(6,1006) (ETA(I),I=1,7)
      1006 FORMAT(10X,14F8,5)
      WRITE(6,1007) (J,J=1,8)
335      1007 FORMAT(/,8(9X,5HEFLUX,11),/)
      WRITE(6,1008) (XM(I),I=1,8)
      1008 FORMAT(9F15,6)
      2001 FORMAT(/,10X,9(3X,5HN,11),10(3X,1HN,12))
      WRITE(6,2001) (I,I=1,19)
340      WRITE(6,2002) (ITT(I),I=1,19)
      2002 FORMAT(10X,9I5,10I6,/)
      C CALCULATE HOURS OF SUNSHINE IN THE YEAR

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400	8105 WRITE(6,8106) (FIELD(I,J),I=1,11)	MONTE	396
	8106 FORMAT(10X,11E11.3)	MONTE	397
	WRITE(6,8203) ENORTH,ESOUTH	MONTE	398
	8203 FORMAT(///,10X,24HNORTH HALF FIELD ENERGY=,3X,E10.4,5X,	MONTE	399
	13HMMWH,/,10X,24HSOUTH HALF FIELD ENERGY=,3X,E10.4,5X,3HMMWH,///)	MONTE	400
405	CALL POLMAP(COUNT,CONV,NTOT,3,ND1)	MONTE	401
	STEST=10.E+30	MONTE	402
	NMX=121.	MONTE	403
	IS=NMX/10	MONTE	404
	K=0	MONTE	405
410	ISTOP=IS	MONTE	406
	DO 3050 NN=1,NMX	MONTE	407
	SMAX=0.0	MONTE	408
	DO 3040 I=1,11	MONTE	409
	DO 3040 J=1,11	MONTE	410
415	3040 IF (FIELD(I,J).GT.SMAX.AND.FIELD(I,J).LT.STEST) SMAX=FIELD(I,J)	MONTE	411
	STEST=SMAX	MONTE	412
	IF (NN.LT.ISTOP) GO TO 3050	MONTE	413
	ISTOP=ISTOP+IS	MONTE	414
	K=K+1	MONTE	415
420	SL(K)=SMAX	MONTE	416
	3050 CONTINUE	MONTE	417
	KK=K-1	MONTE	418
	WRITE (6,3180) (SL(I),I=1,10)	MONTE	419
425	3180 FORMAT(141,///,10X,9HSL ARRAY,10E11.5,/)	MONTE	420
	DO 61 J=1,11	MONTE	421
	DO 73 I=1,11	MONTE	422
73	IO(I)=0	MONTE	423
	DO 70 I=1,11	MONTE	424
	DO 60 KL=1,KK	MONTE	425
430	KLX=KK-KL+1	MONTE	426
	IF (FIELD(I,J).GT.SL(KLX)) GO TO 43	MONTE	427
	GO TO 70	MONTE	428
43	IO(I)=KLX	MONTE	429
	60 CONTINUE	MONTE	430
435	70 CONTINUE	MONTE	431
	WRITE(6,65) (IO(II),II=1,11)	MONTE	432
	65 FORMAT(20X,20I4,///)	MONTE	433
	61 CONTINUE	MONTE	434
	CALL TMAP(1.,1.,MON,COUNT,NTOT,CONV,3)	MONTE	435
440	RETURN	MONTE	436
	END	MONTE	437

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1      SUBROUTINE PTOWER(ND1,IAC,ARATIC)
      C** THIS PROGRAM CONTROLS ALL OF THE CALL FOR ALL OF THE HIT TESTS
      C WHICH ARE DONE. FROM IT, PERT, TRIADS, FINDIT, MIRROR, AND 400N
      C ARE CALLED.
5      C ICMH=1 IF A MIRROR IS HIT.
      C ICMH=0 IF A MIRROR IS NOT HIT.
      REAL N
      COMMON/BEDETST/ALBLJC,ICOD,UHV2(3),UAXV2(3)
      COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,BB1,B2,WGROSS,WDOM,IFRAM
10     *HTMIR,HTCROS,WJCROS
      DIMENSION YDUM(3),VS1(3),VS2(3),VS3(3),VS4(3),VSS(3),VS6(3),VS7(3)
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WVFNHF,XDF,WB2,WV2,
1     1 RHS(3),DELX,DELY,W0,IFV,RRB(3),UAXVP(3),UXV2PP(3),
2     2 UTT(3),UNNP(3),UXV2P(3)
15     3 ,UMNP(3),UMNPP(3),F,ALEN,UBEON(3),IFOC,IDRIVE
      COMMON/JOKER/URP(3),JS1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
      COMMON /RALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
      COMMON/BABA/STH,CTH,SEQ,OME,OMS,W(3),UE(3),
20     1 UN(3),US(3),JA(3),UR(3),THETA,MON,TDAY,SMALR,CAPR,CEG
      COMMON /STATS/TP3,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1     1 ICSS,IFC,IHIT,ICSHZ,NCOL,HOURL,MIN,ELZ,T,TDISX,TDISY,
2     2 DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
25     3 NLONG,ILONG,NLATC,RCD,NPACK,ENHM
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,S,DUM,WCELL,ICELL,JCELL,
1     1 XCSAV,YCSAV,XCM,YCM,ICELM,JCELM
      COMMON/SUPPT/DELT,THES,KSEG,APH,SW,NSUP,RCON,THECON,HTOT
      COMMON/TILTED/TILT,UVT(3),L1(3),U2(3),NAPMAX,WAPMIN,OFFSET
30     COMMON/CAVITY/SEP,DD1,DD2,RCIF,H0IF,HCA,HSWTC(2),RSMTC(2),
      *CILAT(2),CAVLAT(2,21),AIMHGT
      COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STE,T,UTARG(3),DTARG(3)
      DUMA=-A
      DUMB=-B
35     DUMC=C
      SMAX=DCOL*SQRT(1.-C*C)/C
      ICMH=0
      ICSS=0
      IOHIT=0
40     IFC=1
      CALL FINDIT(ND1,IFVHS)
      IF(ICMH.GT.0) GO TO 2172
      RETURN
45     2172 TOTH1=TAN(THSR*DRAD)
      TOTH1=TAN(THSU*DRAD)
      DUM2=SQRT(1.+TOTH1*TOTH1+TOTHU*TOTHU)
      DO 1983 I=1,3
1983   URP(I)=-TOTH1*UMNN1(I)+TOTHU*UMNN2(I)-LR(I)/DUM2
      CALL TRIADS(N,UMNS,UAXV,UHV,UXV2,JBEDN)
50     CALL PERT3(IFVHS)
      CTT=OUTER(URP,UNNP)
      SN=SQRT(1.-CTT*CTT)
      XCTT=SN/CTT
      THNORM=ATAN(XCTT)/DRAD
55     ENHM=ENHF*COUNT
      CALL MIRROR(THNORM,REF)
      COUNT=COUNT+REF

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	DUM3= -XCM	PTOWER	59
	DUM4=YCM	PTOWER	60
60	DUM5=TH-.5*DCOL	PTOWER	61
	DO 1984 I=1,3	PTOWER	62
	US1(I)=-2.*CTT*UNNP(I)+URP(I)	PTOWER	63
1984	D(I)=DUM3*UE(I)-DUM4*UN(I)+DUM5*N(I)+SCDELT(1)*N(I)+SCDELT(2)*UE(I	PTOWER	64
	1)*SCDELT(3)*UN(I)-RRS(I)+SEP*0.5*(N(I)-UVT(I))	PTOWER	65
65	ARATIO=DOTER(URP,N)/DOTER(UMNS,URP)	PTOWER	66
	CALL ONBLOCK(IBLOC,IFVHS,ALBLOC)	PTOWER	67
	ICOD=3	PTOWER	68
	DO 200 I=1,3	PTOWER	69
	YDUM(I)=(ALEN/2.-FLOAT(IFVHS-1)*XDF)*UHV(I)	PTOWER	70
70	VS1(I)=-WHS(I)-YDUM(I)-HTMIR*UBEDN(I)	PTOWER	71
	VS2(I)=VS1(I)+WDUM*UAXV(I)-WSIDE*0.5*UBEDN(I)	PTOWER	72
	VS3(I)=VS1(I)-WDUM*UAXV(I)-WSIDE*0.5*UBEDN(I)	PTOWER	73
	VS4(I)=VS1(I)-HTCROS*0.5*UBEDN(I)	PTOWER	74
	VS5(I)=VS4(I)-XDF*JHV(I)	PTOWER	75
75	VS6(I)=VS4(I) + XDF*UHV(I)	PTOWER	76
	200 VS7(I)=VS1(I) - HTCROS*UBEDN(I)	PTOWER	77
	CALL FRAME(VS1,VS2,VS3,VS4,VS5,VS6,VS7,ALFRAM,JK,M,ALBLOC)	PTOWER	78
	IF(IFRAM.EQ.0.AND.IBLOC.EQ.0) GO TO 100	PTOWER	79
	IF(IFRAM.EQ.0.AND.IBLOC.EQ.1) GO TO 20	PTOWER	80
80	IF(IFRAM.EQ.1.AND.IBLOC.EQ.0) GO TO 30	PTOWER	81
	IF(ALBLOC.LE.ALFRAM) GO TO 20	PTOWER	82
	30 IBLOC=0	PTOWER	83
	IFRAM=3	PTOWER	84
	ND1=17	PTOWER	85
85	IOHIT=1	PTOWER	86
	RETURN	PTOWER	87
	20 IBLOC=1	PTOWER	88
	IFRAM=0	PTOWER	89
	IOHIT=1	PTOWER	90
90	ND1=4	PTOWER	91
	CALL HITFAC(IFVHS,IFV,ND1,2,NHF)	PTOWER	92
	RETURN	PTOWER	93
	100 DUM=.5*DCOL-DOTER(N,RRS)	PTOWER	94
	DUMC=DOTER(N,US1)	PTOWER	95
95	DUMA=DOTER(UN,US1)	PTOWER	96
	DUMB=DOTER(UE,US1)	PTOWER	97
	SMAX=DUM*SQRT(1.-DUMC*DUMC)/DUMC	PTOWER	98
	B1=DOTER(UE,RRS)	PTOWER	99
	A1=DOTER(UN,RRS)	PTOWER	100
100	XP=XCM+B1	PTOWER	101
	YP=YCM+A1	PTOWER	102
	IFC=2	PTOWER	103
	IOHIT=0	PTOWER	104
	CALL FINDIT(ND1,IFVHS)	PTOWER	105
105	IF(IOHIT.EQ.0) GO TO 10	PTOWER	106
	CALL HITFAC(IFVHS,IFV,ND1,2,NHF)	PTOWER	107
	RETURN	PTOWER	108
	10 CALL MOON(ND1,IAC)	PTOWER	109
	CALL HITFAC(IFVHS,IFV,ND1,2,NHF)	PTOWER	110
110	RETURN	PTOWER	111
	END	PTOWER	112

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1      SUBROUTINE PERT3(IFVH)
      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
      COMMON /RALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
5      1      ICSH,IFC,IHIT,ICSH2,NCOL,IMHOUR,MIM,ELZ,T,TDISX,TDISY,
      2      DUMA,DUM9,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
      3      NLONG,ILONG,NLATC,RCO,HPACK,ENHM
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WFV,NHF,XDF,WD2,WV2,
10     1      RMS(3),DELX,DELY,WD,IFV,ERRB(3),UAXVP(3),UXV2PP(3),
      2      UTT(3),UNNP(3),UXV2P(3)
      3      UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLOUM,WCELL,ICELL,JCELL,
      1      XCSAV,YCSAV,XCM,YCM,ICELN,JCELM
15     COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT,UTARG(3),DTARG(3)
      DIMENSION UMNIPP(3),FF(3),UX2IPP(3),RRT(3),RB(3)
      UHOZ(3)=FIRST AXIS OF MURPHY BED
      C      UBEDN(3)=NORMAL TO BED FRAME
      C      UAXVP(3)=UAXV(3) WITH FIRST ERROR ROTATION
      C      UBEDNP(3)=UBEDN(3) WITH FIRST ERROR ROTATION
20     C      UMNP(3)=UMN WITH FIRST ERROR ROTATION
      C      UXV2PP(3)=UXV2P(3) WITH SECOND ERROR ROTATION
      C      UMNPP(3)=UMNP(3) WITH SECOND ERROR ROTATION
      C      SGN=SIGN OF UXV2*UHOZ
25     C      RRS(3)=SAVED VALUE OF VECTOR FROM HELIOSTAT CENTER TO HIT POINT
      C      RMS(3)=VALUE OF VECTOR FROM FACET CENTER TO HIT POINT
      C      RRF(3)=VECTOR FROM FRAME CENTER TO HIT POINT WITH FACETS FLAT
      C      UNNP(3)=MIRROR NORMAL AT HIT POINT WITH FACETS IN PLACE
      C      UNNF(3)=MIRROR NORMAL AT HIT POINT WITH SLOPE ERROR
30     C      THIS ROUTINE FINDS THE ROTATIONS REQUIRED FOR TRACKING ERRORS,
      C      FOCUSING,TOE IN, AND SLOPE ERRORS FOR THE MURPHY BED
      C      HELIOSTAT
      C      PH=UNIFORM 0 TO 360
      C      THSL= (NORMAL) SLOPE ERROR
35     C      PAX1,PAX2=TRACKING ERRORS(NORMAL)
      DIMENSION UBEDNP(3),UNNPP(3),UTTPP(3),UT2PP(3),UHOZ(3)
      DIMENSION FMED(10),RFZ(11)
      IF (EDUMMY.GT.0) GO TO 23
      IF (IFOCUS.EQ.0.OR.IFOCUS.GT.10) GO TO 23
40     IFOCP1=IFOCUS*1
      DLTRAD=(RFIELD-TDISY-RCO)/IFOCUS
      RFZ(1)=RCO
      DO 22 IFL=2,IFOCPI
      RFZ(IFL)=RFZ(IFL-1)+DLTRAD
45     22 FMED(IFL-1)=SQRT(TH*TH+(RFZ(IFL)**2-RFZ(IFL-1)**2)/2.)
      C      SET FOCAL LENGTH EQUAL TO LONGEST PATH WHEN IFOCUS=1
      IF (IFOCUS.EQ.1)
      1 FMED(1)=SQRT(TH*TH+((-TDISY+RFIELD)*(-TDISY+RFIELD))
23     IDUMMY=12
      DO 5 I=1,3
50     UMN(I)=UMNS(I)
      5      UHOZ(I)=UHV(I)
      IF (IDRIVE.EQ.2) CALL FDRIVE(UHOZ,IFVH)
      CP1=COS(PAX1/57.3)
55     CP2=COS(PAX2/57.3)
      SP1=SIN(PAX1/57.3)
      SP2=SIN(PAX2/57.3)

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PERT3 2
PERT3 3
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	D2H=DOTER(UXV2,UHOZ)	PERT3	59
	DMH=DOTER(UMN,UBEDN)	PERT3	60
60	DMH=DOTER(UMN,UHOZ)	PERT3	61
	C MAKE FIRST ROTATION (PAX1)	PERT3	62
	D2R=DOTER(UXV2,UBEDN)	PERT3	63
	DO 10 I=1,3	PERT3	64
	UBEDNP(I)=CP1*UBEDN(I)+SP1*UAXV(I)	PERT3	65
65	UAXVP(I)=CP1*UAXV(I)-SP1*UBEDN(I)	PERT3	66
	UMNP(I)=DMH*UHOZ(I)+DMB*UBEDNP(I)	PERT3	67
	UXV2P(I)=D2H*UHOZ(I)+D2B*UBEDNP(I)	PERT3	68
	UXV2PP(I)=CP2*UXV2P(I)-UMNP(I)*SP2	PERT3	69
10	UMNPP(I)=CP2*UMNP(I)+UXV2P(I)*SP2	PERT3	70
70	CALL CHECKR(UMN,UAXV,UXV2,ICD)	PERT3	71
	IF(ICD.NE.0) WRITE(6,15)	PERT3	72
15	FORMAT(10X,13HUMN UAXV UXV2)	PERT3	73
	CALL CHECKR(UBEDN,UAXV,UHOZ,ICD)	PERT3	74
	IF(ICD.NE.0) WRITE(6,20)	PERT3	75
75	20 FORMAT(10X,15HUBEDN UAXV UHOZ)	PERT3	76
	CALL CHECKR(UBEDNP,UAXVP,UHOZ,ICD)	PERT3	77
	IF(ICD.NE.0) WRITE(6,25)	PERT3	78
25	FORMAT(10X,17HUBEDNP UAXVP UHOZ)	PERT3	79
	CALL CHECKR(UMNP,UXV2P,UAXVP,ICD)	PERT3	80
80	IF(ICD.NE.0) WRITE(6,30)	PERT3	81
	30 FORMAT(10X,16HUMNP UXV2P UAXVP)	PERT3	82
	CALL CHECKR(UBEDNP,UAXVP,UHOZ,ICD)	PERT3	83
	IF(ICD.GT.0) WRITE(6,35)	PERT3	84
35	FORMAT(10X,17HUBEDNP UAXVP UHOZ)	PERT3	85
85	CALL CHECKR(UMNPP,UXV2PP,UAXVP,ICD)	PERT3	86
	IF(ICD.GT.0) WRITE(6,40)	PERT3	87
40	FORMAT(10X,18HUMNPP UXV2PP UAXVP)	PERT3	88
	XF=ALEN*0.5-(IFVH-1)*XDF	PERT3	89
	CALL TOEIN(XF,CTHETO,STHETO,UHV)	PERT3	90
90	DO 300 I=1,3	PERT3	91
	UMNIPP(I)=CTHETO*UMNPP(I)+STHETO*UXV2PP(I)	PERT3	92
	300 UX2IPP(I)=STHETO*UMNPP(I)+CTHETO*UXV2PP(I)	PERT3	93
	CALL CHECKR(UMNIPP,UX2IPP,UAXVP,ICD)	PERT3	94
	IF(ICD.GT.0) WRITE(6,800)	PERT3	95
95	800 FORMAT(10X,21HUMNIPP UX2IPP UAXVP)	PERT3	96
	C CHECK UMN AND RHS FOR PERPENDICULARITY	PERT3	97
	UTEST=DOTER(UMN,RHS)	PERT3	98
	IF (ABS(UTEST).GT.0.0001) WRITE(6,710)	PERT3	99
100	710 FORMAT(10X,26HUMN AND RHS ARE NOT NORMAL)	PERT3	100
	C *** CALCULATE FACET NORMAL	PERT3	101
	C *** IFOCUS=0 FOCUS ALL FACETS INDIVIDUALLY	PERT3	102
	C *** IFOCUS=1 FOCUS FACETS BY ZONES	PERT3	103
	IF (IFOCUS.EQ.0) GO TO 900	PERT3	104
	IF (IFOCUS.GT.10) GO TO 950	PERT3	105
105	GROIST=SQRT(XCM*ACM+YCM*YCM)	PERT3	106
	IFLZ=INT((GROIST-RCO)/DLTRAD)+1	PERT3	107
	FS=FMED(IFLZ)	PERT3	108
	GO TO 975	PERT3	109
	900 CONTINUE	PERT3	110
110	DO 901 I=1,3	PERT3	111
	901 FF(I)=DTARG(I)-XF*UHV(I)	PERT3	112
	FT=SQRT(DOTER(FF,FF))	PERT3	113
	FS=SQRT(FT*FT+XF*XF)	PERT3	114
	GO TO 975	PERT3	115

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115      950 FS=10E10
      975 CONTINUE
      DO 1000 I=1,3
1000    RB(I)=-RHS(I)*2.0*FS*UMNIPP(I)
      RBU=SQRT(DOTER(RB,RB))
120      DO 1100 I=1,3
      1100 UNNPP(I)=RB(I)/RBU
      C *** CALCULATE LOCAL FACET TANGENT
      DO 1200 I=1,3
125      1200 RRT(I)=RHS(I)-DOTER(RHS,UNNPP)*UNNPP(I)
      RRTU=SQRT(DOTER(RRT,RRT))
      DO 1300 I=1,3
      1300 UTPP(I)=RRT(I)/RRTU
      C *** CHECK UTPP AND UNNPP FOR NORMALACY
      FNORM=DOTER(UTPP,UNNPP)
130      IF (ABS(FNORM).GT.0.0001) WRITE (6,1400)
      1400 FORMAT (10X,30HUTPP AND UNNPP ARE NOT NGRMAL)
      1500 CALL CROSS(UTPP,UNNPP,UT2PP)
      CALL CHECKR(UNNPP,UTPP,UT2PP,ICD)
      IF (ICD.GT.0) WRITE (6,1600)
135      1500 FORMAT (10X,19HUNNPP, UTPP, UT2PP)
      C NOW PUT THE SLOPE ERROR THSL ONTO UNNPP TO YIELD UNNP
      CSTHSL=COS(THSL/57.3)
      SNTHSL=SIN(THSL/57.3)
      CSPH=COS(PH/57.3)
      SNPH=SIN(PH/57.3)
140      DO 85 I=1,3
      85 UNNP(I)=(UNNPP(I)*CSTHSL+SNTHSL*(UTPP(I)*CSPH+UT2PP(I)*SNPH)
      TEST = DOTER(UNNP,UNNP)-1.00
      IF (ABS(TEST).GT.0.0001) WRITE(6,90)
145      90 FORMAT(10X,11HUNNP IS NOT,2X,13HA UNIT VECTOR)
      RETURN
      END

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PERT3 148

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1	SUBROUTINE TOEIN(XF,CTHETO,STHETO,UHV)	TOEIN	2
	REAL N	TOEIN	3
	COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),	TOEIN	4
	1 UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ	TOEIN	5
5	COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT,UTARG(3),OTARG(3)	TOEIN	6
	DIMENSION FF(3),UF(3),URT(3),UMNT(3),UMNTI(3),UHOZT(3),UFP(3),	TOEIN	7
	* UHV(3),URTP(3),UMNF(3),UBEDNT(3),UAXVT(3),UXV2T(3)	TOEIN	8
	C ** FOCUS THE NORMAL	TOEIN	9
	C ** SET TOE-IN VECTOR URT	TOEIN	10
10	DO 300 I=1,3	TOEIN	11
	URT(I)=(CTAZT*(-UN(I))-STAZT*UE(I))*CTELT-STELT*N(I)	TOEIN	12
	300 UMNT(I)=UTARG(I)-URT(I)	TOEIN	13
	C ** SET MIRROR NORMAL AND OUTER AXIS VECTOR FOR TOE-IN CALCULATIONS	TOEIN	14
	UMAG=SQRT(DOTER(UMNT,UMNT))	TOEIN	15
15	DO 400 I=1,3	TOEIN	16
	UMNTI(I)=UMNT(I)/UMAG	TOEIN	17
	400 UHOZT(I)=UHV(I)	TOEIN	18
	CALL TRIADS(N,UMNTI,UAXVT,UHV,UXV2T,UBEDNT,2)	TOEIN	19
	DO 500 I=1,3	TOEIN	20
20	500 FF(I)=OTARG(I)-XF*UHV(I)	TOEIN	21
	FMAG=SQRT(DOTER(FF,FF))	TOEIN	22
	DO 600 I=1,3	TOEIN	23
	600 UF(I)=FF(I)/FMAG	TOEIN	24
	C ** ROTATE UF AND URT INTO THE UBEDN AND UHV PLANE	TOEIN	25
25	CTX=DOTER(UF,UBEDNT)	TOEIN	26
	STX=DOTER(UF,UHOZT)	TOEIN	27
	CTX=DOTER(URT,UBEDNT)	TOEIN	28
	STX=DOTER(URT,UHOZT)	TOEIN	29
	DO 700 I=1,3	TOEIN	30
30	UFP(I)=UBEDNT(I)*CTX+UHOZT(I)*STX	TOEIN	31
	700 URTP(I)=UBEDNT(I)*CTX+UHOZT(I)*STX	TOEIN	32
	C ** FIND FACET NORMAL	TOEIN	33
	AMAG=SQRT(DOTER(UFP,UFP))	TOEIN	34
	BMAG=SQRT(DOTER(URTP,URTP))	TOEIN	35
35	DO 800 I=1,3	TOEIN	36
	800 UMNF(I)=UFP(I)/AMAG-URTP(I)/BMAG	TOEIN	37
	UMAG=SQRT(DOTER(UMNF,UMNF))	TOEIN	38
	DO 900 I=1,3	TOEIN	39
	900 UMNF(I)=UMNF(I)/UMAG	TOEIN	40
40	CTHETO=DOTER(UMNF,UMNTI)	TOEIN	41
	STHETO=DOTER(UMNF,UXV2T)	TOEIN	42
	RETURN	TOEIN	43
	END	TOEIN	44

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1      SUBROUTINE FDRIVE(UHOZ,IFVH)
      REAL N
      COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
5      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAG
      COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)

      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
10     ICSH,IFC,IHIT,ICSH2,NCOL,IHOUR,MIN,ELZ,T,TDISX,TDISY,
      DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WVF,NHF,XDF,WD2,WVF2,
15     RHS(3),DELA,DELY,WD,IFV,RRS(3),UAXVP(3),UXV2PP(3),
      UTT(3),UNNP(3),UXV2P(3)
      COMMON /UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLDUM,WCELL,ICELL,JCELL,
      XCSAV,YCSAV,XCM,YCM,ICELM,JCELM
C     THIS ROUTINE SETS UP THE TRIAL AT THE HIT FACET CENTER FOR
C     INDEPENDENT FACET DRIVES.
20     DIMENSION UHOZ(3),XCC(3),DUTF(3),UTF(3),JTFPR(3),URPR(3),UMNF(3)
      DIMENSION UMNDUM(3),AIMP(3)
      DO 101 I=1,3
101    XCC(I)=(ALFN/2.-(FLOAT(IFVH-1))*XDF)*UHOZ(I)
      CALL AIMP(XCM,YCM,2,AIMP)
      DO 102 J=1,3
25     102 DUTF(J)=-XCC(J)-XCM*UE(J)-YCM*UN(J)+(TH-(DCOL/2.0))*N(J)*AIMP(J)
      AMAG=SQRT(DOTER(DUTF,DUTF))
      DO 103 K=1,3
30     103 UTF(K)=DUTF(K)/AMAG
      DO 106 L=1,3
      UTFPR(L)=(DOTER(UBEDN,UTF))*UBEDN(L)+(DOTER(UHOZ,UTF))*UHOZ(L)
106    URPR(L)=(DOTER(UBEDN,UR))*UBEDN(L)+(DOTER(UHOZ,UR))*UHOZ(L)
      AMAG1=SQRT(DOTER(URPR,URPR))
      AMAG2=SQRT(DOTER(UTFPR,UTFPR))
35     DO 107 M=1,3
      UMNF(M)=-URPR(M)/AMAG1+UTFPR(M)/AMAG2
      DO 109 I=1,3
      UMNDUM(I)=-UR(I)*UTF(I)
40     109 CONTINUE
      AMAG3=SQRT(DOTER(UMNDUM,UMNDUM))
      DO 111 I=1,3
      UMNDUM(I)=UMNDUM(I)/AMAG3
111    CONTINUE
      AMAG=SQRT(DOTER(UMNF,UMNF))
45     DO 108 I=1,3
      UMN(I)=UMNF(I)/AMAG
      CALL CPDSS(UAXV,UMN,UXV2)
      RETURN
      END

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1      SUBROUTINE FINDIT(ND1,IFVHS)
C** THIS ROUTINE FINDS THE LIST OF MIRRORS WHICH A RAY FROM THE SUN
C COULD POSSIBLY HAVE HIT. IT ALSO FINDS THE LIST OF MIRRORS WHICH
C A REFLECTED RAY COULD POSSIBLY HIT. FROM IT RINDX, INHIT, AND
C OFFRLOC ARE CALLED.
5      REAL N
COMMON/BA8A/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
1      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XDF,WD2,WV2,
10     RMS(3),DELZ,DELY,WD,IFV,RRB(3),UAXVP(3),UXV2PP(3),
2     UTT(3),UNNP(3),UXV2P(3)
3     UMNPP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1     ICSH,IFC,IHIT,ICSH2,NCOL,INOUR,MIN,ELZ,T,TDISX,TDISY,
15     DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
2     NLONG,ILONG,NLATC,RCO,NPACK,ENHM
3     COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)

COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLOUM,WCELL,ICELL,JCELL,
20     1 XCSAV,YCSAV,XCM,YCM,ICELM,JCELM
COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,B1,B2,
WCRSS,WDOM,IFRAM,HTMIR,HTCRUS,WJCROS
COMMON/BEDTST/ALBLOC,ICOD,UHV2(3),UAXV2(3)
25     DIMENSION VS1(3),VS2(3),VS3(3),VS4(3),VS5(3),VS6(3),VS7(3)
DIMENSION XSAV(20),YSAV(20),ICELS(20),JCELS(20),UHVS(3)
DIMENSION YDUM(3),XDUM(3)

C      ICMH=1 IF MIRROR WAS HIT
C      ICMH=0 IF NO MIRROR WAS HIT
30     ICSH= NUMBER OF MIRRORS
C      HIT AFTER FIRST HIT. IF
C      NUMBER OF SHADOWS
C      UMNS UNIT NORMAL OF THE
C      FIRST MIRROR HIT
35     RRS VECTOR FROM MIRROR
C      CENTER TO HIT POINT ON
C      MIRROR, NONE UNIT
C      (IIM,JJM) INDEXES OF HIT MIRROR
C
40     CHECK END POINTS OF S
C      START POINT FIRST
C      IF(IFC.LT.2) GO TO 1974
XPCOL=XP
YPCOL=YP
45     XSSS=XCM
YSSS=YCM
GO TO 8975
1974 XPCOL=XP
YPCOL=YP
50     COSA=0.
COSB=0.
SLOUM=0.
CALL RINDX
XSAV(1)=XCSAV
55     YSAV(1)=YCSAV
ICELS(1)=ICELL
JCELS(1)=JCELL

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        XSSS=XCSAV
        YSSS=YCSAV
60      8975 ICONT=1
        C      SECOND END POINT
        COSA=DUMA
        COSB=DUMB
        SLOUM=SMAX
65      CALL RINDX
        XSAV(2)=XCSAV
        YSAV(2)=YCSAV
        ICELS(2)=ICELL
        JCELS(2)=JCELL
70      C      MAKE TESTS
        TEST1=ABS(XSAV(2)-XSSS)
        TEST2=ABS(YSAV(2)-YSSS)
        IF(TEST1.GT.0.001) GO TO 40
        IF(TEST2.GT.0.001) GO TO 40
75      IF(IFC.EQ.1) GO TO 50
        INHIT=0
        RETURN
        C      AT THIS POINT START AND END ARE
        C      THE SAME MIRROR      CALL INHIT
80      C      END POINT AND START POINT
        C      DIFFER BY MORE THAN ONE TEST
        C      IN BETWEEN
        40 NSTD=NSTOPS-1
        DNM=FLOAT(NSTD)
85      DO 45 K=1,NSTD
        SLOUM=SMAX*FLOAT(K)/DNM
        CALL RINDX
        TEST1=ABS(XSSS-XCSAV)
        TEST2=ABS(YSSS-YCSAV)
90      IF (TEST1 .LT. 0.001 .AND. TEST2 .LT. 0.001) GO TO 45
        XSSS=XCSAV
        YSSS=YCSAV
        ICONT=ICONT+1
        XSAV(ICONT)=XCSAV
95      YSAV(ICONT)=YCSAV
        ICELS(ICONT)=ICELL
        JCELS(ICONT)=JCELL
        45 CONTINUE
        IF(IFC.EQ.2) GO TO 2001
100      C      ALL POSSIBLE HI'S HAVE BEEN FOUND
        C      NOW CALL INHIT TO TEST
        50 ICSH=0
        IFRAM=0
        ICSH2=0
105      ICMH=0
        DO 100 I=1,ICONT
        XC=XSAV(I)
        YC=YSAV(I)
        DMNH=SQRT(XC*XC+YC*YC)
110      DO 5 KI=1,3
        S UNV(KI)=(YC*UE(KI)-XC*UN(KI))/DMNH
        ISCEL=ICELS(I)
        JSCEL=JCELS(I)
        IF(XCSAV .GT. (9.*TH)) GO TO 100

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115      CALL INHIT(XC,YC,IFVH,ISHAD,ALMIN)
      IF (IHIT.EQ.0) GO TO 100
      IF (ICMH.EQ.1.OR.IFRAM.GT.0) GO TO 70
      C      FOUND FIRST HIT
      ND1=3
120      ICMH=1
      ICELM=ISCEL
      JCELM=JSCEL
      XCM=XC
      YCM=YC
125      RHIT=SQRT(XC*XC+YC*YC)
      IFVHS=IFVH
      ICSH=ICSH+ISHAD
      DO 60 J=1,3
      RHS(J)=RHB(J)
130      UHVS(J)=UHV(J)
      UMNS(J)=UMN(J)
      60 RHS(J)=RHS(J)+(ALEN/2.-(FLOAT(IFVH-1))*XDF)*UHV(J)
      M=1
      DO 103 JK=1,M
135      XC=XSAV(JK)
      YC=YSAV(JK)
      XS=XP
      YS=YP
      CALL MIRROR(XC,YC)
140      DO 107 JR=1,3
      107 UHV(JB)=(YC*UE(JB)-XC*UN(JB))/SQRT(XC*XC+YC*YC)
      CALL TRIADS(N,UMN,UAXV,UHV,UXV2,UBEDN)
      DO 113 JR=1,3
      VS1(JB)=(XC-XS)*UE(JB) + (YC-YS)*UN(JB) - DCOL*0.5*N(JB)
145      * - HTMIR*UBEDN(JB)
      VS2(JB)=VS1(JB)+WDUM*UAXV(JB)-WSIDE*0.5*UBEDN(JB)
      VS3(JB)=VS1(JB)-WDUM*UAXV(JB)-WSIDE*0.5*UBEDN(JB)
      VS4(JB)=VS1(JB) - TCR0S*0.5*UBEDN(JB)
      VS5(JB)=VS4(JB) - XDF*UHV(JB)
150      VS6(JB)=VS4(JB) + XDF*UHV(JB)
      VS7(JB)=VS1(JB) - TCR0S*UBEDN(JB)
113 CONTINUE
      ICOD=1
      JKD=JK
      MDUM=M
155      CALL FRAME(VS1,VS2,VS3,VS4,VSS,VS6,VS7,ALFRAM,JKD,MDUM,ALMIN)
      IF (ALFRAM.GT.ALMIN) IFRAM=0
      IF (IFRAM.EQ.0) GO TO 103
      ND1=15
160      ICMH=0
      IF (IFRAM.GT.1) ND1=16
      GO TO 100
103 CONTINUE
      GO TO 100
165      C      SECOND AND SUCCEEDING HITS
      70 ICSH=ICSH+ISHAD+1
      RSHAD=SQRT(XC*XC+YC*YC)
      IF (ABS(RSHAD-RHIT).GT.10.) ICSH2=ICSH2+ISHAD+1
100 CONTINUE
      DO 6 I=1,3
170      6 UHV(I)=UHVS(I)

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FINDIT 116
FINDIT 117
FINDIT 118
FINDIT 119
FINDIT 120
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FINDIT 172

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SUBROUTINE FINDIT 74/74 OPT=1

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	RETURN	FINDIT	173
2001	DO 1973 <L=2, ICONT	FINDIT	174
	XC=XSAV(XL)	FINDIT	175
175	YC=YSAV(XL)	FINDIT	176
	CALL OFFLOC(XCM,YCM,XC,YC,IBLOC,IFVMS)	FINDIT	177
	ICOD=4	FINDIT	178
	DO 1971 I=1,3	FINDIT	179
	YDUM(I)=(XC-XCM)*UE(I)+(YC-YCM)*UN(I)	FINDIT	180
180	XDUM(I)=(ALEN/2.-FLOAT(IFVMS-1)*XDF)*UHV(I)	FINDIT	181
	VS1(I)=-RHS(I)-XDUM(I)+YDUM(I)-HTMIR*UBEDN(I)	FINDIT	182
	VS2(I)=VS1(I)+WDUM*UAXV2(I)-WSIDE*0.5*UBEDN(I)	FINDIT	183
	VS3(I)=VS1(I)-WDUM*UAXV2(I)-WSIDE*0.5*UBEDN(I)	FINDIT	184
	VS4(I)=VS1(I)-HTCROS*0.5*UBEDN(I)	FINDIT	185
185	VS5(I)=VS4(I) - XDF*UHV2(I)	FINDIT	186
	VS6(I)=VS4(I) + XDF*UHV2(I)	FINDIT	187
1971	VS7(I)=VS1(I) - HTCROS*UBEDN(I)	FINDIT	188
	CALL FRAME(VS1,VS2,VS3,VS4,VS5,VS6,VS7,ALFRAM,JK,M,ALBLOC)	FINDIT	189
	IF(IFRAM.EQ.0.AND.IBLOC.EQ.0) GO TO 1973	FINDIT	190
190	IF(IFRAM.EQ.0.AND.IBLOC.EQ.1) GO TO 7000	FINDIT	191
	IF(IFRAM.EQ.1.AND.IBLOC.EQ.0) GO TO 7010	FINDIT	192
	IF(ALBLOC.LE.ALFRAM) GO TO 7000	FINDIT	193
7010	IBLOC=0	FINDIT	194
	IFRAM=4	FINDIT	195
195	ND1=18	FINDIT	196
	IOHIT=1	FINDIT	197
	RETURN	FINDIT	198
7000	IBLOC=1	FINDIT	199
	IFRAM=0	FINDIT	200
200	IOHIT=1	FINDIT	201
	ND1=5	FINDIT	202
	GO TO 1975	FINDIT	203
1973	CONTINUE	FINDIT	204
1976	RETURN	FINDIT	205
205	END	FINDIT	206

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SUBROUTINE TRIADS 74/74 OPT=1

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1      SUBROUTINE TRIADS(N,UMN,UAXV,UHV,UXV2,UBEDN)
      C      THIS ROUTINE BUILDS THE TWO
      C      TURNTABLE BASES (N,UHV,UAXV)
      C      AND (UMN,UAXV,UXV2) FROM N
5      C      AND UMN.
      C      J.M. HAMMER      OCTOBER 23,1974
      REAL N(3)
      DIMENSION UMN(3),UAXV(3),UHV(3),UXV2(3)
      DIMENSION UBEDN(3)
10     C THE TWO TRIADS FOR A MURPHY BED ARE BUILT FROM UMN AND UHV
      CALL CROSS(UMN,UHV,UAXV)
      AMAG=DOTER(UAXV,UAXV)
      AMAG=SQRT(AMAG)
      DO 120 I=1,3
15     120 UAXV(I)=UAXV(I)/AMAG
      CALL CROSS(UAXV,UMN,UXV2)
      CALL CROSS(UAXV,UHV,UBEDN)
      C FIX SIGN OF BEDN
      DBM=DOTER(UMN,UBEDN)
      SGN=DBM/ABS(DBM)
20     DO 130 I=1,3
      130 UBEDN(I)=SGN*UBEDN(I)
      RETURN
      END

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      TRIADS 2
      TRIADS 3
      TRIADS 4
      TRIADS 5
      TRIADS 6
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      TRIADS 8
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      TRIADS 19
      TRIADS 20
      TRIADS 21
      TRIADS 22
      TRIADS 23
      TRIADS 24
      TRIADS 25

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1      SUBROUTINE INHIT(XC,YC,IFVH,ISHAD,ALMIN)
C      THIS SUBROUTINE FINDS THE
C      HIT POINT, IF ANY, ON LOW
C      PROFILE HELIOSTAT (IT,JT)
5      AND WHICH FACIT
C      J.M. HAMMER   SEPT. 23, 1974
C      REAL N
C      DIMENSION RRIF(3),VC(3)
C      COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XOF,W02,WV2,
10      1      RHS(3),DELX,DELY,WG,IFV,RRB(3),UAXVP(3),UXV2PP(3),
2      UTT(3),UNNP(3),UXV2P(3)
3      ,UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
C      COMMON/BABA/STH,CTH,SEQ,OME,OPS,N(3),UE(3),
1      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
15      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      ICSH,IFC,IHIT,ICSH2,NCOL,ICSH,MIN,ELZ,T,DISX,DISY,
2      DUMA,DUMB,DUMC,UMN1(3),UMN2(3),JMN(3),IOHIT,NLAT,
3      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
C      COMMON/JOKER/URP(3),US(3),THSL,PH,THSR,TASU,COUNT,WAVL(20),DRAD
20      COMMON /STATS/TPB,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B
COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
C      UMN(3)  UNIT MIRROR NORMAL
C      PROVIDED BY CALLING ROUTINE
25      (N,UAXV,UHV)  TRIAD IN TURNABLE
C      UAXV(3)  FACIT ROTATION AXIS
C      UHV(3)   HORIZONTAL IN TURNABLE
C      (UMN,UAXV,UXV2) TRIAD IN FACIT FACE
C      UXV2(3)  VECTOR PERP. TO UAXV IN FACIT PLANE
30      (IT,JT)  INDEX OF TURNABLE TO BE TESTED
C      (XS,YS)  CORDS OF RAY START POINT ON TEST PLANE
C      UR(3)   INCOMING RAY DIRECTION
C      IHIT  HIT CODE, 1 IF HIT, 0 IS NO HIT
C      IFVH  THE INDEX OF HIT FACIT
35      ALEN  LENGTH OF TURNABLE
C      WD    WIDTH OF TURNABLE AND
C      LENGTH OF FACITS
C      WV    WIDTH OF FACITS
C      MHF   NUMBER OF FACITS
40      XOF   SPACING BETWEEN FACIT CENTERS
C      RHS(3) VECTOR FROM FACIT CENTER
C      OUT TO HIT POINT ON FACIT
C      ISHAD  NUMBER OF SHADOWS CAST
C      PAYL  RAY LENGTH
45      DELX  EAST WEST ROW SPACING
C      DELY  NORTH SOUTH ROW SPACING
C      RST(3) VECTOR FROM ORIGIN TO RAY HIT
C      (XL,YL,ZL) START POINT OF REFLECTED RAY
C      BUILD BOTH TRIADS
50      CALL MIPRN(XC,YC)
CALL TRIADS(N,UMN,UAXV,UHV,UXV2,UBEDN)
ONML=DCTER(UR,UMN)
IHIT=0
IHTE=0
55      IFV=0
XS=WP
YS=WP

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      ALMIN=10.E+10
      C      SET UP DO LOOP OVER FACITS
60      DO 50 IFV=1,NHF
      DO 30 I=1,3
      VC(I)=(XS-XC)*UE(I)+(YS-YC)*UN(I)-UHV(I)*(ALEN/2.-
      1 (FLCAT(IFV-1))*XDF)+DCOL*N(I)/2.0
      C      ERROR FOUND IN SIGN OF VC(I) 8/12/75  CHANGE SIGN
65      30  VC(I)=-VC(I)
      ALN=DOTER(UMN,VC)/DN*L
      DO 40 I=1,3
      40  RRIF(I)=ALN*UR(I)-VC(I)
      XVF=DOTER(UAXV,RRIF)
      YVF=DOTER(UXV2,RRIF)
      IF (ABS(XVF).GT.WD2.09.ABS(YVF).GT.WFV2) GO TO 500
      C      THIS FACIT WAS HIT. RECORD HIT
      IHIT=1
      IHTS=IHTS+1
75      IF (ALN.GT.ALMIN) GO TO 500
      ALMIN=ALN
      RAYL=ALN
      DO 65 I=1,3
      65  RRB(I)= RRIF(I)
      IFVH=IFV
80      500 CONTINUE
      IFV=NHF
      ISHAD=IHTS-1
      DO 80 I=1,3
85      80  RST(I)=XC*UE(I)+YC*UN(I)+WFV2*N(I)+UHV(I)*(ALEN/2.-
      1 (FLOAT(IFV-1))*XDF)+RHS(I)
      XL=DOTER(RST,UE)
      YL=DOTER(RST,UN)
      ZL=DOTER(RST,N)
90      RETURN
      END

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      INHIT 59
      INHIT 60
      INHIT 61
      INHIT 62
      INHIT 63
      INHIT 64
      INHIT 65
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      INHIT 88
      INHIT 89
      INHIT 90
      INHIT 91
      INHIT 92

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1      SUBROUTINE OFFBLOC (XCM,YCM,XC,YC,IBLOC,IFV1)
COMMON/REDTST/ALBLOC,ICOD,UHV2(3),UAXV2(3)
COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XDF,WD2,WV2,
5      1      RHS(3),DELX,DELY,WD,IFV,RRB(3),UAXVP(3),UXV2PP(3),
2      UTT(3),UNNP(3),UXV2P(3)
3      ,UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
10     1      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEO
COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      JCSH,IFC,IHIT,ICSH2,NCOL,ICSH,MIN,ELZ,T,TDISX,TDISY,
2      DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
3      NLONG,ILONG,NLATC,RCD,NPACK,ENHM
COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
COMMON /STATS/TPB,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B
15     COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)

C      THIS ROUTINE FINDS IF A RAY
C      FROM TURNTABLE (I1,J1) IS BLOCKED
C      BY A FACIT OF (I2,J2)
20     C      J.M. HAMMER      SEPT. 26,1974
C      IFV1  FACIT ON TURNTABLE (I1,J1)
C      FROM WHENCE THE RAY CAME
C
C      IBLOC  BLOCKAGE CODE.  0 NO BLOCK.
25     C      1 RAY IS BLOCKED
C      REAL N
C      DIMENSION VC(3),VCRH(3),UXV22(3),UMN2(3)
C      CALL MIRRN(XC,YC)
C      ALBLOC=10.E+10
30     DMNH=SQRT(XC*XC+YC*YC)
C      DO 7 I=1,3
7      UHV2(I)=(YC*UE(I)-XC*UN(I))/DMNH
C      CALL TRIADS(N,UMN,UAXV2,UHV2,UXV22,UBEDN)
C      DO 10 I=1,3
35     10     UMN2(I)=UMN(I)
C      IBLOC=0
C      DO 200 IFV=1,NHF
C      DO 20 I=1,3
40     VC(I)=UE(I)*(XC-XCM)+UN(I)*(YC-YCM)+(ALEN/2.0-(FLOAT(IFV-1))
1      *XDF)*UHV2(I)-(ALEN/2.0-(FLOAT(IFV1-1))*XDF)*UMV(I)
20     VCRH(I)=VC(I)-RHS(I)
C      AL=DOTER(VCRH,UMN2)/DOTER(US1,UMN2)
C      DO 30 I=1,3
45     30     RRB(I)=AL*US1(I)-VCRH(I)
C      XVF=DOTER(RRB,UAXV2)
C      YVF=DOTER(RRB,UXV22)
C      IF (ABS(XVF).GT.WD2.OR.ABS(YVF).GT.WV2) GO TO 200
C      THIS FACIT BLOCKED US1
50     C      IBLOC=1
C      ALBLOC=AL
C      GO TO 250
200    CONTINUE
C      IFV=NHF
250    RETURN
55     END

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1      SUBROUTINE MIRRN(XC,YC)
      REAL N
      COMMON/TABLE/UMV(3),UAXV(3),UXV2(3),RST(3),WV,VNH,XDF,WD2,WV2,
5      1    RMS(3),DELX,DELY,WD,IFV,RRB(3),UAXVP(3),UXV2PP(3),
      2    UTT(3),UNNP(3),UXV2P(3)
      3    ,UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE
      COMMON/RABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
      1    UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEG
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
10     1    ICSH,IFC,IHIT,ICSH2,NCOL,IHOUR,MIN,ELZ,T,TDISX,TDISY,
      2    DUVA,DIJMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
      3    NLONG,I LONG,NLATC,RCD,NPACK,ENHM
      COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
15     COMMON/TILTED/TILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET
      COMMON/CAVITY/SEP,DC1-DD2,RDIF,HDIF,HCAV,MSWTC(2),RSWTC(2),
      *CILAT(2),CAVLAT(2,21),A1MHGT
      DIMENSION AIMP(3)
      COMMON/TOE/CTAZT,STAZT,CTELT,IFOCUS,STELT-UTARG(3),OTARG(3)
20     REAL MN(3)
      RC=.5*DCOL
      YC1=YC
      CALL AIMP(XC,YC1,2,AIMP)
      DO 10 I=1,3
25     MN(I)=(TH-RC)*N(I)-XC*UE(I)-YC1*UM(I)+SEP*0.5*(N(I)-UVT(I))*
      * AIMP(I)
10     DTARG(I)=MN(I)
      DNM = DETER(MN,MN)
      DNM = SQRT(DNM)
30     DO 15 I = 1,3
      UTARG(I)=MN(I)/DNM
15     MN(I)=MN(I)/DNM-UR(I)
      XXR = DETER(MN,MN)
      XXR=1./SQRT(XXR)
35     DO 5091 I=1,3
5091  UMN(I)=MN(I)*XXR
      RETURN
      END

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MIRRN 2
MIRRN 3
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MIRRN 5
MIRRN 6
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MIRRN 38
MIRRN 39

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1      SUBROUTINE RINDX
C** THIS ROUTINE FINDS THE CLOSEST HELIOSTAT TO A GIVEN POINT
C XP, YP ON THE TEST PLANE.
      COMMON /RALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
5      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      ICSH,IFC,IHIT,ICSH2,NCOL,IHOUR,MIN,ELZ,T,TDISX,TDISY,
2      DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
10     3      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
      COMMON /CINDEX/ XPCOL,YPCOL,COSA,COSB,SLDUM,WCELL,ICELL,JCELL,
1      XCSAV,YCSAV,XCM,YCM,ICELM,JCELM
      COMMON/MAPS/NRZF,NAZZF,NC(250,8),SRAD(250,8),NPRAD(8),DEG
      XPD=XPCOL*SLDUM*COSB
      YPD=YPCOL*SLDUM*COSA
15     C THIS ROUTINE WAS CHANGED MARCH 1975 J.M.HAMMER G.A.SMITH
      C FIND MAP CELL
      ICELL=INT((XPD+RFIELD-TDISX)/WCELL)+1
      JCELL=INT((RFIELD-YPD-TDISY)/WCELL)+1
20     IF(ICELL.LT.1) ICELL = 1
      IF(JCELL.LT.1) JCELL = 1
      IF(JCELL.GT.10) JCELL = 10
      IF(ICELL.GT.10) ICELL = 10
      C POLAR SPACED FIELD
      C PUT TEST POINT INTO POLAR COORDINATES
25     RHIT=SQRT(XPD*XPD+YPD*YPD)
      ANG=ATAN2(XPD,YPD)
      IF (ANG.LT.0.0) ANG=ANG+2.*3.14159
      JZ=INT(ANG/DEG)+1
      IF (DEG .GT.6.) JZ=1
30     IF(RHIT.GT.RCO) GO TO 101
      IR=1
      GO TO 56
101  IR=INT((RHIT-RCO)/(SRAD((NPRAD(JZ)-1),JZ)-SRAD((NPRAD(JZ)-2),JZ)))
35     10  IR=IR+1
      IF(IR.LT.1) IR=1
      IF (IR.GE. (NPRAD(JZ)-1)) IR=NPRAD(JZ)-1
      IF (IR.EQ. (NPRAD(JZ)-1)) GO TO 56
      IF(RHIT.GT.SRAD(IR+1,JZ)) GO TO 10
      C RADIAL ZONE FOUND IS IR
40     56  RZ1=(SRAD(IR+1,JZ)+SRAD(IR,JZ))/2.
      C FIND THE AZIMUTH ZONE
      DELA=DEG/FLOAT(NC(IR,JZ))
      IZ=INT((ANG-DEG*FLOAT(JZ-1))/DELA)+1
      AZ1=DEG*FLOAT(JZ-1)+DELA*(FLOAT(IZ)-.5)
45     C THE CENTER OF THE HELIOSTAT IN ZONE IR IS
      XCSAV=RZ1*SIN(AZ1)
      YCSAV=RZ1*COS(AZ1)
      YCSAVP=YCSAV+TDISY
      XCSAVP=XCSAV+TDISX
50     XMAGP=SQRT(XCSAVP*XCSAVP+YCSAVP*YCSAVP)
      IF (XMAGP.GT. RFIELD) XCSAV=10.*TH
      RETURN
      END

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RINDX 54

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SUBROUTINE CROSS 74/74 OPT=1

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1      SUBROUTINE CROSS(A,B,C)
      DIMENSION A(3),B(3),C(3)
      C(1) = A(2)*B(3) - A(3)*B(2)
      C(2) = -(A(1)*B(3) - A(3)*B(1))
      C(3) = A(1)*B(2) - A(2)*B(1)
      RETURN
      END
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CROSS 2
CROSS 3
CROSS 4
CROSS 5
CROSS 6
CROSS 7
CROSS 8
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1      SUBROUTINE MOON(ND1,IAC)
C      THIS SUBROUTINE CHECKS FOR RECEIVER HITS FOR ANY RAY WHICH
C      GETS CLEANLY AWAY FROM THE FIELD. IT CHECKS FOR ENTRY INTO
C      THE APERTURE SUPPORT HITS AND CYLINDER HITS. IT MAPS ALL
5      C FLUX WHICH HITS CYLINDER WALLS OR THE ROOF.
C      INTEGER CILAT
      REAL N
      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      ICSH,IFC,IHET,ICSH2,NCOL,1HOUR,MIN,ELZ,T,TDISX,TOISY,
10     DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
      COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
1      UN(3),US(3),UA(3),UR(3),THETA,MON,1DAY,SMALR,CAPR,CEQ
      COMMON/JOKFR/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
15     COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)

      COMMON /STATS/TPB,TSB,PHB,TPV,PHV,AVE,TSV,PAX1V,PAX1B,PAX2V,PAX2B
      COMMON/RANDOM/NRJN,IRANC,IJUMP,MODE,ISRN,IRAYS
20     *IT1,UDNI,ILMC,DINTV,YFRAC
      COMMON/CAVITY/SEP,DD1,DD2,RDIF,HDIF,HVAC,HSWTC(2),RSWTC(2),
1      CILAT(2),CAVLAT(2,21),AIMHGT
      COMMON/CEILING/NAZZ,NRZ,DTAZ(21),DRZ(10),DD3,IZR,IAZ
      COMMON/SUPOT/DELT,THES,KSEG,APH,SW,NSUP,RCONE,THECON,HTOT
      COMMON/TJLTED/TJLT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET
25     COMMON/MOONMP/JWHIS,JCORB,JMISHI,JMISLO,JFRONT
      DIMENSION TEMPD(3),ASUP(3),UPH(3),PV(3),UPV(3),RH(3),DD(3)
      DIMENSION VUP(3),DOP(3),RTH(3),UNA(3)
      IF (IAC.LT.7) GO TO 333
C      CHECK FOR PROPER PIPE DIAMETER.
      DEW=2.*RCONE*(WAPMAX+WAPMIN)*0.5*SIN(THECON)
      DN=2.0*(RCONE+WAPMAX*SIN(THECON)-0.5*SEP*TAN(THECON))
      IF (DN.GT.DEW) DEW=DN
      IF (DD3.GE.(1.01*(DEW-OFFSET))) GO TO 80
      DD3=1.01*(DEW-OFFSET)
35     WRITE(A,500) DD3
500    FORMAT(/,10X,42HINITIAL CAVITY DIAMETER TOO SMALL,RESET TO,
      *F10.1,3X,24FT)
      80 DIST=(WAPMAX+WAPMIN)*0.25*COS(THECON)+SEP*0.5
      VERT=DIST*COS(TJLT)
40     HTMIN=WAPMIN*COS(THECON)
      ABOT=0.0
      RETURN
333    CONTINUE
C      CHECK FOR HIT ON THE CONE.
45     JWHIS=0
      JCORB=0
      JMISHI=0
      JMISLO=0
      JFRONT=0
50     CALL CONE(Z1,Z2,AL1,AL2,ANG1,ANG2,ICHIT,ZZERO)
      IF (ICHIT.GT.0) GO TO 10
      ND1=10
      JFRONT=1
      RETURN
55     C      FIND IF THE HIT IS WITHIN APERTURE BOUNDARIES.
10     IF (AL1.GT.AL2) GO TO 20
      IF (Z1.LE.ZZERO) GO TO 21

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23 ZHIT=Z1
ZOUT=Z2
60   ANG=ANG1
    ANGOUT=ANG2
    GO TO 30
20 IF (Z2.LE.ZZERC) GO TO 22
24 ZHIT=Z2
65   ZOUT=Z1
    ANG=ANG2
    ANGOUT=ANG1
    GO TO 30
70   21 IF (Z2.LE.ZZERO) GO TO 23
    ZHIT=Z2
    ANG=ANG2
    ZOUT=5000.
    GO TO 30
75   22 IF (Z1.LE.ZZERO) GO TO 24
    ZHIT=Z1
    ANG=ANG1
    ZOUT=5000.0
30 IF (ANG.GT.3.14159) ANG=2.*3.14159-ANG
    IF (ANGOUT.GT.3.14159) ANGOUT=2.*3.14159-ANGOUT
80   C FIND WIDTH OF APERTURE AT THE HIT ANGLE.
    WAP2=WAPMIN
    IF (ANG.LT.2.0944) WAP2=WAP2+(WAPMAX-WAPMIN)*(1.0-ANG*0.4775)
    C FIND TOP AND BOTTOM OF SLANT DISTANCE ALONG THE APERTURE.
    ATOP=WAP2*COS(THETAON)
85   IF (ZHIT.GE.ABOT) GO TO 40
    ND1=11
    JMSLO=1
    RETURN
90   40 IF (ZHIT.LE.ATOP) GO TO 50
    ND1=9
    JMSHI=1
    RETURN
95   50 IF (ZOUT.GT.100.) GO TO 60
    CHECK FOR A WHISTLE THROUGH
    WAP2=WAPMIN
    IF (ANGOUT.LT.2.0944) WAP2=WAP2+(WAPMAX-WAPMIN)*
1   (1.0-ANGOUT*0.4775)
    ATOP2=WAP2*COS(THETAON)
100  IF (ZOUT.GT.ATOP2) GO TO 60
    ND1=14
    JWHIS=1
    C WHISTLE THROUGH IS NOT ACCOUNTED FOR IN MONTE
    RETURN
105  60 CONTINUE
    C IF A HIT IS FOUND, CHECK FOR SUPPORT HIT.
    IF (DELTM.GE.0.) THAZS=THES*FLOAT(KSEG)-3.14159/3.0
    IF (DELTM.LT.0.) THAZS=THES*FLOAT(KSEG-1)-3.14159/3.0
    IF (THAZS.LT.0.) THAZS=THAZS+6.283185
    CTHAZS=COS(THAZS)
    STHAZS=SIN(THAZS)
110  DO 61 I=1,3
    TEMPD(I)=U2(I)*STHAZS+U1(I)*CTHAZS
    ASUP(I)=TEMPD(I)*(DD1+DD2)/4.+UVT(I)*SEP/2.
    DD(I)=D(I)+ASUP(I)

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115      UPH(I)=U2(I)*CTHAZS-U1(I)*STHAZS
        61 PV(I)=TEMPD(I)*(DD2-DD1)/4.-UVT(I)*SEP/2.
          PPV=SQRT(DOTER(PV,PV))
          DO 62 I=1,3
        62 UPV(I)=PV(I)/PPV
120      CALL CROSS(UPH,UPV,UNA)
          CALL CHECKR(UPH,UPV,UNA,ICOD)
          AL=DOTER(DI,UNA)/DOTER(US1,UNA)
          DO 63 I=1,3
        63 RH(I)=AL*US1(I)-OD(I)
125      SWP=2.*DOTER(RH,UPH)
          IF (ABS(SWP).GT.SW) GO TO 120
C      HIT SUPPORT
          ND1=12
          JCORB=1
130      RETURN
        120 CONTINUE
C      THE RAY IS KNOWN TO HAVE ENTERED THRU THE UPPER APERTURE.
C      RESET THE D VECTOR TO AXIS OF THE PIPE.
          DO 90 I=1,3
135      90 D(I)=D(I)*DIST*UVT(I)-OFFSET*UN(I)-VERT*N(I)
C      CHECK FOR PIPE HIT.
C      FIRST PASS CHECKS HITS ON DIFFUSER.
          IPASS=2
        33 RCYL=RSWTC(IPASS)
          CALL PIPE(Z1,Z2,AL1,AL2,ANGH1,ANGH2,RCYL,ICHIT)
          IF (ICHIT.NE.0) GO TO 777
          WRITE (6,778) XP,YP,ZHIT,ZOUT,ANG1,ANG2,ANG
140      778 FORMAT (20X,2HXP,10X,2HZHIT,8X,4HZHIT,8X,4HZOUT,8X,4HANG1,8X,
            1 4HANG2,8X,3HANG/,10X,7F12.3)
145      777 CONTINUE
          IF (ICHIT.EQ.0) GO TO 85
          IF (IPASS.EQ.2.AND.AL1.LT.AL2) GO TO 81
          CILAT(IAC)=NUMBER OF HEIGHT ZONE HIT
C      ILONG=NUMBER OF AZIMUTH ZONE HIT
150      Z=Z1
          ANG=ANGH1
          GO TO 82
        81 Z=Z2
          ANG=ANGH2
155      82 IF (Z.GT.(HSWTC(IPASS)*HTMIN)) GO TO 86
          DO 1900 I=1,NLATC
          CILAT(IPASS)=I
          IF (Z.GE.(CAVLAT(IPASS,I)*HTMIN)) GO TO 2000
160      1900 CONTINUE
        2000 DELANG=2.*3.14159/FLOAT(NLONG)
          DO 1901 I=1,NLONG
          ILONG=I
          IF (ANG.GT.(FLOAT(I-1)*DELANG).AND.ANG.LE.(FLOAT(I)*DELANG))
            *GO TO 87
165      1901 CONTINUE
C      IF NO HITS ARE ENCOUNTERED, ND1=3
        85 IF (IPASS.EQ.2) RETURN
        53 IPASS=2
          GO TO 33
170      86 IF (IPASS.EQ.1) GO TO 53
C      HIT CAVITY CEILING, FIND ZONE.

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	DO 4000 I=1,3	MOON	173
	VUP(I)=(4SWTC(2)+H1MIN)*N(I)	MOON	174
175	4000 ODP(I) = D(I)*VUP(I)	MOON	175
	AL = DETER(ODP,N)/COTER(US1,N)	MOON	176
	DO 4005 I=1,3	MOON	177
	4005 RTH(I) = AL*US1(I)-D(I)-VUP(I)	MOON	178
	XHIT = DETER(RTH,JE)	MOON	179
	YHIT = DETER(RTH,JN)	MOON	180
180	RHIT = SORT(XHIT*XHIT+YHIT*YHIT)	MOON	181
	ANGHIT = ATAN2(XHIT,YHIT)	MOON	182
	IF (ANGHIT.LT.0.0) ANGHIT=ANGHIT+2.*3.14159	MOON	183
	IF (RHIT.GT.RSWTC(2)) WRITE(6,4010)	MOON	184
	TEST5 = ABS(DETER(RTH,N))	MOON	185
185	IF (TEST5.GT.0.001) WRITE(6,4015)	MOON	186
	4010 FORMAT (//.5X,48HHIT VECTOR ON CAVITY CEILING IS LONGER THAN THE ,	MOON	187
	113HCAVITY RADIUS.//)	MOON	188
	4015 FORMAT (//.5X,42HHIT VECTOR ON CAVITY CEILING IS NOT NORMAL ,	MOON	189
	118H TO LOCAL VERTICAL.//)	MOON	190
190	NAZZP = NAZZ+1	MOON	191
	DO 3000 I=1,NAZZP	MOON	192
	3000 IF (ANGHIT.GT.DTAZ(I).AND.ANGHIT.LT.DTAZ(I+1)) IZAZ=I	MOON	193
	NRZP = NPZ+1	MOON	194
	DO 3001 I=1,NRZP	MOON	195
195	3001 IF (RHIT.GT.DRZ(I).AND.RHIT.LT.DRZ(I+1)) IZR=I	MOON	196
	IAC=3	MOON	197
	ND1=8	MOON	198
	RETURN	MOON	199
200	87 IAC=IPASS	MOON	200
	ND1=5*IAC	MOON	201
	RETURN	MOON	202
	END	MOON	203

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1      SUBROUTINE PIPE(Z1,Z2,AL1,AL2,ANGHIT1,ANGHIT2,RCYL,ICHT)
C
C THIS SUBROUTINE SOLVES FOR THE HIT POINTS (2) OF A VECTOR WITH A
C RIGHT CIRCULAR CYLINDER
5      C
C REQUIRED INPUTS
C      US1-UNIT VECTOR TO BE TESTED FOR HITS
C      O-VECTOR FROM SAME LOCATION IN SPACE AS US1 TO THE BASE OF THE
C CYLINDER
10     C      RCYL-RADIUS OF CYLINDER
C      N-UNIT VECTOR ALONG THE CYLINDER AXIS
C      UN-UNIT VECTOR IN A PLANE NORMAL TO UN
C      UE-UNIT VECTOR SUCH THAT N,UN,UE FORM AN ORTHONORMAL TRIAD SET
15     C
C OUTPUTS
C      Z1 AND Z2-LENGTHS ALONG CYLINDER AXIS TO THE HIT PLANES
C      AL1 AND AL2-SHORTEST AND LONGEST LENGTHS OF THE HIT VECTOR
C (US1 EXTENDED)
C      ANGHIT1 AND ANGHIT2-ANGLES FROM UN TO THE HIT POINT IN THE
20     C PLANE NORMAL TO N
C      ICHIT-CODE FOR HIT TEST.
C          0 FOR MISSING THE CYLINDER
C          1 FOR HITTING
25     C
C      DIMENSION RHC1(3),RHC2(3)
C      REAL N
C      COMMON/BABA/STH,CTH,SE0,OME,OMS,N(3),UE(3),
C          UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEO
C      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
C      COMMON /BALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3)
30     C
C      ICHIT=0
C      DUSN=DOTER(US1,N)
C      DDD=DOTER(D,D)
C      DDN=DOTER(D,N)
C      DDUS=DOTER(D,US1)
35     C      A=1.0/(DUSN*DUSN)-1.0
C      B=2.0*DDN/(DUSN*DUSN)-2.0*DDUS/DUSN
C      C=DDN*DDN/(DUSN*DUSN)-2.0*DDN*DDUS/DUSN+DDD-RCYL*RCYL
C      B2=B*B
40     C      FAC=4.0*A*C
C      ARG=B2-FAC
C      IF(ARG.LT.0.0) RETURN
C      ICHIT=1
C HIT CYLINDER. SOLVE FOR HEIGHT
45     C      SB2=SQRT(ARG)
C      Z1=(-B-SB2)/(2.0*A)
C      Z2=(-B+SB2)/(2.0*A)
C SOLVE FOR LENGTH OF HIT VECTORS
C      AL1=(DDN+Z1)/DUSN
C      AL2=(DDN+Z2)/DUSN
50     C
C SET UP VECTOR IN HIT PLANE NORMAL
C TO AXIS
C      DO 10 I=1,3
C      RHC1(I)=AL1*US1(I)-Z1*N(I)-D(I)
55     C      10 RHC2(I)=AL2*US1(I)-Z2*N(I)-D(I)
C SOLVE FOR HIT ANGLES
C      XI=DOTER(RHC1,UE)

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SUBROUTINE PIPE

74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE 2

	X2=DOTER(RHC2,UE)	PIPE	59
	Y1=DOTER(RHC1,UN)	PIPE	60
60	Y2=DOTER(RHC2,UN)	PIPE	61
	IF (ABS(X1).GT.0.0001) GO TO 100	PIPE	62
	ANGHIT1=0.0	PIPE	63
	IF (Y1.LT.0.0) ANGHIT1=3.14159	PIPE	64
	GO TO 200	PIPE	65
65	100 ANGHIT1=ATAN2(X1,Y1)	PIPE	66
	200 IF (ABS(Y2).GT.0.0001) GO TO 300	PIPE	67
	ANGHIT2=0.0	PIPE	68
	IF (Y2.LT.0.0) ANGHIT2=3.14159	PIPE	69
	GO TO 400	PIPE	70
70	300 ANGHIT2=ATAN2(X2,Y2)	PIPE	71
	400 IF (ANGHIT1.LT.0.) ANGHIT1=ANGHIT1+2.0*3.14159	PIPE	72
	IF (ANGHIT2.LT.0.) ANGHIT2=ANGHIT2+2.0*3.14159	PIPE	73
	TEST1=DOTER(RHC1,N)	PIPE	74
	TEST2=DOTER(RHC2,N)	PIPE	75
75	IF (ABS(TEST1).GT.0.001.OR.ABS(TEST2).GT.0.001) WRITE(6,20)	PIPE	76
	20 FORMAT(//,10X,48H HIT VECTOR FROM CENTER OF CYLINDER IS NOT NORMAL,	PIPE	77
	1 7HTO AXIS.//)	PIPE	78
	RETURN	PIPE	79
	END	PIPE	80

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SUBROUTINE LIMDR 74/74 OPI=1

FTN 4:5+410A

03/21/77 21:51:16

PAGE 1

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1      SUBROUTINE LIMDR(YRN,LIMC,ROERN)
      C** THIS SUBROUTINE GENERATES THE INTENSITY DISTRIBUTION OF ENERGY
      C ACROSS THE SURFACE OF THE SUN. IT HAS 3 DIFFERENT SUN MODES
      C LIMC=1      FLAT SUN
5      C LIMC=2      SUN WITH LINE DARKENING AND SOLAR RADIATION
      C LIMC=3      SUN WITH LINE DARKENING
      GO TO (21,22,23),LIMC
21     ROERN=.2665*SQRT(YRN)
      RETURN
10    22     Y=YRN*16.98
      I=INT(Y/7.5) + 1
      GO TO (31,32,33),I
31     ROERN=0.06408*(Y**.4878)
      RETURN
15    32     ROERN=0.010956*Y+0.092413
      RETURN
      33     IF(Y.GT.16.7) GO TO 34
      ROERN=0.353-0.038345*(SQRT(-193.2-Y*Y+28.28*Y))
      RETURN
20    34     ROERN=0.3486*Y-5.5007
      RETURN
      23     Y=YRN*15.94
      IF(Y.GT.7.) GO TO 41
      ROERN=0.06408*(Y**.4878)
      RETURN
25    41     ROERN=.010956*Y+0.092413
      RETURN
      END

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40703-II-2

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1      SUBROUTINE VECTS
C** THIS ROUTINE CALCULATES THE SUNS VECTOR UR FOR A GIVEN MONTH, DAY
C AND TIME OF THE YEAR.
      REAL N
5      COMMON /JEFF/ UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH,
1      ICSH,IFC,IHIT,ICSH2,NCOL,IHCUR,MIN,ELZ,T,TOISX,TOISY,
2      DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT,
3      NLONG,ILONG,NLATC,RCO,NPACK,ENHM
      COMMON /GALL/ DCOL,ECDEL1(3),XP,YP,PAX1,PAX2,D(3)
10     COMMON/BABA/STH,CTH,SEQ,CME,OMS,N(3),UE(3),
1      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
      DIMENSION U(3), ITOTD(12)
      EQUIVALENCE (U(1),UE(1))
15     DATA ITOTD/0,31,59,90,120,151,181,212,243,273,304,334/
      ARG=OMS*(FLOAT(ITOTD(MON)+IDAY-1)*8.556)
C      SUBTRACT OMS*LONGITUDE/360. FROM ARG FOR LONG. CORRECTION
C      THIS WILL CHANGE THE SUNS POSITION BY NO MORE THAN 0.2 DEGREES
      ARGW = OME*(T - 12.0) + ARG + OMS*0.5 + 3.141592
20     C THE PHASE ANGLES IN ARGW INSURE SOLAR NOON TIME
      SW = SIN(ARGW)
      CW = COS(ARGW)
      N(1)=STH*SEQ+CTH*CEQ*CW
      N(2)=-CTH*SW
25     N(3)=STH*CEQ-CTH*CW*SEQ
      UE(1)=-SW*CEQ
      UE(2)=-CW
      UE(3)=SW*SEQ
      UN(1) = (N(2)*U(3) - N(3)*U(2))
      UN(2) = -(N(1)*U(3) - U(1)*N(3))
30     UN(3) = (N(1)*U(2) - U(1)*N(2))
      DO 10 I=1,3
10     UN(I) = -UN(I)
      ARG=ARG+OMS*(T/24.)
35     US(1)=-COS(ARG)
      US(2)= SIN(ARG)
      US(3)=0.
      DENOM=0.
      DO 20 I=1,3
40     UR(I)=SMALR*N(I)-CAPR*US(I)
20     DENOM=DENOM+UR(I)**2
      DO 30 I=1,3
30     UR(I)=UR(I)/SQRT(DENOM)
      A=-DOTER(UN,UR)
45     R=-DOTER(UE,UR)
      C=-DOTER(N,UR)
      DUM2=0.
      DO 1981 I=1,3
      UMNN1(I)=N(I)*C*UR(I)
50     1981 DUM2=DUM2+UMNN1(I)*UMNN1(I)
      DUM2=SQRT(DUM2)
      DO 1982 I=1,3
      UMNN1(I)=UMNN1(I)/DUM2
      CALL CROSS(UMNN1,UR,UMNN2)
55     RETURN
      END

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VECTS 2
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VECTS 25
VECTS 26
VECTS 27
VECTS 28
VECTS 29
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VECTS 31
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VECTS 48
VECTS 49
VECTS 50
VECTS 51
VECTS 52
VECTS 53
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VECTS 55
VECTS 56
VECTS 57

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FUNCTION DOTER

74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE 1

```

1      FUNCTION DOTER (A,B)
      DIMENSION A(3),B(3)
      DOTER=0.
      DO 10 I=1,3
5      10  DOTER=DOTER+A(I)*B(I)
      RETURN
      END

```

```

DOTER      2
DOTER      3
DOTER      4
DOTER      5
DOTER      6
DOTER      7
DOTER      8

```

SUBROUTINE CHECKR

74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE 1

```

1      SUBROUTINE CHECKR (A,B,C,ICOD)
      C TEST ORTHONORMALITY OF TRIAD ABC ICODE=0 IF OK =1 OTHERWISE
      DIMENSION A(3), B(3), C(3), ADB(6)
      ADB(1)=DOTER(A,B)
      ADB(2)=DOTER(A,C)
      ADB(3)=DOTER(C,B)
      ADB(4)=DOTER(A,A)
      ADB(5)=DOTER(B,B)
      ADB(6)=DOTER(C,C)
10     DO 10 I=2,6
      IF (ABS(ADB(I)).GT.0.00001 .AND. I.LE.3) GO TO 20
      TEST = ABS(ADB(I) - 1.0)
      IF (TEST .GT. 0.0001 .AND. I .GE. 4) GO TO 20
15     10 CONTINUE
      ICODE=0
      RETURN
20     ICODE=1
      WRITE(6,21) (ADB(I),I=1,6)
21     FORMAT(//, 10X 9H3AD TRIAD ,/,5X,6F10.5)
      RETURN
      END

```

```

CHECKR      2
CHECKR      3
CHECKR      4
CHECKR      5
CHECKR      6
CHECKR      7
CHECKR      8
CHECKR      9
CHECKR     10
CHECKR     11
CHECKR     12
CHECKR     13
CHECKR     14
CHECKR     15
CHECKR     16
CHECKR     17
CHECKR     18
CHECKR     19
CHECKR     20
CHECKR     21
CHECKR     22

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SUBROUTINE RNORM

74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE

1

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1      SUBROUTINE RNORM(D1,D2)
C *** THIS SUBROUTINE GENERATES PAIRS OF INDEPENDENT
C *** NORMAL RANDOM DEVIATES (MEAN=0,STANDARD DEVIATION=1).
C *** D1 AND D2 ARE NORMALLY DISTRIBUTED ON THE
5      C *** INTERVAL (-INF,INF).
C *** IT ASSUMES A FUNCTION RANF(X) WHICH RETURNS A
C *** RANDOM NUMBER UNIFORMLY DISTRIBUTED ON (0,1).
      10 X=RANF(0.0)
          Y=2.0*RANF(0.0)-1.0
          XX=X*X
          YY=Y*Y
          S=XX+YY
          Y3
          IF(S-1.0) 20,20,10
15      20 XL=SQRT(-2.0*ALOG(RANF(0.0)))/S
          D1=(XX-YY)*XL
          D2=2.0*X*Y*XL
          RETURN
          END

```

```

RNORM 2
RNORM 3
RNORM 4
RNORM 5
RNORM 6
RNORM 7
RNORM 8
RNORM 9
RNORM 10
RNORM 11
RNORM 12
/=RANF(0.0)
RNORM 14
RNORM 15
RNORM 16
RNORM 17
RNORM 18
RNORM 19

```

RNORM

1

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SUBROUTINE MIRROR

74/74 OPT=1

FTN 4.5*410A

03/21/77 21.51.16

PAGE

1

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1      SUBROUTINE MIRROR (A_PHA,R)
          R=0.90
          RETURN
          END

```

```

MIRROR 2
MIRROR 3
MIRROR 4
MIRROR 5

```

SUBROUTINE INTEN

74/74 OPT=1

FTN 4.5+410A

03/21/77 21.31.16

PAGE

1

1	SUBROUTINE INTEN(MON,ICAY,BETA,DNI)	INTEN	2
	C** THIS ROUTINE CALCULATES THE DIRECT NORMAL INTENSITY FOR THE	INTEN	3
	C THE GIVEN MONTH, DAY, AND TIME.	INTEN	4
	DIMENSION NDM(13),A(14),B(14) ,C(14)	INTEN	5
5	DATA NCM/31,31,28,31,30,31,30,31,31,30,31,30,31/	INTEN	6
	DATA A/391.,390.,385.,376.,360.,350.,345.,344.,351.,365.,378.,387.	INTEN	7
	1.391.,390./	INTEN	8
	DATA B/.142.,.142.,.144.,.156.,.180.,.196.,.205.,.207.,.201.,.177.,.160.,.149	INTEN	9
	1.,.142.,.142/	INTEN	10
10	DATA C/.057.,.058.,.060.,.071.,.097.,.121.,.134.,.136.,.122.,.092.,.073.,.063	INTEN	11
	1.,.057.,.058/	INTEN	12
	CLEAR=1.00	INTEN	13
	J=MON+1	INTEN	14
	DAE=FLOAT(IDAY)-21.	INTEN	15
15	IF (IDAY-.LT.21) GO TO 1	INTEN	16
	GO TO 2	INTEN	17
	1 J=J-1	INTEN	18
	DAE=FLOAT(IDAY+NDM(J))-21.	INTEN	19
	2 AINT=(A(J+1)-A(J))/(FLOAT(NDM(J)))*DAE+A(J)	INTEN	20
20	BINT=(B(J+1)-B(J))/(FLOAT(NDM(J)))*DAE+B(J)	INTEN	21
	CINT=(C(J+1)-C(J))/(FLOAT(NDM(J)))*DAE+C(J)	INTEN	22
	C CALCULATE DIRECT NORMAL INTENSITY	INTEN	23
	DNI=(AINT/EXP(BINT/SIN(BETA)))*CLEAR	INTEN	24
	RETURN	INTEN	25
25	END	INTEN	26

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B-55

```

1      SUBROUTINE TSHAD(WBASE, WTOP, ICOD)
      REAL N
      COMMON/DARKLE/DDTOP, DDBASE
      COMMON/CAVITY/SEP, DD1, DD2, RDIF, HDIF, HCAV, HSWTC(2), RSWTC(2),
5      1 CILAT(2), CAVLAT(2,21), AIMHGT
      COMMON /BALL/ DCOL, SCDELT(3), XP, YP, PAX1, PAX2, D(3)

      COMMON/BABA/STH, CT4, SEQ, OME, OMS, N(3), UE(3),
10     1 UN(3), US(3), UA(3), UR(3), THETA, MON, IDAY, SMALR, CAPR, CEQ
      COMMON /JEFF/ UMNS(3), RRS(3), NSTOPS, A, B, C, SMAX, RFIELD, TH, ICMH,
      1 ICSH, IFC, I, HIT, ICSH2, NCCL, I, HOUR, MIN, ELZ, T, TDISX, TDISY,
      2 DUMA, DUMB, DUMC, UMNN1(3), UMNN2(3), UMN(3), IOHIT, NLAT,
      3 NLONG, ILONG, NLATC, RCO, NPACK, ENHM
      C THIS ROUTINE FINDS IF THE RAU HITS THE TOWER BASEV(3) VECTOR FORM
15     C PAY UR TO THE TOWER BASE
      C WTOP= WIDTH OF TOWER TOP
      C WBASE= & WIDTH OF TOWER BOTTOM
      C ICOD HIT CODE 0= MISS 1= HIT
      DIMENSION BASEV(3), UR1(3), RES(3)
20     DO 5 I=1,3
      5 BASEV(I)=-XP*UE(I)-YP*UN(I)
      WTOP=DDTOP
      WBASE=DDBASE
      ICOD=0
25     C THE TOWER CAN NO LONGER BE SHIFTED FROM THE CENTER OF THE FIELD
      TEST=-DOTER(BASEV, UR)
      IF (TEST.LT.0) RETURN
      DURUN=-DOTER(UR, UN)
      DURUE=-DOTER(UR, UE)
      DENOM=1./SQRT(DURUE*DURUE+DURUN*DURUN)
30     C NORMAL TO THE TEST PLANE UR1
      DO 10 I= 1,3
      10 UR1(I)=(DURUE*UE(I)+DURUN*UN(I))*DENOM
      AL=-DOTER(BASEV, UR1)/DOTER(UR, UR1)
35     DO 20 I=1,3
      20 RES(I)=-AL*UR(I)-BASEV(I)
      C TEST IF RES IS NORMAL TO UR1
      TEST=DOTER(RES, UR1)
      IF (ABS(TEST).GT.0.001) WRITE(6,130) TEST
40     130 FORMAT(/,10X,13H***ERROR***,5X,21HRES NOT NORMAL TO UR1,5X,5HTES
      2T=,E10.3)
      C PULL TEST AFTER DEBUG
      HX=DOTER(RES, UE)
      HY=DOTER(RES, UN)
45     H0Z=SQRT(HX*HX+HY*HY)
      VERT=DOTER(RES, N)
      WD=WBASE-(WTOP-WBASE)*VERT/TH
      WD2=WD/2.0
      IF (VERT.GT.TH+SEP+HCAV) RETURN
      IF (VERT.GT.TH) WD2=(DD1+(DD2-DD1)*((VERT-TH)/SEP))/2.
50     IF (VERT.GT.TH+SEP) WD2=RSWTC(2)
      IF (ABS(H0Z).LT.WD2) ICOD=1
      RETURN
      END

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TSHAD 4
TSHAD 5
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TSHAD 55

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1      SUBROUTINE WALLMP(FLUX,NAZ,NHT,HCAV)
      COMMON/CELLING/NAZZ,NRZ,DTAZ(21),DRZ(10),DD3,IZR,IZAZ
      DIMENSION FLUX(21,36),DAZ(50),HCEL(50),IFRS(5),ISND(5)
      DIMENSION AVER(50),SFTOP(50),SFBOT(50)
5      C   BETH WILLIAMS AND J. M. HAMMER AUG. 16 1975
      C   FIRST SUBSCRIPT HEIGHT
      C   SECOND SUBSCRIPT IS AZZIMUTH
      C   THIS IS THE CAVITY WALL FLUX MAP PRINTOUT ROUTINE
10     I1=1
      I2=NAZ
      SFTOP(1)=0.0
      SFBOT(1)=0.0
      NAZP=NAZ+1
      NHTP=NHT+1
15     DO 10 I=1,NAZP
10      DAZ(I)=360.0*FLOAT(I-1)/FLOAT(NAZ)
      DO 20 I=1,NHTP
20      HCEL(I)=HCAV*FLOAT(I-1)/FLOAT(NHT)
      IFRS(I)=1
      ISND(I)=NAZ
25     NPTS=NAZ/10+1
      IF (NPTS.EQ.1) GO TO 45
      DO 25 I=1,NPTS
      IFRS(I)=10*(I-1)+1
      ISND(I)=10*I
25     IF (ISND(I).GT.NAZ) ISND(I)=NAZ
45     DO 300 IPTS=1,NPTS
      I1=IFRS(IPTS)
      I2=ISND(IPTS)
30     WRITE (6,50) (DAZ(I),I=I1,I2)
50     FORMAT( //,5X,6HCAVITY,2X,4HWALL,2X,3HMAP,///,16X,4HFROM,
      1 10F10.1)
      I11=I1+1
      I12=I2+1
35     WRITE(6,55) 10DAZ(I),I=I11,I12)
55     FORMAT (18X,2HTO,10F10.1)
      WRITE (6,61)
61     FORMAT (//,4X,3HTOP,/,4X,4HFROM,4X,2HTO)
40     60     FORMAT(//,4X,4HFROM,4X,2HTO,8X,8HAVE FLUX,13X,2HAT,6X,
      1 13HSUM BOTTOM UP,7X,2HAT,6X,12HSUM TOP DOWN)
      DO 100 IHT=1,NHT
      M1=NHT-IHT+2
45     WRITE(6,75) HCEL(M1-1),HCEL(M1),(FLUX(IHT,J),J=I1,I2)
75     FORMAT (2(2X,F6.1),4X,10F10.3)
50     100     CONTINUE
      WRITE (6,62)
62     FORMAT (4X,6HBOTTOM)
      300     CONTINUE
      WRITE(6,325)
50     325     FORMAT(///,10X, 15HCIRCUMFERENTIAL ,2X, 3HAVE ,2X4HWALL
      1 ,2X,4HFLUX )
      WRITE(6,60)
      DO 400 I = 1,NHT
      AVE = 0.0
55     DO 350 J = 1,NAZ
      350     AVE = AVE + FLUX(I,J)
      400     AVER(I)=AVE/FLOAT(NAZ)

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WALLMP 2
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WALLMP 58

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SUBROUTINE WALLMP 74/74 OPT=1

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        AREA=.0929*DD3*HCEL(2)*3.14159
        DO 150 I=1,NHT
          SFBOT(I)=AVER(I)*AREA+SFBOT(I)
150      SFTOP(I)=AVER(NHTP-I)*AREA+SFTOP(I)
        DO 450 I=1,NHT
          J=NHTP-I
450      WRITE(6,76) HCEL(I),HCEL(I+1),AVER(I),HCEL(J+1),SFTOP(I),
           1 HCEL(I),SFBOT(I)
        76 FORMAT(2:2X,F6.1),4X,F10.3,10X,F6.1,4X,F10.3,8X,
           1 F6.1,4X,F10.3)
        WRITE(6,77) HCEL(1),SFTOP(NHTP),HCEL(NHTP),SFBOT(NHTP)
        77 FORMAT(40X,F6.1,4X,F10.3,8X,F6.1,4X,F10.3)
        RETURN
        END

```

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WALLMP 59
WALLMP 60
WALLMP 61
WALLMP 62
WALLMP 63
WALLMP 64
WALLMP 65
WALLMP 66
WALLMP 67
WALLMP 68
WALLMP 69
WALLMP 70
WALLMP 71
WALLMP 72

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1      SUBROUTINE POLMAP(COUNT, CONV, NRAYS, ICOD, ND1)
      C (IANG, IRAD), ARE COORDINATES OF THE ZONE IN WHICH THE MIRROR LIES.
      C THIS ROUTINE REWRITTEN 3/2/76.
      C RFIELD OUTER FIELD RADIUS IN FEET
      C RCO INNER FIELD RADIUS IN FEET
      C ALL ZONES HAVE EQUAL AREA
      C DIMENSION IRRAY(10,10), ERRAY(10,10), SHRAY(10,10),
      C   BLRAY(10,10), SHHTH(10,10)
      C DIMENSION FTAR(10,10), SHADP(10,10), BLP(10,10), TLOSP(10,10)
      C COMMON /JEFF/ UMNS(3), RRS(3), NSTOPS, A, B, C, SMAX, RFIELD, TH, ICMH,
      C   ICSH, IFC, IMIT, ICSH2, NCOL, IHOURL, MIN, ELZ, T, TOISX, TOISY,
      C   DUMA, DUMB, DUMC, UMNN1(3), UMNN2(3), UMN(3), IOHIT, NLAT,
      C   NLONG, JLONG, NLATC, RCO, NPACK, ENHM
      C COMMON /MAPS/ NRZF, MAZZF, NC(250,8), SRAD(250,8), NPRAD(8), DEG
      C COMMON /TABLE/ UHV(3), UAXV(3), UXV2(3), RST(3), WFF, NHF, XDF, WD2, WFF2,
      C   RHS(3), DELX, DELY, WD, IFV, RRB(3), UAXVP(3), UXV2PP(3),
      C   UTT(3), UNNP(3), UXV2P(3)
      C , UMNP(3), UMNPP(3), F, ALN, UBEDN(3), IFOC, IDRIVE
      C COMMON /CINDEX/ XPCOL, YPCOL, COSA, COSB, SLDUM, WCELL, ICELL, JCELL,
      C   XCSAV, YCSAV, XCM, YCM, ICELM, JCELM
      C COMMON /MOONMP/ JWHIS, JCORB, JMISHI, JMISLO, JFRONT
      C DIMENSION IWHIS(10,10), ICORB(10,10), IMISHI(10,10), IMISLO(10,10),
      C   IFRONT(10,10)
      C IF (ICOD.GT.1) GO TO 420
      C INITIALIZE
      C SET ARRAY TO 0
      C DO 410 I=1,10
      C DO 410 J=1,10
      C   IRRAY(I,J)=0
      C   ERRAY(I,J)=0.
      C   SHRAY(I,J)=0.0
      C   BLRAY(I,J)=0.0
      C   SHHTH(I,J)=0.0
      C   ICORB(I,J)=0
      C   IWHIS(I,J)=0
      C   IFRONT(I,J)=0
      C   IMISLO(I,J)=0
      C   IMISHI(I,J)=0
      C 410 CONTINUE
      C 420 IF (ICOD.GT.2) GO TO 617
      C LOCATE THE POINT IN A ZONE
      C IANG=ICELM
      C IRAD=JCELM
      C SUM HITS AND ENERGY
      C IF (ND1 .EQ. 7 .OR. ND1 .EQ. 8) IRRAY(IANG,IRAD)=IRRAY(IANG,IRAD)+1
      C IF (ND1 .EQ. 7 .OR. ND1 .EQ. 8) ERRAY(IANG,IRAD)=ERRAY(IANG,IRAD)+
      C   1 COUNT
      C SHRAY(IANG,IRAD)=SHRAY(IANG,IRAD)+COUNT*FLOAT(ICSH)
      C BLRAY(IANG,IRAD)=BLRAY(IANG,IRAD)+COUNT*FLOAT(IOHIT)
      C SHHTH(IANG,IRAD)=SHHTH(IANG,IRAD)+COUNT*FLOAT(ICSH2)
      C ICORB(IANG,IRAD)=ICORB(IANG,IRAD)+JCORB
      C IWHIS(IANG,IRAD)=IWHIS(IANG,IRAD)+JWHIS
      C IFRONT(IANG,IRAD)=IFRONT(IANG,IRAD)+JFRONT
      C IMISHI(IANG,IRAD)=IMISHI(IANG,IRAD)+JMISHI
      C IMISLO(IANG,IRAD)=IMISLO(IANG,IRAD)+JMISLO
      C IF (ICOD.LT.3) GO TO 1000
      C 617 FCONV=CONV/FLOAT(NRAYS)

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        DO 70 I=1,10
        DO 70 J=1,10
        ERRAY(I,J)=FCONV*ERRAY(I,J)
        SHRAY(I,J)=SHRAY(I,J)*FCONV
        BLRAY(I,J)=BLRAY(I,J)*FCONV
        SHHTH(I,J)=SHHTH(I,J)*FCONV
    60      71 CONTINUE
    65      C OUTPUT HITS
        WRITE(6,205)
    205  FORMAT(///,25X,23HITS ON THE HELIO FIELD,/)
        DO 240 I=1,10
    240  WRITE(6,248) (ERRAY(J,I),J=1,10)
    70      245  FORMAT(2X,10I10)
        C
        C OUTPUT ENERGY
        WRITE(6,39)
    75      33  FORMAT(///,5X,17HFLUX ON THE FIELD,/)
        DO 120 I=1,10
    120  WRITE(6,245) (ERRAY(J,I),J=1,10)
    245  FORMAT(2X,10E10.3)
        WRITE(6,246)
    80      246  FORMAT(///,1X,22HFLUX LOST TO SHADOWING,/)
        DO 247 I=1,10
    247  WRITE(6,298) (SHRAY(J,I),J=1,10)
    298  FORMAT(5X,10E12.5)
        WRITE(6,700)
    85      700  FORMAT(///,5X,43HFLUX LOST TO HELIOSTAT TO HELIOSTAT SHADING,/)
        DO 710 I=1,10
    710  WRITE(6,249) (SHHTH(J,I),J=1,10)
        WRITE(6,249)
    90      249  FORMAT(///,1X,21HFLUX LOST TO BLOCKAGE,/)
        DO 299 I=1,10
    299  WRITE(6,289) (BLRAY(J,I),J=1,10)
    289  FORMAT(5X,10E12.5)
        WRITE(6,550)
    95      550  FORMAT(///,5X,10HTOTAL FLUX,/)
        DO 560 I=1,10
        DO 560 J=1,10
        FTAR(I,J)=ERRAY(I,J)+SHRAY(I,J)+BLRAY(I,J)
        SHADP(I,J)=SHRAY(I,J)/FTAR(I,J)
        BLP(I,J)=BLRAY(I,J)/FTAR(I,J)
    100     560  TLOSP(I,J)=(SHRAY(I,J)+BLRAY(I,J))/FTAR(I,J)
        DO 570 I=1,10
    570  WRITE(6,789) (FTAR(J,I),J=1,10)
        WRITE(6,580)
    105     580  FORMAT(///,5X,28HPERCENT FLUX LOST TO SHADOWS,/)
        DO 585 I=1,10
    585  WRITE(6,289) (SHADP(J,I),J=1,10)
        WRITE(6,590)
    110     590  FORMAT(///,5X,29HPERCENT FLUX LOST TO BLOCKAGE,/)
        DO 595 I=1,10
    595  WRITE(6,289) (BLP(J,I),J=1,10)
        WRITE(6,599)
    599  FORMAT(///,5X,26HTOTAL PERCENT OF FLUX LOST,/)
        DO 123 I=1,10
    123  WRITE(6,289) (TLOSP(J,I),J=1,10)
        WRITE(6,310)

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POLMAP 108
POLMAP 109
POLMAP 110
POLMAP 111
POLMAP 112
POLMAP 113
POLMAP 114
POLMAP 115

SUBROUTINE POLMAP 74/74 OPT=1

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115      310 FORMAT (////,5X,22HRAYS WHICH MISSED HIGH)
          DO 315 I=1,10
      315 WRITE (6,248) (IMISHI(J,I),J=1,10)
          WRITE (6,320)
      320 FORMAT (////,5X,21HRAYS WHICH MISSED LOW)
          DO 325 I=1,10
      325 WRITE (6,248) (IMISLO(J,I),J=1,10)
          WRITE (6,330)
      330 FORMAT (////,5X,30HRAYS WHICH MISSED ACROSS FRONT)
          DO 335 I=1,10
      335 WRITE (6,248) (IFRONT(J,I),J=1,10)
          WRITE (6,340)
      340 FORMAT (////,5X,27HRAYS WHICH WHISTLED THROUGH)
          DO 345 I=1,10
      345 WRITE (6,248) (IWHIS(J,I),J=1,10)
          WRITE (6,350)
      350 FORMAT (////,5X,22HRAYS WHICH HIT CORBELS)
          DO 355 I=1,10
      355 WRITE (6,248) (ICORB(J,I),J=1,10)
1000 RETURN
135      END

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POLMAP 116
POLMAP 117
POLMAP 118
POLMAP 119
POLMAP 120
POLMAP 121
POLMAP 122
POLMAP 123
POLMAP 124
POLMAP 125
POLMAP 126
POLMAP 127
POLMAP 128
POLMAP 129
POLMAP 130
POLMAP 131
POLMAP 132
POLMAP 133
POLMAP 134
POLMAP 135
POLMAP 136

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B-62

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1      SUBROUTINE HITFAC(NFHIT,NFBLOC,ND1,ICOD,NHF)
      C      THIS ROUTINE TOTALS THE
      C      NUMBER OF HITS AND BLOCKS
      C      FOR AND FROM EACH HELIOSTAT
      C      FACET
      C      NFHIT=INDEX OF HIT FACET
      C      NFBLOC=INDEX OF FACET WHICH BLOCKED THE RAY
      C      ND1=EVENT CODE. ND1=4, RAY IS BLOCKED BY FACET ON HIT
      C      TURNTABLE. ND1=5, RAY IS BLOCKED BY ADJACENT TURNTABLE.
      C      ND1.GT.5, RAY GOT AWAY CLEAN.
      C      ICHIT(IF)=COUNT OF HITS ON FACET(IF).
      C      ICHITM(IF)=COUNT OF HITS ON FACET (IF), NOT COUNTING BLOCKED RAYS.
      C      INBLOC(I,J)=COUNT OF RAYS FROM FACET I WHICH WERE BLOCKED BY
      C      FACET J ON THE SAME TURNTABLE.
      C      IFBLOC(I,J)=COUNT OF RAYS FROM FACET I WHICH WERE BLOCKED BY
      C      FACET J ON ADJACENT HELIOSTAT.
      C      NHF=NUMBER OF HELIOSTAT FACETS.
      C      ICOD=CONTROL CODE. ICOD=1,INITIALIZE. ICOD=2,INCREMENT
      C      COUNTERS. ICODE=3,PRINT RESULTS.
      C      DIMENSION ICHIT(10),ICHITM(10),INBLOC(10,10),IFBLOC(10,10)
      C      GO TO (10,100,200),ICOD
      10  DO 20 I=1,10
      C      ICHIT(I)=0
      C      ICHITM(I)=0
      C      DO 20 J=1,10
      C      INBLOC(I,J)=0
      C      IFBLOC(I,J)=0
      20  IF(ND1.EQ.4) GO TO 180
      C      IF(ND1.EQ.5) GO TO 150
      C      IF(ND1.LT.4) RETURN
      C      ND1 IS .GT. 5 SO INCREMENT ICHIT AND ICHITM.
      C      ICHIT(NFHIT)=ICHIT(NFHIT)+1
      C      ICHITM(NFHIT)=ICHITM(NFHIT)+1
      C      RETURN
      150 CONTINUE
      C      ND1 IS 5 SO INCREMENT ICHIT AND IFBLOC.
      C      ICHIT(NFHIT)=ICHIT(NFHIT)+1
      C      IFBLOC(NFHIT,NFBLOC)=IFBLOC(NFHIT,NFBLOC)+1
      C      RETURN
      180 CONTINUE
      C      ND1 IS 4 SO INCREMENT ICHIT AND INBLOC
      C      ICHIT(NFHIT)=ICHIT(NFHIT)+1
      C      INBLOC(NFHIT,NFBLOC)=INBLOC(NFHIT,NFBLOC)+1
      C      RETURN
      200 WRITE(6,210) (IFAC,IFAC=1,NHF)
      210 FORMAT(////,10X,7HSUMMARY,2X,2HOF,2X,3HHIT,2X,3HAND,2X,8HBLOCKAGE,
      C      1 2X,6HCOUNTS,2X,2HBY,2X,5HFACET,///,5X,5HFACET,5X,5HTOTAL,1X,
      C      2 9HHITS LESS,5X,4HHITS,2X,7HBLOCKED,2X,2HBY,/,5X,5HINDEX,6X,
      C      3 4HHITS,4X,6HHLOCKS,8(5X,15))
      C      DO 215 IFAC=1,NHF
      215 WRITE(6,220) IFAC,ICHIT(IFAC),ICHITM(IFAC),(INBLOC(IFAC,JB),
      C      JB=1,NHF)
      220 FORMAT(11(5X,15))
      C      WRITE(6,230) (IFAC,IFAC=1,NHF)
      230 FORMAT(///,5X,8HOFBLOC,2X,7HSUMMARY,///,5X,5HFACET,8(5X,15))
      C      DO 250 IFAC=1,NHF
      250 WRITE(6,260) IFAC,(IFBLOC(IFAC,JB),JB=1,NHF)

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      HITFAC 2
      HITFAC 3
      HITFAC 4
      HITFAC 5
      HITFAC 6
      HITFAC 7
      HITFAC 8
      HITFAC 9
      HITFAC 10
      HITFAC 11
      HITFAC 12
      HITFAC 13
      HITFAC 14
      HITFAC 15
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      HITFAC 44
      HITFAC 45
      HITFAC 46
      HITFAC 47
      HITFAC 48
      HITFAC 49
      HITFAC 50
      HITFAC 51
      HITFAC 52
      HITFAC 53
      HITFAC 54
      HITFAC 55
      HITFAC 56
      HITFAC 57
      HITFAC 58

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SUBROUTINE HITFAC 74/74 OPT=1

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60 260 FORMAT(10(SX,I5))
RETURN
END

HITFAC 59
HITFAC 60
HITFAC 61

CARD NR. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

21 I

AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRANCH COMPUTED GO TO STATEMENT.

40703-II-2

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1      SUBROUTINE ROOF(ICCD,CONV,
COMMON/CEILING/NAZZ,NRZ,DTAZ(21),DRZ(10),DD3,IZR,IAZ
COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
DIMENSION TOPMAP(21,10), DRZAV(10)
5      C DD3 DIAMETER OF IN FEET
C      TOPMAP(I,J) FLUX MAP
C      IZAZ INDEX OF AZIMUTH ZONE
C      IZR INDEX OF RADIAL ZONE
C      AZIMUTH ZONE INDEX FIRST
10     C ALL ZONES HAVE EQUAL AREA
C      DTAZ(I) ZONE BOUNDARY VECTOR(AZZ)
C      DRZ(I) ZONE BOUNDARY VECTOR(RADIAL)
C      NAZZ NUMBER OF AZIMUTH ZONES
C      NRZ NUMBER OF RADIAL ZONES
15     C IAC CODE FOR HIT . IT MUST BE 3
C      GO TO (5,50,100),ICCD
C      DELTA = 2.0*3.14159/FLOAT(NAZZ)
C      NAZZP1 = NAZZ+1
C      NRZP1 = NRZ+1
20     C
C      DO 10 I = 1,NAZZP1
10     DTAZ(I) = DELTA*FLOAT(I-1)
C      INITIALIZE
C      NZONS = NAZZ*NRZ
25     C AZONE = 0.25*(DD3**2)/FLOAT(NRZ)
C      DRZ(1) = 0.0
C      NOTE AZONE NEEDS A PI ABOVE
C      DO 20 I = 2,NRZP1
30     DRZAV(I-1) = SORT( D.50*AZONE + CRZ(I-1)**2)
20     DRZ(I) = SORT(AZONE*DRZ(I-1)**2)
C      AZONE = 3.14159*AZONE*0.0529/FLOAT(NAZZ)
C      AZONE NOW HAS ITS PI VALUE IN M**2
C      DO 30 I = 1,NAZZ
C      DO 30 J = 1,NRZ
35     30 TOPMAP(I,J) = 0.0
C      RETURN
50     CONTINUE
C      INCREMENT MAP CELL
C      TOPMAP(IZAZ,IZR) = TOPMAP(IZAZ,IZR)+COUNT
40     RETURN
100    CONTINUE
C      CONVERT TO UNITS AND PRINT OUT
C      DO 110 I=1,NAZZ
C      DO 110 J=1,NRZ
45     110 TOPMAP(I,J) = TOPMAP(I,J)*CONV/AZONE
C      NRZM1 = NRZ
C      WRITE(6,120) (DRZ(I),I=1,NRZM1)
120    FORMAT (1///,5X,6HCAVITY,2X,7HCEILING,2X,3HMAP,///,21X,4HFROM,10F10
1.2)
50     WRITE(6,121) (DRZ(I),I=2,NRZP1)
121    FORMAT (23X,2H10,10F10.2)
C      WRITE(6,122) (DRZAV(I), I = 1,NRZ)
122    FORMAT (22X, 3HAVE, 10F10.2)
C      WRITE (6,125)
55     125 FORMAT (1//,4X,4HFROM,4X,2H10,6X,3HAVE)
C      DO 200 IAZ = 1,NAZZ
C      AFRCM = DTAZ(IAZ)*57.296

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ROOF 58

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SUBROUTINE ROOF

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      ATO = DTAZ(IAZ+1)*57.296
      AVE = (AFROM+ATO)/2.0
      WRITE(6,130) AFROM,ATO,AVE,(TOPMAP(IAZ,I),I=1,NRZ)
130  FORMAT (3(2X,F6.1),1X,10F10.4)
200  CONTINUE
      WRITE(6,210)
210  FORMAT(///,10X, 9HAZZIMOUTH., 2X, 3HAVE, 2X, 7HCEILING ,2X,4HFLUX)
      WRITE(6,125)
      DO 300 I=1,NRZ
      AVE = 0.0
      DO 250 IAZ = 1,NAZZ
250  AVE = AVE + TOPMAP(IAZ,I)
      AVE = AVE/FLOAT(NAZZ)
70  300  WRITE(6,130) DRZ(I), DRZ(I+1), DRZAV(I), AVE
      RETURN
      END

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      ROOF 59
      ROOF 60
      ROOF 61
      ROOF 62
      ROOF 63
      ROOF 64
      ROOF 65
      ROOF 66
      ROOF 67
      ROOF 68
      ROOF 69
      ROOF 70
      ROOF 71
      ROOF 72
      ROOF 73
      ROOF 74

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B-65

40703-II-2

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1      SUBROUTINE THAP(XC,YC,MON,COUNT,NRAYS,CONV,ICOD)
      C      THIS ROUTINE MAPS THE YEARLY PERFORMANCE OF VARIOUS SEGMENTS OF THE
      C      FIELD AROUND THE YEAR
      DIMENSION IARY(11,16),EARY(11,16)
      IF (ICOD.GT.1) GO TO 50
      DO 100 I=1,11
      DO 100 J=1,16
      IARY(I,J)=0
      100 EARY(I,J)=0.0
      GO TO 1000
      50  THETAZ=ATAN2(XC,YC)*57.3
      IF (ICOD.GT.2) GO TO 66
      IF (THETAZ.LT.0.0) THETAZ=THETAZ+360.
      C      TEST THETAZ FOR WHICH QUADRANTS
      IQUAD=INT(THETAZ/90.0)+1
      IF (THETAZ.GE.315..OR.THETAZ.LT.45.) IQUAD2=7
      IF (THETAZ.GE.45..AND.THETAZ.LT.135.) IQUAD2=10
      IF (THETAZ.GE.135..AND.THETAZ.LT.225.) IQUAD2=9
      IF (THETAZ.GE.225..AND.THETAZ.LT.315.) IQUAD2=8
      20  IARY(IQUAD,MON)=IARY(IQUAD,MON)+1
      IARY(IQUAD2,MON)=IARY(IQUAD2,MON)+1
      EARY(IQUAD,MON)=EARY(IQUAD,MON)+COUNT
      EARY(IQUAD2,MON)=EARY(IQUAD2,MON)+COUNT
      DO 120 J=1,12
      IARY(5,J)=IARY(1,J)+IARY(2,J)
      IARY( 6,J)=IARY( 4,J)+IARY(3,J)
      IARY(11,J)=IARY(10,J)+IARY(8,J)
      EARY(5,J)=EARY(1,J)+EARY(4,J)
      EARY( 6,J)=EARY(2,J)+EARY(3,J)
      EARY(11,J)=EARY(10,J)+EARY(8,J)
      30  120 CONTINUE
      DO 130 I=1,11
      IARY(I,13)=IARY(I,1)+IARY(I,2)+IARY(I,11)+IARY(I,12)
      EARY(I,13)=EARY(I,1)+EARY(I,2)+EARY(I,11)+EARY(I,12)
      35  IARY(I,14)=IARY(I,5)+IARY(I,6)+IARY(I,7)+IARY(I,8)
      EARY(I,14)=EARY(I,5)+EARY(I,6)+EARY(I,7)+EARY(I,8)
      IARY(I,15)=IARY(I,3)+IARY(I,4)+IARY(I,9)+IARY(I,10)
      EARY(I,15)=EARY(I,3)+EARY(I,4)+EARY(I,9)+EARY(I,10)
      130 CONTINUE
      40  66 IF (ICOD.LT.3) GO TO 1000
      DCONV=CONV/FLOAT(NRAYS)*0.001
      DO 150 I=1,11
      DO 150 J=1,15
      EARY(I,J)=DCONV*EARY(I,J)
      45  150 CONTINUE
      DO 160 I=1,11
      DO 160 J=13,15
      160 EARY(I,16)=EARY(I,16)+EARY(I,J)
      WRITE (6,200)
      50  200 FORMAT (1H)////,25X,36MHITS IN EAST NORTH DIVIDED QUADRANTS,///
      1 3X,5HMONTH,7X,3HE/N,6X,4HE/N,5X,5HE/N,
      2 6X,4HE/-N,4X,7HN FIELD,3X,7HS FIELD)
      DO 300 J=1,15
      300 WRITE (6,250) J,(IARY(I,J),I=1,6)
      55  250 FORMAT ( 5X,I2,6(5X,I5))
      WRITE (6,220)
      220 FORMAT ( ///,25X,28MHITS IN NORTHEAST NORTHWEST

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      THAP      2
      THAP      3
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      THAP     57
      THAP     58

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	1 17H DIVIDED QUADRANTS, ///, 3X, 5H MONTH, 5X,	TMAP	59
	2 5H NE/NW, 5X, 6H NE/NW, 5X,	TMAP	60
60	3 7H NE/-NW, 4X, 6H NE/-NW, 2X,	TMAP	61
	4 13H NE/NW, NE/-NW)	TMAP	62
	DO 310 J=1,15	TMAP	63
	310 WRITE (6,250) J, (IARY(I,J), I=7,11)	TMAP	64
	WRITE (6,270)	TMAP	65
65	WRITE (6,230)	TMAP	66
	230 FORMAT (1H1, ///, 24X, 3H ENERGY IN EAST NORTH DIVIDED QUADRANTS,	TMAP	67
	1 ///, 3X, 5H MONTH, 6X,	TMAP	68
	2 3H NE, 10X, 4H SE, 9X, 5H SW,	TMAP	69
	3 10X, 4H NW, 8X, 7H FIELD, 7X, 7H FIELD)	TMAP	70
70	DO 320 J=1,16	TMAP	71
	320 WRITE (6,210) J, (EARY(I,J), I=1,6)	TMAP	72
	210 FORMAT (5X, 12, 6(5X, E9.3))	TMAP	73
	WRITE (6,240)	TMAP	74
	240 FORMAT (///, 24X, 20H ENERGY IN NORTHEAST	TMAP	75
75	1 27H NORTHWEST DIVIDED QUADRANTS, ///, 3X, 5H MONTH, 6X,	TMAP	76
	2 5H NORTH, 8X, 6H WEST, 8X,	TMAP	77
	3 7H SOUTH, 7X, 6H EAST, 5X,	TMAP	78
	4 13H EAST + WEST)	TMAP	79
	DO 330 J=1,16	TMAP	80
80	330 WRITE (6,210) J, (EARY(I,J), I=7,11)	TMAP	81
	WRITE (6,270)	TMAP	82
	270 FORMAT (///, 25X, 23H 13 IS THE WINTER MONTHS, ///, 25X, 10H 14 IS THE	TMAP	83
	1 13H SUMMER MONTHS, ///, 25X, 32H 15 IS THE SPRING AND FALL MONTHS,	TMAP	84
	1 ///, 25X, 29H 16 IS THE TOTAL YEARLY ENERGY)	TMAP	85
85	1000 RETURN	TMAP	86
	END	TMAP	87

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1      SUBROUTINE CONE(Z1,Z2,AL1,AL2,ANGHIT1,ANGHIT2,ICHIT,ZZERO)
C
C THIS SUBROUTINE SOLVES FOR THE HIT POINTS (2) OF A VECTOR WITH A
C INVERTED CONE
5      C:
C REQUIRED INPUTS
C      US1-UNIT VECTOR TO BE TESTED FOR HITS
C      D-VECTOR FROM SAME LOCATION IN SPACE AS US1 TO THE BASE OF THE
C
C      RCONE-RADIUS OF THE CONE HALFWAY TO THE POINT
10     C      HTOT-HEIGHT OF THE CONE
C      THECON=CONE ANGLE
C      N-UNIT VECTOR ALONG THE CONE AXIS
C      UN-UNIT VECTOR UN A PLANE NORMAL TO UN
15     C      UE-UNIT VECTOR SUCH THAT N,UN,UE FORM AN ORTHONORMAL TRIAD SET
C
C OUTPUTS
C      Z1 AND Z2-LENGTHS ALONG CONE AXIS TO THE HIT PLANES
C      AL1 AND AL2-SHORTEST AND LONGEST LENGTHS OF THE HIT VECTOR
20     C (US1 EXTENDED)
C      ANGHIT1 AND ANGHIT2-ANGLES FROM UN TO THE HIT POINT IN THE
C PLANE NORMAL TO N
C      ICHIT-CODE FOR HIT TEST
C      0 FOR MISSING THE CONE
25     C      1 FOR HITTING
C
C      DIMENSION RHC1(3),RHC2(3)
C      REAL N
C      COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),DRAD
C      COMMON /RALL/ DCOL,SCOELT(3),XP,YP,PAX1,PAX2,D(3)
30     C
C      COMMON/BABA/STH,CTH,SEQ,OME,OMS,N(3),UE(3),
C      UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEQ
C      COMMON/SUPPT/DELTH,THES,KSEG,APR,SM,NSUP,RCONE,THECON,HTOT
C      COMMON/TILTED/TILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET
35     ICHIT=0
C      TTCON=TAN(THECON)
C      DUSUV=DOTP(US1,UVT)
C      DUVD=COTER(UVT,D)
C      DUSD=COTER(US1,D)
40     A1=1.
C      ZZERO=HTOT/2.0-RCONE/TTCON
C      FIX=DUSUV*DUSUV
C      A2=TTCON*TTCON*FIX
C      A=A1-A2-FIX
45     B1=2.*DUVD
C      B2=2.*DUSD*DUSUV
C      B3=2.0*ZZERO*TTCON*FIX*TTCON
C      B=B1-B2*B3
C      C1=DUVD*DUVD
50     C2=2.*DUVD*DUSD*DUSUV
C      C3=COTER(D,D)*FIX
C      C4=ZZERO*ZZERO*A2
C      C=C1-C2*C3-C4
C      RAD=R*3/4.*A*A)-C/A
55     IF(RAD.LT.0.) RETURN
C      ICHIT=1
C      IF (ABS(A).GT.0.0001) GO TO 44

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CONE 2
CONE 3
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CONE 58

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	Z1=ZERO	CONE	59
	Z2=10000.	CONE	60
60	GO TO 46	CONE	61
	44 Z1=-B/(2.0*A)*SQRT(RAD)	CONE	62
	Z2=-B/(2.0*A)*SQRT(RAD)	CONE	63
	C SOLVE FOR LENGTH OF HIT VECTORS	CONE	64
	46 AL1=(Z1*DUVD)/DUSUV	CONE	65
65	AL2=(Z2*DUVD)/DUSUV	CONE	66
	DO 10 I=1,3	CONE	67
	RHC1(I)=AL1*US1(I)-D(I)-Z1*UVT(I)	CONE	68
	10 RHC2(I)=AL2*US1(I)-D(I)-Z2*UVT(I)	CONE	69
	C SOLVE FOR HIT ANGLES	CONE	70
70	X1=DOTER(RHC1,UE)	CONE	71
	X2=DOTER(RHC2,UE)	CONE	72
	Y1=DOTER(RHC1,U1)	CONE	73
	Y2=DOTER(RHC2,U1)	CONE	74
	IF(ABS(X1).GT.0.0001) GO TO 100	CONE	75
75	ANGHIT1=0.0	CONE	76
	IF(Y1.LT.0.0) ANGHIT1=3.14159	CONE	77
	GO TO 200	CONE	78
	100 ANGHIT1=ATAN2(X1,Y1)	CONE	79
	200 IF(ABS(X2).GT.0.0001) GO TO 300	CONE	80
80	ANGHIT2=0.0	CONE	81
	IF(Y2.LT.0.0) ANGHIT2=3.14159	CONE	82
	GO TO 400	CONE	83
	300 ANGHIT2=ATAN2(X2,Y2)	CONE	84
	400 IF(ANGHIT1.LT.0.) ANGHIT1=ANGHIT1+2.0*3.14159	CONE	85
85	IF(ANGHIT2.LT.0.) ANGHIT2=ANGHIT2+2.0*3.14159	CONE	86
	TEST1=DOTER(RHC1,UVT)	CONE	87
	TEST2=DOTER(RHC2,UVT)	CONE	88
	IF(ABS(TEST1).GT.0.001.OR.ABS(TEST2).GT.0.001) WRITE(6,20)	CONE	89
	20 FORMAT(//,10X,48MHIT VECTOR FROM CENTER OF CYLINDER IS NOT NORMAL.	CONE	90
90	1 7HTO AXIS,/)	CONE	91
	RETURN	CONE	92
	END	CONE	93

```

1      SUBROUTINE POLSP2(ACOL, NNU, SPACEF, NTOTAL, GCOVER)
      C      THIS ROUTINE INITIALIZES THE PARAMETERS REQUIRED FOR
      C      NON-UNIFORM POLAR PACKING.
      DIMENSION AAZ(4), GRC(250,8)
5      COMMON /JEFF/ UMNS(3), PRS(3), NSTOPS, A, B, C, SMAX, RFIELD, TH, ICMH,
      1      ICSH, IFC, IHIT, ICSH2, WCOL, I HOUR, MIN, ELZ, T, TOISX, TOISY,
      2      DUMA, DUMB, DUMC, UMNN1(3), UMNN2(3), UMN(3), IOHIT, NLAT,
      3      NLONG, ILONG, NLATC, RCD, NPACK, ENHM
      COMMON/STRUCT/GAP, WLONG, WSIDE, WTRI, XLTRI, BB01, BB02, WCROSS,
10     1 WDUH, IFRAM, HTMIR, HRCROS, WJCROS
      COMMON/TABLE/UHV(3), UAXV(3), UXV2(3), RST(3), WfV, NHF, XDF, WD2, WfV2,
      1RHS(3), DELX, DELY, WD, IFV, RRB(3), UAXVP(3), UXV2PP(3),
      2UTT(3), UUNP(3), UXV2P(3)
      3, UUNP(3), UUNPP(3), F, ALEN, UBEDN(3), IFOC, IDRIE
15     COMMON/MAPS/NRZF, NAZZF, MC(250,8), SRAD(250,8), NPRAD(8), DEG
      DO 5 I=1,8
      5 NPRAD(I)=0
      NTOTAL=0
      PDA=SPACEF*(XDF-WFV)
20     CL2=((NHF-1)*XDF-WFV)/2.
      CLT=2.*CL2/PDA
      CWTW=WD*GAP*2.*WLONG
      A1=NHF*WfV*WD/CLT
      AAZ(1)=0.0
25     JMAX=NNU
      IF (NNU.LT.6) GO TO 70
      JMAX=4
      DO 10 I=1,4
      10 AAZ(I)=3.14159/4.*(FLOAT(I)-1.)
30     70 DEG=2.*3.14159/FLOAT(NNU)
      DO 200 J=1, JMAX
      SRAD(1,J)=RCO
      I=0
35     25 I=I+1
      C      AZIMUTH SPACING GROUND COVER WAS CHANGED BY GA SMITH 9/8/76
      A3=0.078*0.5/TH
      A2=0.425*0.012*AAZ(J)
      IF ((SRAD(1,J)/TH).LE.3.4) GO TO 50
      GCOV=0.12
40     DR=A1/GCOV
      SRAD(I+1,J)=SRAD(I,J)+DR
      GO TO 110
50     A4=A2-2.*SRAD(I,J)*A3
      R1=-A4/A3
      C1=A1/A3
45     ARG1=R1*31-4.*C1
      IF (ARG1.LE.0.0) GO TO 53
      DR=-R1*0.5-SORT(ARG1)/2.
53     IF (NPACK.EQ.4) DR=A1/GCOVER
      BR=1.3334*(SRAD(I,J)-CWTW*0.5)
      CR=1.3334*(SRAD(I,J)*CWTW+CWTW*0.25+CL2*CL2)
      DRPR=-RP*0.5+SORT(BR*BR*4.*CR)*0.5
      IF (DR.LT.DRPR) DR=DRPR
      SRAD(I+1,J)=SRAD(I,J)+DR
55     GCOV=A2-A3*(SRAD(I,J)+SRAD(I+1,J))
      IF (NPACK.EQ.4) GCOV=GCOVER
      C      DR, SRAD(I+1), AND GCOV ARE SET

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110 RNC=DEG*SCOV*(SRAD(I+1,J)*SRAD(I+1,J)-SRAD(I,J)*SRAD(I,J))/
  *(2.*ACOL)
60 NC(I,J)=INT(RNC*0.5)
C CHECK FOR HELIOSTAT WITHIN ZONE BOUNDARIES
  IF(NC(I,J).LT.1) GO TO 64
  RTLE=(SRAD(I+1,J)*SRAD(I,J))/2.-CWTH*0.5
  THE2=ATAN2(CL2,RTLE)
65 59 IF(THE2.LE.(DEG/FLOAT(2*NC(I,J)))) GO TO 62
  NC(I,J)=NC(I,J)-1
  GO TO 59
62 IF(NPRAD(J).NE.0) GO TO 64
  NSC=NC(I,J)
70 DO 63 IC=1,NSC
  THE1=DEG*((FLOAT(IC)-0.5)/NC(I,J)*FLOAT(J-1))
  XI=(RTLE*CWTH*0.5)*SIN(THE1)
  YIP=(RTLE*CWTH*0.5)*COS(THE1)*TDISY
  DIST=SQRT(XI*XI+YIP*YIP)
75 IF(DIST.LE.RFIELD) NTOTAL=NTOTAL+2
63 CONTINUE
64 CONTINUE
  DELRAD=SRAD(I+1,J)-SRAD(I,J)
C RESOLVE FOR GROUND COVER IN THIS ZONE
80 GRC(I,J)=2.*ACOL*FLOAT(NC(I,J))/(DEG*(SRAD(I+1,J)*SRAD(I+1,J)
  *-SRAD(I,J)*SRAD(I,J)))
  RTLE=RTLE*CWTH
  DTOE=SQRT(RTLE*RTLE+CL2*CL2)
  IF(DTOE.GT.SRAD(I+1,J)) WRITE(6,90)
  IF(DTOE.GT.SRAD(I+1,J)) SRAD(I+1,J)=DTOE
85 90 FORMAT(10X,24HPADIAL SPACING TOO SMALL)
  IF(SRAD(I+1,J).GT.(RFIELD*ABS(TDISY)-DELRAD*0.5)) GO TO 6071
  GO TO 25
6071 IF(NPRAD(J).GT.0) GO TO 201
  NPRAD(J)=1+1
90 201 IF(1.GT.(NPRAD(J)+1)) GO TO 200
  GO TO 25
200 CONTINUE
C SET WEST FIELD RADII AND COLLECTOR COUNT PARAMETERS
95 DO 1100 J1=1,JMAX
  J2=9-J1
  NLIM=NPRAD(J1)+2
  NPRAD(J2)=NPRAD(J1)
  DO 1100 J1=1,NLIM
  SRAD(I1,J2)=SRAD(I1,J1)
100 1100 NC(I1,J2)=NC(I1,J1)
  JLIM=2*JMAX
  DO 1110 J1=1,JLIM
  NEND=NPRAD(J1)
105 WRITE(6,1120) J1
1120 FORMAT(/,10X,27HPOLAR RADII IN AZIMUTH ZONE,15,/)
  WRITE(6,1130) ((I,SRAD(I,J1)),I=1,NEND)
1130 FORMAT(8(1X,2HR(,13,2H)=,F6.1,1X))
  WRITE(6,1140) J1
110 1140 FORMAT(/,10X,37HPOLAR COLLECTOR COUNT IN AZIMUTH ZONE,15,/)
  WRITE(6,1150) ((I,NC(I,J1)),I=1,NEND)
1110 CONTINUE
1150 FORMAT(8(1X,2HR(,13,2H)=,15,1X))
  DO 1210 J1=1,JMAX

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SUBROUTINE POLSP2 74/74 OPT=1

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115 NEND=NPRAD(J1)
WRITE(6,1220) J1
1220 FORMAT(/,10X,26H3ROUND COVER IN POLAR ZONE,15,/)
WRITE(6,1240) ((I,GRC(I,J1)),I=1,NEND)
1210 CONTINUE
120 1240 FORMAT(7(1X,3HGC(,13,2H)=,F5.3,1X))
IF(NNU.EQ.1) NTOTAL=NTOTAL/2
RETURN
END

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1      SUBROUTINE FRAME(VS1,VS2,VS3,VS4,VS5,VS6,VS7,ALFRAM,JK,M,ALENG) FRAME 2
COMMON/PLANE/PLAN(7) FRAME 3
COMMON/BEDTST/ALBLOC,ICOD,UHV2(3),UAXV2(3) FRAME 4
COMMON/JEFF/UMNS(3),RRS(3),NSTOPS,A,B,C,SMAX,RFIELD,TH,ICMH, FRAME 5
5      1 ICSH,IFC,IHIT,ICSH2,NCOL,IMHOUR,MIN,ELZ,T,TDISA,TDISY, FRAME 6
2      2 DUMA,DUMB,DUMC,UMNN1(3),UMNN2(3),UMN(3),IOHIT,NLAT, FRAME 7
3      3 NLONG,ILGNS,NLATC,RCO,NPACK,ENHM FRAME 8
COMMON/TABLE/UHV(3),UAXV(3),UXV2(3),RST(3),WV,V,NHF,XDF,W02,WV2, FRAME 9
1      1 RHS(3),DELX,DELY,W0,IFV,RRB(3),UAXVP(3),UXV2PP(3), FRAME 10
10     2 UTT(3),UNNP(3),UXV2P(3) FRAME 11
3      3 ,UMNP(3),UMNPP(3),F,ALEN,UBEDN(3),IFOC,IDRIVE FRAME 12
COMMON/BABA/STH,CTH,SEC,OME,OMS,N(3),UE(3), FRAME 13
1      1 UN(3),US(3),UA(3),UR(3),THETA,MON,IDAY,SMALR,CAPR,CEO FRAME 14
COMMON/CINDEX/ XPCOL,YPCOL,COSA,COSB,SLODUM,WCELL,ICELL,JCELL, FRAME 15
1      1 XCSAV,YCSAV,XCM,YCM,ICELM,JCELM FRAME 16
COMMON /RALL/ DCOL,SCDELT(3),XP,YP,PAX1,PAX2,D(3) FRAME 17
FRAME 18
COMMON/JOKER/URP(3),US1(3),THSL,PH,THSR,THSU,COUNT,WAVL(20),ORAD FRAME 19
COMMON/TILTED/TILT,UVT(3),U1(3),U2(3),WAPMAX,WAPMIN,OFFSET FRAME 20
20     COMMON/STRUCT/GAP,WLONG,WSIDE,WTRI,XLTRI,B1,B2,WCROSS,W0UM,IFRAM FRAME 21
* ,HTMIR,HTCROS,WJCROS FRAME 22
DIMENSION URDUM(3),UHV0UM(3),UAXV0UM(3) FRAME 23
DIMENSION VS1(3),VS2(3),VS3(3),VS4(3),VS5(3),VS6(3),VS7(3), FRAME 24
* RHIT1(3),RHIT2(3),RHIT3(3),RHIT4(3),RHIT5(3),RHIT6(3),RHIT7(3) FRAME 25
25     REAL L,N FRAME 26
L=0.0 FRAME 27
AL1=10.E+10 FRAME 28
AL2=10.E+10 FRAME 29
AL3=10.E+10 FRAME 30
30     AL4=10.E+10 FRAME 31
AL5=10.E+10 FRAME 32
AL6=10.E+10 FRAME 33
AL7=10.E+10 FRAME 34
GO TO (10,10,20,30),ICOD FRAME 35
35     10 DO 11 I=1,3 FRAME 36
URDUM(I)=UR(I) FRAME 37
UHV0UM(I)=UHV(I) FRAME 38
11 UAXV0UM(I)=UAXV(I) FRAME 39
GO TO 1200 FRAME 40
40     20 DO 21 I=1,3 FRAME 41
URDUM(I)=US1(I) FRAME 42
UHV0UM(I)=UHV(I) FRAME 43
21 UAXV0UM(I)=UAXV(I) FRAME 44
GO TO 1200 FRAME 45
45     30 DO 31 I=1,3 FRAME 46
URDUM(I)=US1(I) FRAME 47
UHV0UM(I)=UHV2(I) FRAME 48
31 UAXV0UM(I)=UAXV2(I) FRAME 49
1200 AL1=DOTER(VS1,UBEDN)/DOTER(URDUM,UBEDN) FRAME 50
50     C TOP FRAME HIT TEST FRAME 51
IF(AL1.LT.0.0) GO TO 50 FRAME 52
DO 101 I=1,3 FRAME 53
101 RHIT1(I)=AL1*URDUM(I)-VS1(I) FRAME 54
XHIT=ARS(DOTER(UHV0UM,RHIT1)) FRAME 55
YHIT=ARS(DOTER(UAXV0UM,RHIT1)) FRAME 56
55     C CHECK FOR HIT IN BED BOUNDARIES FRAME 57
IF(XHIT.GT.(ALEN*0.5)) GO TO 50 FRAME 58

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        IF (YHIT.GT.(WDUM*WLONG*0.5)) GO TO 50
C FOLLOWING CHECKS FOR HITS - TRUE IS HIT
        IF (YHIT.GT.(WDUM*WLONG*0.5)) GO TO 40
        IF (XHIT.GT.(XDF*WCROSS*0.5).AND.XHIT.LT.(XDF*WCROSS*0.5)) GO TO 40
        IF (XHIT.LT.(WJCROSS*0.5)) GO TO 40
C CHECK FOR TRIANGLE HIT
        IF (XHIT.GT.(WCROSS*0.5*XLTRI*0.70711)) XHIT=ABS(XHIT-XDF)
        IF (YHIT.LT.(XHIT*82).AND.YHIT.GT.(XHIT*81)) GO TO 40
        GO TO 50
C***** HIT TOP FRAME
        40 IFRAM=1
        IF (JK.NE.M) IFRAM=2
        GO TO 51
C***** CHECK FRAME SIDES
        50 AL1=10.E+10
        51 CONTINUE
        AL2=DOTER(UAXVDUM,VS2)/DOTER(URDUM,UAXVDUM)
        IF (AL2.LT.0.0) GO TO 100
        DO 102 I=1,3
        102 RHIT2(I)=-VS2(I) + AL2*URDUM(I)
        YHIT=ABS(DOTER(RHIT2,UREDN))
        XHIT=ABS(DOTER(RHIT2,UHVDUM))
        IF (XHIT.GT.(ALEN/2.)) GO TO 100
        IF (YHIT.GT.(WSIDE/2.)) GO TO 100
C***** NO.2 IS HIT
        IFRAM=1
        IF (JK.NE.M) IFRAM=2
        GO TO 109
        108 AL2=10.E+10
        109 CONTINUE
        AL3=DOTER(UAXVDUM,VS3)/DOTER(URDUM,UAXVDUM)
        IF (AL3.LT.0.0) GO TO 500
        DO 103 I=1,3
        103 RHIT3(I)=-VS3(I) + AL3*URDUM(I)
        YHIT=ABS(DOTER(RHIT3,UREDN))
        XHIT=ABS(DOTER(RHIT3,UHVDUM))
        IF (XHIT.GT.(ALEN/2.)) GO TO 500
        IF (YHIT.GT.(WSIDE/2.)) GO TO 500
C***** NO.3 IS HIT
        IFRAM=1
        IF (JK.NE.M) IFRAM=2
        GO TO 510
        500 AL3=10.E+10
        510 CONTINUE
        AL4=DOTER(UHVDUM,VS4)/DOTER(URDUM,UHVDUM)
        IF (AL4.LT.0.0) GO TO 530
        DO 520 I=1,3
        520 RHIT4(I)=-VS4(I) + AL4*URDUM(I)
        XHIT=ABS(DOTER(RHIT4,UAXVDUM))
        YHIT=ABS(DOTER(RHIT4,UREDN))
        IF (XHIT.GT.((WD*GAP)*0.5).OR.(YHIT.GT.(W*CROSS*0.5)) GO TO 530
C***** NO.4 IS HIT
        IFRAM=1
        IF (JK.NE.M) IFRAM=2
        GO TO 540
        530 AL4=10.E+10
        540 CONTINUE

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115      ALS=DOTER(UHVDUM,V55)/DOTER(URDUM,UHVDUM)
      IF (ALS.LT.0.0) GO TO 560
      DO 550 I=1.3
120      550 RHIT5(I)=-V55(I) + ALS*URDUM(I)
      XHIT=ABS(DOTER(RHIT5,UAXVDUM))
      YHIT=ABS(DOTER(RHIT5,UBEDN))
      IF (XHIT.GT.((WD*GAP)*0.5). OR.(YHIT.GT.HTCROS*0.5)) GO TO 560
      C***** PLANE NO.5 IS HIT
      IFRAM=1
      IF (JK.NE.M) IFRAM=2
125      GO TO 570
      560 ALS=10.E+10
      570 CONTINUE
      AL6=DOTER(UHVDUM,V56)/DOTER(URDUM,UHVDUM)
      IF (AL6.LT.0.0) GO TO 590
130      DO 580 I=1.3
      580 RHIT6(I)=-V56(I) + AL6*URDUM(I)
      XHIT=ABS(DOTER(RHIT6,UAXVDUM))
      YHIT=ABS(DOTER(RHIT6,UBEDN))
      IF (XHIT.GT.((WD*GAP)*0.5). OR.(YHIT.GT.HTCROS*0.5)) GO TO 590
135      C***** PLANE NO.6 IS HIT
      IFRAM=1
      IF (JK.NE.M) IFRAM=2
      GO TO 600
140      590 AL6=10.E+10
      600 CONTINUE
      AL7=DOTER(UBEDN,V57)/DOTER(URDUM,UBEDN)
      IF (AL7.LT.0.0) GO TO 620
      DO 610 I=1.3
145      610 RHIT7(I)=-V57(I) + AL7*URDUM(I)
      XHIT=ABS(DOTER(RHIT7,UHVDUM))
      YHIT=ABS(DOTER(RHIT7,UAXVDUM))
      C***** CHECK FOR BOTTOM FRAME BOUNDARY
      IF (XHIT.GT.(ALEN*0.5)) GO TO 620
      IF (YHIT.GT.(WDUM*WLONG*0.5)) GO TO 620
150      C***** WITHIN FRAME BOUNDARY - CHECK FOR ACTUAL HIT
      IF (YHIT.GT.(WDUM*WLONG*0.5)) GO TO 630
      IF (XHIT.GT.(XDF*WCROSS*0.5).AND.XHIT.LT.(XDF*WCROSS*0.5)) GO TO 630
      IF (XHIT.LT.(WJCROS*0.5)) GO TO 630
      GO TO 620
155      630 IFRAM=1
      IF (JK.NE.M) IFRAM=2
      GO TO 625
      620 AL7=10.E+10
      625 CONTINUE
      L=AMIN1(AL1,AL2,AL3,AL4,AL5,AL6,AL7)
      ALFRAM=L
160      IF (L.EQ.AL1) IP=1
      IF (L.EQ.AL2) IP=2
      IF (L.EQ.AL3) IP=3
      IF (L.EQ.AL4) IP=4
165      IF (L.EQ.AL5) IP=5
      IF (L.EQ.AL6) IP=6
      IF (L.EQ.AL7) IP=7
      IF (L.GT.10E+06) GO TO 900
      IF (ALEN.GT.ALFRAM) GO TO 900
170      IPLAN(IP)=IPLAN(IP)+1

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SUBROUTINE FRAME 74/74 OPT=1

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900 RETURN
END

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FRAME 174

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APPENDIX C
GLOSSARY OF VARIABLES APPEARING IN COMMON

This appendix contains those variables which appear in all common blocks in the program. The table lists the FORTRAN names in alphabetical order, the common block in which each occur, a description of each, and the subroutine in which the variable is defined. The figure numbers following the description indicates a figure to refer to for further definition.

FORTTRAN Name	Common Block	Description	Subroutine Defined
A	JEFF	Cosine of angle between sun and local north (Figure 3-2)	VECTS
ACOL	None	Area of collector	INITCOL
AIMHGT	CAVITY	The height up the aperture at which all the mirrors are aimed (ft)	INITCOL
ALBLOC	BEDTST	Distance from ray hit on a facet to nearest block by another facet (Figure 3-25)	OFFBLOC
ALEN	TABLE	Length of a heliostat from outer mirror axle to mirror axle (ft) (Figure F-3)	INITCOL
APH	SUPPT	Average aperture slant height	AIMPP
B	JEFF	Cosine of angle between sun and local east (Figure 3-2)	VECTS
B1	STRUCT	Collector frame geometry constant (ft)	INITCOL
B2	STRUCT	Collector frame geometry constant (ft)	INITCOL
C	JEFF	Cosine of angle between sun and local vertical (Figure 3-2)	VECTS
CAPR	BABA	Mean radius of earth's orbit in nautical miles	INITCOL
CAVLAT	CAVITY	Height zone boundaries in the cavity (ft)	MOON
CEQ	BABA	Cosine of 23.5 deg, the solar declination angle for summer solstice	INITCOL
CILAT	CAVITY	Zone indices for height zones in the cavity	MOON
CONV	None	Conversion factor to weight each ray with a KW value	

FORTTRAN Name	Common Block	Description	Subroutine Defined
COSA	CINDEX	North direction cosine of the sun ray	FINDIT
COSB	CINDEX	East direction cosine of the sun ray	FINDIT
COUNT	JOKER	The normalized value of a given ray	MONTE MONTE2
CTAZT	TOE	Cosine of the sun's azimuth angle at the toe-in setpoint.	INITCOL
CTELT	TOE	Cosine of the sun's elevation angle at the toe-in set point	INITCOL
CTH	BABA	Cosine of the latitude	INITCOL
D	BALL	Vector from hit heliostat center to the tower top	PTOWER MOON
DCOL	BALL	Height of facet axis off the ground (ft)	INITCOL
DDBASE	DARKLE	Diameter of the tower base (ft) (Figure F-2)	INITCOL
DDTOP	DARKLE	Diameter of the tower top (ft) (Figure F-2)	INITCOL
DD1	CAVITY	Diameter of lower disc of annulus cavity (tower top diameter) (Figure F-4)	INITCOL
DD2	CAVITY	Average diameter of upper disc of annulus cavity (Figure F-4)	INITCOL
DD3	CEILING	Inner cavity diameter (ft) (Figure F-4)	NAMELIST
DEG	MAPS	Angle of one azimuth zone on the field	POLSP2
DELTm	SUPPT	Angle between the midpoint of the supports and the hit heliostat field position	AIMPP
DINTV	RANDOM	Number of hours per day that are integrated over in annual energy runs	INITCOL
DRAD	JOKER	Factor to convert degrees to radians	INITCOL

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FORTTRAN Name	Common Block	Description	Subroutine Defined
DRZ	CEILING	Distance of the radial borders on the ceiling of the receiver	ROOF
DTARG	TOE	Vector from heliostat center to the aimpoint	MIRRN
DTAZ	CEILING	Azimuthal borders on the ceiling (radians) of the receiver	ROOF
DUMA	JEFF	Same as A	PTOWER
DUMB	JEFF	Same as B	PTOWER
DUMC	JEFF	Same as C	PTOWER
ELZ	JEFF	Elevation of the sun at a given time	MONTE2 INITCOL
ENHM	JEFF	Sum of COUNT	MONTE MONTE2
F	TABLE	Focal length of a facet	NAMELIST
GAP	STRUCT	Space between the frame side beams not taken up by a facet (ft) (Figure F-3)	NAMELIST
GCOVER	None	Fraction of ground covered by heliostats	NAMELIST
HCAV	CAVITY	Height of the receiver cavity (ft) (Figure F-4)	NAMELIST
HDIF	CAVITY	Height of the diffuser (ft)	NAMELIST
HSWTC	CAVITY	CAVITY heights (= to HCAV and HDIF)	INITCOL
HTCROS	STRUCT	Height of the frame cross beams (ft) (Figure F-4)	NAMELIST
HTMIR	STRUCT	Height of the facet axle above the top of the heliostat frame (ft) (Figure F-4)	NAMELIST

FORTTRAN Name	Common Block	Description	Subroutine Defined
HTOT	SUPPT	Average distance from the tower top to the cavity bottom (Figure F-4)	INITCOL
ICELL	CINDEX	Field cell index	RINDX
ICELM	CINDEX	Field cell index	FINDIT
ICMH	JEFF	Mirror hit flag 0 - no mirror hit 1 - mirror hit	FINDIT
ICOD	BEDTST	Flag for setting the correct vectors 1 shading on different heliostat 2 shading on same heliostat 3 blocking on different heliostat 4 blocking on same heliostat	PTOWER FINDIT
ICSH	JEFF	A counter to indicate that a ray was shadowed by a facet 0 - no shadows 1 - number of shadow hits	FINDIT
ICSH2	JEFF	A flag to indicate that a ray was shadowed by a facet on a different heliostat than it would have encountered. 0 - no shadows 1 - number of shadow hits	FINDIT
IDAY	BABA	The day of the month to be run	NAMELIST
IDAYT	None	The day of the toe-in set	NAMELIST
IDRIVE	TABLE	Option code for facets to be driven on a heliostat individually or all together. 1 = ganged 2 = independent in one axis	NAMELIST
IFC	JEFF	Initialization flag 1 first call to FINDIT 2 second call to FINDIT	PTOWER
IFOC	TABLE	Option code for focal lengths of the facets (obsolete)	NAMELIST

FORTRAN Name	Common Block	Description	Subroutine Defined
IFOCUS	TOE	An option to model the curve of the facets individually or to zone the field into areas with the facets all having the same curve. IFOCUS=0 means each facet has its own focus. IFOCUS=1-10 means there are 1-10 zones in each of which the facets all have the same focal length. IFOCUS=11 means flat-mirrors.	NAMELIST
IFRAM	STRUCT	A flag to indicate whether or not a ray encountered the frame of a heliostat in its path. 0 - no encounter 1 - frame hit	FRAME
IFV	TABLE	Index of a facet on a heliostat	INHIT
IHIT	JEFF	A flag to indicate a ray hit a facet 0 - no facet hit 1 - facet hit	INHIT
IHOUR	JEFF	Hour of the day run	INITCOL
IJUMP	RANDOM	Option code for a time point or annual energy run 0 - time point 1 - time integration 2 - time point and time integration	NAMELIST
ILONG	JEFF	Index of azimuth zone hit on the cavity wall	MOON
IPLAN	PLANE	Counter for ray hits on each frame plane	FRAME
IOHIT	JEFF	A flag to indicate a ray block 0 - no block 1 - blocked	
IRANC	RANDOM	A flag to initialize the random number generator	INITCOL
IRAYS	RANDOM	Number of rays per NRUN to be drawn	NAMELIST

FORTTRAN Name	Common Block	Description	Subroutine Defined
ISLAN	RANDOM	Initial random seed	NAMelist
IT1	RANDOM	Control variable for terminating the program (= 3 to stop)	NAMelist
ITOE	None	An option to adjust the facets relative to each other in zones or to adjust each heliostat separately. ITOE=0 means the facets are toed-in individually. ITOE=1-10 are the number of zones for similar toe-in relationships.	NAMelist
ITT	None	Integer ray counter array	MONTE or MONTE2
IZAZ	CEILING	Index of azimuth zone on the ceiling	MOON
IZR	CEILING	Index of the radial zone on the ceiling	MOON
JCELL	CINDEX	Field cell index	RINDX
JCELM	CINCEX	Field cell index	FINDIT
JCORB	MOONMP	A flag to indicate a corbel hit 0 - the ray entered the cavity 1 - ray hit the corbel	MOON
JFRONT	MOONMP	A flag to indicate a ray missed the aperture completely 0 - ray entered cavity 1 - ray missed aperture	MOON
JMISHI	MOONMP	Flag to indicate a ray hit the receiver above the aperture 0 - ray entered cavity 1 - ray missed high	MOON
JMISLO	MOONMP	A flag to indicate a ray hit the tower below the aperture 0 - ray entered cavity 1 - ray missed low	MOON

FORTRAN Name	Common Block	Description	Subroutine Defined
JWHIS	MOONMP	A flag to indicate a ray entered the aperture but did not hit the cavity 0 - ray entered cavity 1 - ray entered aperture and exited without getting into the cavity	MOON
KSEG	SUPPT	Integer segment indice to indicate field position relative to corbel location	AIMPP
LIMC	RANDOM	Option code for choice of sun mode 1 - flat sun 2 - sun with limb darkening and solar radiation 3 - sun with limb darkening	INITCOL
MIN	JEFF	Minute of the hour of the day	INITCOL
MODE	RANDOM	A flag that indicates whether all variables need to be initialized or not 1 = initialize all variables 2 = read namelist	INITCOL
MON	BABA	Month of the year to be run	NAMELIST
MONT	None	Month of the toe-in set point	NAMELIST
N	BABA	Unit ray vertical to the ground plane (real variable)	VECTS
NAZZ	CEILING	Number of azimuth zones on the ceiling	INITCOL
NAZZF	MAPS	Number of azimuth zones in field	NAMELIST
NC	MAPS	Number of collectors in a zone	POLSP2
NCOL	JEFF	Number of collectors in the field	POLSP2
ND1	None	Disposition code for a given ray	
NHF	TABLE	Number of heliostat facets (must be 4 in this code version)	NAMELIST

FORTRAN Name	Common Block	Description	Subroutine Defined
NLAT	JEFF	Number of height zones on the diffuser	NAMelist
NLATC	JEFF	Number of height zones on the cavity wall	NAMelist
NLONG	JEFF	Number of azimuth zones on cavity walls	NAMelist
NNU	None	Number of azimuth zones on the field (either 1 or 8)	NAMelist
NPACK	JEFF	Option code for arrangement of heliostats in the field 4 - uniform polar packing 5 - nonuniform polar packing	NAMelist
NPRAD	MAPS	Number of polar radial zones in an azimuth section (Figure F-5)	POLSP2
NRUN	RANDOM	Number of iterations on IRAYS to be run	NAMelist
NRZ	CEILING	Number of radial zones on the cavity roof (Figure F-5)	NAMelist
NRZF	MAPS	Number of radial zones on the field (Figure F-1)	NAMelist
NSTOPS	JEFF	Number of points along a projected ray path to be checked for closest heliostat (Figure 3-4)	NAMelist
NSUP	SUPPT	Number of cavity supports	NAMelist
OFFSET	TILTED	North-south distance that the cavity center is offset from the upper aperture east-west axis	
OME	BABA	Hourly angular displacement of the earth about its rotation axis	INITCOL
OMS	BABA	Daily angular displacement of the earth in its orbit	INITCOL
PAX1	BALL	Tracking error in degrees, for the outer axis	MONTE2

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FORTRAN Name	Common Block	Description	Subroutine Defined
PAX1B	STATS	Mean tracking error, in degrees, for the outer axis	INITCOL
PAX1V	STATS	Variance tracking error, in degrees, for the outer axis	NAMELIST
PAX2	BALL	Tracking error, in degrees, for the inner axis	MONTE2
PAX2B	STATS	Mean tracking error, in degrees, for the inner axis	INITCOL
PAX2V	STATS	Variance tracking error, in degrees, for the inner axis	NAMELIST
PH	JOKER	The angular rotation for mirror surface slope errors	MONTE MONTE2
PHB	STATS	Heliostat optical parameters	NAMELIST
PHV	STATS	Heliostat optical parameters	NAMELIST
RCO	JEFF	Radius of the heliostat field cutout around the tower (ft) (Figure F-1)	NAMELIST
RCONE	SUPPT	Radius of the conical aperture half-way between the tower and the cavity (ft) (Figure F-4)	NAMELIST
RDIF	CAVITY	Radius of the diffuser	NAMELIST
RFIELD	JEFF	Radius of the heliostat field (ft) (Figure F-1)	NAMELIST
RHS	TABLE	= RRB	FINDIT
RRB	TABLE	Vector from the ray start point to the heliostat hit point	INHIT
RRS	JEFF	Vector from facet center to hit-point of the ray	FINDIT
RST	TABLE	Vector from center of field to ray hit point on a facet	INHIT

FORTTRAN Name	Common Block	Description	Subroutine Defined
RSWTC	CAVITY	Radius of the cavity or diffuser	INITCOL
SCDELT	BALL	Uncertainty vector in position of the aimpoint	NAMELIST
SEP	CAVITY	Distance of separation between the tower and the receiver (Figure F-4)	INITCOL
SEQ	BABA	Sine of 23.5 deg, the solar declination angle for summer solstice	INITCOL
SLDUM	CINDEX	Horizontal length along ray path from start point to the point to be checked for the closest heliostat	FINDIT
SMALR	BABA	Earth's diameter in nautical miles	INITCOL
SMAX	JEFF	Horizontal component of the ray from the start point to the hit point on a test plane	PTOWER
SPACEF	None	Spacing factor between heliostats	NAMELIST
SRAD	MAPS	Radial zones borders measured from the tower	POLSP2
STAZT	TOE	Sine of the sun's azimuth angle at the toe-in setpoint	INITCOL
STELT	TOE	Sine of the sun's elevation angle at the toe-in setpoint	INITCOL
STH	BABA	Sine of the latitude of the plant	INITCOL
SW	SUPPT	Support width	NAMELIST
T	JEFF	Time of the day to be run	NAMELIST
TAZT	None	Azimuth angle of the sun at the given toe-in time. It is used to vary the toe-in strategy (radians).	NAMELIST
TDISX	JEFF	Tower distance from center of the field in an east-west direction - where east is positive x (ft) (Figure F-2)	NAMELIST

FORTRAN Name	Common Block	Description	Subroutine Defined
TDISY	JEFF	Tower distance from center of the field in a north-south direction - where north is positive y (ft) (Figure F-1)	NAMELIST
TELT	None	Elevation angle of the sun at the given toe-in time. It is used to vary the toe-in strategy (radians).	NAMELIST
TH	JEFF	Tower height (ft) (Figure F-2)	NAMELIST
THECON	SUPPT	Aperture cone angle (radians) (Figure F-2)	INITCOL
THES	SUPPT	The angle between the supports	AIMPP
THETA	BABA	Latitude of the tower (degrees)	NAMELIST
THSL	JOKER	Mirror surface slope error angle	MONTE MONTE2
THSR	JOKER	Rotation angle of the sun vector to account for limb darkening	MONTE MONTE2
THSU	JOKER	Rotation angle of the sun vector to account for limb darkening	MONTE MONTE2
TIMET	None	Time of the toe-in setpoint	NAMELIST
TPB	STATS	Heliostat optical parameter	NAMELIST
TPV	STATS	Heliostat optical parameter	NAMELIST
TSB	STATS	Mean of mirror surface slope error (degrees)	NAMELIST
TSV	STATS	Variance of mirror surface slope error (degrees)	NAMELIST
TTILT	TILTED	Tilt of the aperture cone axis	INITCOL
UA	BABA	Vector at 235 deg in north-south vertical plane	INITCOL
UAXV	TABLE	Unit vector along the facet axle	TRIADS

FORTTRAN Name	Common Block	Description	Subroutine Defined
UAXV2	BEDTST	Unit vector along the facet axle	TRIADS
UAXVP	TABLE	UAXV perturbed for tracking error	PERT3
UBEDN	TABLE	Unit vector perpendicular to the top plane of the heliostat (Figure 4-25)	TRIADS
UDNI	RANDOM	Direct normal intensity (Langleys)	INTEN
UE	BABA	Unit vector in the local east direction (Figure 3-2)	VECTS
UHV	TABLE	Horizontal unit vector along the heliostat outer axis (Figure 3-25)	MONTE2 MONTE
UHV2	BEDTST	Horizontal unit vector along the heliostat outer axis (Figure 3-25)	OFFBLOC
UMN	JEFF	Nominal unit mirror normal vector (Figure 3-25)	MIRRN
UMNN1	JEFF	Unit vector normal to the sun vector UR	VECTS
UMNN2	JEFF	Unit vector normal to the sun vector UR	VECTS
UMNP	TABLE	Heliostat unit normal vector rotated for the outer axis tracking error	PERT3
UMNPP	TABLE	Heliostat unit normal vector rotated for both axes tracking errors	PERT3
UMNS	JEFF	Same as UMN for the hit heliostat	FINDIT
UN	BABA	Unit vector in the local north direction (Figure 3-2)	VECTS
UNNP	TABLE	Mirror normal at hit point with slope error and tracking errors (Figures 4-22 and 3-23)	PERT3
UR	BABA	Unit ray from the center of the sun	VECTS

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FORTRAN Name	Common Block	Description	Subroutine Defined
URP	JOKER	The sun's perturbed unit ray based on where on the sun the ray originated	PTOWER
US	BABA	Unit vector along the path from the center of the sun to the center of the earth	VECTS
US1	JOKER	Unit vector in the direction which the ray is reflected from a mirror surface	PTOWER
UTARG	TOE	Unit vector along path from heliostat center to the aimpoint	MIRRN
UTT	TABLE	Unit vector tangent to the hit point mirror normal	PERT3
UT2	TABLE	Unit vector tangent to the hit point mirror normal	PERT3
UVT	TILTED	Unit vector along the cone axis	AIMPP
UXV2	TABLE	Unit vector perpendicular to the facet axle in the plane of the facet	TRIADS
UXV2P	TABLE	UXV2 rotated for the outer axis tracking error	PERT3
UXV2PP	TABLE	UXV2 rotated for both tracking axes errors	PERT3
U1	TILTED	Unit vector normal to cone axis and in north direction	AIMPP
U2	TILTED	Unit vector normal to cone axis and in east direction	AIMPP
WAPMAX	TILTED	Maximum aperture width (ft)	NAMELIST
WAPMIN	TILTED	Minimum aperture width (ft)	NAMELIST
WAVL	JOKER	Wavelengths of solar spectrum divided in equal energy bands	INITCOL

FORTTRAN Name	Common Block	Description	Subroutine Defined
WCELL	CINDEX	Width of a cell on a field with rectangular cells (ft)	INITCOL
WCROSS	STRUCT	Width of the frame cross beams (ft)	NAMELIST
WD	TABLE	Width of a mirror facet (ft)	NAMELIST
WDUM	STRUCT	Half of the collector width (ft)	INITCOL
WD2	TABLE	Half the width of a facet (ft)	INITCOL
WFOV	TABLE	Length of a facet (ft)	NAMELIST
WFOV2	TABLE	Half the length of a facet (ft)	INITCOL
WJCROS	STRUCT	Width of the center cross piece on the frame (ft)	NAMELIST
WLONG	STRUCT	Width of the frame side beams (ft)	NAMELIST
WSIDE	STRUCT	Height of the frame side beams (ft)	NAMELIST
WTRI	STRUCT	Width of the diagonal braces in the top plane of the frame (ft)	NAMELIST
XCM	CINDEX	The east-west coordinate of a heliostat center hit by a ray	FINDIT
XCSAV	CINDEX	The east-west coordinate of a heliostat center to be checked for an encounter with a ray	RINDX
XDF	TABLE	Facet axle to axle distance (ft)	NAMELIST
XLTRI	STRUCT	Length of the diagonal frame braces (ft)	NAMELIST
XM	None	Flux total array	MONTE MONTE2
XP	BALL	The east-west coordinate in the test plane from which a test ray originates	FINDIT

FORTTRAN Name	Common Block	Description	Subroutine Defined
XPCOL	CINDEX	The east-west coordinate of a heliostat center	FINDIT
YCM	CINDEX	The north-south coordinate of a heliostat center hit by a ray	FINDIT
YCSAV	CINDEX	The north-south coordinate of a heliostat center to be checked for an encounter with a ray	RINDX
YFRAC	RANDOM	Number of days over which the program integrates	INITCOL
YP	BALL	The north-south coordinate in the test plane from which a test ray originates	FINDIT
YPCOL	CINDEX	The north-south coordinate of a heliostat center	FINDIT

APPENDIX D

INPUT INSTRUCTIONS

All input to this program is in the form of NAMELIST input cards.

The following variables are in NAMELIST CHANGE:

```

C *****NAMELIST DICTIONARY
  NAMELIST /CHANGE/ RFIELD, TH, NSTOPS, TDISX, TDISY, IRAYS, TPB, TSB, PHB,
1      TPV, TSV, PHV, THETA, MON, IDAY, T, IJUMP, IT1, NRUN, ISRN,
2      PAX1V, PAX2V, SCDLT, NLONG, NLATC, GCOVER, RCD, RCONE, HCAV,
3      SW, NSUP, ID3, NRZ, NRZF, NAZZF, WD, WDV, XDF, NPACK, SPACEF,
4      IDRIVE, NNU, WAPMAX, WAPMIN, OFFSET, WLONG, WCROSS, WTRI, GAP,
5      XLTRI, HTMIR, HXCROSS, WCROSS, ITDE, IFOCUS, TAZT, TELT,
6      MONT, IDAYT, TIMET

```

Appendix C, glossary of variable names, and Appendix E, input default values and ranges, provides a description of these variables.

When preparing NAMELIST input cards, observe the following rules:*

1. The first column must be blank.
2. The second column must contain the character \$.
3. This character is immediately followed by the NAMELIST name (change), with no embedded blanks.

*Reference FORTRAN IV Programming for Engineers and Scientists by Murril and Smith, copyright 1968 by International Textbook Company, page 159.

4. The NAMELIST name is followed by a blank.
5. The items in the list must be separated by commas.
6. The order is insignificant, but all variable and array names must have appeared in the NAMELIST list.
7. The list of items is terminated with \$.

For example:

```

TH=450.,SPACE=1.103,SI=3.5,IT1=34
WI=7.33,MFW=7.33,XDF=11.73,PAX1V=.1146,PAX2V=.1146,GCOVER=0.3,RFIELD=950.,
$CHANGE NPACK=4,IRAYS=1500,RCONE=15.,IFOCUS=2,

```

[illegible]

all input variables have a default value, thus those not appearing on these input cards, but listed in the NAMELIST dictionary, are set to the default value.

There must be one group of NAMELIST input cards for each design option to be investigated. For example:

```
$CHANGE RCON=81.,GCOVER=0.3,RFIELD=950.,ITI=8$  
$CHANGE RCON=18.,GCOVER=0.3,RFIELD=950.$  
TH=450.,SPACEF=1.103,SW=3.5$  
$CHANGE NPACK=4.,IRAYS=1500,RCON=15.,IFOCUS=2,
```

[illegible]

This set of cards specifies three design options to be investigated. Variables changed by a NAMELIST input card maintain that value through subsequent option executions. Thus, in this case:

- a. All variables not mentioned on the first group of NAMELIST cards take on their default values.
- b. Only RCONE is changed for the second and third option executions. All other variables maintain either their default values, or the values specified in the first NAMELIST group.
- c. IT1=3 is the stop flag. This variable must be set on the final option execution.

APPENDIX E
GLOSSARY OF NAMELIST VARIABLES
AND DEFAULT VALUES

This appendix includes the NAMELIST dictionary variables along with their default values and meaningful range of value. Definition of these variables are given in Appendix C, Glossary of Variables Appearing in Common.

The default value of each variable shown in this appendix represents the baseline model which would be simulated upon execution of the program without input. Only those variables which are different from those given in this table need be changed with input cards to simulate a problem other than the baseline model.

Variable Name	Default	Range
DD3	42 ft	> 0
GAP	0.25 ft	> 0
GCOVER	0.3	0-1
HCAV	46.1 ft	> 0
HTCROSS	0.833 ft	> 0
HTMIR	0.833 ft	
IDAY	21	1-31
IDAYT	21	1-31
IDRIVE	1	1, 2
IFOCUS	0	0-11 by integer
IJUMP	1	0, 1, 2
IRAYS	2	Integer > 0
ISLAN	27641	Integer random II > 0
ITOE	0	0-11 by integer
IT1	2	1, 2, 3
MON	6	1-12 by integer
MONT	3	1-21 integer
NAZZF	8	1-16 integer
NLATC	5	1-16 integer
NLONG	8	1-16 integer
NNU	8	1 or 8 only
NPACK	5	4, 5
NRUN	10	Integer > 0
NRZ	5	1-16
NRZF	7	1-16
NSTOPS	11	Integer > 5
NSUP	3	Integer > 0
OFFSET	0	
PAXIV	0.05	> 0
PAX2V	0.05	> 0

E-3

Variable Name	Default	Range
PHB	0	
PHV	0	> 0
RCO	120 ft	> 0
RCONE	20 ft	> 0
RFIELD	826 ft	> RCO
SCDELT	0	
SPACEF	1.1	> 0
SW	2 ft	≥ 0
T	12 hr	0-24
TAZT	3.14159 rad	0-2 π
TDISX	0 ft	
TDISY	0 ft	
TELT	0.4948 rad	0-2 π
TH	392 ft	> 0
THETA	33 deg	-60 → +60
TIMET	12 hr	0-24
TPB	0	
TPV	0.05	> 0
TSB	0	
TSV	0.05	> 0
WAPMAX	24 ft	> 0
WAPMIN	18 ft	> 0
WCROSS	0.385 ft	≥ 0
WD	10 ft	≥ 0
WFV	10 ft	≥ 0
WJCROS	0.224 ft	≥ 0
WLONG	0.48 ft	≥ 0
WTRI	0.177 ft	≥ 0
XDF	16 ft	> WD
XLTRI	4.681 ft	≥ 0

APPENDIX F SAMPLE PROBLEMS AND DESCRIPTION OF OUTPUT

This appendix includes two sample problems, a time point simulation and an annual energy time integration simulation, both of the same geometric configuration. A reproduction of the input cards for both samples, and a copy of the actual output for each sample is included.

```

$CHANGE RFIELD=278.,TH=415.,WFV=10.375,WD=10.375,XDF=16.6,SPAECF=1.0,
THETA=35.68,
TDISY=-439.,RCO=165.,MDN=3,IDAY=81,T=12.,DD3=49.5,HCAV=54.,RCONE=18.06,
WAPMAX=25.,WAPMIN=18.8,PAX1V=.115,PAX2V=.115,PHV=0.5,IJUMP=0,IRAYS=800$
$CHANGE IJUMP=1,IT1=3,THETA=35.68$

```

Figures F-1 and F-2 show the field layout with tower location and the receiver / tower configuration. Any variable shown on the input cards and not defined in the figures can be determined from Appendix C, Glossary of Variable Appearing in Common, and Appendix E, Namelist Variables and Default Values.

The output for each of the examples is numbered to the right of each major block of output. Following the listing is an explanation of those major blocks of output numbered to match those numbers in the output.

Figure F-1. Heliostat Field with Tower One-Half South of Center

F-3

Figure F-2. Diagram of Receiver and Aperture

OUTPUT DESCRIPTION

1. Number with which the random number generator is initialized.
2. Warning message. Dimensions specified for the cavity diameter have been reset. (Does not appear in this sample.)
3. Summary of heliostat layout. The heliostats are arranged around the tower such that a line drawn from the center of a given heliostat to the center of the tower is perpendicular to the outer axis of the heliostat.

For each of eight azimuth zones, heliostats are arranged in concentric arcs. "Polar radii in azimuth zone n" are the distances from the tower center to the heliostats' boundaries for each concentric arc. "Polar collector count in azimuth zone n" is the number of heliostats within each of these concentric arcs (see Figure F-1).

4. Ground cover summary. Since the field is symmetric for this heliostat arrangement, only four zones are listed. The ground cover ratio (area of mirror/ground area in a zone) is given for each arc of heliostats in an azimuth zone.
5. Field and heliostat description. See Appendix C for definition of terms. Figures F-1 through F-4 are diagrams of the model of the field, tower, and heliostat.
6. Center wavelengths of equal energy bands for the solar spectrum.
7. Continued summary of variables describing the field.
8. Plant locations, date and time of operation.

Figure F-3. Tower/Receiver Configuration

F-6

Figure F-4. Heliostat Model (not to scale) with Associated Unit Vectors and Variable Names

- 9 & 10. Receiver and aperture dimensions. Refer to diagram in Figure F-2. and Appendix C for definitions.
11. Short option summary.
12. Tracking error factors.
13. Elevation and azimuth angles of the sun. Direct normal intensity (KW/M^2).
14. Conversion factor = total possible power falling on the heliostat field.
15. Number of rays to be traced.
16. Description of headings for ray trace results. Most are self explanatory. Reflectance refers to that property of the mirrors.

Rays which "whistled thru" refers to those rays which entered on one side of the aperture and left on the opposite side, without entering the cavity.

"ONBLOCKS" are reflected rays that were blocked by a different part of the same heliostat.

"OFFBLOCKS" are reflected rays that were blocked by a part of a different heliostat.

"Cleanly away from field" refers to rays that are not blocked by any heliostat after being reflected.

17. Type of simulation.
18. Calculated mirror area and direct normal intensity of the sun (KW/M^2).

19. All values are given in KW/M^2 of mirror.
20. Tracking efficiency.
21. Summary of frame hits and blocks.
22. Onblock, offblock ray hit summaries: a grid showing a) the hit facet, b) the facet blocking the reflected ray (used mainly for debug).
23. A map of flux on the tower cavity, zoned by height up the wall and azimuth position. For time point the units are MW/M^2 . For time integration the units are MWH/M^2 . Figure F-5 is a diagram of the flux map structure of the receiver walls and roof.
24. Summary of flux on the cavity walls. Columns one and two show the range of the wall covered. Column three shows the average flux in this ring per square foot. Columns four and five show the resultant running sums of the total flux on the ring from bottom to top. Columns six and seven do the same thing from top to bottom. Flux is measured in MW for time point and MWH for time integration.
25. A map of flux (MW/M^2 for time point MWH/M^2 for time integration) over 90 equal area zones of the roof. The zones are divided into four radial sections and 16 azimuth sections (0° is north, 90° is east, etc.) (see Figure F-5).
26. A map of flux (MW/M^2 for time point, MWH/M^2 for time integration) on the roof. The roof is zoned into five equal area concentric doughnut shaped sections (see Figure F-5).

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F-9

Figure F-5. Flux Map Structure

F-10

27. A map of incident flux on the mirrors. The field is zoned into a 10-by-10 rectangular grid. Units are MW/M^2 for time point and MWH/M^2 for time integration (see Figure F-6).

Figure F-6. Heliostat Field Zoning

28. A map of hits on the mirrors. The field is zoned into a 10-by-10 rectangular grid.
29. A map of redirected flux on the mirrors (KW for time point, KWH for time integration).
30. A map of flux lost to shadowing. Units are KW for time point and KWH for time integration. This map includes shadowing from heliostat to heliostat as well as facet-to-facet shading.
31. A map of flux lost due to heliostat-to-heliostat shading. Units are KW for time point and KWH for time integration.
32. A map of flux lost due to blockage. Units are KW for time point and KWH for time integration.

33. A map of total flux on the mirrors, i.e., the sum of grids 30, 31, 32 and 33. Units are KW for time point and KWH for time integration.

34a,b,c. Maps of losses divided by total flux on the mirrors (grid 33).

35a,b,c,d,e. Maps of the origin on the field of these rays which did not enter the cavity. That is, the origin of those rays which:

- a. Missed high
- b. Missed low
- c. Missed across the front
- d. Entered through one side of the aperture and went out the other side
- e. Struck corbels

36. SL array is a weighted ranking (0-9) of the field in a 10x10 rectilinear array.

****additional output for time integration run****

37. A map showing origin of the redirected rays which entered the cavity by month of the year. The field is divided into four sections, where the axes are north-south and east-west. Column 2 shows hits in the NE, column 3 shows hits in NW, column 4 shows hits in SW, column 5 shows hits in SE, column 6 is the sum of columns 2 and 3, column 7 is the sum of columns 4 and 5 (see Figure F-7).

The row showing month 13 is the sum of months 1, 2, 11 and 12; row 14 is the sum of months 5, 6, 7, and 8; row 15 is the sum of 3, 4, 9 and 10.

F-12

Figure F-7. Field Zoning

38. A map similar to the one described in 37, except the axes that define the quadrants of the field are diagonals, i. e., from NW to SE and NE to SW. See Figure F-8 for explanation of quadrant system.

Figure F-8. Field Zoning

39. Maps of the origin of redirected energy (in KW) zoned in the same way as the ray count maps discussed in 37 and 38.

F-13

INITIAL RANDOM SPEED= 27641 NUMBER OF RUNS PER HATCH= 10

(1)

INITIAL CAVITY DIAMETER (Does not appear in this sample)

(2)

POLAR RADII IN AZIMUTH ZONE 1

(3)

R(1)= 165.0 R(2)= 181.6 R(3)= 198.3 R(4)= 215.1 R(5)= 232.0 R(6)= 249.1 R(7)= 266.3 R(8)= 283.6
R(9)= 301.2 R(10)= 318.9 R(11)= 336.7 R(12)= 354.7 R(13)= 372.9 R(14)= 391.2 R(15)= 409.8 R(16)= 428.5
R(17)= 447.4 R(18)= 466.4 R(19)= 485.9 R(20)= 505.4 R(21)= 525.2 R(22)= 545.2 R(23)= 565.4 R(24)= 585.9
R(25)= 606.6 R(26)= 627.6 R(27)= 648.8 R(28)= 670.4 R(29)= 692.2 R(30)= 714.4 R(31)= 736.8 R(32)= 759.6
R(33)= 782.8 R(34)= 806.3 R(35)= 830.2 R(36)= 854.5 R(37)= 879.3 R(38)= 904.5 R(39)= 930.1 R(40)= 956.3
R(41)= 983.0 R(42)=1010.3 R(43)=1038.2 R(44)=1066.7 R(45)=1096.0 R(46)=1126.0 R(47)=1156.8 R(48)=1188.5
R(49)=1221.1 R(50)=1254.9 R(51)=1289.7 R(52)=1325.9 R(53)=1362.7 R(54)=1400.0 R(55)=1437.8 R(56)=1476.1
R(57)=1514.9 R(58)=1553.6 R(59)=1592.9 R(60)=1632.8 R(61)=1673.3 R(62)=1714.4 R(63)=1756.1 R(64)=1798.4
R(65)=1841.3 R(66)=1884.7 R(67)=1928.6 R(68)=1973.1 R(69)=2018.1 R(70)=2063.6 R(71)=2109.1 R(72)=2155.6
R(73)=2202.1 R(74)=2249.6 R(75)=2297.6 R(76)=2346.1 R(77)=2395.1 R(78)=2444.6 R(79)=2494.6 R(80)=2545.1
R(81)=2596.1 R(82)=2647.1 R(83)=2698.6 R(84)=2750.6 R(85)=2803.1 R(86)=2856.1 R(87)=2909.6 R(88)=2963.6
R(89)=3018.1 R(90)=3072.6 R(91)=3127.6 R(92)=3183.1 R(93)=3239.1 R(94)=3295.6 R(95)=3352.6 R(96)=3410.1
R(97)=3468.1 R(98)=3526.1 R(99)=3584.6 R(100)=3643.6 R(101)=3703.1 R(102)=3763.1 R(103)=3823.6 R(104)=3884.6
R(105)=3946.1 R(106)=4008.1 R(107)=4070.6 R(108)=4133.6 R(109)=4197.1 R(110)=4261.1 R(111)=4325.6 R(112)=4390.6
R(113)=4456.1 R(114)=4522.1 R(115)=4588.6 R(116)=4655.6 R(117)=4723.1 R(118)=4791.1 R(119)=4859.6 R(120)=4928.6
R(121)=5000.1 R(122)=5069.6 R(123)=5139.6 R(124)=5210.1 R(125)=5281.1 R(126)=5352.6 R(127)=5424.6 R(128)=5497.1
R(129)=5570.1 R(130)=5643.6 R(131)=5717.6 R(132)=5792.1 R(133)=5867.6 R(134)=5943.1 R(135)=6019.6 R(136)=6096.1
R(137)=6173.6 R(138)=6251.1 R(139)=6329.6 R(140)=6408.1 R(141)=6487.6 R(142)=6567.1 R(143)=6647.6 R(144)=6728.1
R(145)=6809.6 R(146)=6891.1 R(147)=6973.6 R(148)=7056.1 R(149)=7139.6 R(150)=7223.1 R(151)=7307.6 R(152)=7392.1
R(153)=7477.6 R(154)=7563.1 R(155)=7649.6 R(156)=7736.1 R(157)=7823.6 R(158)=7911.1 R(159)=7999.6 R(160)=8088.1
R(161)=8177.6 R(162)=8267.1 R(163)=8357.6 R(164)=8448.1 R(165)=8539.6 R(166)=8631.1 R(167)=8723.6 R(168)=8816.1
R(169)=8909.6 R(170)=9003.1 R(171)=9097.6 R(172)=9192.1 R(173)=9287.6 R(174)=9383.1 R(175)=9479.6 R(176)=9576.1
R(177)=9673.6 R(178)=9771.1 R(179)=9869.6 R(180)=9968.1 R(181)=10067.6 R(182)=10167.1 R(183)=10267.6 R(184)=10368.1
R(185)=10469.6 R(186)=10570.1 R(187)=10671.6 R(188)=10773.1 R(189)=10875.6 R(190)=10978.1 R(191)=11081.6 R(192)=11185.1
R(193)=11289.6 R(194)=11394.1 R(195)=11499.6 R(196)=11605.1 R(197)=11711.6 R(198)=11818.1 R(199)=11925.6 R(200)=12033.1
R(201)=12141.6 R(202)=12250.1 R(203)=12359.6 R(204)=12469.1 R(205)=12579.6 R(206)=12690.1 R(207)=12801.6 R(208)=12913.1
R(209)=13025.6 R(210)=13138.1 R(211)=13251.6 R(212)=13365.1 R(213)=13479.6 R(214)=13594.1 R(215)=13709.6 R(216)=13825.1
R(217)=13941.6 R(218)=14058.1 R(219)=14175.6 R(220)=14293.1 R(221)=14411.6 R(222)=14530.1 R(223)=14649.6 R(224)=14769.1
R(225)=14889.6 R(226)=15010.1 R(227)=15131.6 R(228)=15253.1 R(229)=15375.6 R(230)=15498.1 R(231)=15621.6 R(232)=15745.1
R(233)=15869.6 R(234)=15994.1 R(235)=16119.6 R(236)=16245.1 R(237)=16371.6 R(238)=16498.1 R(239)=16625.6 R(240)=16753.1
R(241)=16881.6 R(242)=17010.1 R(243)=17139.6 R(244)=17269.1 R(245)=17399.6 R(246)=17530.1 R(247)=17661.6 R(248)=17793.1
R(249)=17925.6 R(250)=18058.1 R(251)=18191.6 R(252)=18325.1 R(253)=18459.6 R(254)=18594.1 R(255)=18729.6 R(256)=18865.1
R(257)=19001.6 R(258)=19138.1 R(259)=19275.6 R(260)=19413.1 R(261)=19551.6 R(262)=19690.1 R(263)=19829.6 R(264)=19969.1
R(265)=20109.6 R(266)=20250.1 R(267)=20391.6 R(268)=20533.1 R(269)=20675.6 R(270)=20818.1 R(271)=20961.6 R(272)=21105.1
R(273)=21249.6 R(274)=21394.1 R(275)=21539.6 R(276)=21685.1 R(277)=21831.6 R(278)=21978.1 R(279)=22125.6 R(280)=22273.1
R(281)=22421.6 R(282)=22570.1 R(283)=22719.6 R(284)=22869.1 R(285)=23019.6 R(286)=23170.1 R(287)=23321.6 R(288)=23473.1
R(289)=23625.6 R(290)=23778.1 R(291)=23931.6 R(292)=24085.1 R(293)=24239.6 R(294)=24394.1 R(295)=24549.6 R(296)=24705.1
R(297)=24861.6 R(298)=25018.1 R(299)=25175.6 R(300)=25333.1 R(301)=25491.6 R(302)=25650.1 R(303)=25809.6 R(304)=25969.1
R(305)=26129.6 R(306)=26290.1 R(307)=26451.6 R(308)=26613.1 R(309)=26775.6 R(310)=26938.1 R(311)=27101.6 R(312)=27265.1
R(313)=27429.6 R(314)=27594.1 R(315)=27759.6 R(316)=27925.1 R(317)=28091.6 R(318)=28258.1 R(319)=28425.6 R(320)=28593.1
R(321)=28761.6 R(322)=28930.1 R(323)=29099.6 R(324)=29269.1 R(325)=29439.6 R(326)=29610.1 R(327)=29781.6 R(328)=29953.1
R(329)=30125.6 R(330)=30298.1 R(331)=30471.6 R(332)=30645.1 R(333)=30819.6 R(334)=30994.1 R(335)=31169.6 R(336)=31345.1
R(337)=31521.6 R(338)=31698.1 R(339)=31875.6 R(340)=32053.1 R(341)=32231.6 R(342)=32410.1 R(343)=32589.6 R(344)=32769.1
R(345)=32949.6 R(346)=33130.1 R(347)=33311.6 R(348)=33493.1 R(349)=33675.6 R(350)=33858.1 R(351)=34041.6 R(352)=34225.1
R(353)=34409.6 R(354)=34594.1 R(355)=34779.6 R(356)=34965.1 R(357)=35151.6 R(358)=35338.1 R(359)=35525.6 R(360)=35713.1
R(361)=35901.6 R(362)=36090.1 R(363)=36279.6 R(364)=36469.1 R(365)=36659.6 R(366)=36850.1 R(367)=37041.6 R(368)=37233.1
R(369)=37425.6 R(370)=37618.1 R(371)=37811.6 R(372)=38005.1 R(373)=38199.6 R(374)=38394.1 R(375)=38589.6 R(376)=38785.1
R(377)=38981.6 R(378)=39178.1 R(379)=39375.6 R(380)=39573.1 R(381)=39771.6 R(382)=39970.1 R(383)=40169.6 R(384)=40369.1
R(385)=40569.6 R(386)=40770.1 R(387)=40971.6 R(388)=41173.1 R(389)=41375.6 R(390)=41578.1 R(391)=41781.6 R(392)=41985.1
R(393)=42189.6 R(394)=42394.1 R(395)=42599.6 R(396)=42805.1 R(397)=43011.6 R(398)=43218.1 R(399)=43425.6 R(400)=43633.1
R(401)=43841.6 R(402)=44050.1 R(403)=44259.6 R(404)=44469.1 R(405)=44679.6 R(406)=44890.1 R(407)=45101.6 R(408)=45313.1
R(409)=45525.6 R(410)=45738.1 R(411)=45951.6 R(412)=46165.1 R(413)=46379.6 R(414)=46594.1 R(415)=46809.6 R(416)=47025.1
R(417)=47241.6 R(418)=47458.1 R(419)=47675.6 R(420)=47893.1 R(421)=48111.6 R(422)=48330.1 R(423)=48549.6 R(424)=48769.1
R(425)=48989.6 R(426)=49210.1 R(427)=49431.6 R(428)=49653.1 R(429)=49875.6 R(430)=50098.1 R(431)=50321.6 R(432)=50545.1
R(433)=50769.6 R(434)=50994.1 R(435)=51219.6 R(436)=51445.1 R(437)=51671.6 R(438)=51898.1 R(439)=52125.6 R(440)=52353.1
R(441)=52581.6 R(442)=52810.1 R(443)=53039.6 R(444)=53269.1 R(445)=53499.6 R(446)=53730.1 R(447)=53961.6 R(448)=54193.1
R(449)=54425.6 R(450)=54658.1 R(451)=54891.6 R(452)=55125.1 R(453)=55359.6 R(454)=55594.1 R(455)=55829.6 R(456)=56065.1
R(457)=56301.6 R(458)=56538.1 R(459)=56775.6 R(460)=57013.1 R(461)=57251.6 R(462)=57490.1 R(463)=57729.6 R(464)=57969.1
R(465)=58209.6 R(466)=58450.1 R(467)=58691.6 R(468)=58933.1 R(469)=59175.6 R(470)=59418.1 R(471)=59661.6 R(472)=59905.1
R(473)=60149.6 R(474)=60394.1 R(475)=60639.6 R(476)=60885.1 R(477)=61131.6 R(478)=61378.1 R(479)=61625.6 R(480)=61873.1
R(481)=62121.6 R(482)=62370.1 R(483)=62619.6 R(484)=62869.1 R(485)=63119.6 R(486)=63370.1 R(487)=63621.6 R(488)=63873.1
R(489)=64125.6 R(490)=64378.1 R(491)=64631.6 R(492)=64885.1 R(493)=65139.6 R(494)=65394.1 R(495)=65649.6 R(496)=65905.1
R(497)=66161.6 R(498)=66418.1 R(499)=66675.6 R(500)=66933.1 R(501)=67191.6 R(502)=67450.1 R(503)=67709.6 R(504)=67969.1
R(505)=68229.6 R(506)=68490.1 R(507)=68751.6 R(508)=69013.1 R(509)=69275.6 R(510)=69538.1 R(511)=69801.6 R(512)=70065.1
R(513)=70329.6 R(514)=70594.1 R(515)=70859.6 R(516)=71125.1 R(517)=71391.6 R(518)=71658.1 R(519)=71925.6 R(520)=72193.1
R(521)=72461.6 R(522)=72730.1 R(523)=73001.6 R(524)=73273.1 R(525)=73545.6 R(526)=73818.1 R(527)=74091.6 R(528)=74365.1
R(529)=74639.6 R(530)=74914.1 R(531)=75189.6 R(532)=75465.1 R(533)=75741.6 R(534)=76018.1 R(535)=76295.6 R(536)=76573.1
R(537)=76851.6 R(538)=77130.1 R(539)=77409.6 R(540)=77689.1 R(541)=77969.6 R(542)=78250.1 R(543)=78531.6 R(544)=78813.1
R(545)=79095.6 R(546)=79378.1 R(547)=79661.6 R(548)=79945.1 R(549)=80229.6 R(550)=80514.1 R(551)=80799.6 R(552)=81085.1
R(553)=81371.6 R(554)=81658.1 R(555)=81945.6 R(556)=82233.1 R(557)=82521.6 R(558)=82810.1 R(559)=83099.6 R(560)=83389.1
R(561)=83679.6 R(562)=83970.1 R(563)=84261.6 R(564)=84553.1 R(565)=84845.6 R(566)=85138.1 R(567)=85431.6 R(568)=85725.1
R(569)=86019.6 R(570)=86314.1 R(571)=86609.6 R(572)=86905.1 R(573)=87201.6 R(574)=87498.1 R(575)=87795.6 R(576)=88093.1
R(577)=88391.6 R(578)=88690.1 R(579)=88989.6 R(580)=89289.1 R(581)=89589.6 R(582)=89890.1 R(583)=90191.6 R(584)=90493.1
R(585)=90795.6 R(586)=91098.1 R(587)=91401.6 R(588)=91705.1 R(589)=92009.6 R(590)=92314.1 R(591)=92619.6 R(592)=92925.1
R(593)=93231.6 R(594)=93538.1 R(595)=93845.6 R(596)=94153.1 R(597)=94461.6 R(598)=94770.1 R(599)=95079.6 R(600)=95389.1
R(601)=95699.6 R(602)=96010.1 R(603)=96321.6 R(604)=96633.1 R(605)=96945.6 R(606)=97258.1 R(607)=97571.6 R(608)=97885.1
R(609)=98199.6 R(610)=98514.1 R(611)=98829.6 R(612)=99145.1 R(613)=99461.6 R(614)=99778.1 R(615)=100095.6 R(616)=100413.1
R(617)=100731.6 R(618)=101050.1 R(619)=101369.6 R(620)=101689.1 R(621)=102009.6 R(622)=102330.1 R(623)=102651.6 R(624)=102973.1
R(625)=103295.6 R(626)=103618.1 R(627)=103941.6 R(628)=104265.1 R(629)=104589.6 R(630)=104914.1 R(631)=105239.6 R(632)=105565.1
R(633)=105891.6 R(634)=106218.1 R(635)=106545.6 R(636)=106873.1 R(637)=107201.6 R(638)=107530.1 R(639)=107859.6 R(640)=108189.1
R(641)=108519.6 R(642)=108850.1 R(643)=109181.6 R(644)=109513.1 R(645)=109845.6 R(646)=110178.1 R(647)=110511.6 R(648)=110845.1
R(649)=111179.6 R(650)=111514.1 R(651)=111849.6 R(652)=112185.1 R(653)=112521.6 R(654)=112858.1 R(655)=113195.6 R(656)=113533.1
R(657)=113871.6 R(658)=114210.1 R(659)=114549.6 R(660)=114889.1 R(661)=115229.6 R(662)=115570.1 R(663)=115911.6 R(664)=116253.1
R(665)=116595.6 R(666)=116938.1 R(667)=117281.6 R(668)=117625.1 R(669)=117969.6 R(670)=118314.1 R(671)=118659.6 R(672)=119005.1
R(673)=119351.6 R(674)=119698.1 R(675)=120045.6 R(676)=120393.1 R(677)=120741.6 R(678)=121090.1 R(679)=121439.6 R(680)=121789.1
R(681)=122139.6 R(682)=122490.1 R(683)=122841.6 R(684)=123193.1 R(685)=123545.6 R(686)=123898.1 R(687)=124251.6 R(688)=124605.1
R(689)=124959.6 R(690)=125314.1 R(691)=125669.6 R(692)=126025.1 R(693)=126381.6 R(694)=126738.1 R(695)=127095.6 R(696)=127453.1
R(697)=127811.6 R(698)=128170.1 R(699)=128529.6 R(700)=128889.1 R(701)=129249.6 R(702)=129610.1 R(703)=130000.6 R(704)=130390.1
R(705)=130781.6 R(706)=131173.1 R(707)=131565.6 R(708)=131958.1 R(709)=132351.6 R(710)=132745.1 R(711)=133139.6 R(712)=133534.1
R(713)=133929.6 R(714)=134325.1 R(715)=134721.6 R(716)=135118.1 R(717)=135515.6 R(718)=135913.1 R(719)=136311.6 R(720)=136710.1
R(721)=137109.6 R(722)=137509.1 R(723)=137909.6 R(724)=138310.1 R(725)=138711.6 R(726)=139113.1 R(727)=139515.6 R(728)=139918.1
R(729)=140321.6 R(730)=140725.1 R(731)=141129.6 R(732)=141534.1 R(733)=141939.6 R(734)=142345.1 R(735)=142751.6 R(736)=143158.1
R(737)=143565.6 R(738)=143973.1 R(739)=144381.6 R(740)=144790.1 R(741)=145199.6 R(742)=145609.1 R(743)=146019.6 R(744)=146430.1
R(745)=146841.6 R(746)=147253.1 R(747)=147665.6 R(748)=148078.1 R(749)=148491.6 R(750)=148905.1 R(751)=149319.6 R(752)=149734.1
R(753)=150149.6 R(754)=150565.1 R(755)=150981.6 R(756)=151398.1 R(757)=151815.6 R(758)=152233.1 R(759)=152651.6 R(760)=153070.1
R(761)=153489.6 R(762)=153909.1 R(763)=154329.6 R(764)=154750.1 R(765)=155171.6 R(766)=155593.1 R(767)=156015.6 R(768)=156438.1
R(769)=156861.6 R(770)=157285.1 R(771)=157709.6 R(772)=158134.1 R(773)=158559.6 R(774)=158985.1 R(775)=159411.6 R(776)=159838.1
R(777)=160265.6 R(778)=160693.1 R(779)=161121.6 R(780)=161550.1 R(781)=161979.6 R(782)=162409.1 R(783)=162839.6 R(784)=163270.1
R(785)=163701.6 R(786)=164133.1 R(787)=164565.6 R(788)=164998.1 R(789)=165431.6 R(790)=165865.1 R(791)=166299.6 R(792)=166734.1
R(793)=167169.6 R(794)=167605.1 R(795)=168041.6 R(796)=168478.1 R(797)=168915.6 R(798)=169353.1 R(799)=169791.6 R(800)=170230.1
R(801)=170669.6 R(802)=171109.1 R(803)=171549.6 R(804)=171990.1 R(805)=172431.6 R(806)=172873.1 R(807)=173315.6 R(808)=173758.1
R(809)=174201.6 R(810)=174645.1 R(811)=175089.6 R(812)=175534.1 R(813)=175979.6 R(814)=176425.1 R(815)=176871.6 R(816)=177318.1
R(817)=177765.6 R(818)=178213.1 R(819)=178661.6 R(820)=179110.1 R(821)=179559.6 R(822)=180009.1 R(823)=180459.6 R(824)=180910.1
R(825)=181361.6 R(826)=181813.1 R(827)=182265.6 R(828)=182718.1 R(829)=183171.6 R(830)=183625.1 R(831)=184079.6 R(832)=184534.1
R(833)=184989.6 R(834)=185445.1 R(835)=185901.6 R(836)=186358.1 R(837)=186815.6 R(838)=187273.1 R(839)=187731.6 R(840)=188190.1
R(841)=188649.6 R(842)=189109.1 R(843)=189569.6 R(844)=190030.1 R(845)=190491.6 R(846)=190953.1 R(847)=191415.6 R(848)=191878.1
R(849)=192341.6 R(850)=192805.1 R(851)=193269.6 R(852)=193734.1 R(853)=194199.6 R(854)=194665.1 R(855)=195131.6 R(856)=195598.1
R(857)=196065.6 R(858)=196533.1 R(859)=196999.6 R(860)=197467.1 R(861)=197935.6 R(862)=198404.1 R(863)=198873.6 R(864)=199343.1
R(865)=199813.6 R(866)=200284.1 R(867)=200755.6 R(868)=201227.1 R(869)=201699.6 R(870)=202172.1 R(871)=202645.6 R(872)=203119.1
R(873)=203593.6 R(874)=204068.1 R(875)=204543.6 R(876)=205019.1 R(877)=205495.6 R(878)=205972.1 R(879)=206449.6 R(880)=206927.1
R(881)=207405.6 R(882)=207884.1 R(883)=208363.6 R(884)=208843.1 R(885)=209323.6 R(886)=209804.1 R(887)=210285.6 R(888)=210767.1
R(889)=211249.6 R(890)=211732.1 R(891)=212215.6 R(892)=212699.1 R(893)=213183.6 R(894)=213668.1 R(895)=214153.6 R(896)=214639.1
R(897)=215125.6 R(898)=215612.1 R(899)=216099.6 R(900)=216587.1 R(901)=217075.6 R(902)=217564.1 R(903)=218053.6 R(904)=218543.1
R(905)=219033.6 R(906)=219524.1 R(907)=220015.6 R(908

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POLAR RADII IN AZIMUTH ZONE 5

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 213.6	R(5)= 229.4	R(6)= 245.3	R(7)= 261.2	R(8)= 277.3
R(9)= 293.6	R(10)= 309.9	R(11)= 326.4	R(12)= 343.0	R(13)= 359.8	R(14)= 376.6	R(15)= 393.7	R(16)= 410.8
R(17)= 428.2	R(18)= 445.6	R(19)= 463.3	R(20)= 481.0	R(21)= 499.0	R(22)= 517.1	R(23)= 535.4	R(24)= 553.9
R(25)= 572.6	R(26)= 591.4	R(27)= 610.5	R(28)= 629.7	R(29)= 649.2	R(30)= 668.9	R(31)= 688.8	R(32)= 708.9
R(33)= 729.3	R(34)= 749.9	R(35)= 770.8	R(36)= 792.0	R(37)= 813.4	R(38)= 835.2	R(39)= 857.2	R(40)= 879.6
R(41)= 902.3	R(42)= 925.3	R(43)= 948.7	R(44)= 972.5	R(45)= 996.6	R(46)= 1021.2	R(47)= 1046.3	R(48)= 1071.8
R(49)= 1097.8	R(50)= 1124.3	R(51)= 1151.4	R(52)= 1179.1	R(53)= 1207.4	R(54)= 1236.4	R(55)= 1266.1	R(56)= 1296.6
R(57)= 1328.0	R(1)=						

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 5

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 4	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 6	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 9	N(37)= 10	N(38)= 10	N(39)= 10	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 11	N(44)= 12	N(45)= 12	N(46)= 12	N(47)= 13	N(48)= 13
N(49)= 13	N(50)= 13	N(51)= 14	N(52)= 14	N(53)= 14	N(54)= 15	N(55)= 15	N(56)= 16
N(57)= 16	N(1)=						

POLAR RADII IN AZIMUTH ZONE 6

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 213.8	R(5)= 229.9	R(6)= 246.2	R(7)= 262.5	R(8)= 279.0
R(9)= 295.7	R(10)= 312.4	R(11)= 329.4	R(12)= 346.4	R(13)= 363.6	R(14)= 380.9	R(15)= 398.4	R(16)= 416.1
R(17)= 433.9	R(18)= 451.9	R(19)= 470.0	R(20)= 488.4	R(21)= 506.9	R(22)= 525.6	R(23)= 544.5	R(24)= 563.6
R(25)= 582.8	R(26)= 602.3	R(27)= 622.1	R(28)= 642.0	R(29)= 662.2	R(30)= 682.6	R(31)= 703.3	R(32)= 724.2
R(33)= 745.4	R(34)= 766.9	R(35)= 788.7	R(36)= 810.8	R(37)= 833.2	R(38)= 856.0	R(39)= 879.1	R(40)= 902.5
R(41)= 926.4	R(42)= 950.6	R(43)= 975.3	R(44)= 1000.4	R(45)= 1026.0	R(46)= 1052.1	R(47)= 1078.7	R(48)= 1105.9
R(49)= 1133.6	R(50)= 1162.1	R(51)= 1191.2	R(52)= 1221.1	R(53)= 1251.7	R(54)= 1283.3	R(55)= 1315.7	R(1)=

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 6

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 9	N(37)= 10	N(38)= 10	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 12	N(44)= 12	N(45)= 12	N(46)= 13	N(47)= 13	N(48)= 13
N(49)= 14	N(50)= 14	N(51)= 14	N(52)= 15	N(53)= 15	N(54)= 15	N(55)= 16	N(1)=

POLAR RADII IN AZIMUTH ZONE 7

R(1)= 165.0	R(2)= 181.6	R(3)= 197.9	R(4)= 214.3	R(5)= 230.8	R(6)= 247.4	R(7)= 264.2	R(8)= 281.1
R(9)= 298.2	R(10)= 315.4	R(11)= 332.8	R(12)= 350.3	R(13)= 367.9	R(14)= 385.8	R(15)= 403.8	R(16)= 422.0
R(17)= 440.3	R(18)= 458.9	R(19)= 477.6	R(20)= 496.5	R(21)= 515.6	R(22)= 534.9	R(23)= 554.4	R(24)= 574.2
R(25)= 594.1	R(26)= 614.3	R(27)= 634.8	R(28)= 655.5	R(29)= 676.5	R(30)= 697.7	R(31)= 719.2	R(32)= 741.1
R(33)= 763.2	R(34)= 785.4	R(35)= 808.4	R(36)= 831.5	R(37)= 855.0	R(38)= 878.9	R(39)= 903.2	R(40)= 927.9
R(41)= 953.1	R(42)= 978.8	R(43)= 1004.9	R(44)= 1031.6	R(45)= 1058.8	R(46)= 1086.7	R(47)= 1115.2	R(48)= 1144.4
R(49)= 1174.3	R(50)= 1205.1	R(51)= 1236.7	R(52)= 1269.3	R(53)= 1303.0	R(1)=		

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 7

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 10	N(36)= 10	N(37)= 10	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 12	N(43)= 12	N(44)= 12	N(45)= 13	N(46)= 13	N(47)= 13	N(48)= 14
N(49)= 14	N(50)= 14	N(51)= 15	N(52)= 15	N(53)= 16	N(1)=		

POLAR RADII IN AZIMUTH ZONE 8

R(1)= 165.0	R(2)= 181.6	R(3)= 198.3	R(4)= 215.1	R(5)= 232.0	R(6)= 249.1	R(7)= 266.3	R(8)= 283.6
R(9)= 301.2	R(10)= 318.9	R(11)= 336.7	R(12)= 354.7	R(13)= 372.9	R(14)= 391.2	R(15)= 409.8	R(16)= 428.5
R(17)= 447.4	R(18)= 466.6	R(19)= 485.9	R(20)= 505.4	R(21)= 525.2	R(22)= 545.2	R(23)= 565.4	R(24)= 585.9
R(25)= 606.6	R(26)= 627.6	R(27)= 648.8	R(28)= 670.4	R(29)= 692.2	R(30)= 714.4	R(31)= 736.8	R(32)= 759.6
R(33)= 782.8	R(34)= 806.3	R(35)= 830.2	R(36)= 854.5	R(37)= 879.3	R(38)= 904.5	R(39)= 930.1	R(40)= 956.3
R(41)= 983.0	R(42)= 1010.3	R(43)= 1038.2	R(44)= 1066.7	R(45)= 1096.0	R(46)= 1126.0	R(47)= 1156.8	R(48)= 1188.5
R(49)= 1221.1	R(50)= 1254.9	R(51)= 1289.7	R(52)= 1325.9	R(1)=			

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 8

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 7	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 8	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 9	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 10	N(35)= 10	N(36)= 10	N(37)= 11	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 12	N(42)= 12	N(43)= 12	N(44)= 13	N(45)= 13	N(46)= 14	N(47)= 14	N(48)= 14
N(49)= 15	N(50)= 15	N(51)= 15	N(52)= 16	N(1)=			

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GROUND COVER IN POLAR ZONE 1

(4)

GC(1)= .381 GC(2)= .347 GC(3)= .316 GC(4)= .290 GC(5)= .400 GC(6)= .371 GC(7)= .344
GC(8)= .321 GC(9)= .300 GC(10)= .375 GC(11)= .352 GC(12)= .332 GC(13)= .313 GC(14)= .309
GC(15)= .349 GC(16)= .331 GC(17)= .314 GC(18)= .357 GC(19)= .340 GC(20)= .323 GC(21)= .307
GC(22)= .342 GC(23)= .324 GC(24)= .311 GC(25)= .296 GC(26)= .323 GC(27)= .309 GC(28)= .295
GC(29)= .287 GC(30)= .303 GC(31)= .289 GC(32)= .276 GC(33)= .264 GC(34)= .280 GC(35)= .268
GC(36)= .256 GC(37)= .268 GC(38)= .256 GC(39)= .244 GC(40)= .233 GC(41)= .242 GC(42)= .230
GC(43)= .219 GC(44)= .225 GC(45)= .214 GC(46)= .218 GC(47)= .207 GC(48)= .195 GC(49)= .197
GC(50)= .185 GC(51)= .174 GC(52)= .173 GC(53)= .191 GC(54)= .195 GC(55)= .196 GC(56)= .210 GC(57)= .202

GROUND COVER IN POLAR ZONE 2

GC(1)= .381 GC(2)= .355 GC(3)= .325 GC(4)= .298 GC(5)= .413 GC(6)= .383 GC(7)= .356
GC(8)= .333 GC(9)= .311 GC(10)= .390 GC(11)= .367 GC(12)= .346 GC(13)= .326 GC(14)= .306
GC(15)= .365 GC(16)= .346 GC(17)= .329 GC(18)= .375 GC(19)= .357 GC(20)= .340 GC(21)= .324
GC(22)= .309 GC(23)= .344 GC(24)= .329 GC(25)= .314 GC(26)= .300 GC(27)= .328 GC(28)= .314
GC(29)= .301 GC(30)= .288 GC(31)= .310 GC(32)= .296 GC(33)= .284 GC(34)= .272 GC(35)= .289
GC(36)= .277 GC(37)= .265 GC(38)= .279 GC(39)= .266 GC(40)= .255 GC(41)= .243 GC(42)= .254
GC(43)= .242 GC(44)= .231 GC(45)= .239 GC(46)= .227 GC(47)= .216 GC(48)= .221 GC(49)= .210
GC(50)= .199 GC(51)= .201 GC(52)= .190 GC(53)= .191 GC(54)= .195 GC(55)= .196 GC(56)= .210 GC(57)= .202

GROUND COVER IN POLAR ZONE 3

GC(1)= .381 GC(2)= .357 GC(3)= .333 GC(4)= .306 GC(5)= .425 GC(6)= .395 GC(7)= .368
GC(8)= .344 GC(9)= .323 GC(10)= .404 GC(11)= .381 GC(12)= .359 GC(13)= .340 GC(14)= .324
GC(15)= .381 GC(16)= .362 GC(17)= .344 GC(18)= .328 GC(19)= .374 GC(20)= .357 GC(21)= .341
GC(22)= .325 GC(23)= .363 GC(24)= .347 GC(25)= .332 GC(26)= .318 GC(27)= .304 GC(28)= .333
GC(29)= .319 GC(30)= .306 GC(31)= .293 GC(32)= .317 GC(33)= .304 GC(34)= .291 GC(35)= .279
GC(36)= .298 GC(37)= .285 GC(38)= .274 GC(39)= .289 GC(40)= .277 GC(41)= .265 GC(42)= .254
GC(43)= .265 GC(44)= .254 GC(45)= .243 GC(46)= .251 GC(47)= .240 GC(48)= .229 GC(49)= .235
GC(50)= .224 GC(51)= .213 GC(52)= .217 GC(53)= .206 GC(54)= .195 GC(55)= .196 GC(56)= .210 GC(57)= .202

GROUND COVER IN POLAR ZONE 4

GC(1)= .381 GC(2)= .357 GC(3)= .336 GC(4)= .314 GC(5)= .437 GC(6)= .406 GC(7)= .379
GC(8)= .355 GC(9)= .333 GC(10)= .418 GC(11)= .394 GC(12)= .373 GC(13)= .353 GC(14)= .336
GC(15)= .397 GC(16)= .377 GC(17)= .359 GC(18)= .342 GC(19)= .392 GC(20)= .374 GC(21)= .357
GC(22)= .342 GC(23)= .327 GC(24)= .365 GC(25)= .350 GC(26)= .335 GC(27)= .321 GC(28)= .352
GC(29)= .338 GC(30)= .324 GC(31)= .312 GC(32)= .337 GC(33)= .323 GC(34)= .311 GC(35)= .298
GC(36)= .287 GC(37)= .304 GC(38)= .294 GC(39)= .282 GC(40)= .298 GC(41)= .287 GC(42)= .275
GC(43)= .264 GC(44)= .276 GC(45)= .265 GC(46)= .254 GC(47)= .264 GC(48)= .253 GC(49)= .242
GC(50)= .231 GC(51)= .238 GC(52)= .227 GC(53)= .217 GC(54)= .221 GC(55)= .210 GC(56)= .213
GC(57)= .202

HELIAXI VERSION 13. TIME POINT AND/OR ANNUAL ENERGY ROUND FIELD WITH LOW PROFILE HELIOSTATS

(5)

NSTOPS 11	NCOL 1596	RFIELD R7R.000	TOWER H 415.000	GCOVER .300
NMF 4	WV 10.3R	WJ 10.3R	XDF 16.60	ALEN 49.80
				SPACEF 1.00
GAP .250	WLONG .480	WCROSS .385	WTRI .177	ALTRI 4.681
				WIDE .840
				WJCROS .224
				HTMIR .833
				HTCROS .833

THE CENTER WAVELENGTHS OF THE TWENTY EQUAL ENERGY BANDS

(6)

.39000	.40000	.48000	.51000	.54000	.57000	.60000	.63000	.66000	.70000
.74000	.78000	.82000	.87000	.96000	1.02000	1.08000	1.22000	1.48000	1.68000

TDISA 0.000	TOISY -439.000	AFIELD 2336271.678	RCO 165.000
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(7)

LATITUDE= 35.64 HOUR 12 3/21/80 MIN 0

(8)

CAVITY RECEIVER SPECS

(9)

SEP 19.3	DD1 26.3	DD2 45.9	RUIF 0.0	HCAV 54.0	DD3 49.5	AIMHGT 9.6
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RCONE 18.06	THECON .47	HTOT 19.29	TTILT 0.00
WAPMAX 25.0	WAPMIN 18.3	OFFSET 0.0	

(10)

PROGRAM OPTIONS USED
INDIVIDUAL FOCUSING
INDIVIDUAL TOE-IN
TOEIN STRATEGY FOR 3/21 AT 12.0
FACETS GANGED

(11)

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HELIOSTAT OPTICAL PARAMETERS (12)

PAX1B	PAX2B	TSB	PHB	PAX1V	PAX2V	TSV	PHV
0.00000	0.00000	0.00000	0.00000	.11500	.11500	.05000	.05000

ELZ THETAZ KXWNI (13)

ELZ	THETAZ	KXWNI
55.76166	179.54158	.98072

***** CONVERSION FACTOR = .1984517112E+06 ***** (14)

STATISTICS FOR 10 RUNS AT 800 RAYS PER RUN (15)

*****OUTPUT CODE***** (16)

ETA1=FACTION OF FIELD FLUX THAT HIT MIRRORS
 ETA2=REFLECTANCE
 ETA3=FACTION OF FLUX NOT ONSHED ON THE WAY OUT
 ETA4=FACTION OF FLUX THAT HIT TOWER
 ETA5=FACTION OF FIELD FLUX THAT HIT CAVITY
 ETA6=FACTION OF FIELD FLUX THAT HIT THE CAVITY WALLS
 ETA7=FACTION OF FIELD FLUX THAT WAS IN TOWER SHADOW

EFLUX1=TOTAL FLUX ON FIELD IN KW
 EFLUX2=TOTAL FLUX ON MIRRORS IN KW
 EFLUX3=TOTAL FLUX LEAVING MIRRORS IN KW
 EFLUX4=TOTAL FLUX CLEANLY AWAY FROM FIELD IN KW
 EFLUX5=TOTAL FLUX ON POWER TOWER IN KW
 EFLUX6=FLUX ON CAVITY DIFFUSER IN KW
 EFLUX7=FLUX ON CAVITY WALLS IN KW
 EFLUX8=FLUX ON CAVITY CEILING IN KW

N1=RAVS DRAWN BEFORE SUNRISE
 N2=RAVS DRAWN WHEN THE SUN WAS TOO LOW
 N3=RAVS DRAWN THAT HIT THE OPEN FIELD
 N4=RAVS WHICH HIT MIRROR BUT WERE LOST IN SPACE
 N5=RAVS DRAWN THAT WERE BLOCKED IN ONBLOCKS
 N6=RAVS THAT WERE ONSHED IN OFFBLOCK
 N7=RAVS WHICH HIT CAVITY DIFFUSER
 DN4=RAVS WHICH HIT WALLS
 N9=RAVS WHICH HIT ROOF
 N10=RAVS WHICH MISSED HIGH
 N11=RAVS WHICH MISSED ACROSS THE FRONT
 N12=RAVS WHICH MISSED LOW
 N13=RAVS WHICH HIT SUPPORTS
 N14=RAVS WHICH WERE IN THE TOWER SHADOW
 N15=RAVS WHICH WHISTLED THRU
 N16=RAVS WHICH FRAME SHADOWED ON SAME HELIO
 N17=RAVS WHICH FRAME SHADOWED ON OTHER HELIO
 N18=RAVS WHICH FRAME BLOCKED ON SAME HELIO
 N19=RAVS WHICH FRAME BLOCKED ON OTHER HELIO

ETA1	ETA2	ETA3	ETA4	ETA5	ETA6	ETA7
.29788	.90000	1.00000	.97944	.25257	.23670	.00363

EFLUX1	EFLUX2	EFLUX3	EFLUX4	EFLUX5	EFLUX6	EFLUX7	EFLUX8
.198452E+06	.591134E+05	.532024E+05	.532024E+05	.521085E+05	.267910E+06	.469735E+05	.513494E+04

N1	N2	N3	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19
0	0	5586	0	0	0	0	2104	230	14	3	4	3	29	25	2	0	0	0

TIME POINT RUN (17)

ACTUAL HIRROD ANPA DIRECT HIRROD ENERGY (18)

ACTUAL HIRROD ANPA	DIRECT HIRROD ENERGY
63938.8130	.9807

ENERGY (KWH) PER SQ. METER (19)

UNSHADOWED	SHADOWED	LEAVING MIRROR	CLEANLY AWAY	THRU APERTURE	ABSORBED
.9268	.9260	.8334	.8334	.9163	.7346

TRACKING EFFICIENCY (UNSHADOWED) (CLEANLY AWAY) (20)

TRACKING EFFICIENCY	(UNSHADOWED)	(CLEANLY AWAY)
	.9450	.8498

NUMBER OF SUPPORTS	SUPPORT WIDTH	KWH ON SUPPORTS
3	2.0	67.0

HELIOSTAT FRAME HITS (21)

TOP FRAME	SIDE FRAMES	CROSS FRAMES	BOTTOM FRAME
2	0 0	0 0 0	0

ENERGY LOST ON FRAME IN KWH

FRAME SHADOW ON SAME HELIO	FRAME SHADOW ON DIFF HELIO	FRAME BLOCK ON SAME HELIO	FRAME BLOCK ON DIFF HELIO
49.5	0.0	0.0	0.0

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SUMMARY OF HIT AND BLOCKAGE COUNTS BY FACET

(22)

FACET INDEX	TOTAL HITS	LESS BLOCKS	HITS	BLOCKED BY	3	4
1	568	568	0	0	0	0
2	615	615	0	0	0	0
3	624	624	0	0	0	0
4	574	576	0	0	0	0

OFFBLOCK SUMMARY

FACET	1	2	3	4
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0

CAVITY WALL MAP

(23)

FROM	TO	0.0	45.0	90.0	135.0	180.0	225.0	270.0	315.0
TO		45.0	90.0	135.0	180.0	225.0	270.0	315.0	360.0
TOP									
FROM	TO								
43.2	54.0	.014	.019	.031	.025	.022	.030	.015	.019
32.4	43.2	.014	.025	.062	.048	.035	.073	.019	.045
21.6	32.4	.019	.040	.117	.112	.117	.140	.038	.022
10.8	21.6	.003	.027	.200	.222	.242	.207	.029	.001
0.0	10.8	0.000	.008	.070	.119	.078	.064	.006	0.000
BOTTOM									

CIRCUMFERENTIAL AVE WALL FLUX

(24)

FROM	TO	AVE FLUX	AT	SUM BOTTOM UP	AT	SUM TOP DOWN
0.0	10.8	.023	54.0	0.000	0.0	0.000
10.8	21.6	.043	43.2	6.720	10.8	3.527
21.6	32.4	.076	32.4	24.893	21.6	10.292
32.4	43.2	.116	21.6	36.681	32.4	22.080
43.2	54.0	.043	10.8	43.446	43.2	40.253
			0.0	46.973	54.0	46.973

CAVITY CEILING MAP

(25)

FROM	TO	AVE	0.00	11.07	15.65	19.17	22.14
TO			11.07	15.65	19.17	22.14	24.75
AVE			7.83	13.56	17.50	20.71	23.48
FROM	TO	AVE					
0.0	45.0	22.5	.0200	.0150	.0300	.0200	.0200
45.0	90.0	67.5	.0300	.0300	.0200	.0250	.0500
90.0	135.0	112.5	.0300	.0400	.0200	.0200	.0450
135.0	180.0	157.5	.0200	.0250	.0050	.0350	.0050
180.0	225.0	202.5	.0250	.0450	.0350	.0150	.0250
225.0	270.0	247.5	.0450	.0500	.0300	.0599	.0500
270.0	315.0	292.5	.0400	.0500	.0250	.0150	.0200
315.0	360.0	337.5	.0250	.0250	.0250	.0250	.0150

CAVITY CEILING FLUX

(26)

FROM	TO	AVE	0.00	11.07	15.65	19.17	22.14
TO			11.07	15.65	19.17	22.14	24.75
AVE			7.83	13.56	17.50	20.71	23.48
FROM	TO	AVE					
0.0	11.1	7.8	.0293				
11.1	15.7	13.6	.0350				
15.7	19.2	17.5	.0237				
19.2	22.1	20.7	.0268				
22.1	24.8	23.5	.0287				

KW/SQ.M FLUX MAP OF POWER TOWER MIRROR FIELD

(27)

0.000000	0.000000	.046762	.093524	.155874	.163667	.085730	.031175	0.000000	0.000000
0.000000	.101318	.210429	.179655	.155874	.163667	.140286	.194842	.132493	0.000000
.046762	.179255	.194842	.280573	.241604	.202636	.264985	.202636	.148080	.054556
.132493	.194842	.296160	.218223	.241604	.257191	.296160	.163667	.187048	.163667
.116905	.249398	.179255	.264985	.296160	.257191	.202636	.288366	.187048	.187048
.264985	.327335	.202636	.428652	.241604	.296160	.342922	.327335	.311747	.210429
.163667	.218223	.280573	.311747	.179255	.264985	.288366	.350716	.272779	.163667
.085730	.233810	.257191	.202636	.038968	.023381	.319541	.327335	.187048	.101318
0.000000	.163667	.249398	.272779	.179255	.148080	.296160	.210429	.148080	0.000000
0.000000	0.000000	.116905	.241604	.381890	.264985	.163667	.077937	0.000000	0.000000

F-18

HITS ON THE HELIO FIELD

0	0	6	12	20	21	11	4	0	0
0	13	27	23	20	21	18	25	17	0
6	23	25	36	31	26	34	26	19	7
17	25	38	28	31	33	38	21	24	71
15	37	23	34	38	33	26	37	24	24
34	42	26	55	31	38	44	42	40	26
21	24	36	40	23	34	37	45	35	21
11	30	33	26	5	3	41	42	24	13
0	21	32	35	23	19	38	27	19	0
0	0	15	31	49	34	21	10	0	0

(28)

FLUX ON THE FIELD

[illegible]

(29)

FLUX LOST TO SHADOWING

[illegible]

(30)

FLUX LOST TO HELIOSTAT TO HELIOSTAT SHADING

[illegible]

(31)

FLUX LOST TO BLOCKAGE

[illegible]

(32)

TOTAL FLUX

[illegible]

(33)

PERCENT FLUX LOST TO SHADOWS

[illegible]

(34a)

F-19

PERCENT FLUX LOST TO BLOCKAGE

(34b)

[illegible]

TOTAL PERCENT OF FLUX LOST

(34c) -

[illegible]

WAYS WHICH MISSED HIGH

(35a)

[illegible]

WAYS WHICH MISSED LOW

(35b)

0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0

RAY'S WHICH MISSED ACROSS FRONT

(35c)

[illegible]

RAYS WHICH WHISTLED THROUGH

(35d)

[illegible]

RAY'S WHICH HIT CONBELS

(35e)

[illegible][illegible]

0	0	4	3	3	3	3	4	0	0	0
0	3	2	3	3	3	2	3	0	0	0
4	3	2	1	2	2	2	2	3	4	0
3	2	1	2	2	2	1	3	2	3	0
3	2	3	3	1	2	2	1	2	2	0
2	1	2	1	2	1	1	1	1	2	0
3	2	1	1	3	2	1	1	2	3	0
3	2	2	2	4	4	1	1	2	3	0
0	3	2	2	3	3	1	2	3	0	0
0	0	3	2	1	2	3	3	0	0	0

Used only on nonsequential simulation

(1)
(2)

POLAR RADII IN AZIMUTH ZONE 1

(3)

R(1)= 165.0	R(2)= 181.6	R(3)= 194.3	R(4)= 215.1	R(5)= 232.0	R(6)= 249.1	R(7)= 266.3	R(8)= 283.6
R(9)= 301.2	R(10)= 318.9	R(11)= 336.7	R(12)= 354.7	R(13)= 372.9	R(14)= 391.2	R(15)= 409.8	R(16)= 428.5
R(17)= 447.4	R(18)= 465.6	R(19)= 483.9	R(20)= 502.4	R(21)= 520.2	R(22)= 538.2	R(23)= 556.4	R(24)= 574.9
R(25)= 593.6	R(26)= 612.6	R(27)= 631.8	R(28)= 650.4	R(29)= 669.2	R(30)= 688.2	R(31)= 707.3	R(32)= 726.6
R(33)= 746.0	R(34)= 765.3	R(35)= 784.2	R(36)= 803.5	R(37)= 823.3	R(38)= 842.5	R(39)= 861.9	R(40)= 881.3
R(41)= 900.0	R(42)= 919.3	R(43)= 938.2	R(44)= 957.6	R(45)= 976.0	R(46)= 994.0	R(47)= 1012.8	R(48)= 1031.5
R(49)= 1050.0	R(50)= 1068.9	R(51)= 1087.7	R(52)= 1106.5	R(53)= 1125.1	R(54)= 1143.6	R(55)= 1162.0	R(56)= 1180.5

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 1

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 7	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 8	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 9	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 10	N(35)= 10	N(36)= 10	N(37)= 11	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 12	N(42)= 12	N(43)= 12	N(44)= 13	N(45)= 13	N(46)= 14	N(47)= 14	N(48)= 14
N(49)= 15	N(50)= 15	N(51)= 15	N(52)= 16	N(53)= 16	N(54)= 16	N(55)= 16	N(56)= 16

POLAR RADII IN AZIMUTH ZONE 2

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 214.3	R(5)= 230.8	R(6)= 247.4	R(7)= 264.2	R(8)= 281.1
R(9)= 298.2	R(10)= 315.4	R(11)= 332.8	R(12)= 350.3	R(13)= 367.9	R(14)= 385.8	R(15)= 403.8	R(16)= 422.0
R(17)= 440.3	R(18)= 458.8	R(19)= 477.6	R(20)= 496.5	R(21)= 515.6	R(22)= 534.9	R(23)= 554.4	R(24)= 574.2
R(25)= 594.1	R(26)= 614.7	R(27)= 634.8	R(28)= 655.5	R(29)= 676.5	R(30)= 697.7	R(31)= 719.2	R(32)= 741.1
R(33)= 763.2	R(34)= 785.6	R(35)= 808.4	R(36)= 831.5	R(37)= 855.0	R(38)= 878.9	R(39)= 903.2	R(40)= 927.9
R(41)= 953.1	R(42)= 978.8	R(43)= 1004.9	R(44)= 1031.6	R(45)= 1058.8	R(46)= 1086.7	R(47)= 1115.2	R(48)= 1144.4
R(49)= 1174.3	R(50)= 1205.1	R(51)= 1236.7	R(52)= 1269.3	R(53)= 1303.0	R(54)= 1336.7	R(55)= 1371.5	R(56)= 1407.4

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 2

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 10	N(36)= 10	N(37)= 10	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 12	N(43)= 12	N(44)= 12	N(45)= 13	N(46)= 13	N(47)= 13	N(48)= 14
N(49)= 14	N(50)= 14	N(51)= 15	N(52)= 15	N(53)= 16	N(54)= 16	N(55)= 16	N(56)= 16

POLAR RADII IN AZIMUTH ZONE 3

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 213.8	R(5)= 229.9	R(6)= 246.2	R(7)= 262.5	R(8)= 279.0
R(9)= 295.7	R(10)= 312.4	R(11)= 329.4	R(12)= 346.4	R(13)= 363.6	R(14)= 380.9	R(15)= 398.4	R(16)= 416.1
R(17)= 433.9	R(18)= 451.9	R(19)= 470.0	R(20)= 488.4	R(21)= 506.9	R(22)= 525.6	R(23)= 544.5	R(24)= 563.6
R(25)= 582.8	R(26)= 602.3	R(27)= 622.1	R(28)= 642.0	R(29)= 662.2	R(30)= 682.6	R(31)= 703.3	R(32)= 724.2
R(33)= 745.4	R(34)= 766.9	R(35)= 788.7	R(36)= 810.8	R(37)= 833.2	R(38)= 855.8	R(39)= 878.7	R(40)= 902.5
R(41)= 926.4	R(42)= 950.4	R(43)= 975.3	R(44)= 1000.4	R(45)= 1026.0	R(46)= 1052.1	R(47)= 1078.7	R(48)= 1105.9
R(49)= 1133.6	R(50)= 1162.1	R(51)= 1191.2	R(52)= 1221.1	R(53)= 1251.7	R(54)= 1283.3	R(55)= 1315.7	R(56)= 1349.0

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 3

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 10	N(37)= 10	N(38)= 10	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 12	N(44)= 12	N(45)= 12	N(46)= 13	N(47)= 13	N(48)= 13
N(49)= 14	N(50)= 14	N(51)= 14	N(52)= 15	N(53)= 15	N(54)= 15	N(55)= 16	N(56)= 16

POLAR RADII IN AZIMUTH ZONE 4

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 211.6	R(5)= 229.4	R(6)= 245.3	R(7)= 261.2	R(8)= 277.3
R(9)= 293.6	R(10)= 309.9	R(11)= 326.4	R(12)= 343.0	R(13)= 359.8	R(14)= 376.6	R(15)= 393.7	R(16)= 410.8
R(17)= 428.2	R(18)= 445.4	R(19)= 463.3	R(20)= 481.0	R(21)= 499.0	R(22)= 517.1	R(23)= 535.4	R(24)= 553.9
R(25)= 572.6	R(26)= 591.4	R(27)= 610.5	R(28)= 629.7	R(29)= 649.2	R(30)= 668.9	R(31)= 688.8	R(32)= 708.9
R(33)= 729.3	R(34)= 749.9	R(35)= 770.8	R(36)= 792.0	R(37)= 813.4	R(38)= 835.2	R(39)= 857.2	R(40)= 879.6
R(41)= 902.3	R(42)= 925.3	R(43)= 948.7	R(44)= 972.5	R(45)= 996.6	R(46)= 1021.2	R(47)= 1046.3	R(48)= 1071.8
R(49)= 1097.8	R(50)= 1124.3	R(51)= 1151.4	R(52)= 1179.1	R(53)= 1207.4	R(54)= 1236.4	R(55)= 1266.1	R(56)= 1296.6
R(57)= 1328.0	R(58)= 1359.1	R(59)= 1390.8	R(60)= 1423.1	R(61)= 1456.0	R(62)= 1489.5	R(63)= 1523.6	R(64)= 1558.3

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 4

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 4	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 6	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 9	N(37)= 10	N(38)= 10	N(39)= 10	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 11	N(44)= 12	N(45)= 12	N(46)= 12	N(47)= 13	N(48)= 13
N(49)= 13	N(50)= 13	N(51)= 14	N(52)= 14	N(53)= 14	N(54)= 15	N(55)= 15	N(56)= 16
N(57)= 16	N(58)= 16	N(59)= 16	N(60)= 16	N(61)= 16	N(62)= 16	N(63)= 16	N(64)= 16

POLAR RADII IN AZIMUTH ZONE 5

R(1)= 165.0	R(2)= 181.6	R(3)= 197.8	R(4)= 213.6	R(5)= 229.4	R(6)= 245.3	R(7)= 261.2	R(8)= 277.3
R(9)= 293.6	R(10)= 309.9	R(11)= 326.4	R(12)= 343.0	R(13)= 359.8	R(14)= 376.6	R(15)= 393.7	R(16)= 410.8
R(17)= 428.2	R(18)= 445.4	R(19)= 463.3	R(20)= 481.0	R(21)= 499.0	R(22)= 517.1	R(23)= 535.4	R(24)= 553.9
R(25)= 572.6	R(26)= 591.4	R(27)= 610.5	R(28)= 629.7	R(29)= 649.2	R(30)= 668.9	R(31)= 688.8	R(32)= 708.9
R(33)= 729.3	R(34)= 749.9	R(35)= 770.8	R(36)= 792.0	R(37)= 813.4	R(38)= 835.2	R(39)= 857.2	R(40)= 879.6
R(41)= 902.3	R(42)= 925.3	R(43)= 948.7	R(44)= 972.5	R(45)= 996.6	R(46)= 1021.2	R(47)= 1046.3	R(48)= 1071.8
R(49)= 1097.8	R(50)= 1124.3	R(51)= 1151.4	R(52)= 1179.1	R(53)= 1207.4	R(54)= 1236.4	R(55)= 1266.1	R(56)= 1296.6
R(57)= 1328.0	R(58)= 1359.1	R(59)= 1390.8	R(60)= 1423.1	R(61)= 1456.0	R(62)= 1489.5	R(63)= 1523.6	R(64)= 1558.3

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 5

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 4	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 6	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 9	N(37)= 10	N(38)= 10	N(39)= 10	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 11	N(44)= 12	N(45)= 12	N(46)= 12	N(47)= 13	N(48)= 13
N(49)= 13	N(50)= 13	N(51)= 14	N(52)= 14	N(53)= 14	N(54)= 15	N(55)= 15	N(56)= 16
N(57)= 16	N(58)= 16	N(59)= 16	N(60)= 16	N(61)= 16	N(62)= 16	N(63)= 16	N(64)= 16

POLAR RADII IN AZIMUTH ZONE 6

R(1)= 165.0	R(2)= 181.4	R(3)= 197.8	R(4)= 213.8	R(5)= 229.9	R(6)= 246.2	R(7)= 262.5	R(8)= 279.0
R(9)= 295.7	R(10)= 312.4	R(11)= 329.4	R(12)= 346.4	R(13)= 363.6	R(14)= 380.9	R(15)= 398.4	R(16)= 416.1
R(17)= 433.9	R(18)= 451.9	R(19)= 470.0	R(20)= 488.4	R(21)= 506.9	R(22)= 525.6	R(23)= 544.5	R(24)= 563.6
R(25)= 582.8	R(26)= 602.3	R(27)= 622.1	R(28)= 642.0	R(29)= 662.2	R(30)= 682.6	R(31)= 703.3	R(32)= 724.2
R(33)= 745.4	R(34)= 766.9	R(35)= 788.7	R(36)= 810.8	R(37)= 833.2	R(38)= 856.0	R(39)= 879.1	R(40)= 902.5
R(41)= 926.4	R(42)= 950.4	R(43)= 975.3	R(44)= 1000.4	R(45)= 1026.0	R(46)= 1052.1	R(47)= 1078.7	R(48)= 1105.9
R(49)= 1133.6	R(50)= 1162.1	R(51)= 1191.2	R(52)= 1221.1	R(53)= 1251.7	R(54)= 1283.3	R(55)= 1315.7	

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 6

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 5	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 7	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 8	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 9	N(36)= 10	N(37)= 10	N(38)= 10	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 11	N(43)= 12	N(44)= 12	N(45)= 12	N(46)= 13	N(47)= 13	N(48)= 13
N(49)= 14	N(50)= 14	N(51)= 14	N(52)= 15	N(53)= 15	N(54)= 15	N(55)= 16	

POLAR RADII IN AZIMUTH ZONE 7

R(1)= 165.0	R(2)= 181.4	R(3)= 197.9	R(4)= 214.3	R(5)= 230.8	R(6)= 247.4	R(7)= 264.2	R(8)= 281.1
R(9)= 298.2	R(10)= 315.4	R(11)= 332.8	R(12)= 350.3	R(13)= 367.9	R(14)= 385.8	R(15)= 403.8	R(16)= 422.0
R(17)= 440.3	R(18)= 458.8	R(19)= 477.6	R(20)= 496.5	R(21)= 515.6	R(22)= 534.9	R(23)= 554.4	R(24)= 574.2
R(25)= 594.1	R(26)= 614.3	R(27)= 634.8	R(28)= 655.5	R(29)= 676.5	R(30)= 697.7	R(31)= 719.2	R(32)= 741.1
R(33)= 763.2	R(34)= 785.6	R(35)= 808.4	R(36)= 831.5	R(37)= 855.0	R(38)= 878.9	R(39)= 903.2	R(40)= 927.9
R(41)= 953.1	R(42)= 978.8	R(43)= 1004.9	R(44)= 1031.6	R(45)= 1058.8	R(46)= 1086.7	R(47)= 1115.2	R(48)= 1144.4
R(49)= 1174.3	R(50)= 1205.1	R(51)= 1236.7	R(52)= 1269.3	R(53)= 1303.0			

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 7

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 6	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 7	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 8	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 9	N(35)= 10	N(36)= 10	N(37)= 10	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 11	N(42)= 12	N(43)= 12	N(44)= 12	N(45)= 13	N(46)= 13	N(47)= 13	N(48)= 14
N(49)= 14	N(50)= 14	N(51)= 15	N(52)= 15	N(53)= 16			

POLAR RADII IN AZIMUTH ZONE 8

R(1)= 165.0	R(2)= 181.4	R(3)= 198.3	R(4)= 215.1	R(5)= 232.0	R(6)= 249.1	R(7)= 266.3	R(8)= 283.6
R(9)= 301.2	R(10)= 318.4	R(11)= 336.7	R(12)= 354.7	R(13)= 372.9	R(14)= 391.2	R(15)= 409.8	R(16)= 428.5
R(17)= 447.4	R(18)= 466.4	R(19)= 485.9	R(20)= 505.4	R(21)= 525.2	R(22)= 545.2	R(23)= 565.4	R(24)= 585.9
R(25)= 606.6	R(26)= 627.6	R(27)= 648.8	R(28)= 670.4	R(29)= 692.2	R(30)= 714.4	R(31)= 736.8	R(32)= 759.6
R(33)= 782.8	R(34)= 806.1	R(35)= 830.2	R(36)= 854.5	R(37)= 879.3	R(38)= 904.5	R(39)= 930.1	R(40)= 956.3
R(41)= 983.0	R(42)= 1010.3	R(43)= 1038.2	R(44)= 1066.7	R(45)= 1096.0	R(46)= 1126.0	R(47)= 1156.8	R(48)= 1188.5
R(49)= 1221.1	R(50)= 1254.9	R(51)= 1289.7	R(52)= 1325.4				

POLAR COLLECTOR COUNT IN AZIMUTH ZONE 8

N(1)= 2	N(2)= 2	N(3)= 2	N(4)= 2	N(5)= 3	N(6)= 3	N(7)= 3	N(8)= 3
N(9)= 3	N(10)= 4	N(11)= 4	N(12)= 4	N(13)= 4	N(14)= 5	N(15)= 5	N(16)= 5
N(17)= 5	N(18)= 6	N(19)= 6	N(20)= 6	N(21)= 6	N(22)= 7	N(23)= 7	N(24)= 7
N(25)= 7	N(26)= 8	N(27)= 8	N(28)= 8	N(29)= 8	N(30)= 9	N(31)= 9	N(32)= 9
N(33)= 9	N(34)= 10	N(35)= 10	N(36)= 10	N(37)= 11	N(38)= 11	N(39)= 11	N(40)= 11
N(41)= 12	N(42)= 12	N(43)= 12	N(44)= 13	N(45)= 13	N(46)= 14	N(47)= 14	N(48)= 14
N(49)= 15	N(50)= 15	N(51)= 15	N(52)= 16				

GROUND COVER IN POLAR ZONE 1

GC(1)= .391	GC(2)= .347	GC(3)= .316	GC(4)= .290	GC(5)= .400	GC(6)= .371	GC(7)= .344
GC(8)= .321	GC(9)= .300	GC(10)= .375	GC(11)= .352	GC(12)= .332	GC(13)= .313	GC(14)= .369
GC(15)= .349	GC(16)= .331	GC(17)= .314	GC(18)= .357	GC(19)= .340	GC(20)= .323	GC(21)= .307
GC(22)= .342	GC(23)= .326	GC(24)= .311	GC(25)= .296	GC(26)= .323	GC(27)= .309	GC(28)= .295
GC(29)= .282	GC(30)= .303	GC(31)= .289	GC(32)= .276	GC(33)= .266	GC(34)= .280	GC(35)= .268
GC(36)= .256	GC(37)= .264	GC(38)= .256	GC(39)= .244	GC(40)= .233	GC(41)= .242	GC(42)= .230
GC(43)= .219	GC(44)= .225	GC(45)= .214	GC(46)= .218	GC(47)= .207	GC(48)= .195	GC(49)= .197
GC(50)= .185	GC(51)= .174	GC(52)= .173				

GROUND COVER IN POLAR ZONE 2

GC(1)= .381	GC(2)= .355	GC(3)= .325	GC(4)= .298	GC(5)= .413	GC(6)= .383	GC(7)= .356
GC(8)= .333	GC(9)= .311	GC(10)= .330	GC(11)= .367	GC(12)= .346	GC(13)= .326	GC(14)= .386
GC(15)= .365	GC(16)= .346	GC(17)= .329	GC(18)= .375	GC(19)= .357	GC(20)= .340	GC(21)= .324
GC(22)= .309	GC(23)= .344	GC(24)= .329	GC(25)= .314	GC(26)= .300	GC(27)= .328	GC(28)= .314
GC(29)= .319	GC(30)= .288	GC(31)= .310	GC(32)= .296	GC(33)= .284	GC(34)= .272	GC(35)= .269
GC(36)= .277	GC(37)= .265	GC(38)= .279	GC(39)= .266	GC(40)= .255	GC(41)= .243	GC(42)= .254
GC(43)= .242	GC(44)= .231	GC(45)= .239	GC(46)= .227	GC(47)= .216	GC(48)= .221	GC(49)= .210
GC(50)= .199	GC(51)= .201	GC(52)= .190	GC(53)= .191			

GROUND COVER IN POLAR ZONE 3

GC(1)= .391	GC(2)= .357	GC(3)= .333	GC(4)= .305	GC(5)= .425	GC(6)= .395	GC(7)= .368
GC(8)= .344	GC(9)= .323	GC(10)= .404	GC(11)= .381	GC(12)= .359	GC(13)= .340	GC(14)= .402
GC(15)= .391	GC(16)= .362	GC(17)= .344	GC(18)= .328	GC(19)= .374	GC(20)= .357	GC(21)= .341
GC(22)= .325	GC(23)= .367	GC(24)= .347	GC(25)= .332	GC(26)= .314	GC(27)= .304	GC(28)= .333
GC(29)= .319	GC(30)= .306	GC(31)= .293	GC(32)= .317	GC(33)= .304	GC(34)= .291	GC(35)= .279
GC(36)= .248	GC(37)= .285	GC(38)= .274	GC(39)= .289	GC(40)= .277	GC(41)= .265	GC(42)= .254
GC(43)= .265	GC(44)= .254	GC(45)= .243	GC(46)= .251	GC(47)= .240	GC(48)= .229	GC(49)= .235
GC(50)= .224	GC(51)= .213	GC(52)= .217	GC(53)= .206	GC(54)= .195	GC(55)= .196	

GROUND COVER IN POLAR ZONE 4

GC(1)= .381	GC(2)= .357	GC(3)= .336	GC(4)= .314	GC(5)= .437	GC(6)= .405	GC(7)= .379
GC(8)= .355	GC(9)= .333	GC(10)= .418	GC(11)= .394	GC(12)= .373	GC(13)= .353	GC(14)= .434
GC(15)= .397	GC(16)= .377	GC(17)= .359	GC(18)= .342	GC(19)= .392	GC(20)= .374	GC(21)= .357
GC(22)= .342	GC(23)= .327	GC(24)= .365	GC(25)= .350	GC(26)= .335	GC(27)= .321	GC(28)= .352
GC(29)= .338	GC(30)= .324	GC(31)= .312	GC(32)= .337	GC(33)= .323	GC(34)= .311	GC(35)= .298
GC(36)= .287	GC(37)= .304	GC(38)= .294	GC(39)= .282	GC(40)= .298	GC(41)= .287	GC(42)= .275
GC(43)= .264	GC(44)= .274	GC(45)= .265	GC(46)= .254	GC(47)= .264	GC(48)= .253	GC(49)= .242
GC(50)= .231	GC(51)= .234	GC(52)= .227	GC(53)= .217	GC(54)= .221	GC(55)= .210	GC(56)= .213
GC(57)= .202						

HELIA-1 VERSION 13. TIME POINT AND/OR ANNUAL ENERGY
ROUND FIELD WITH LOW PROFILE HELIOSTATS

(5)

NSTOPS 11	NCOL 1596	HFIELD 874.000	TOWER H 415.000	GCOVER .300				
NHF 4	WV 10.39	WD 10.39	XDF 16.60	ALEN 49.80	SPACEP 1.00			
GAP .250	WLONG .480	WCROSS .395	WTRI .177	XLTRI 4.681	WSIDE .840	WJCHOS .224	HTMIR .833	HTCROS .833

THE CENTER WAVELENGTHS OF THE TWENTY EQUAL ENERGY BANDS

.39000	.44000	.49000	.51000	.54000	.57000	.60000	.63000	.66000	.70000
.74000	.79000	.82000	.87000	.96000	1.02000	1.04000	1.22000	1.48000	1.68000

(6)

TDISK 0.000	TDISY -439.000	AFIELD 2336271.679	RCO 165.000
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(7)

LATITUDE= 35.88 HOUR 12 6/21/80
MIN 0

(8)

GRAVITY RECEIVED SPEEDS

(9)

SEP 19.3	DD1 26.3	DD2 45.9	RDIF 0.0	HCAV 54.0	UD3 49.5	AIMHGT 9.6
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RCONE 18.06	THECON .47	HTOT 19.29	TTILT 0.00
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(10)

WAPMAX 25.0	WAPMIN 19.3	OFFSET 0.0
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PROGRAM OPTIONS USED
INDIVIDUAL FOCUSING
INDIVIDUAL TOE-IN
TOE-IN STRATEGY FOR 3/21 AT 12.0
FACTS GANGED

(11)

HELIOSTAT OPTICAL PARAMETERS

(12)

PAX1R 0.00000	PAX2R 0.00000	TSR 0.00000	PHM 0.00000	PAX1V .11500	PAX2V .11500	TSV .05000	PHV .05000
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***** CONVECTION FACTOR = .108894904E+10 *****

(14)

STATISTICS FOR 10 RUNS AT 800 HAYS PER RUN

(15)

*****OUTPUT CODE*****

(16)

ETA1=FACTION OF FIELD FLUX THAT HIT MIRRORS
ETA2=REFLECTANCY
ETA3=FACTION OF FLUX NOT OHSCHUD ON THE WAY OUT
ETA4=FACTION OF FLUX THAT HIT TOWER
ETA5=FACTION OF FIELD FLUX THAT HIT CAVITY
ETA6=FACTION OF FIELD FLUX THAT HIT THE CAVITY WALLS
ETA7=FACTION OF FIELD FLUX THAT WAS IN TOWER SHADOW

EFLUX1=TOTAL FLUX ON FIELD IN KWH
EFLUX2=TOTAL FLUX ON MIRRORS IN KWH
EFLUX3=TOTAL FLUX LEAVING MIRRORS IN KWH
EFLUX4=TOTAL FLUX CLEANLY AWAY FROM FIELD IN KWH
EFLUX5=TOTAL FLUX ON POWER TOWER IN KWH
EFLUX6=FLUX ON CAVITY DIFFUSER IN KWH
EFLUX7=FLUX ON CAVITY WALLS IN KWH
EFLUX8=FLUX ON CAVITY CEILING IN KWH.

N1=RAVS DRAWN BEFORE SUNRISE
N2=RAVS DRAWN WHEN THE SUN WAS TOO LOW
N3=RAVS DRAWN THAT HIT THE OPEN FIELD
N4=RAVS WHICH HIT MIRROR BUT WERE LOST IN SPACE
N5=RAVS DRAWN THAT WERE BLOCKED IN ONDLUCKS
N6=RAVS THAT WERE OHSCHUD IN OFFBLOCK
N7=RAVS WHICH HIT CAVITY DIFFUSER
N8=RAVS WHICH HIT WALLS
N9=RAVS WHICH HIT ROOF
N10=RAVS WHICH MISSED HIGH
N11=RAVS WHICH MISSED ABOVE THE FRONT
N12=RAVS WHICH MISSED LOW
N13=RAVS WHICH HIT SUPPORTS
N14=RAVS WHICH WERE IN THE TOWER SHADOW
N15=RAVS WHICH WHISTLED THROUGH
N16=RAVS WHICH FRAME SHADOWED ON SAME HELIO
N17=RAVS WHICH FRAME SHADOWED ON OTHER HELIO
N18=RAVS WHICH FRAME BLOCKED ON SAME HELIO
N19=RAVS WHICH FRAME BLOCKED ON OTHER HELIO

ETA1 .33905	ETA2 .90000	ETA3 .99845	ETA4 .97835	ETA5 .29620	ETA6 .26431	ETA7 .00810								
EFLUX1 .471890E+04	EFLUX2 .159994E+09	EFLUX3 .143995E+07	EFLUX4 .143929E+09	EFLUX5 .140715E+09	EFLUX6 .969703E+09	EFLUX7 .124777E+09	EFLUX8 .159886E+08							
N1 1140	N2 26 3960	N3 0	N4 0	N5 0 2394	N6 301	N7 25	N8 0	N9 12	N10 54	N11 22	N12 49	N13 67	N14 5	N15 1

TIME INTEGRATION RUN

(17)

HOURS OF SUNSHINE IN THE YEAR = 4356.3

ACTUAL MIRROR AREA DIRECT NORMAL ENERGY
63838.8130 3200.7738

(18)

ENERGY (KWH) PER SQ. METER
UNSHADOWED 2665.8241
SHADOWED 2505.2242
LEAVING MIRROR 2255.6018
CLEANLY AWAY 2253.0077
THRU APERTURE 2204.2308
ASHOWNED 1983.8075

(19)

TRACKING EFFICIENCY (UNSHADOWED) .8332
(CLEANLY AWAY) .7039

(20)

NUMBER OF SUPPORT KWH ON
SUPPORTS WIDTH SUPPORTS
3 2.0 .223F.05

HELIOSTAT FRAME HITS

(21)

TOP FRAME SIDE FRAMES CROSS FRAMES BOTTOM FRAME
60 32 5 13

ENERGY LOST ON FRAME IN KWH

FRAME SHADOW FRAME BLOCK
ON SAME HELIO ON DIFF HELIO ON SAME HELIO ON DIFF HELIO
1194427.2 1054119.4 94570.6 71034.0

(22)

SUMMARY OF HIT AND BLOCKAGE COUNTS BY FACET

FACET INDEX	TOTAL HITS	LESS BLOCKS	HITS	1	2	3	4
1	675	675	0	0	0	0	0
2	683	683	0	0	0	0	0
3	675	675	0	0	0	0	0
4	725	725	0	0	0	0	0

OFFBLOCK SUMMARY

FACET	1	2	3	4
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0

CAVITY WALL MAP

(23)

FROM	TO	0.0	45.0	90.0	135.0	180.0	225.0	270.0	315.0
TO		45.0	90.0	135.0	180.0	225.0	270.0	315.0	360.0

TOP FROM	TO	AVE FLUX	AT	SUM BOTTOM UP	AT	SUM TOP DOWN
0.0	43.2	54.0	60.042	54.0	0.000	0.000
43.2	32.4	105.390	119.476	43.2	18144.635	10.8
32.4	21.6	68.469	201.821	32.4	65166.090	21.6
21.6	10.8	2.072	301.371	21.6	96655.137	32.4
10.8	0.0	0.000	114.293	10.8	115358.728	43.2
0.0				0.0	124726.813	54.0

CIRCUMFERENTIAL AVE WALL FLUX

(24)

FROM	TO	AVE FLUX	AT	SUM BOTTOM UP	AT	SUM TOP DOWN
0.0	10.8	60.042	54.0	0.000	0.0	0.000
10.8	21.6	119.476	43.2	18144.635	10.8	9368.085
21.6	32.4	201.821	32.4	65166.090	21.6	28071.677
32.4	43.2	301.371	21.6	96655.137	32.4	59560.724
43.2	54.0	114.293	10.8	115358.728	43.2	105592.178
			0.0	124726.813	54.0	124726.813

CAVITY CEILING MAP

(25)

FROM	TO	AVE FLUX	AT	SUM BOTTOM UP	AT	SUM TOP DOWN
0.0	11.07	15.65	19.17	22.14		
11.07	15.65	19.17	22.14	24.75		
15.65	19.17	22.14	24.75	23.48		

FROM	TO	AVE FLUX	AT	SUM BOTTOM UP	AT	SUM TOP DOWN
0.0	45.0	22.5	104.7365	115.0195	75.7623	23.8508
45.0	90.0	67.5	20.0650	109.0395	98.2583	115.5579
90.0	135.0	112.5	174.7050	111.6969	168.1673	62.3136
135.0	180.0	157.5	11.0231	104.7280	59.0258	32.9210
180.0	225.0	202.5	47.4252	143.0458	59.3144	48.6988
225.0	270.0	247.5	86.9970	101.3623	144.5728	160.1393
270.0	315.0	292.5	100.5537	76.7920	171.7405	44.2384
315.0	360.0	337.5	17.8462	102.2823	144.7743	93.3370

F-24

AZZIMOUTH AVE CEILING FLUX

(26)

FROM	TO	AVE	
0.0	11.1	7.8	72.9191
11.1	15.7	13.6	107.9950
15.7	19.2	17.5	116.6527
19.2	22.1	20.7	72.8821
22.1	24.8	23.5	76.7112

MMH/SD.M ENERGY MAP OF POWER TOWER MIPROD FIELD

(27)

0.	0.	.460E-01	.315E-00	.296E-00	.530E-00	.357E-00	.677E-01	0.	0.	0.
0.	0.	.185E-00	.367E-00	.426E-00	.372E-00	.534E-00	.502E-00	.530E-00	.226E-00	0.
0.	.143E+00	.474E-00	.588E-00	.781E-00	.607E-00	.652E-00	.590E-00	.525E-00	.144E-00	.945E-01
0.	.474E+00	.535E-00	.668E-00	.561E-00	.533E-00	.579E-00	.695E-00	.690E-00	.566E-00	.348E-00
0.	.412E+00	.515E-00	.794E-00	.660E-00	.799E-00	.696E-00	.822E-00	.758E-00	.700E-00	.686E-00
0.	.624E+00	.561E-00	.768E-00	.777E-00	.575E-00	.663E-00	.725E-00	.561E-00	.562E-00	.408E-00
0.	.661E+00	.635E-00	.556E-00	.894E-00	.745E-00	.720E-00	.802E-00	.758E-00	.661E-00	.411E-00
0.	.270E+00	.731E-00	.765E-00	.671E-00	.117E-00	.516E-01	.749E-00	.856E-00	.759E-00	.204E-00
0.	0.	.119E+00	.484E-00	.886E-00	.711E-00	.759E-00	.109E-01	.676E-00	.392E-00	0.
0.	0.	.755E-00	.716E-00	.875E-00	.995E-00	.452E-00	.418E-00	0.	0.	0.

NORTH HALF FIELD ENERGY= .6326E+05 MMH
 SOUTH HALF FIELD ENERGY= .7745E+05 MMH

HITS ON THE HELIO FIELD

(28)

0	0	6	19	33	19	5	0	0
0	11	24	27	33	30	29	12	0
0	25	29	30	32	39	28	14	4
20	31	42	31	37	31	41	31	20
22	32	43	42	45	45	42	38	35
26	29	46	46	35	39	44	32	24
22	35	34	40	41	39	52	38	15
11	32	42	7	6	42	42	43	4
0	17	30	46	33	34	39	18	0
0	0	13	31	44	55	24	20	0

FLUX ON THE FIELD

(29)

0.	0.	.249E+06	.903E+06	.849E+06	.152E+07	.102E+07	.194E+06	0.	0.
0.	0.	.530E+06	.122E+07	.107E+07	.153E+07	.144E+07	.152E+07	.647E+06	0.
0.	.410E+06	.136E+07	.168E+07	.224E+07	.174E+07	.187E+07	.169E+07	.150E+07	.413E+06
0.	.121E+07	.133E+07	.191E+07	.161E+07	.154E+07	.166E+07	.199E+07	.198E+07	.142E+07
0.	.118E+07	.147E+07	.228E+07	.246E+07	.229E+07	.194E+07	.239E+07	.219E+07	.197E+07
0.	.179E+07	.161E+07	.220E+07	.222E+07	.165E+07	.190E+07	.208E+07	.161E+07	.141E+07
0.	.132E+07	.142E+07	.154E+07	.243E+07	.214E+07	.208E+07	.241E+07	.217E+07	.191E+07
0.	.775E+06	.209E+07	.219E+07	.192E+07	.336E+06	.148E+06	.214E+07	.245E+07	.217E+07
0.	0.	.914E+06	.139E+07	.254E+07	.204E+07	.217E+07	.311E+07	.194E+07	.112E+07
0.	0.	0.	.730E+06	.205E+07	.251E+07	.245E+07	.130E+07	.120E+07	0.

FLUX LOST TO SHADOWING

(30)

0.	0.	.7874E+03	.12631E+05	.27254E+05	.16290E+06	.68899E+05	0.	0.	0.
0.	0.	.5092E+04	.88411E+05	.74917E+05	.36877E+05	.10626E+06	.61120E+05	.17072E+06	.43112E+05
0.	.79932E+03	.40443E+05	.54909E+05	.11289E+06	.92924E+05	.75231E+05	.10868E+06	.18763E+05	.25617E+05
0.	.46195E+04	.00145E+06	.15208E+06	.65841E+05	.12829E+06	.57650E+05	.69414E+05	.38450E+05	.45071E+05
0.	.13641E+05	.21024E+05	.88194E+05	.17891E+06	.16165E+05	.16560E+06	.13740E+06	.10317E+05	.11301E+04
0.	.12108E+06	.58613E+05	.14204E+06	.24694E+06	.13279E+06	.20101E+06	.21224E+06	.10441E+06	.18475E+06
0.	.60797E+04	.40752E+05	.14717E+06	.11391E+06	.15066E+06	.11661E+06	.36647E+05	.88414E+05	.77399E+05
0.	0.	.57944E+05	.15871E+06	.54155E+05	.10545E+05	.21848E+05	.19387E+06	.22735E+04	.15076E+06
0.	0.	.44156E+04	.19170E+06	.13682E+06	.16495E+06	.74289E+05	.83994E+05	.87166E+05	.13530E+05
0.	0.	0.	.71174E+04	.33794E+05	.13223E+06	.15973E+06	.63264E+05	.25352E+05	0.

FLUX LOST TO HELIOSTAT TO HELIOSTAT SHADING

(31)

0.	0.	.44495E+02	.23610E+01	.51071E+02	.53514E+03	.69230E+03	0.	0.	0.
0.	0.	.13576E+05	.11441E+05	.70580E+04	.96144E+04	.54712E+04	.14701E+05	.14444E+03	0.
0.	0.	.24324E+03	.22564E+01	.12925E+05	.18957E+05	.661811E+04	.25224E+05	.18411E+05	.24446E+05
0.	.40895E+05	.79876E+04	.71171E+05	.36249E+05	.14687E+05	.99012E+04	.23220E+05	.17883E+05	.33096E+05
0.	.13841E+05	.70291E+04	.32513E+05	.38023E+05	.69337E+05	.85207E+05	.78465E+05	.57883E+05	.11381E+06
0.	.49264E+05	.58613E+05	.10190E+06	.14522E+06	.75780E+05	.70777E+05	.96454E+05	.34408E+05	.10798E+06
0.	.60797E+04	.60752E+05	.14717E+06	.87546E+05	.14714E+05	.58176E+05	.24277E+04	.88414E+05	.77399E+05
0.	0.	.57944E+05	.15871E+06	.54155E+05	.10545E+05	.21848E+05	.10387E+06	.17078E+06	.83148E+05
0.	0.	.44156E+04	.19170E+06	.13682E+06	.16495E+05	.74289E+05	.83994E+05	.87166E+05	.13530E+05
0.	0.	0.	.63145E+04	.33794E+05	.13223E+06	.15973E+06	.63264E+05	.25352E+05	0.

FLUX LOST TO BLOCKAGE

(32)

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	.75656E+03	0.	0.	0.	0.	0.	0.	.71034E+05
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	.29420E+04	0.	0.	0.	0.	0.	0.	.33498E+05
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	.30903E+05	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TOTAL FLUX

(33)

0.	0.	.2497E+06	.9160E+06	.87657E+06	.16802E+07	.10924E+07	.19185E+06	0.	0.
0.	.54135E+06	.11401E+07	.12954E+07	.11013E+07	.1636E+07	.14982E+07	.16968E+07	.69012E+06	0.
.41115E+06	.14179E+07	.1738E+07	.23489E+07	.18322E+07	.19441E+07	.17996E+07	.15221E+07	.43982E+06	.30185F+06
.13983E+07	.16240F+07	.20443E+07	.16530E+07	.16537E+07	.17158E+07	.20611E+07	.20146F+07	.16672E+07	.11461F+07
.11940E+07	.16850E+07	.23434E+07	.26419E+07	.24493E+07	.21593E+07	.24910E+07	.22340F+07	.21915E+07	.19705F+07
.19091E+07	.16651F+07	.23424E+07	.24715E+07	.17810E+07	.21007E+07	.22896E+07	.17115E+07	.17939F+07	.12208F+07
.13268E+07	.19098F+07	.17394E+07	.26404E+07	.22921E+07	.22012E+07	.27179E+07	.22593F+07	.20198E+07	.99655F+06
.77476F+06	.21528F+07	.23507E+07	.19762E+07	.34689E+06	.16975E+06	.22485E+07	.26791F+07	.23248E+07	.58530F+06
0.	.95839F+06	.15793E+07	.26761E+07	.22023E+07	.22492E+07	.32233E+07	.20233F+07	.11353E+07	0.
0.	0.	.73751E+06	.20839E+07	.26378E+07	.30082E+07	.13595E+07	.12223E+07	0.	0.

PERCENT FLUX LOST TO SHADOWS

(34a)

I	I	.31530E-02	.1378E-01	.31091E-01	.96950E-01	.63069E-01	0.	I	I
I	.87661F-01	.77725E-01	.57832E-01	.33466E-01	.64915E-01	.40796E-01	.10592F+00	.62469E-01	I
.19441E-02	.42629F-01	.31456E-01	.48054E-01	.50719E-01	.38697E-01	.60393E-01	.12327F-01	.58377E-01	.10340F+00
.29104E-01	.55632F-01	.73674E-01	.27726E-01	.77574E-01	.33600E-01	.33680E-01	.19284E-01	.27034E-01	.13042F+00
.11424E-01	.12477F+00	.37313E-01	.57380E-01	.66000E-01	.76692E-01	.55159E-01	.28287F-01	.51332E-01	.25217F-02
.63424E-01	.35201F+00	.60444E-01	.99915E-01	.74561E-01	.95886E-01	.92719E-01	.61005F-01	.10299F+00	.42447F-01
.45821F-02	.31811F-01	.84599E-01	.43143E-01	.65730E-01	.52974E-01	.11276E+00	.39222F-01	.38321E-01	.23472F-01
0.	.26916F-01	.67517E-01	.27404E-01	.30400E-01	.12870E+00	.46195E-01	.84861E-01	.64852E-01	0.
I	.46073F-01	.12138E+00	.51126E-01	.74897E-01	.33029E-01	.26027E-01	.43082F-01	.11918E-01	I
I	I	.96504E-02	.16294E-01	.50131E-01	.52766E-01	.46534E-01	.20741E-01	I	I

PERCENT FLUX LOST TO BLOCKAGE

(34b)

I	I	0.	0.	0.	0.	0.	0.	I	I
I	0.	0.	0.	0.	0.	0.	0.	0.	I
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	.44901F-03	0.	0.	0.	0.	0.	0.	.32414E-01	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	.15405F-01	0.	0.	0.	0.	0.	0.	.16581E-01	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
I	0.	0.	0.	0.	0.	.95873E-02	0.	0.	I
I	I	I	0.	0.	0.	0.	0.	I	I

TOTAL PERCENT OF FLUX LOST

(34c)

I	I	.31530E-02	.1378E-01	.31091E-01	.96950E-01	.63069E-01	0.	I	I
I	.87661F-01	.77725E-01	.57832E-01	.33466E-01	.64915E-01	.40796E-01	.10592F+00	.62469E-01	I
.19441E-02	.42629F-01	.31456E-01	.48054E-01	.50719E-01	.38697E-01	.60393E-01	.12327F-01	.58377E-01	.10340F+00
.29104E-01	.55632F-01	.73674E-01	.27726E-01	.77574E-01	.33600E-01	.33680E-01	.19284E-01	.27034E-01	.13042F+00
.11424E-01	.12522F+00	.37313E-01	.57380E-01	.66000E-01	.76692E-01	.55159E-01	.28287F-01	.84346F-01	.25217F-02
.63424E-01	.35201F-01	.60444E-01	.99915E-01	.74561E-01	.95886E-01	.92719E-01	.61005F-01	.10299F+00	.42447F-01
.45821E-02	.47216F-01	.84599E-01	.43143E-01	.65730E-01	.52974E-01	.11276E+00	.39222F-01	.54902E-01	.23472F-01
0.	.26916F-01	.67517E-01	.27404E-01	.30400E-01	.12870E+00	.46195E-01	.84861E-01	.64852E-01	0.
I	.46073F-01	.12138E+00	.51126E-01	.74897E-01	.33029E-01	.35614E-01	.43082F-01	.11918E-01	I
I	I	.96504E-02	.16294E-01	.50131E-01	.52766E-01	.46534E-01	.20741E-01	I	I

RAYS WHICH MISSED HIGH

(35a)

0	0	0	0	0	0	0	0	0	0
0	1	1	0	1	0	1	1	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	0	0	0	0
1	0	1	0	0	0	0	0	0	0
1	0	0	1	0	0	0	0	1	1
0	2	1	1	0	0	0	0	2	1
0	0	1	3	0	0	1	0	0	0
0	1	1	0	0	1	0	0	0	0
0	0	0	0	1	0	0	0	0	0

RAYS WHICH MISSED LOW

(35b)

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

RAYS WHICH MISSED ACROSS FRONT

(35c)

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	2	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	2
2	0	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

RAYS WHICH WHISTLED THROUGH

(35d)

0	0	0	0	0	0	1	0	0	0
0	1	1	0	0	1	0	0	1	0
1	2	0	0	0	0	1	0	0	1
0	1	0	0	0	0	0	0	1	2
3	0	0	0	0	0	0	0	0	1
1	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0

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RAYS WHICH HIT CORBELS

0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	1
1	0	1	0	0	0	0	0	0	0	0
0	0	2	1	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0

(35e)

SL ARRAY .78055E+00 .72517E+00 .56317E+00 .56103E+00 .47391E+00 .34791E+00 .11741E+00.

0.

0. (36)

0	0	8	7	7	5	6	6	0	0	0
0	7	6	6	6	5	5	5	7	0	0
7	6	4	2	4	4	4	5	7	8	0
6	5	3	4	5	4	3	3	4	7	0
6	5	1	1	1	3	1	2	3	3	0
4	5	2	2	4	4	3	5	4	6	0
6	4	5	1	2	2	1	2	3	7	0
7	2	2	3	8	8	2	1	2	7	0
0	7	5	1	3	2	1	3	6	0	0
0	0	7	3	1	1	6	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0

HITS IN EAST NORTH DIVIDED QUADRANTS

(37)

MONTH	E/N	-E/N	-E/-N	E/-N	N FIELD	S FIELD
1	86	25	28	94	111	123
2	97	21	22	71	118	93
3	83	39	29	83	124	112
4	74	22	20	77	101	97
5	83	28	26	86	111	112
6	90	28	14	96	118	114
7	84	26	30	83	115	113
8	92	27	25	74	119	99
9	87	27	13	91	114	110
10	85	24	23	89	109	112
11	98	24	17	100	122	117
12	96	27	14	83	123	102
13	377	67	87	348	474	435
14	354	109	99	339	463	439
15	336	112	91	340	448	431

HITS IN NORTHEAST NORTHWEST DIVIDED QUADRANTS

(38)

MONTH	NE/NW	-NE/NW	-NE/-NW	NE/-NW	-NE/NW/-NW
1	113	44	14	43	107
2	109	39	14	45	84
3	102	52	21	61	113
4	101	41	17	39	80
5	101	51	24	47	98
6	103	55	17	57	112
7	111	50	20	60	102
8	100	45	13	54	99
9	113	46	15	50	96
10	110	45	15	51	96
11	138	38	15	48	86
12	124	35	13	53	88
13	355	176	60	100	346
14	415	189	64	213	402
15	429	184	64	201	385

13 IS THE WINTER MONTHS

14 IS THE SUMMER MONTHS

15 IS THE SPRING AND FALL MONTHS

16 IS THE TOTAL YEARLY ENERGY

ENERGY IN EAST NORTH DIVIDED QUADRANTS

(39)

MONTH	NE	SE	SW	NW	N FIELD	S FIELD
1	.339E+04	.923E+03	.125E+04	.405E+04	.745E+04	.219E+04
2	.473E+04	.101E+04	.105E+04	.388E+04	.861E+04	.205E+04
3	.483E+04	.218E+04	.175E+04	.439E+04	.921E+04	.394E+04
4	.393E+04	.141E+04	.874E+03	.435E+04	.827E+04	.225E+04
5	.473E+04	.202E+04	.200E+04	.456E+04	.929E+04	.402E+04
6	.488E+04	.213E+04	.107E+04	.570E+04	.106E+05	.319E+04
7	.507E+04	.172E+04	.137E+04	.522E+04	.103E+05	.369E+04
8	.507E+04	.187E+04	.130E+04	.419E+04	.946E+04	.378E+04
9	.479E+04	.169E+04	.104E+04	.548E+04	.103E+05	.271E+04
10	.485E+04	.176E+04	.103E+04	.442E+04	.847E+04	.233E+04
11	.421E+04	.800E+03	.748E+03	.405E+04	.877E+04	.184E+04
12	.361E+04	.116E+04	.753E+03	.328E+04	.690E+04	.192E+04
13	.159E+05	.389E+04	.381E+04	.155E+05	.314E+05	.770E+04
14	.197E+05	.773E+04	.693E+04	.197E+05	.394E+05	.147E+05
15	.176E+05	.654E+04	.474E+04	.186E+05	.362E+05	.113E+05
16	.533E+05	.182E+05	.155E+05	.538E+05	.107E+06	.337E+05

ENERGY IN NORTHEAST NORTHWEST DIVIDED QUADRANTS

MONTH	NORTH	WEST	SOUTH	EAST	EAST + WEST
1	.459E+04	.294E+04	.459E+03	.163E+04	.457E+04
2	.509E+04	.217E+04	.873E+03	.254E+04	.471E+04
3	.555E+04	.328E+04	.139E+04	.294E+04	.622E+04
4	.533E+04	.214E+04	.888E+03	.220E+04	.434E+04
5	.575E+04	.305E+04	.183E+04	.267E+04	.572E+04
6	.570E+04	.339E+04	.113E+04	.356E+04	.695E+04
7	.632E+04	.257E+04	.155E+04	.354E+04	.611E+04
8	.549E+04	.254E+04	.139E+04	.360E+04	.614E+04
9	.643E+04	.277E+04	.873E+03	.293E+04	.570E+04
10	.552E+04	.213E+04	.682E+03	.247E+04	.460E+04
11	.571E+04	.169E+04	.636E+03	.197E+04	.366E+04
12	.485E+04	.143E+04	.585E+03	.195E+04	.338E+04
13	.202E+05	.823E+04	.255E+04	.809E+04	.163E+05
14	.233E+05	.115E+05	.590E+04	.134E+05	.249E+05
15	.228E+05	.103E+05	.383E+04	.105E+05	.209E+05
16	.663E+05	.301E+05	.123E+05	.320E+05	.621E+05

13 IS THE WINTER MONTHS

14 IS THE SUMMER MONTHS

15 IS THE SPRING AND FALL MONTHS

16 IS THE TOTAL YEARLY ENERGY

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TCY  TCY SCOPE 3.4.3  406E.275  02/22/77
21.46.16.DOC00RN FROM /IN
21.46.16.IP 00000256 WORDS - FILE INPUT , DC 00. IN
21.46.16.DOC.T1500.MT1.P4.
21.46.16.
21.46.17.USER(ZXF17TC.)
21.46.18.PROJECT(*819*)
21.46.19.ACCN. TM911. *819*
21.46.19.LABEL(SAMPLE,L=DOCMEN,VSN=X305R,R)
21.51.00.MT50 VOLUME SERIAL NUMBER IS 0X3058
21.51.00.MT50 ASSIGNED TO SAMPLE
21.51.04.VSN= 0X3058. RD ACCESS GRANTED
21.51.05. LABEL READ WAS DOCMEN
21.51.05. EDITION NUMBER 01
21.51.05. RETENTION CYCLE 000
21.51.05. CREATION DATE 77060
21.51.05. REEL NUMBER 0001
21.51.05.UPDATE(IP=SAMPLE,W=C,F)
21.51.15. UPDATE COMPLETE.
21.51.15.FTN(I=COMPILE)
21.53.02. 22.873 CP SECONDS COMPILATION TIME
21.53.02.LGO.
21.53.44.LOCKIN.
21.57.51. STOP
21.57.51.OP 00075008 WORDS - FILE OUTPUT , DC 40. IN
21.57.51.ISEQ. ENTERED QUEUE 21.46.11 77080
21.57.51.ISSW. 275.270 EXECUTION TIME
21.57.51.MS 136192 WORDS ( 182784 MAX USED)
21.57.51.CPA 166.701 SEC.
21.57.53.IO 108.569 SEC.
21.57.53.CM 2208.491 KWS.
21.57.53.ISSN. 200.220 TOTAL SRUS NON-APPLICATION
21.57.53.PP 94.725 SEC. DATE 03/21/77
21.57.53.EJ END OF JOB. IN

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TCY  TCY SCOPE 3.4.3  406E.275  02/22/77
21.46.16.DOC00RN FROM /IN
21.46.16.IP 00000256 WORDS - FILE INPUT , DC 00. IN
21.46.16.DOC.T1500.MT1.P4.
21.46.16.
21.46.17.USER(ZXF17TC.)
21.46.18.PROJECT(*819*)
21.46.19.ACCN. TM911. *819*
21.46.19.LABEL(SAMPLE,L=DOCMEN,VSN=X305R,R)
21.51.00.MT50 VOLUME SERIAL NUMBER IS 0X3058
21.51.00.MT50 ASSIGNED TO SAMPLE
21.51.04.VSN= 0X3058. RD ACCESS GRANTED
21.51.05. LABEL READ WAS DOCMEN
21.51.05. EDITION NUMBER 01
21.51.05. RETENTION CYCLE 000
21.51.05. CREATION DATE 77069
21.51.05. REEL NUMBER 0001
21.51.05.UPDATE(IP=SAMPLE,W=C,F)
21.51.15. UPDATE COMPLETE.
21.51.15.FTN(I=COMPILE)
21.53.02. 22.873 CP SECONDS COMPILATION TIME
21.53.02.LGO.
21.53.44.LOCKIN.
21.57.51. STOP
21.57.51.OP 00075008 WORDS - FILE OUTPUT , DC 40. IN
21.57.51.ISEQ. ENTERED QUEUE 21.46.11 77080
21.57.51.ISSW. 275.270 EXECUTION TIME
21.57.51.MS 136192 WORDS ( 182784 MAX USED)
21.57.51.CPA 166.701 SEC.
21.57.53.IO 108.569 SEC.
21.57.53.CM 2208.491 KWS.
21.57.53.ISSN. 200.220 TOTAL SRUS NON-APPLICATION
21.57.53.PP 94.725 SEC. DATE 03/21/77
21.57.53.EJ END OF JOB. IN

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