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FOREWORD

This report entitled, "Computer Program for the Calculation of Incident Orbital Heat Flux," LR 18904, was prepared by the Lockheed-California Company under NASA Contract NAS 9-3349. The Orbital Heat Flux Program utilized under this contract is a modified version of a computer program originally developed by Lockheed in 1960.

Other reports prepared under this contract are:

LR 18899 A Transient Heat Transfer and Thermodynamic Analysis of the Apollo Service Module Propulsion System - Final Report

- Volume I: Phase I - Transient Thermal Analysis
- Volume II: Phase II - Thermal Test Program

LR 18900 A Transient Heat Transfer and Thermodynamic Analysis of the Apollo Service Module Propulsion System - Summary Report

LR 18901 An Introduction to Spacecraft Thermal Control

LR 18902 Thermal Analyzer Computer Program for the Solution of General Heat Transfer Problems

LR 18903 Thermal Analyzer Computer Program for the Solution of Fluid Storage and Pressurization Problems

LR 18905 Computer Program for the Calculation of Three-Dimensional Configuration Factors.

This report was written by Mr. B. A. Nevelli of Lockheed's Thermodynamics Department. The contributions of Messrs. W. L. Francis, R. B. David, and E. V. Ashburn, also of the Lockheed-California Company, to this report are gratefully acknowledged. Mr. Francis developed the logic of the original version of the program. Mr. David programmed both the original and present versions and has continually improved and updated the program over the past several years. Mr. Ashburn provided improved values of the radiative heat losses and diffuse reflectance of the Earth-plus-atmosphere system.

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SUMMARY

A computer program has been developed by the Lockheed-California Company for the computation of orbital variation in incident and reflected solar and planetary emission radiant heat flux on plane surface elements. The program computes the orbit, given the altitude at perigee, eccentricity, inclination, etc., and handles planetary or inertial orientations in either Earth or lunar orbits. The program also handles individual points in space. Non-uniform radiosity of the Earth due to latitude, seasonal variations, etc., is accounted for. By adding appropriate data constants, the program can be extended to include other planets. Computer output is in tabular form. Output options provide punched cards suitable for direct insertion into the Thermal Analyzer program and/or plotted heat input vs. time data.

The program is arranged so that a set of angles completely defines the geometry at any given instant. The planet's equator and the direction of the sun define the basic coordinate system. Angles measured from the planet-element line define the orientation of the element in space. Planetary radiations are computed by a double integration over that portion of the planet that can be "seen" from the element. The program is written in FORTRAN IV for the IBM 7094. The use of this program is described in detail and is illustrated by several example problems.

I INTRODUCTION

The thermal environment associated with orbiting spacecraft is a critical factor in determining its operating capability. With the advent of manned spacecraft, the thermal environment problem becomes even more critical from the standpoint of maintaining a suitable biological environment for the human occupants. For spacecraft above a planet's atmosphere, the primary mode of heat transfer between the spacecraft and its external environment is by radiation. In this case, the external heat gain or loss of the spacecraft by convection and/or conduction is negligible. A heat balance of the external radiation exchange and any internal heat generation thus completely determine the thermal environment of the spacecraft and its surface temperature.

For a given application and resulting design, the contribution of any internal heat generation to the thermal environment may be calculated with a high degree of reliability. The determination of the external radiation exchanges, however, is subject to a number of uncertainties. The amount of radiation actually absorbed and emitted by the external surface depends upon its characteristics (i.e., absorptivity and emissivity). The absorptivity and emissivity of a material are a function of the wave length of the incident and emitted radiation, respectively, and also of the mechanical and chemical character of the surface. In general, one must resort to an experimental technique for obtaining the surface characteristics. The remaining item to be analyzed in a determination of the external radiation exchanges is the kind and quantity of incident radiation. The primary sources of incident radiation include direct insolation (solar radiation) and the thermal radiation from nearby planets, such as the Earth or moon.

The purpose of this report is to describe a computer program developed by the Lockheed-California Company to compute the irradiation of a plane surface element (a differential surface in comparison to all others) in orbit about, or in, the vicinity of a planetary body. The radiant inputs to any spacecraft can be obtained, since its external surfaces can be approximated

by a series of plane surfaces. The irradiation as determined by this program can then be used to write the applicable heat balance on the surface. This heat balance may be concerned with either radiation equilibrium or transient conditions.

The present computer program is basically an improved version of an earlier Lockheed-developed program (Ref. 1). The principal modifications are an improved method of computing Earth emission and reflected solar radiation, optional punched card and plotted output, the addition of lunar orbits, and the provision to extend the program to other planets as the need arises.

II PROGRAM DESCRIPTION AND CAPABILITIES

The program is written in FORTRAN IV for the IBM 7094. It computes the orbital variation in incident and reflected solar and planetary emission flux on plane surface elements. The program is arranged so that a set of angles completely defines the geometry at any given instant. Planetary radiations are computed by a double integration over that portion of the planet that can be seen from the element. Since these integral expressions cannot be solved in closed form, a solution by numerical techniques was developed. This was accomplished by finite differences on a digital computer.

To set up the problem for computation, the user first determines the angles defining the declination of the sun, inclination of the orbit, and orientation of the surface element, and orbit parameters such as altitude, eccentricity, time of launch, etc. The planet (Earth or Moon), type of orientation (planet or inertial), types of radiations (solar, solar plus planet, etc.), and planetary integration grid size are specified. Finally the user specifies the optional output forms, if any, which are desired (punched heating curves for the Thermal Analyzer program, or plotted output). Standard output is tabular in form and includes individual incident irradiations (e.g., direct solar and planetary emission), and combinations of irradiations (e.g., total solar spectrum). Optionally, total absorbed irradiation is computed if surface absorptivity and emissivity are specified. Total irradiation to a spacecraft can be determined by dividing the exterior into a number of plane surfaces. Non-orbital situations (e.g., ballistic or inter-planetary trajectories) are handled as a series of individual points.

The program is presently limited to Earth- and lunar-referenced missions. By adding other planetary constants, the program can readily be extended to include additional planets as the need arises. Earth reflection and emission calculations take into account the non-uniform radiosity of the earth due to lattitude, seasonal variations, etc. Lunar emission calculations account for the extreme surface temperature variations of the moon. Planetary emission

calculations for other planets would be based on an "average" temperature if there is significant atmosphere. If not, calculations would be based on temperature gradients as is done for the moon.

III GEOMETRY

COORDINATE SYSTEM

Planet Coordinates

A spherical coordinate system with origin at the center of the planet is selected with coordinates $(R + A, \Omega, \psi)$ based on rectangular coordinates (X_o, Y_o, Z_o). Referring to Figure 3-1 and the nomenclature (Appendix A), the definitions made for these coordinates are as follows:

1. R = mean radius of the planet (assumed to be a perfect sphere) in statute miles
2. A = altitude above the surface of the planet in statute miles
3. $X_o - Z_o$ plane = equatorial plane
4. Z_o axis = projection of the planet-sun line in equatorial plane
5. Y_o axis = north pole of planet
6. Ω is measured in $X_o - Z_o$ plane
7. ψ is angle measured between (R + A) and its projection in the equatorial plane.
8. Direction of sun: $\Omega = \Omega_S = 0$

   $\psi = \psi_S = f$ (date)
9. Location of the moon with respect to the Earth:

   $\Omega = \Omega_M$

   $\psi = \psi_M$

A coordinate system is defined which is moving with the planet in its path around the sun. As noted, the Z_o axis is the projection of the planet-sun line into the equatorial plane. Relative to an observer moving with the coordinate system, the only effect of the planet's revolution around the sun is to cause a change in the declination of the sun, ψ_S. This angle will vary for the Earth from about +23.5° to -23.5° from summer to winter (Northern

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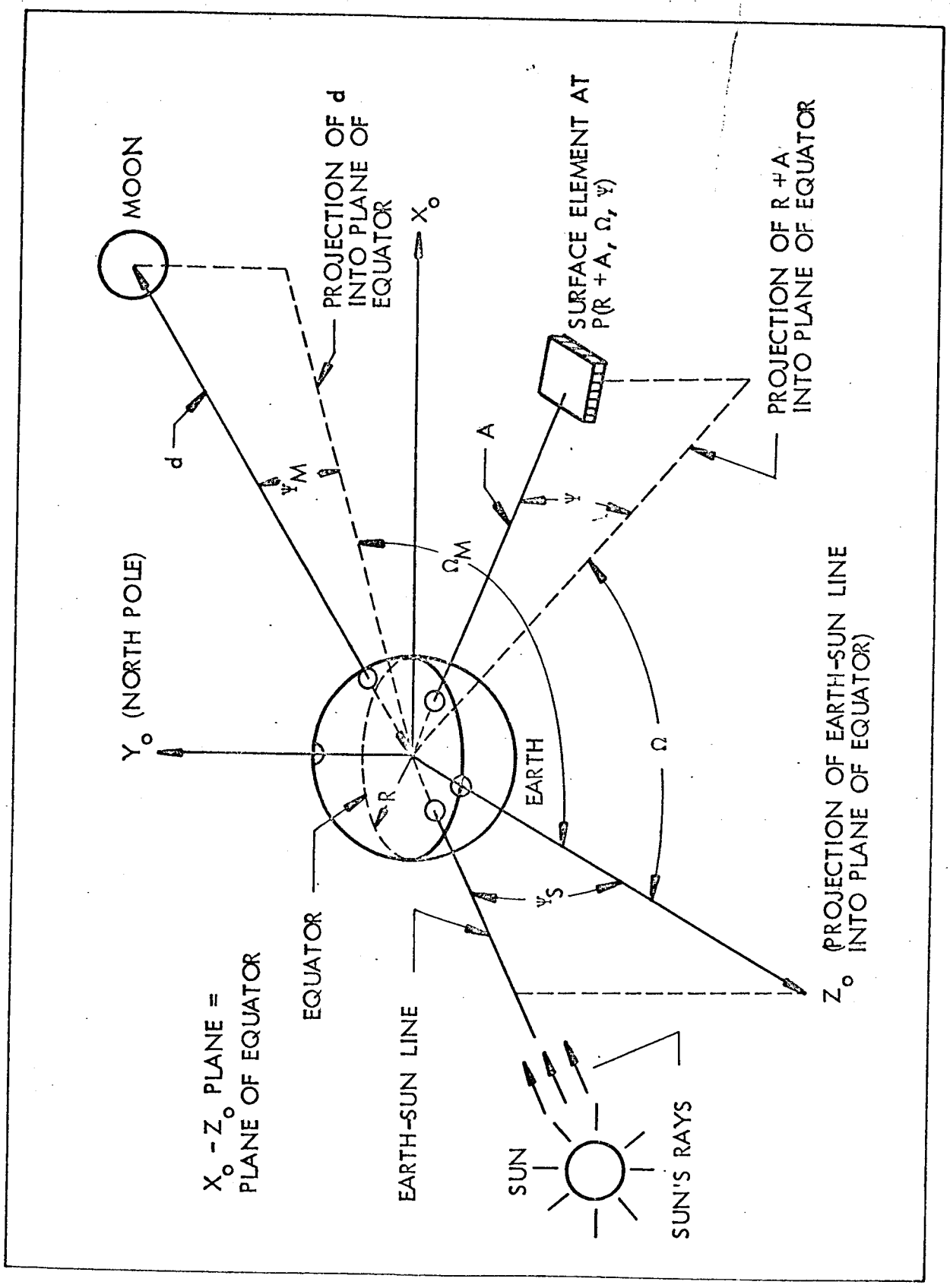

Figure 3-1. Basic Coordinate System

Hemisphere), and may be obtained exactly for any given time from the American Ephemeris and Nautical Almanac (Ref. 2). For convenience, the analemma giving both the declination of the sun and the equation of time for every day of the year is shown in Figure 3-2. ψ_S can be input directly, or as an option, automatically input as an "average" value for each month (taken as of the 15th of the month.

In this coordinate system the direction of the moon with respect to the Earth may also be obtained directly from the Ephemeris data for any given time. Angle ψ_M is the declination of the moon, and Ω_M may be obtained by taking the difference in right ascensions of the moon and the sun (also tabulated in the Ephemeris), and converting to degrees:

Ω_M, degrees = 15 (right ascension of moon, decimal hours - right ascension of sun, decimal hours), degrees

The distance, d, from the Earth to the moon is here taken as the mean distance. While the three-body (Earth-moon-sun) solution is available, it has been found for Earth orbits and near-Earth trajectories that the presence of the moon is usually negligible and is normally ignored.

Lunar orbits and near-lunar trajectories are handled directly by treating the moon as a planet. Lunar orbits are handled geometrically the same as Earth orbits. The distance from the moon to the sun is taken to be the same as the distance from the Earth to the sun.

Local Orientation of Surface Element

A local set of coordinates is defined so that z lies in the direction of the zenith, and x lies within the orbit plane (positive x is in the general direction of travel around the orbit, the exact direction of travel in the case of circular orbits). The origin of this system is at the point P (R + A, Ω_P, ψ_P). This coordinate system is illustrated in Figure 3-3.

The local orientation of the surface element may be determined by locating the unit normal, $\hat{n}_P$, to the surface. To do this, spherical coordinates σ and τ are assumed, based on the rectangular coordinate system x-y-z. Referring to Figure 3-3, σ is measured from +z toward +x in the x-z plane, and τ is the angle between the unit normal, $\hat{n}_P$, and its projection in the x-z plane. τ is measured from the x-z plane toward +y ($\tau = 90°$ when $\hat{n}_P$ is coincident with the y axis).

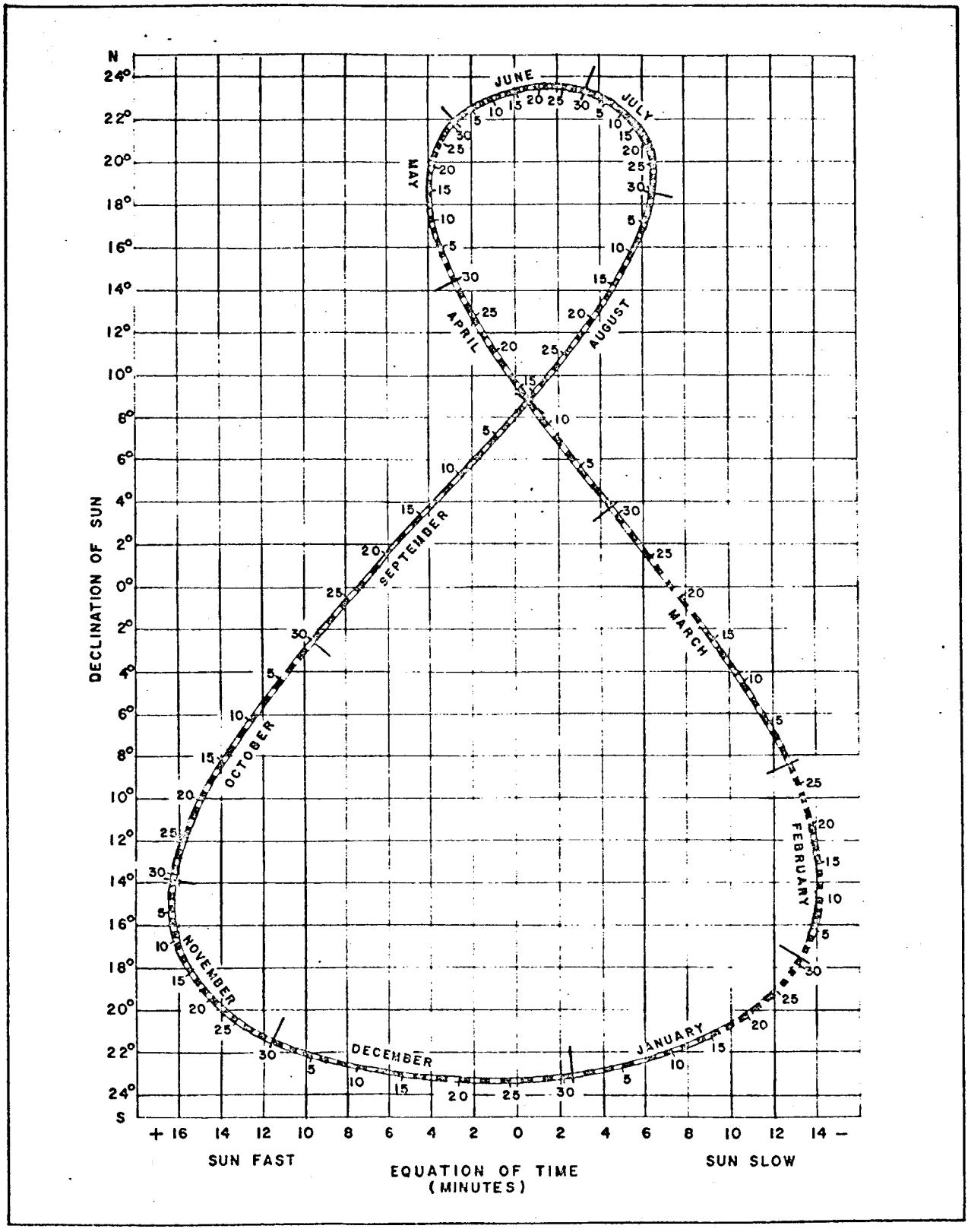

Figure 3-2. The Analemma

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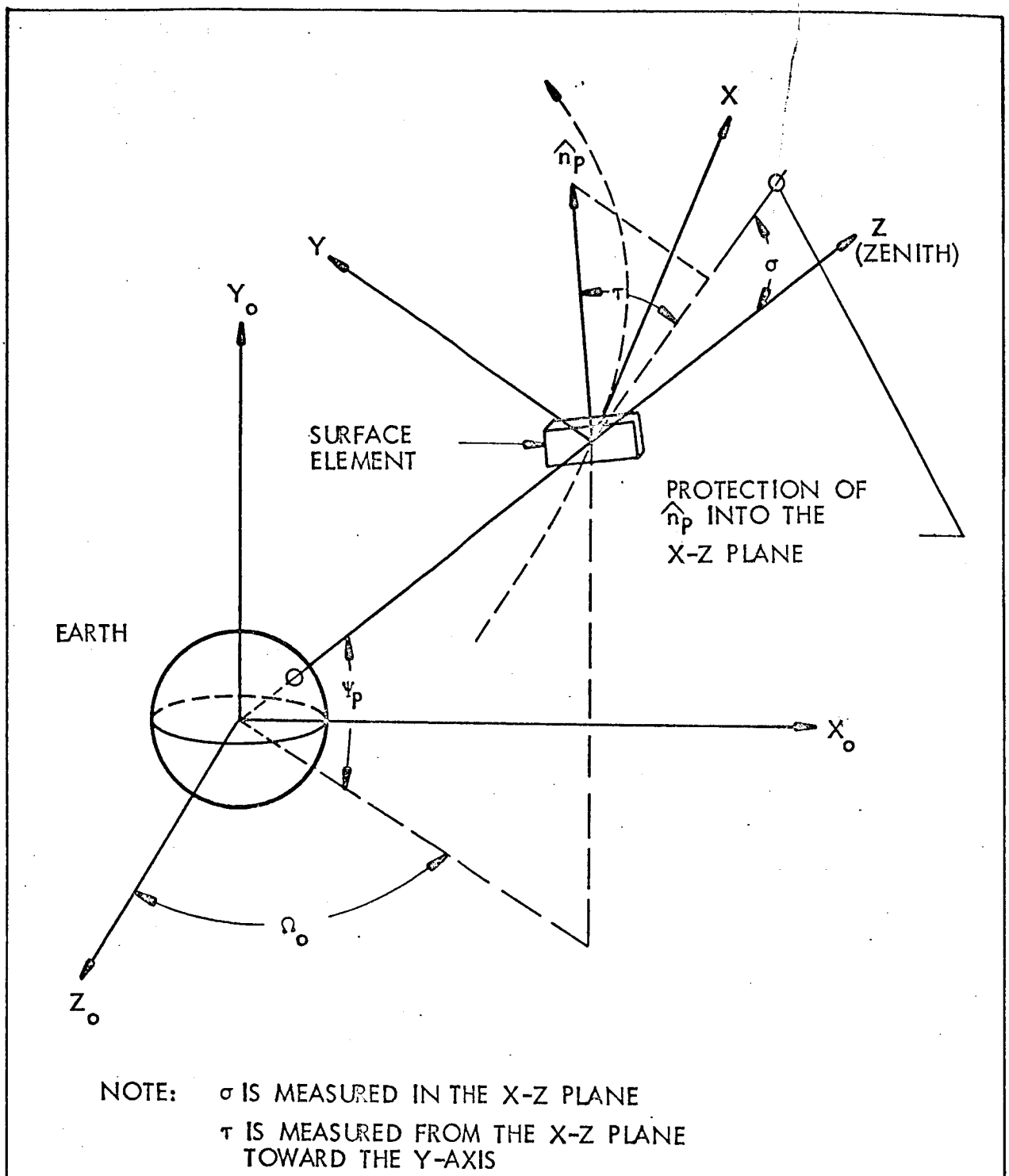

Figure 3-3. Orientation of Surface Element

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In the case of planet orientation, these angles are determined once and apply to any position in orbit. In the case of inertial orientation, the angles σ and τ are determined for the point of entry into orbit or the point from which the fixed orientation is established. This point is ν_o. This inertial orientation is held as the planet is orbited. The varying orientation of the surface element with respect to the planet is accounted for by the computer program.

ARBITRARY ELLIPTICAL ORBITS

Since the principal application of this program is to compute the irradiation of a spacecraft in orbit, it is desirable to obtain the geometric inputs necessary for all points of arbitrary orbits. Also, since all orbits are elliptical, the equations for arbitrary elliptical orbits within the present coordinate system will be derived. The equations can then be used to provide the geometric inputs.

Referring to Figure 3-4, an orbit plane with a set of axes, X, Y, Z, is defined by a simple rotation of the X_o, Y_o, Z_o axes as follows:

1. Rotate Z about the Y_o axis toward X_o by the angle Ω_o. The value of Ω_o is determined so that the X axis is the intersection of the orbit plane and the equatorial plane.

2. Rotate Z about the X axis toward Y_o by the angle ψ_o. This angle is the inclination of the orbit with respect to the equatorial plane.

Note that the X axis remains in the X_o - Z_o plane. The angles Ω_o and ψ_o now define the orbit plane for a spacecraft or satellite moving in the general direction Z to X.

If, however, motion in the opposite direction, but in the same plane, is desired, the orbit plane must be inverted so X* coincides with -X, Y* with -Y, and Z* with +Z, as shown in Figure 3-5. This can be accomplished by simple rotation as follows:

1. Rotate Z* about the Y_o axis toward X_o by the angle $\Omega_o^* = \Omega_o + 180°$.

2. Rotate Z* about the X* axis toward Y_o by the angle $\psi_o^* = 180° - \psi_o$.

Note that Z* now coincides with Z and X* is opposite X. The angles Ω_o^* and ψ_o^* now define the orbit plane for a spacecraft moving in the direction Z* to X*, which is opposite the original direction Z to X.

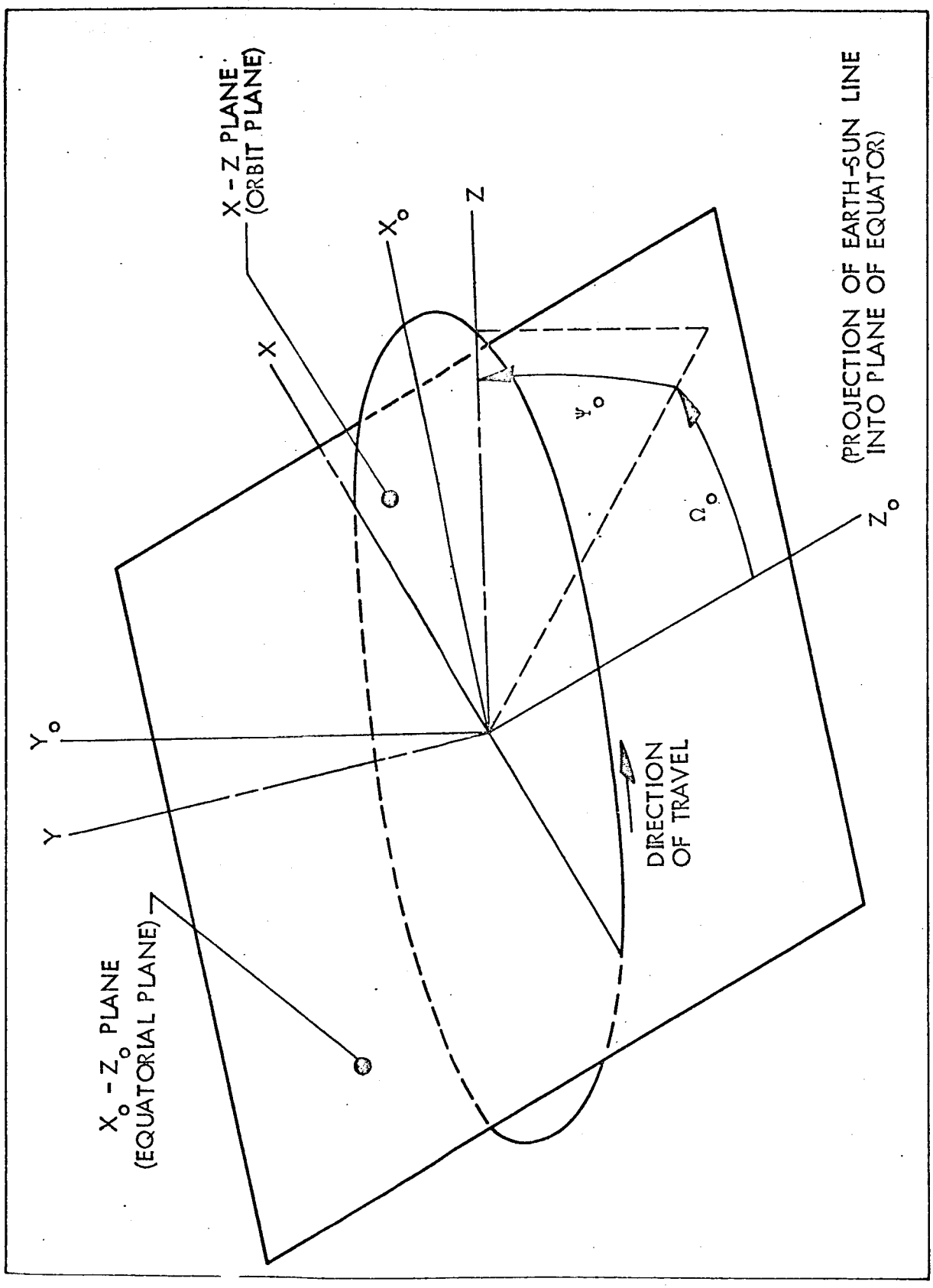

Figure 3-4. Description of Orbit Plane

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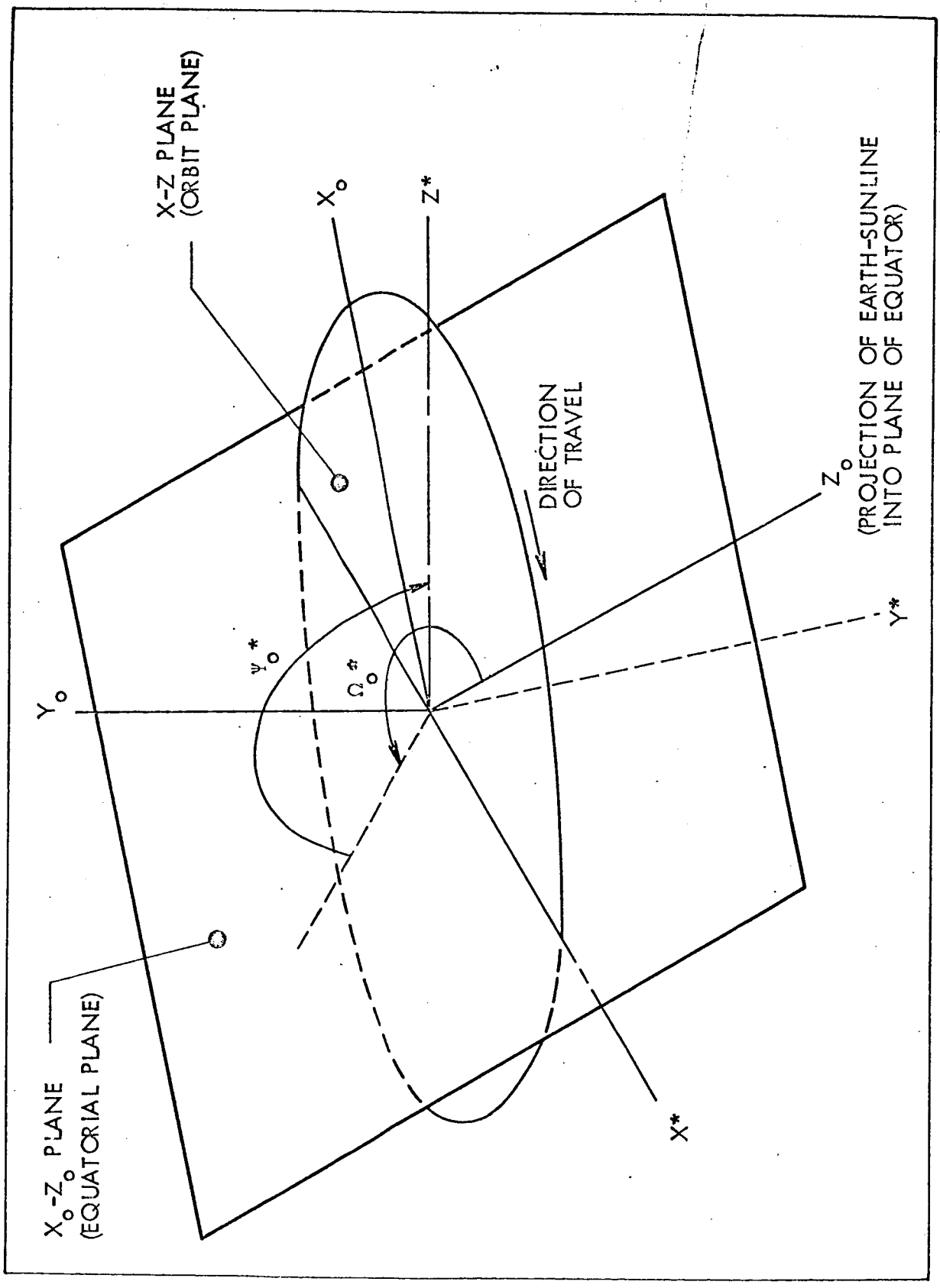

Figure 3-5. Description of Inverted Orbit Plane

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Now, consider an arbitrary elliptical orbit in the X-Z (orbit) plane with the origin (center of the planet) as one of the focii, as shown in Figure 3-6. In the X-Z plane, consider a rotation of axes by the angle ω to X', Z' (Y' axis coincides with Y axis) so that Z' coincides with the semi-major axis of the elliptical trajectory, and the center of the ellipse lies on the -Z' axis. The orbit has eccentricity, e, which equals $\sqrt{(a^2 - b^2)}/a$, where a is the semi-major axis and b is the semi-minor axis. The center of the orbit lies at (0, - ae), and the focii at (0, 0), and (0, - 2 ae). In the primed coordinates, the equation of the orbit is:

$$\frac{(Z' + ae)^2}{a^2} + \frac{X'^2}{b^2} = 1 \qquad (3\text{-}1)$$

$$(Y' = 0)$$

In polar coordinates:

$$\frac{(\rho \cos \nu + ae)^2}{a^2} + \frac{\rho^2 \sin^2 \nu}{b^2} = 1 \qquad (3\text{-}2)$$

where the angle, ν (known as the "true anomaly") is the angle between the perigee (measured in the direction of motion) and the point in question. This rearranges algebraically to

$$\rho = \frac{a\,(1 + e^2)}{1 + e \cos \nu} \qquad (3\text{-}3)$$

An arbitrary elliptical orbit has now been established, relative to the X_o, Y_o, Z_o axes, which is completely specified by the following geometric quantities: Ω_o, ψ_o, ω, a, e. In general, these geometric quantities may be selected, and all positions of the corresponding elliptical trajectory computed by varying ν. A non-zero initial value of the true anomaly, ν_o, can be specified. The local surface orientation is determined at ν_o for inertial orientation of the spacecraft. The altitude at perigee, $A_o = a\,(1 - e)$, is an input quantity.

For the special case of circular orbits, it is seen the $e = \omega = 0$ and $a = (R + A)$. For equatorial orbits, $\Omega_o = \psi_o = 0$. For polar orbits, $\psi_o = 90°$ and Ω_o determines the inclination of the orbit plane to the suns rays, or to the Y_o - Z_o plane.

ECLIPSES OF THE SURFACE ELEMENT

In determining the quantity of incident radiation on the surface element, it is important to know the duration and variation of exposure to the various sources. One of the most important radiation sources is direct solar energy, which is abruptly removed when the surface passes into a planet's shadow. In this simplified treatment to determine when the surface element passes into a planet's shadow, the following assumptions are made for two-body motion:

1. The planet's shadow is a circular cylinder with a diameter equal to the mean diameter of the planet.

2. The shadow has no penumbra.

3. Atmospheric refraction effects are negligible.

Relative to the planet-sun line, the surface element will pass into the planet's shadow at an angle, η_{SH}, so that

$$\cos \eta_{SH} = - \sqrt{1 - \left(\frac{R}{\rho_{SH}}\right)^2} \tag{3-4}$$

As shown in Figure 3-7, the surface is in shadow for

$$\cos \eta_P \leq - \sqrt{1 - \left(\frac{R}{\rho}\right)^2} \tag{3-5}$$

where $\cos \eta_P = \cos \eta_{SH}$ for $\rho = \rho_{SH}$.

Since all points in an orbit will be specified, the corresponding value of ρ can be found from equation (3-3). Also, since the direction of both ρ and the planet-sun line are known, $\cos \eta_P$ can be found and compared with the value of $\left[- \sqrt{1 - (R/\rho)^2}\right]$ to determine if the surface is in the planet's shadow. In addition to the calculation at regularly spaced intervals around the orbit as specified by the user, the computer program calculates the irradiation just before and after entering or leaving the planet's shadow.

ORBITAL POSITION AS A FUNCTION OF TIME

For the general case of elliptical orbits, the integrated radiant inputs can be obtained only if they are known as a function of time. This can be ascertained if the variation of the true anomaly, ν, for a given orbit is known as a function of time. The problem of describing the path or orbit of an

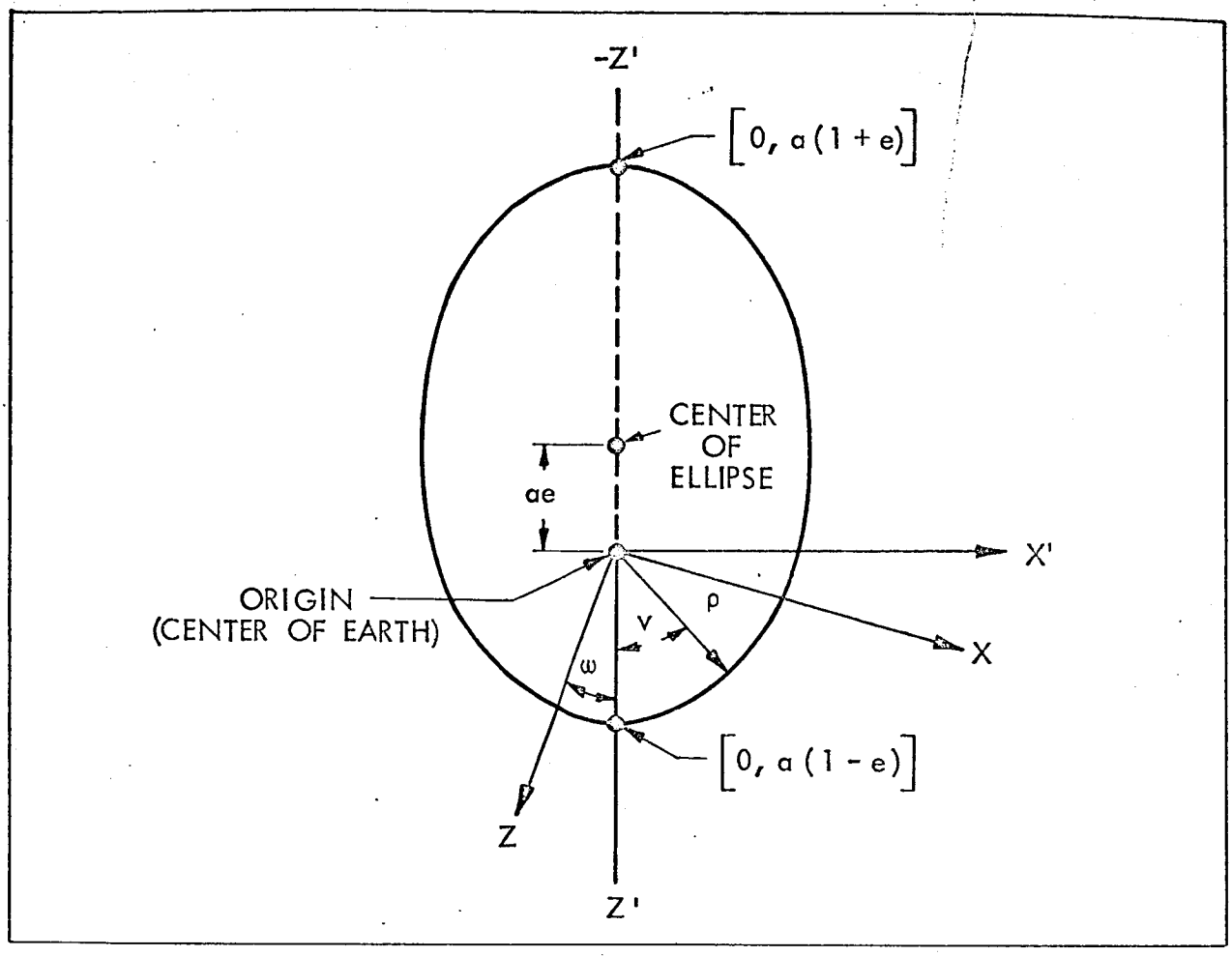

Figure 3-6. Elliptical Orbit Trajectory

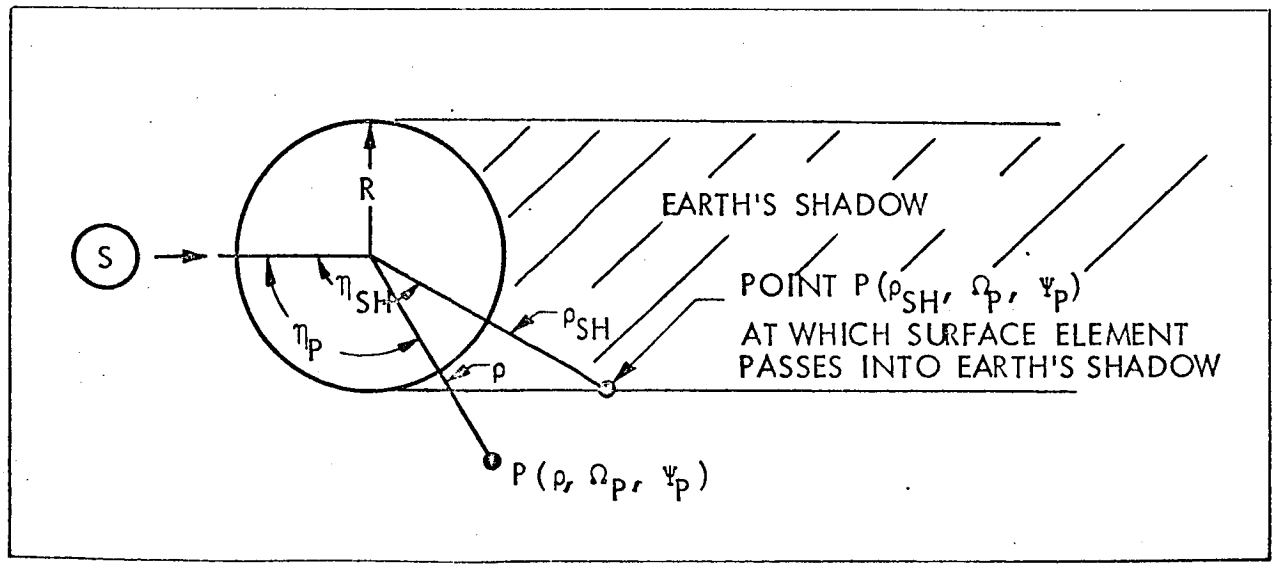

Figure 3-7. Eclipse of the Surface Element

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object about a body is described in most texts on the dynamics of motion or celestial mechanics, such as Moulton (Ref. 3). For the simple two-body problem, the differential equation relating the time, t, at any point in the orbit to its coordinates is

$$\rho^2 \frac{d\nu}{dt} = k \sqrt{Mp} = \text{constant} \tag{3-6}$$

where k is the gravitational constant,

M is the planet's mass, and

$p = a(1 - e^2)$

It is now assumed that time at perigee is zero, and that ν is measured from perigee in the orbit plane. Then

$$k\sqrt{Mp} \int_0^t dt = \int_0^\nu \rho^2 \, d\nu = \int_0^\nu \frac{p^2 \, d\nu}{(1 + e \cos \nu)^2} \tag{3-7}$$

The period of one body of infinitesinal mass about another body of mass, M, is (Ref. 3):

$$T = \frac{2\pi a^{3/2}}{k \sqrt{M}} \tag{3-8}$$

Then by integrating and substituting,

$$t = \frac{a^{3/2}}{k \sqrt{M}} \left[2 \tan^{-1}(E^{1/2} \tan \frac{\nu}{2}) - \frac{e(1 - e^2)^{1/2} \sin \nu}{1 + e \cos \nu} \right] \tag{3-9}$$

where $E = (1 - e)/(1 + e)$. For the special case of circular orbits, it can be seen that equation (1-9) reduces to the expected results of a linear variation of ν with time:

$$t = \left(a^{3/2} \nu\right) \Big/ \left(k \sqrt{M}\right) \tag{3-10}$$

It can also be seen that equation (3-9) reduces to equation (3-8) for the period of orbit with $\nu = 2\pi$.

IV CALCULATION OF ORBITAL IRRADIATIONS

DIRECT SOLAR IRRADIATION

The actual amount of solar radiation falling on a surface element is dependent upon its distance from the sun and the rate of radiant energy emitted from the sun. At large distances from the sun (such as the distance of the Earth), the sun's rays are approximately parallel, and the radiation per unit area which is incident on a surface normal to the rays may be considered to vary as the inverse square of the distance from the sun. For small changes in distance from the sun, such as a spacecraft in orbit around a planet, the solar irradiation of a surface undergoes no noticeable change and may be considered to be constant. On the other hand, the solar irradiation of a surface near the Earth varies by approximately ±3.5 percent in the course of a year due to the eccentricity of the Earth's orbit around the sun.

The irradiation of a surface normal to the sun's rays due to solar radiation can now be obtained from the "solar constant" for any point in the Earth's revolution around the sun, or at the mean distance from the sun for any other planet. The "solar constant," S', is defined as the rate at which energy is received upon a unit surface, perpendicular to the sun's rays, in free space at the Earth's mean distance from the sun. Then, the irradiation on the normal surface according to the "inverse-square of the distance" law is given by

$$S = \frac{S'}{\left| \vec{r} \right|^2} \tag{4-1}$$

where $\vec{r}$ is the radius vector of the planet being orbited, normalized to the Earth's mean distance from the sun. The value of the solar constant, S', is taken to be 2.00 cal cm^{-2} min^{-1}, as presented by Johnson (Ref. 4).

The solar irradiation of a surface element in space is given by appropriate geometric considerations and equation (4-1). The quantity of solar radiant energy incident on the surface is given by

$$q_S = C_F \, S \cos \theta_S \tag{4-2}$$

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The angle, θ_S, is measured between the sun's rays and the normal to the surface element. The function, C_F, is a factor to account for the possibility of the surface being in the planet's shadow.

It is assumed in all determinations of the irradiation to be made, that all surfaces are approximated by Lambert surfaces. The configuration factors associated with computing the thermal radiation from various sources to the surface element then reduce to purely geometric functions. With this assumption the reciprocity theorem holds and may be used to simplify the geometric configuration factor determination.

Now, let the direction cosines of the normal, $\hat{n}_P$, to the surface element be ℓ_1, m_1, and n_1 with respect to the X_o, Y_o, and Z_o axes. From Figure 3-1 it is seen that the direction cosines of the sun's rays are 0, $\sin \psi_S$, and $\cos \psi_S$, with respect to the X_o, Y_o, and Z_o axes. From Figure 3-3, the values of ℓ_1, m_1, n_1 are found to be:

$$\left.\begin{aligned} \ell_1 &= \cos \Omega_P \cos \tau \sin \sigma - \sin \psi_P \sin \Omega_P \sin \tau \\ &\quad + \cos \psi_P \sin \Omega_P \cos \tau \cos \sigma \\ m_1 &= \cos \psi_P \sin \tau + \sin \psi_P \cos \tau \cos \sigma \\ n_1 &= - \sin \Omega_P \cos \tau \sin \sigma - \sin \psi_P \cos \Omega_P \sin \tau \\ &\quad + \cos \psi_P \cos \Omega_P \cos \tau \cos \sigma \end{aligned}\right\} \qquad (4\text{-}3)$$

The function, $\cos \theta_S$, is then given by:

$$\cos \theta_S = m_1 \sin \psi_S + n_1 \cos \psi_S \qquad (4\text{-}4)$$

Similarly, from consideration of the direction cosines of the sun's rays and the planet-surface line, the angle between the sun's rays and the line to the point, P, which determines the eclipse factor, is given by

$$\eta_P = \cos^{-1} (\sin \psi_S \sin \psi_P + \cos \psi_S \cos \psi_P \cos \Omega_P) \qquad (4\text{-}5)$$

The eclipse factor, C_F, is now defined to be

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$$\left.\begin{aligned} C_F &= 1.0, \quad \cos\eta_P > -\sqrt{1-\left(\frac{R}{\rho}\right)^2} \\ C_F &= 0, \quad \cos\eta_P \le -\sqrt{1-\left(\frac{R}{\rho}\right)^2} \end{aligned}\right\} \qquad (4\text{-}6)$$

It is obvious that when $\cos\theta_S \le 0$, no direct solar radiation will be received by the surface. The value of q_S will therefore be evaluated as

$$q_S = C_F\, S \left[\max\left(\cos\theta_S, 0\right)\right] \qquad (4\text{-}7)$$

The expression, max (a, b), is evaluated as the maximum of the two quantities a and b.

From equations (4-1), (4-3) - (4-7), the value of solar irradiation incident on a surface above a planet's atmosphere is completely determined.

IRRADIATION BY THE EARTH

A unique feature of Lockheed's Orbital Radiation program is that it accounts for non-uniform radiosity of the Earth's surface. The determination of the radiative heat budget of the Earth is one of the fundamental problems of meteorology. For this reason, some of the classic papers in meteorological literature are discussions of the emission and diffuse reflectance of the Earth's surface and atmosphere. All but a few of these papers, however, are restricted to discussions of the annual radiative heat budget. Francis (Ref. 1) selected Simpson's work (Ref. 5) as a basis for his analysis, because Simpson presented the results of calculations of the mean monthly radiative budget. Gabites (Ref. 6) repeated Simpson's analysis using more recent and improved data on the radiative heat transfer in a water vapor - CO_2 mixture, but Gabites' work was published as a doctoral thesis, and hence was not as readily available.

The present data are based on the work of Gabites (Ref. 6) and Houghton (Ref. 7). The relative values were taken from Gabites and the absolute magnitudes were adjusted to fit Houghton's annual averages. The data for the Southern Hemisphere were based largely upon Gabites' work. Table 4-1 gives values of Earth emission, W_E, as a function of month and latitude. Table 4-2 gives values of diffuse reflectance, R_a, computed from the data of Gabites and Houghton. The energy reflected from the Earth-atmosphere system, S_r, is given by

TABLE 4-1

RADIATIVE HEAT LOSS OF THE EARTH, W_E (cal/cm^2 day)

(Reference Level Approximately 50,000 ft above Sea Level)

		J	F	M	A	M	J	J	A	S	O	N	D
Latitude N	90	328	326	343	392	420	422	430	413	395	387	375	336
	80	330	328	348	393	425	427	435	419	402	389	376	344
	70	345	341	366	402	436	446	452	437	424	407	382	355
	60	376	373	390	428	457	477	478	481	453	439	408	328
	50	399	393	409	438	463	482	483	495	477	455	415	396
	40	431	430	441	461	482	497	508	520	500	477	440	432
	30	466	466	475	485	502	512	515	528	514	498	479	464
	20	494	498	497	503	510	510	506	514	510	504	501	490
	10	500	506	503	512	505	496	500	502	497	505	502	500
	0	484	490	490	494	487	483	486	487	488	487	487	486
Latitude S	10	501	503	503	505	498	501	497	499	503	502	502	502
	20	506	514	509	508	500	502	486	494	504	505	505	505
	30	514	515	510	500	489	485	479	474	487	493	497	508
	40	493	495	487	475	471	461	462	450	465	472	480	488
	50	472	469	465	450	445	430	427	424	439	445	456	466
	60	456	460	450	433	425	407	407	401	418	425	438	448
	70	417	416	416	388	383	379	362	360	380	394	402	409
	80	401	393	389	346	356	349	340	336	360	377	382	384
	90	384	386	378	327	347	327	329	321	347	363	368	364

TABLE 4-2

DIFFUSE REFLECTANCE OF THE EARTH PLUS ATMOSPHERE SYSTEM, R_a

(Solar Constant 2.0 cal/cm^2 min)

		J	F	M	A	M	J	J	A	S	O	N	D
	90	-	-	-	.67	.67	.67	.67	.67	.67	-	-	-
	80	-	-	.60	.60	.60	.62	.63	.58	.56	.60	-	-
	70	-	.65	.57	.46	.43	.44	.46	.51	.53	.55	.65	-
Latitude N	60	.51	.46	.40	.40	.40	.36	.39	.42	.47	.50	.50	.52
	50	.42	.38	.37	.37	.38	.33	.33	.33	.36	.42	.46	.47
	40	.42	.34	.34	.32	.32	.25	.24	.25	.31	.31	.33	.41
	30	.30	.30	.28	.28	.26	.24	.24	.24	.27	.29	.32	.32
	20	.29	.25	.25	.24	.24	.27	.27	.26	.30	.31	.31	.30
	10	.29	.27	.28	.26	.28	.32	.34	.36	.34	.32	.32	.32
	0	.33	.30	.33	.30	.34	.33	.32	.32	.34	.33	.34	.35
	10	.34	.35	.34	.32	.32	.32	.29	.27	.28	.26	.28	.32
	20	.27	.26	.30	.31	.31	.30	.29	.25	.25	.24	.24	.24
Latitude S	30	.24	.24	.27	.29	.32	.32	.30	.30	.28	.28	.26	.24
	40	.24	.24	.27	.29	.32	.32	.30	.30	.28	.28	.26	.24
	50	.33	.33	.36	.42	.46	.47	.42	.38	.37	.37	.38	.33
	60	.39	.42	.46	.48	.48	.48	.48	.45	.40	.40	.40	.36
	70	.50	.52	.53	.60	.63	-	-	.63	.60	.57	.50	.50
	80	.63	.60	.60	.60	-	-	-	-	.60	.60	.60	.62
	90	.67	.67	.67	-	-	-	-	-	-	.67	.67	.67

$$S_r = S_\ell \cdot R_a \tag{4-8}$$

where S_ℓ is the solar energy incident on the atmosphere at any point. S_ℓ is given by

$$S_\ell = S\,(\cos\Omega\ \cos\psi\ \cos\psi_S + \sin\psi\ \sin\psi_S) \tag{4-9}$$

The geometry for determining the reflective irradiation of the surface element is identical to that of the emissive irradiation. No reflected energy will be received by the surface element from any point on the Earth which is "in shadow." It is assumed that no atmospheric refraction effects exist and that a "sharp" great circle on the Earth differentiates night and day.

The emissive and reflective irradiation of the surface element at an arbitrary point in space, P $(R + A,\ \Omega_P,\ \psi_P)$, can now be computed from geometric considerations and the determination of magnitude and distribution of the Earth's emissive and reflective power. The general expression for the irradiation of the surface element in spherical coordinates is:

$$q = \frac{1}{\pi} \int_{-\pi/2}^{\pi/2} \int_0^{2\pi} \frac{I \max(\cos\theta_E,\ 0)\ \max(\cos\theta_P,\ 0)\ \cos\psi\ d\,\Omega\ d\,\psi}{(r/R)^2} \tag{4-9}$$

For the Earth's emissive power, $I = W_E$, and for the reflective power, $I = S_r$.

The user must determine the grid size ($\Delta\psi$ and $\Delta\Omega$) to be used by the computer to numerically integrate equation (4-9). The grid size is usually specified in degrees as 1/100 of the altitude in statute miles. The specification of grid size is discussed in more detail in Section VII under "Accuracy of Integration."

IRRADIATION BY THE MOON

To determine the lunar emissive and reflective power in the absence of an atmosphere, the surface characteristics (i.e., absorptivity and emissivity) and temperature distribution over the surface must be known.

The reflectivity of the lunar surface for solar radiation is generally given as 0.070 or slightly higher. The value of 0.073 is used in the present program. The computations which have been made of the lunar temperatures

have assumed emissivities of about unity. A good summary of the moon's physical characteristics are given by Kiess and Lassovsky (Ref. 8). The computed surface temperature and assumed emissivity will give the magnitude of emitted infrared radiation from the lunar surface. An assumed emissivity of one is probably reasonable, in view of the nature of the lunar surface and known characteristics of materials emitting radiation in the infrared.

The most striking observations of lunar surface temperatures are those made during the eclipse of the moon. A temperature change at the same place of 270°F (from 160°F to -110°F) has been observed in a period of only one hour. This fact, along with photomic and polarmetric observations, has led many observers to conclude that the lunar surface is covered with a coarse layer of dust of extremely low thermal conductivity, since a high heat conducting material could not cool so rapidly. Is is also concluded that the moon will have a fairly uniform, although low, temperature on the dark side, and the temperature on the sunlit side will vary by considerable amounts with increasing distance from the subsolar point because of the increasing angle between the sun's rays and the local normal to the surface. The temperature measurements (Ref. 8) tend to verify these conclusions and are summarized below:

Location	Temperature, °F
Subsolar (at full moon)	214 to 264
Subsolar (at half moon)	187 to 239
Terminator	-80
Dark side	-244

On the basis of these observations and measurements, it is concluded that it is reasonable to assume that a thermal radiation equilibrium condition exists on the major sunlit portions of the lunar surface, since the amount of heat conducted into the moon's interior is probably negligible. This equilibrium condition would apply for all sunlit areas except those in the near vicinity of the terminator. Assuming a space temperature of 0°R, the surface temperature at any point on the sunlit side would be given by:

$$T_M = \left(\frac{\alpha_S \, S}{\epsilon_I \, \sigma} \cos \theta_{M-S} \right)^{1/4} \qquad (4\text{-}10)$$

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In the region of the terminator, a linear extrapolation from 75° to the measured value at the terminator is used. A sharp drop at the terminator to a constant value of 216°R on the dark side is also assumed. The solution for the lunar surface temperature at any point is then given by:

$$\left.\begin{aligned}
T_M &= \left(\frac{\alpha_S\, S}{\epsilon_I\, \sigma} \cos \theta_{M-S}\right)^{1/4} && \left\{-75° \le \theta_{M-S} \le 75°\right\} \\
T_M &= \frac{12}{\pi}\left[387 - \left(\frac{\alpha_S\, S}{\epsilon_I\, \sigma} \cos 75°\right)^{1/4}\right] \theta_{M-S} \\
&\quad + 6\left(\frac{\alpha_S\, S}{\epsilon_I\, \sigma} \cos 75°\right)^{1/4} - 1935 && \left\{\begin{matrix} 75° < \theta_{M-S} < 90° \\ -75° > \theta_{M-S} > 90° \end{matrix}\right\} \\
T_M &= 216°R && \left\{90 \le \theta_{M-S} \le 270°\right\}
\end{aligned}\right\} \quad (4\text{-}11)$$

Figure 4-1 is a plot of equation (4-11), using the values $(1 - \alpha_S) = 0.073$, $\epsilon_I = 1.0$, and $S = 443$ Btu/hr-ft^2.

The irradiation of the surface element as a result of the lunar emissive power may also be computed from geometric considerations and knowledge of the lunar surface temperatures. This irradiation is given by

$$q_M = \frac{\sigma\, \epsilon_I}{\pi} \int_{-\pi/2}^{\pi/2} \int_0^{2\pi} \frac{T_M^{\,4} \max(\cos \theta_M, 0) \max(\cos \theta_P, 0) \cos \psi' d\Omega' d\psi'}{(r'/R')^2} \quad (4\text{-}12)$$

where the primed quantities are lunar parameters. These quantities can be evaluated for both lunar-based and Earth-based coordinate systems (Appendix B). The geometry for the solar energy reflected diffusely from the moon's surface back into space is the same as in the case of the Earth. The flux density of reflected energy is

$$S_r' = (1 - \alpha_S)\, S \cos \theta_{M-S} \quad (4\text{-}13)$$

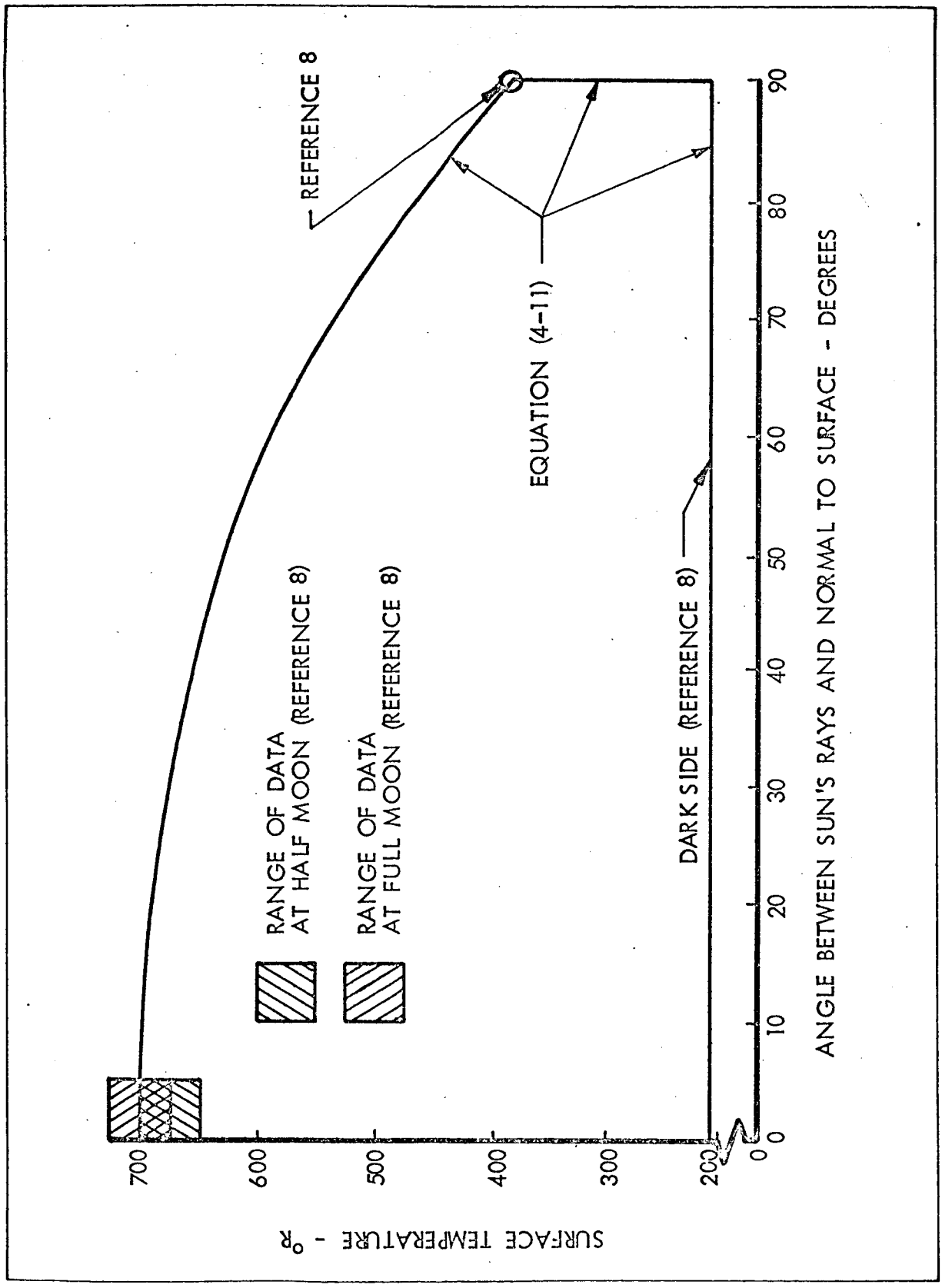

Figure 4-1. Lunar Surface Temperatures

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The spectral distribution is assumed to agree with the solar spectrum. The irradiation of the surface element will then be

$$q_{MR} = \frac{(1-\alpha_S)S}{\pi} \int_{-\pi/2}^{\pi/2} \int_{0}^{2\pi} \frac{\max(\cos\theta_{M-S},0)\max(\cos\theta_M,0)\max(\cos\theta_P',0)\cos\psi' d\Omega' d\psi'}{(r'/R')^2} \tag{4-14}$$

As in the case of Earth irradiation, the grid size for integration ($\Delta\psi'$ and $\Delta\Omega'$) is specified by the user.

V PROGRAM INPUT AND OUTPUT

INPUT OPTIONS

The user can specify Earth or lunar orbits with planetary or inertial orientations, or individual points in space. At the users option, computations can be made for solar irradiation only, solar plus planet (the usual option), solar plus planet's satellite (i.e., the moon as referenced to an Earth orbit), or solar plus planet plus satellite. The program computes individual irradiations on a plane surface and combinations of irradiations such as direct solar plus reflected solar. The program will also compute total absorbed radiation if the user specifies the absorbtivity and emissivity of the surface.

OUTPUT OPTIONS

The printed output contains a listing of input parameters, a tabulation of heating rates in Btu/hr vs. time in hours and position in orbit, planetary view factors vs. position in orbit, and an indication of when the surface is in the shadow of the planet. The tabulated heating rates provided are:

1. Direct solar irradiation
2. Reflected solar irradiation (planet)
3. Infrared emission (planet)
4. Reflected solar irradiation (planet's satellite)
5. Infrared emission (planet's satellite)
6. Total solar spectrum irradiation (1+2+4)
7. Total infrared emission (3+5)
8. Total absorbed irradiation (α_S x 6 + ϵ_I x 7, if computed; 0 if not computed)

Lunar irradiation can be referenced to either an Earth orbit or a lunar orbit.

Optional outputs available are punched cards and plotted output. Punched cards are tables of heating rates in Btu/sec versus time in seconds, in the correct format for direct insertion into the Thermal Analyzer program (Ref. 9). The punched cards include a five-digit sequence number consisting of the three-digit curve number plus consecutive numbers as needed starting with 01.

Available punched curves are:

1. Solar spectrum irradiation
2. Infrared irradiation
3. Absorbed irradiation (if computed)

Plotted output is any of the eight tabulated heating rates as desired. All curves for a given case are plotted on the same figure.

INPUT DATA CARD FORMATS

The proper formats for the input data cards are shown in Table 5-1. A case to be submitted requires three cards; multiple cases are input as successive groups of three cards each. A case is here defined as a single position of one surface element in space, or as all of the positions computed for an orbit trajectory. A final card, with case = 0, is required to terminate the case(s).

The inputs required for the first card are flags specifying the planet, orientation, and type of irradiations to be computed, case number, curve number(s) and identification for punched output (if required), surface absorptivity and emissivity (if required), and any desired identification or comment. All numbers on the first card are fixed-point numbers (no decimal point), with the exception of the case number, absorptivity, and emissivity, which are floating-point numbers (with decimal point). A three-digit case number does not require a decimal point.

The second card contains the month (1 to 12), declination of the sun (Ψ_S), description of the orbit plane (Ψ_o, Ω_o), surface orientation (σ, τ), and trajectory data (ω, A_o, e, ν_o, $\Delta\nu$). All numbers on the second card are floating-point numbers, with the exception of the month, which is a fixed-point number.

The third card contains the planet surface integration grid size ($\Delta\Psi_i$, $\Delta\Omega_i$), position parameters for the planet's satellite (Ψ_M, Ω_M), satellite surface integration grid size ($\Delta\Psi_j$, $\Delta\Omega_j$), and flags to trigger the output plotter. All numbers on the third card are floating-point numbers, with the exception of plot trigger flags, which are individual digits. $\Delta\Psi_i$ and $\Delta\Omega_i$ are required only when a planet's reflected solar radiation and infrared emission are computed. Ψ_M, Ω_M, $\Delta\Psi_j$, and $\Delta\Omega_j$ are required only when

computations are made for a planet's satellite (i.e., the moon referenced to an Earth orbit). Non-zero flags trigger the output plotter. The third card is required, even if all entries are zero or blank.

TABLE 5-1

INPUT DATA CARD FORMATS (1 of 3)

SEQ. CARD 77-80	1	2	3	4-6	7-12	13-18	19-24	25-30	31-36	37-42	43-48	49-54	55-72	ID 73-76
1	J	K	L	CASE.	KNØ1	BCD1	KNØ2	BCD2	KNØ3	BCD3	α_S.	ϵ_I.	IDENTIFICATIØN	

```
CARD 1 HAS FØRMAT (3I1,F3.0,3(2X,I3,1X,A6),2F6.0,3A6)
J=PLANET NØ. (1=EARTH, 2=MØØN)
K=ØRIENTATIØN (1=PLANET, 2=INERTIAL)
L=TYPE (1=SØLAR, 2=SØLAR+PLANET, 3=SØLAR+SATELLITE, 4=SØLAR+PLAN+SAT)
CASE.=ARBITRARY ID NØ.    (CASE =0. TERMINATES THE RUN)
KNØ1=CURVE NØ. ASSIGNED TØ PUNCHED SØLAR SPECTRUM CURVE        (ØPTIØNAL)
BCD1=CURVE ID PUNCHED INTØ FIRST CARD ØF CURVE KNØ1            (ØPTIØNAL)
     NØTE: "SØLAR SPEC" IS AUTØMATICALLY PUNCHED INTØ FIRST CARD
KNØ2=CURVE NØ. ASSIGNED TØ PUNCHED INFRARED SPECTRUM CURVE     (ØPTIØNAL)
BCD2=CURVE ID PUNCHED INTØ FIRST CARD ØF CURVE KNØ2            (ØPTIØNAL)
     NØTE: "INFRA-RED" IS AUTØMATICALLY PUNCHED INTØ FIRST CARD
KNØ3=CURVE NØ. ASSIGNED TØ PUNCHED Q-ABSØRBED CURVE            (ØPTIØNAL)
BCD3=CURVE ID PUNCHED INTØ FIRST CARD ØF CURVE KNØ3            (ØPTIØNAL)
     NØTE: "Q ABSØRBED" IS AUTØMATICALLY PUNCHED INTØ FIRST CARD
αS.=SØLAR ABSØRPTIVITY      (REQUIRED ØNLY IF Q ABSØRBED IS CØMPUTED)
εI.=INFRARED EMISSIVITY     (REQUIRED ØNLY IF Q ABSØRBED IS CØMPUTED)
IDENTIFICATIØN=18 CØLUMNS ØF ARBITRARY BCD CØMMENT             (ØPTIØNAL)
```


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TABLE 5-1

INPUT DATA CARD FORMATS (2 of 3)

CARD	Cols 1–2	7–12	13–18	19–24	25–30	31–36	37–42	43–48	49–54	55–60	61–66
2	MΦ	ψ_s.	ψ_o.	Ω_o.	σ.	τ.	ω.	A_o.	e.	ν_o.	$\Delta\nu$.

CARD 2 HAS FΦRMAT (I2,4X,11F6.0)

MΦ=MΦNTH (1-12)

ψ_s.=DECLINATIΦN ΦF SUN (IF INPUT AS >360., ψ_s TAKEN AS ΦF 15TH ΦF MΦNTH)

ψ_o., Ω_o.=ΦRBIT PLANE PARAMETERS

σ., τ. =SURFACE ΦRIENTATIΦN PARAMETERS

ω. =MAJΦR AXIS ANGLE (=0. FΦR CIRCULAR ΦRBITS)

A_o. =ALTITUDE ABΦVE PLANET SURFACE AT PERIGEE, STATUTE MILES

e. =ΦRBIT ECCENTRICITY

ν_o. =INITIAL PΦSITIΦN IN ΦRBIT

NΦTE: ν_o IS LΦCATIΦN AT WHICH σ AND τ ARE SPECIFIED FΦR INERTIAL ΦRIENTATIΦN

$\Delta\nu$. =STEP SIZE ARΦUND ΦRBIT

NΦTE: $\Delta\nu$=0. IS FLAG FΦR SINGLE-PΦINT CΦMPUTATIΦN

TABLE 5-1

INPUT DATA CARD FORMATS (3 of 3)

SEQ.								ID
CARD								
3	$\Delta\Psi_i$.	$\Delta\Omega_i$.	Ψ_m.	Ω_m.	$\Delta\Psi_j$.	$\Delta\Omega_j$.	<-PLOT->	

CARD 3 HAS FORMAT (6F6.0, 8I)

$\Delta\Psi_i$., $\Delta\Omega_i$. = INTEGRATION GRID SIZE, PLANET SURFACE (REQ'D IF L=2 OR 4)

Ψ_m., Ω_m. = POSITION PARAMETERS FOR SATELLITE (REQ'D IF L=3 OR 4)

$\Delta\Psi_j$., $\Delta\Omega_j$. = INTEGRATION GRID SIZE, SAT. SURFACE (REQ'D IF L=3 OR 4)

PLOT: NON-ZERO ENTRY IN ANY COLUMN 37-44 TRIGGERS PLOTTER

COL. 37: DIRECT SOLAR IRRADIATION

COL. 38: REFLECTED SOLAR IRRADIATION, PLANET

COL. 39: INFRARED EMISSION, PLANET

COL. 40: REFLECTED SOLAR IRRADIATION, SATELLITE

COL. 41: INFRARED EMISSION, SATELLITE

COL. 42: TOTAL SOLAR SPECTRUM IRRADIATION

COL. 43: TOTAL INFRARED IRRADIATION

COL. 44: TOTAL ABSORBED IRRADIATION (IF COMPUTED)

NOTE: CARD 3 IS REQUIRED EVEN IF ALL ENTRIES ARE ZERO OR BLANK

VI EXAMPLE PROBLEMS

Several example problems are presented to demonstrate most of the input situations likely to be encountered. Included are the input sheets, regular tabular output, listings of optional punched heating rate tables, and optional graphical output.

EXAMPLE 1: CYLINDER IN CIRCULAR EARTH ORBIT WITH PLANETARY ORIENTATION

Assume a Cape Kennedy launch into a 300-statute mile circular orbit with an inclination of 30° to the equator. Orbit insertion at 30° N latitude is achieved at noon (local sun time) on 9 February. The cylinder's axis is aligned with the flight path. The body angles of interest (measured counter-clockwise from the vertical, looking forward) are 45°, 135°, 225°, and 315°. The geometry is illustrated in Figure 6-1. It is desired to compute solar and Earth irradiations every 15° around the orbit. In addition, it is desired to punch solar spectrum and infrared tables, and to plot solar, planet emission, and planet reflection curves.

The input parameters are as follows:

Card 1:

J = 1 (Earth)

K = 1 (planet orientation)

L = 2 (solar and planetary irradiations)

Case No. (arbitrary)

Punch triggers in 2nd and 4th 6-column fields (table numbers)

Punched table ID in 3rd and 5th fields (arbitrary)

Identification in 10th through 12th fields (arbitrary)

Card 2:

MO = 02 (February)

$\Psi_S = -15^{\circ}$ (declination of sun on February 9)

$\Psi_o = 30^{\circ}$ (inclination of orbit)

$\Omega_o = 0^{\circ}$ (based on being at highest latitude at noon)

$\sigma = 0^{\circ}$ (horizontal cylinder)

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$\tau = 45^\circ, 135^\circ, 225^\circ, 315^\circ$ (same as body angles in this case)

$\omega = 0^\circ$ (circular orbit)

$A_o = 300$ miles (altitude)

$e = 0$ (circular orbit)

$\nu_o = 0$ (starting point of orbital calculation)

$\Delta\nu = 15^\circ$ (step size around orbit)

Card 3:

$\Delta\Psi_i = \Delta\Omega_i = 3^\circ$ (integration grid size, numerically = $0.01\ A_o$)

Plot triggers in columns 37, 38, 39

There are four separate cases, one for each body angle. Each case requires its own set of 3 cards.

The input sheet and tabular output are shown in Tables 6-1 and 6-2. Table 6-3 is a listing of the punched output tables. Output plots are shown in Figures 6-2 through 6-5.

EXAMPLE 2: CYLINDER IN CIRCULAR EARTH ORBIT WITH INERTIAL ORIENTATION

Assume the same orbit conditions as for Example 1, illustrated in Figure 6-1. Assume that inertial orientation is desired with the axis of the cylinder perpendicular to the sun line. Note that in this case, the attitude of the cylinder coincides with planet orientation at $\nu = 0$. Orientation parameters are then determined at $\nu_o = 0$. Therefore, all input parameters are the same as for Example 1 except for the orientation flag.

Card 1:

K = 2 (inertial orientation)

Table 6-1 shows the program input. Output is shown in Tables 6-2 and 6-3, and Figures 6-6 through 6-9.

EXAMPLE 3: CYLINDER IN ELLIPTICAL POLAR EARTH ORBIT WITH PLANETARY ORIENTATION

Assume a Vandenberg AFB launch into a polar orbit with a perigee of 1000 statute miles and an apogee of 2000 statute miles. The major axis of the orbit is the intersection of the orbit plane and the equatorial plane, with the perigee in the Earth's shadow. Launch toward the south is at noon (local sun time) on March 21. The cylinder's axis is aligned with the zenith (local vertical). The body angles of interest (measured counter-clockwise from the leading edge, looking toward the center of the Earth) are 0°, 90°, 180°, and 270°. It is desired to compute solar and Earth irradiations every 15° around the orbit. In addition, it is desired to punch solar spectrum and infrared tables and to plot solar, planet emission, and planet reflection curves.

The orbit geometry is illustrated in Figure 6-10. The input parameters are as follows:

Card 1:

Same as for Example 1

Card 2:

MO = 03 (March)

ψ_S = 0° (Declination of sun on March 21)

ψ_o = 90° (polar orbit)

Ω_o = 270° ("noon" polar orbit launched toward south)

σ = 90° (vertical cylinder)

τ = 0°, 90°, 180°, 270° (same as body angles in this case)

ω = 270° (perigee over the equator and in Earth's shadow)

A_o = 1000 miles (altitude at perigee)

e = 0.0915 (altitude at perigee = 1000 miles, altitude at apogee = 2000 miles, radius of Earth = 3959 miles)

ν_o = 0° (start calculations at perigee)

$\Delta\nu$ = 15° (step size around orbit)

Card 3:

$\Delta\psi_i = \Delta\Omega_i$ = 10° (integration grid size, numerically = 0.01 A_o)

Plot triggers in columns 37, 38, 39

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Table 6-4 shows the program input. Output is shown in Tables 6-5 and 6-6, and Figures 6-11 through 6-14.

EXAMPLE 4: CONICAL SURFACE IN ELLIPTICAL POLAR EARTH ORBIT WITH PLANETARY ORIENTATION

Assume the same orbit conditions as for Example 3, illustrated in Figure 6-10. Assume the surface of interest to be a 45° vertical cone with apex toward the Earth. All input parameters are the same as for Example 3 with the exception of the orientation angles σ and τ on Card 2. These angles are specified as follows:

Body angle	0°	90°	180°	270°
σ	135°	180°	225°	180°
τ	0°	45°	0°	315°

Table 6-4 shows the program input. Output is shown in Tables 6-5 and 6-6 and Figures 6-15 through 6-18.

EXAMPLE 5: CYLINDER IN CIRCULAR LUNAR ORBIT WITH PLANETARY ORIENTATION

Assume an 86-statute-mile circular lunar equatorial orbit sometime in May. Neglect the declination of the sun (which is nearly 0°). The cylinder's axis is vertical and the body angles of interest (measured counter-clockwise from the leading edge, looking toward the center of the moon) are 0°, 90°, 180°, and 270°. Assume the Earth-sun-moon relationship to be as shown in Figure 6-19. The angle between the moon-sun line and the moon-Earth line is 38°. The point of entry into the clockwise lunar orbit is 168° from the moon-Earth line. It is desired to compute solar and planetary incident and absorbed irradiations every 15° around the orbit. Assume $\alpha_S = \epsilon_I = 0.5$. It is also desired to punch absorbed irradiation tables and to plot solar, planet reflection, planet emission, and absorbed irradiation.

The input parameters are as follows:

Card 1:

J = 2 (moon)

K = 1 (planet orientation)

L = 2 (solar and planetary irradiations)

Case no. (arbitrary)

Punch trigger in 6th field (table no.)

Punch table ID in 7th field (arbitrary)

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α_S = 0.5

ϵ_I = 0.5

Identification in 10th - 12th fields (arbitrary)

Card 2:

MO = 05 (May)

ψ_S = 0° (assumed declination of sun)

ψ_o = 180° (inverts orbit plane)

Ω_o = 0° (equatorial orbit)

σ = 90° (vertical cylinder)

τ = 0°, 90°, 180°, 270° (same as body angle in this case)

ω = 0° (circular orbit)

A_o = 86 miles (altitude)

e = 0 (circular orbit)

ν_o = 50° (38° + 180° - 168° = 50°)

$\Delta\nu$ = 15° (step size around orbit)

Card 3:

$\Delta\psi_i = \Delta\Omega_i = 1°$ (minimum practical grid size)

Plot triggers in columns 37, 38, 39, 44

Program input is shown in Table 6-7. Output is shown in Tables 6-8 and 6-9, and Figures 6-20 through 6-23.

EXAMPLE 6: ARBITRARY POINT IN SPACE

Assume a plane surface facing the Earth, located at 40° North latitude, 60° East longitude, and an altitude of 1000 statute miles. Assume the time to be 1400 GMT (2 PM) on December 25th. It is desired to compute solar and planet irradiations.

The program input is as follows:

Card 1:

J = 1 (Earth)

K = 1 (planet orientation)

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L = 2 (solar plus planetary irradiations)

Identification in 10th - 12th fields (arbitrary)

Card 2:

MO = 12 (December)

ψ_S = -23.5° (declination of sun on December 25)

ψ = 40° (north latitude)

Ω = 90° (60° east longitude plus 30° west longitude position of sun at 1400 GMT)

σ = 0°, τ = 180° (horizontal surface facing Earth)

A_o = 1000 miles (altitude)

ω = e = ν_o = $\Delta\nu$ = 0 (no orbit reference)

Card 3:

$\Delta\psi_i$ = $\Delta\Omega_i$ = 10° (integration grid size, numerically = 0.01 A_o)

Program input and output are shown on Tables 6-10 and 6-11, respectively.

EXAMPLE 7: SPECIFIC POINT IN A GIVEN ORBIT

Assume the same orbital conditions as for Example 1. It is desired to compute solar and planetary irradiations for Side 4 (τ = 315°) at a point 30° beyond orbit insertion.

The input is the same as for Example 1, Side 4, except as shown below:

Card 1:

No punch triggers or punched table ID.

Card 2:

ν_o = 30° (locates point in orbit for computation)

$\Delta\nu$ = 0° (one point only; computations are not to be made around the orbit)

Card 3:

No plot triggers

Program input and output are shown on Tables 6-10 and 6-11, respectively.

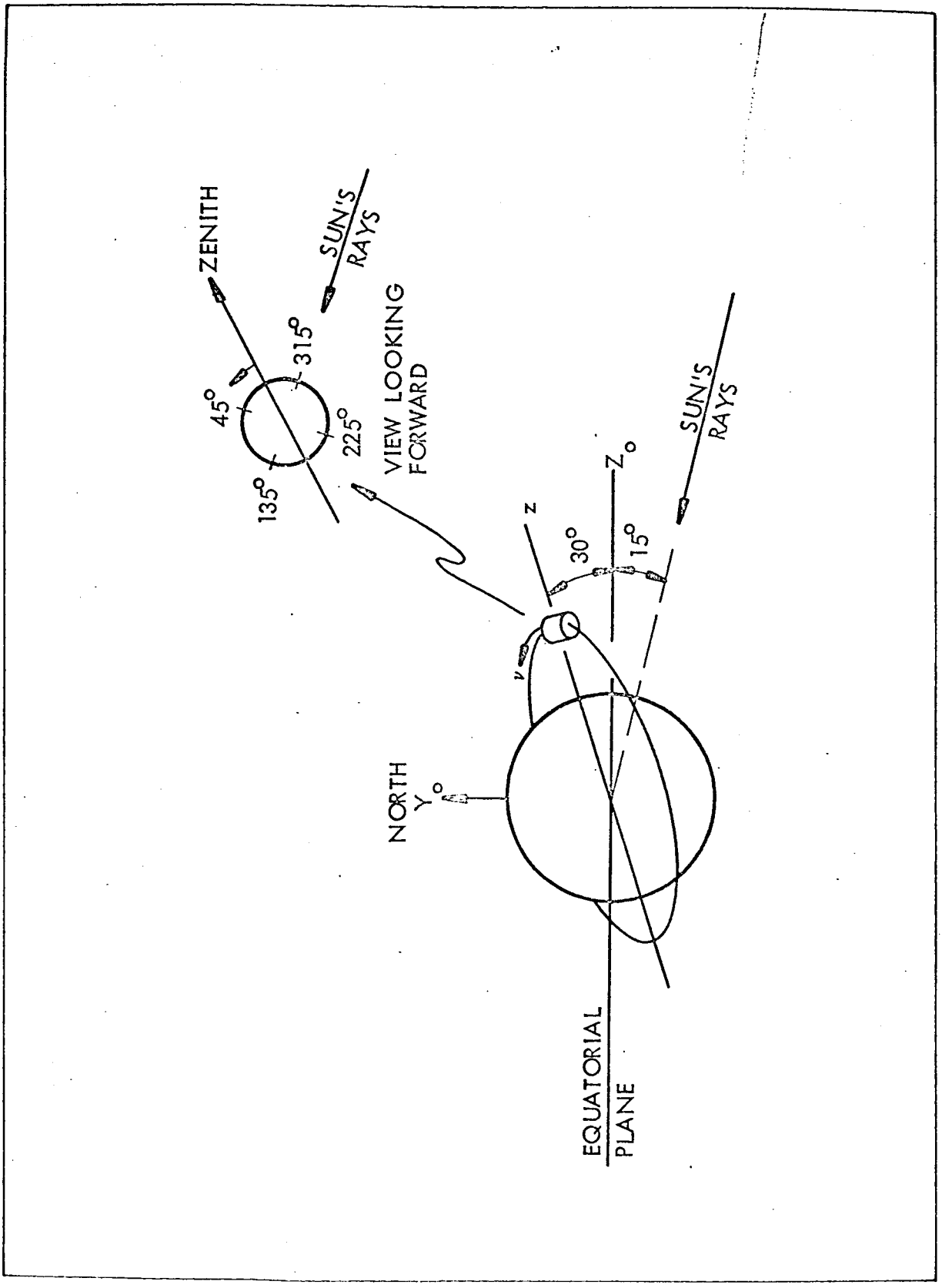

Figure 6-1. Geometry for Examples 1 and 2

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TABLE 6-1

INPUT FOR EXAMPLES 1 AND 2

SEQ.													ID
77 80	1 5	10	15	20	25 30	35	40	45	50	55 60	65	70 72	73 76
1101	11211.	111	HØRIZ.	112	HØRIZ.					EXAMPLE 1, SIDE 1			
1102	02	-15.	30.	0.	0.	45.	0.	300.	0.	0.	15.		
1103	3.	3.					111						
1201	11212.	121	HØRIZ.	122	HØRIZ.					EXAMPLE 1, SIDE 2			
1202	02	-15.	30.	0.	0.	135.	0	300.	0.	0.	15.		
1203	3.	3.					111						
1301	11213.	131	HØRIZ.	132	HØRIZ.					EXAMPLE 1, SIDE 3			
1302	02	-15.	30.	0.	0.	225.	0.	300.	0.	0.	15.		
1303	3.	3.					111						
1401	11214.	141	HØRIZ.	142	HØRIZ.					EXAMPLE 1, SIDE 4			
1402	02	-15.	30.	0.	0.	315.	0.	300.	0.	0.	15.		
1403	3.	3.					111						
2101	12221.	211	INERT.	212	INERT.					EXAMPLE 2, SIDE 1			
2102	02	-15.	30.	0.	0.	45.	0.	300.	0.	0.	15.		
2103	3.	3.					111						
2201	12222.	221	INERT.	222	INERT.					EXAMPLE 2, SIDE 2			
2202	02	-15.	30.	0.	0.	135.	0.	300.	0.	0.	15.		
2203	3.	3.					111						
2301	12223.	231	INERT.	232	INERT.					EXAMPLE 2, SIDE 3			
2302	02	-15.	30.	0.	0.	225.	0.	300.	0.	0.	15.		
2303	3.	3.					111						
2401	12224.	241	INERT.	242	INERT.					EXAMPLE 2, SIDE 4			
2402	02	-15.	30.	0.	0.	315.	0.	300.	0.	0.	15.		
2403	3.	3.					111						
2999	0.									END CARD			

TABLE 6-2. TABULAR OUTPUT FOR EXAMPLES 1 AND 2

ORBITAL RADIATION - 2374

CASE 11. EXAMPLE 1, SIDE 1

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
2	-15.000	30.000	0.	0.	45.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 111 HORIZ. 112 HORIZ. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR) (ALL Q IN BTU/HR/SQ.FT.)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
	0.	300.	0.	1.769	2.124	0.000			2.124	1.769	-0.	0.02579	
	15.	300.	0.065	1.946	2.113	0.			2.113	1.946	-0.	0.02764	
	30.	300.	0.131	2.021	1.869	0.			1.869	2.021	-0.	0.02837	
	45.	300.	0.196	2.113	1.295	0.			1.295	2.113	-0.	0.02842	
	60.	300.	0.262	2.160	0.748	0.			0.748	2.160	-0.	0.02823	
	75.	300.	0.327	2.184	0.236	0.			0.236	2.184	-0.	0.02821	
	90.	300.	0.393	2.153	0.003	0.			0.003	2.153	-0.	0.02825	
	105.	300.	0.458	2.139	0.	0.			0.	2.139	-0.	0.02821	
	120.	300.	0.524	2.186	0.	0.			0.	2.186	-0.	0.02834	
	121.	300.	0.528	2.197	0.	0.			0.	2.197	-0.	0.02834	
SH	122.	300.	0.532	2.197	0.	0.			0.	2.197	-0.	0.02835	
SH	135.	300.	0.589	2.236	0.	0.			0.	2.236	-0.	0.02845	
SH	150.	300.	0.654	2.241	0.	0.			0.	2.241	-0.	0.02842	
SH	165.	300.	0.720	2.153	0.	0.			0.	2.153	-0.	0.02726	
SH	180.	300.	0.785	2.080	0.	0.			0.	2.080	-0.	0.02632	
SH	195.	300.	0.851	2.153	0.	0.			0.	2.153	-0.	0.02726	
SH	210.	300.	0.916	2.241	0.	0.			0.	2.241	-0.	0.02842	
SH	225.	300.	0.982	2.236	0.	0.			0.	2.236	-0.	0.02845	
SH	238.	300.	1.038	2.197	0.	0.			0.	2.197	-0.	0.02835	
	239.	300.	1.043	2.197	0.	0.			0.	2.197	-0.	0.02834	
	240.	300.	1.047	2.186	0.	0.			0.	2.186	-0.	0.02834	
	255.	300.	1.113	2.139	0.	0.			0.	2.139	-0.	0.02821	
	270.	300.	1.178	2.153	0.003	0.			0.003	2.153	-0.	0.02825	
	285.	300.	1.243	2.184	0.236	0.			0.236	2.184	-0.	0.02821	
	300.	300.	1.309	2.160	0.748	0.			0.748	2.160	-0.	0.02823	
	315.	300.	1.374	2.113	1.295	0.			1.295	2.113	-0.	0.02842	
	330.	300.	1.440	2.021	1.869	0.			1.869	2.021	-0.	0.02837	
	345.	300.	1.505	1.946	2.113	0.			2.113	1.946	-0.	0.02764	
	360.	300.	1.571	1.769	2.124	0.000			2.124	1.769	-0.	0.02579	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 12. EXAMPLE 1, SIDE 2

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	135.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 121 HORIZ. 122 HORIZ. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
	0.	300.	0.	45.993	56.012	0.			56.012	45.993	-0.	0.63635	
	15.	300.	0.065	46.215	53.806	0.			53.806	46.215	-0.	0.63727	
	30.	300.	0.131	47.648	44.456	0.			44.456	47.648	-0.	0.63835	
	45.	300.	0.196	48.804	34.502	0.			34.502	48.804	-0.	0.63822	
	60.	300.	0.262	49.397	24.630	0.			24.630	49.397	-0.	0.63799	
	75.	300.	0.327	48.546	12.514	0.			12.514	48.546	-0.	0.63776	
	90.	300.	0.393	48.419	1.024	0.			1.024	48.419	-0.	0.63775	
	105.	300.	0.458	49.116	0.004	0.			0.004	49.116	-0.	0.63774	
	120.	300.	0.524	49.956	0.	0.			0.	49.956	-0.	0.63787	
	121.	300.	0.528	50.183	0.	0.			0.	50.183	-0.	0.63789	
SH	122.	300.	0.532	50.184	0.	0.			0.	50.184	-0.	0.63790	
SH	135.	300.	0.589	50.382	0.	0.			0.	50.382	-0.	0.63823	
SH	150.	300.	0.654	50.441	0.	0.			0.	50.441	-0.	0.63833	
SH	165.	300.	0.720	50.031	0.	0.			0.	50.031	-0.	0.63766	
SH	180.	300.	0.785	49.901	0.	0.			0.	49.901	-0.	0.63583	
SH	195.	300.	0.851	50.031	0.	0.			0.	50.031	-0.	0.63766	
SH	210.	300.	0.916	50.441	0.	0.			0.	50.441	-0.	0.63833	
SH	225.	300.	0.982	50.382	0.	0.			0.	50.382	-0.	0.63823	
SH	238.	300.	1.038	50.184	0.	0.			0.	50.184	-0.	0.63790	
	239.	300.	1.043	50.183	0.	0.			0.	50.183	-0.	0.63789	
	240.	300.	1.047	49.956	0.	0.			0.	49.956	-0.	0.63787	
	255.	300.	1.113	49.116	0.004	0.			0.004	49.116	-0.	0.63775	
	270.	300.	1.178	48.419	1.024	0.			1.024	48.419	-0.	0.63775	
	285.	300.	1.243	48.546	12.514	0.			12.514	48.546	-0.	0.63776	
	300.	300.	1.309	49.397	24.630	0.			24.630	49.397	-0.	0.63799	
	315.	300.	1.374	48.804	34.502	0.			34.502	48.804	-0.	0.63822	
	330.	300.	1.440	47.648	44.456	0.			44.456	47.648	-0.	0.63835	
	345.	300.	1.505	46.215	53.807	0.			53.807	46.215	-0.	0.63727	
	360.	300.	1.571	45.993	56.012	0.			56.012	45.993	-0.	0.63635	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 13. EXAMPLE 1, SIDE 3

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	225.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 131 HORIZ. 132 HORIZ. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
	0.	300.	0.	48.071	55.515	0.			55.515	48.071	-0.	0.63583	
	15.	300.	0.065	48.186	53.918	7.730			61.648	48.186	-0.	0.63766	
	30.	300.	0.131	48.898	47.415	30.392			77.806	48.898	-0.	0.63833	
	45.	300.	0.196	49.383	41.014	66.442			107.457	49.383	-0.	0.63823	
	60.	300.	0.262	49.010	31.484	113.424			144.908	49.010	-0.	0.63787	
	75.	300.	0.327	48.246	19.248	168.135			187.383	48.246	-0.	0.63775	
	90.	300.	0.393	49.021	4.373	226.848			231.221	49.021	-0.	0.63775	
	105.	300.	0.458	49.654	0.138	285.560			285.699	49.654	-0.	0.63776	
	120.	300.	0.524	50.337	0.000	340.272			340.272	50.337	-0.	0.63799	
	121.	300.	0.528	50.367	0.	343.683			343.683	50.367	-0.	0.63800	
SH	122.	300.	0.532	50.368	0.	0.			0.	50.368	-0.	0.63801	
SH	135.	300.	0.589	50.336	0.	0.			0.	50.336	-0.	0.63822	
SH	150.	300.	0.654	49.754	0.	0.			0.	49.754	-0.	0.63835	
SH	165.	300.	0.720	48.820	0.	0.			0.	48.820	-0.	0.63727	
SH	180.	300.	0.785	48.638	0.	0.			0.	48.638	-0.	0.63635	
SH	195.	300.	0.851	48.820	0.	0.			0.	48.820	-0.	0.63727	
SH	210.	300.	0.916	49.754	0.	0.			0.	49.754	-0.	0.63835	
SH	225.	300.	0.982	50.336	0.	0.			0.	50.336	-0.	0.63822	
SH	238.	300.	1.038	50.368	0.	0.			0.	50.368	-0.	0.63801	
	239.	300.	1.043	50.367	0.	343.683			343.683	50.367	-0.	0.63801	
	240.	300.	1.047	50.337	0.000	340.272			340.272	50.337	-0.	0.63799	
	255.	300.	1.113	49.654	0.138	285.560			285.699	49.654	-0.	0.63776	
	270.	300.	1.178	49.021	4.373	226.848			231.221	49.021	-0.	0.63775	
	285.	300.	1.243	48.246	19.248	168.135			187.383	48.246	-0.	0.63775	
	300.	300.	1.309	49.010	31.484	113.424			144.908	49.010	-0.	0.63787	
	315.	300.	1.374	49.384	41.015	66.442			107.457	49.384	-0.	0.63823	
	330.	300.	1.440	48.898	47.415	30.392			77.806	48.898	-0.	0.63833	
	345.	300.	1.505	48.187	53.918	7.730			61.648	48.187	-0.	0.63766	
	360.	300.	1.571	48.071	55.515	0.			55.515	48.071	-0.	0.63584	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 14. EXAMPLE 1, SIDE 4

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	315.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 141 HORIZ. 142 HORIZ. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR) (ALL Q	Q(SOL) IN BTU/HR/SQ.FT.)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
	0.	300.	0.	2.032	2.551	453.696			456.247	2.032	-0.	0.02632	
	15.	300.	0.065	2.102	2.556	445.966			448.522	2.102	-0.	0.02726	
	30.	300.	0.131	2.199	2.503	423.304			425.807	2.199	-0.	0.02842	
	45.	300.	0.196	2.197	2.172	387.253			389.425	2.197	-0.	0.02845	
	60.	300.	0.262	2.137	1.814	340.272			342.086	2.137	-0.	0.02834	
	75.	300.	0.327	2.165	1.282	285.560			286.842	2.165	-0.	0.02821	
	90.	300.	0.393	2.201	0.489	226.848			227.337	2.201	-0.	0.02825	
	105.	300.	0.458	2.226	0.033	168.135			168.168	2.226	-0.	0.02821	
	120.	300.	0.524	2.227	0.000	113.424			113.424	2.227	-0.	0.02823	
	121.	300.	0.528	2.227	0.	110.013			110.013	2.227	-0.	0.02823	
SH	122.	300.	0.532	2.227	0.	0.			0.	2.227	-0.	0.02823	
SH	135.	300.	0.589	2.210	0.	0.			0.	2.210	-0.	0.02842	
SH	150.	300.	0.654	2.150	0.	0.			0.	2.150	-0.	0.02837	
SH	165.	300.	0.720	2.078	0.	0.			0.	2.078	-0.	0.02764	
SH	180.	300.	0.785	1.905	0.	0.			0.	1.905	-0.	0.02579	
SH	195.	300.	0.851	2.078	0.	0.			0.	2.078	-0.	0.02764	
SH	210.	300.	0.916	2.150	0.	0.			0.	2.150	-0.	0.02837	
SH	225.	300.	0.982	2.210	0.	0.			0.	2.210	-0.	0.02842	
SH	238.	300.	1.038	2.227	0.	0.			0.	2.227	-0.	0.02823	
	239.	300.	1.043	2.227	0.	110.012			110.012	2.227	-0.	0.02823	
	240.	300.	1.047	2.227	0.000	113.424			113.424	2.227	-0.	0.02823	
	255.	300.	1.113	2.226	0.033	168.135			168.168	2.226	-0.	0.02821	
	270.	300.	1.178	2.201	0.489	226.848			227.337	2.201	-0.	0.02825	
	285.	300.	1.243	2.165	1.282	285.560			286.842	2.165	-0.	0.02821	
	300.	300.	1.309	2.137	1.814	340.272			342.086	2.137	-0.	0.02834	
	315.	300.	1.374	2.197	2.172	387.253			389.425	2.197	-0.	0.02845	
	330.	300.	1.440	2.199	2.503	423.304			425.806	2.199	-0.	0.02842	
	345.	300.	1.505	2.102	2.556	445.966			448.522	2.102	-0.	0.02726	
	360.	300.	1.571	2.032	2.551	453.696			456.247	2.032	-0.	0.02633	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 21. EXAMPLE 2, SIDE 1

ORBIT EARTH RADIUS = 3959. ORIENTATION INERT.

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI	OMEGA (SATELLITE)
2	-15.000	30.000	0.	0.	45.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 211 INERT. 212 INERT. -0 . ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR) (ALL Q IN BTU/HR/SQ.FT.)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
	0.	300.	0.	1.769	2.124	0.000			2.124	1.769	-0.	0.02579	
	15.	300.	0.065	2.347	2.621	0.000			2.621	2.347	-0.	0.03330	
	30.	300.	0.131	3.781	3.861	0.000			3.861	3.781	-0.	0.05302	
	45.	300.	0.196	6.279	4.507	0.000			4.507	6.279	-0.	0.08365	
	60.	300.	0.262	9.938	5.109	0.000			5.109	9.938	-0.	0.12910	
	75.	300.	0.327	15.167	4.450	0.000			4.450	15.167	-0.	0.19680	
	90.	300.	0.393	20.879	1.097	0.000			1.097	20.879	-0.	0.27605	
	105.	300.	0.458	27.198	0.036	0.000			0.036	27.198	-0.	0.35455	
	120.	300.	0.524	33.859	0.	0.000			0.000	33.859	-0.	0.43392	
	121.	300.	0.528	34.467	0.	0.000			0.000	34.467	-0.	0.43897	
SH	122.	300.	0.532	34.858	0.	0.			0.	34.858	-0.	0.44392	
SH	135.	300.	0.589	40.626	0.	0.			0.	40.626	-0.	0.51485	
SH	150.	300.	0.654	45.951	0.	0.			0.	45.951	-0.	0.58127	
SH	165.	300.	0.720	48.871	0.	0.			0.	48.871	-0.	0.62253	
SH	180.	300.	0.785	49.901	0.	0.			0.	49.901	-0.	0.63583	
SH	195.	300.	0.851	48.871	0.	0.			0.	48.871	-0.	0.62253	
SH	210.	300.	0.916	45.951	0.	0.			0.	45.951	-0.	0.58127	
SH	225.	300.	0.982	40.626	0.	0.			0.	40.626	-0.	0.51485	
SH	238.	300.	1.038	34.858	0.	0.			0.	34.858	-0.	0.44393	
	239.	300.	1.043	34.467	0.	0.000			0.000	34.467	-0.	0.43897	
	240.	300.	1.047	33.859	0.	0.000			0.000	33.859	-0.	0.43392	
	255.	300.	1.113	27.198	0.036	0.000			0.036	27.198	-0.	0.35456	
	270.	300.	1.178	20.879	1.097	0.000			1.097	20.879	-0.	0.27605	
	285.	300.	1.243	15.167	4.450	0.000			4.450	15.167	-0.	0.19680	
	300.	300.	1.309	9.938	5.109	0.000			5.109	9.938	-0.	0.12910	
	315.	300.	1.374	6.279	4.507	0.000			4.507	6.279	-0.	0.08365	
	330.	300.	1.440	3.781	3.861	0.000			3.861	3.781	-0.	0.05302	
	345.	300.	1.505	2.347	2.621	0.000			2.621	2.347	-0.	0.03330	
	360.	300.	1.571	1.769	2.124	0.000			2.124	1.769	-0.	0.02579	

LR 18904

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 22. EXAMPLE 2, SIDE 2

ORBIT EARTH RADIUS = 3959. ORIENTATION INERT.

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	135.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 221 INERT. 222 INERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
	0.	300.	0.	45.993	56.012	0.			56.012	45.993	-0.	0.63635	
	15.	300.	0.065	45.255	52.349	0.			52.349	45.255	-0.	0.62352	
	30.	300.	0.131	43.390	39.616	0.			39.616	43.390	-0.	0.58046	
	45.	300.	0.196	39.380	26.654	0.			26.654	39.380	-0.	0.51416	
	60.	300.	0.262	33.725	15.208	0.			15.208	33.725	-0.	0.43642	
	75.	300.	0.327	26.913	4.924	0.			4.924	26.913	-0.	0.35388	
	90.	300.	0.393	21.021	0.	0.			0.	21.021	-0.	0.27605	
	105.	300.	0.458	15.131	0.	0.			0.	15.131	-0.	0.19612	
	120.	300.	0.524	10.287	0.	0.			0.	10.287	-0.	0.13159	
	121.	300.	0.528	10.016	0.	0.			0.	10.016	-0.	0.12748	
SH	122.	300.	0.532	9.691	0.	0.			0.	9.691	-0.	0.12336	
SH	135.	300.	0.589	6.545	0.	0.			0.	6.545	-0.	0.08299	
SH	150.	300.	0.654	4.125	0.	0.			0.	4.125	-0.	0.05224	
SH	165.	300.	0.720	2.710	0.	0.			0.	2.710	-0.	0.03429	
SH	180.	300.	0.785	2.080	0.	0.			0.	2.080	-0.	0.02632	
SH	195.	300.	0.851	2.710	0.	0.			0.	2.710	-0.	0.03429	
SH	210.	300.	0.916	4.125	0.	0.			0.	4.125	-0.	0.05224	
SH	225.	300.	0.982	6.545	0.	0.			0.	6.545	-0.	0.08299	
SH	238.	300.	1.038	9.691	0.	0.			0.	9.691	-0.	0.12336	
	239.	300.	1.043	10.016	0.	0.			0.	10.016	-0.	0.12748	
	240.	300.	1.047	10.287	0.	0.			0.	10.287	-0.	0.13159	
	255.	300.	1.113	15.131	0.	0.			0.	15.131	-0.	0.19612	
	270.	300.	1.178	21.021	0.	0.			0.	21.021	-0.	0.27605	
	285.	300.	1.243	26.913	4.924	0.			4.924	26.913	-0.	0.35388	
	300.	300.	1.309	33.725	15.208	0.			15.208	33.725	-0.	0.43642	
	315.	300.	1.374	39.380	26.654	0.			26.654	39.380	-0.	0.51416	
	330.	300.	1.440	43.390	39.616	0.			39.616	43.390	-0.	0.58046	
	345.	300.	1.505	45.255	52.349	0.			52.349	45.255	-0.	0.62352	
	360.	300.	1.571	45.993	56.012	0.			56.012	45.993	-0.	0.63635	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 23. EXAMPLE 2, SIDE 3

ORBIT EARTH RADIUS = 3959. ORIENTATION INERT.

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	225.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 231 INERT. 232 INERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
	0.	300.	0.	48.071	55.515	0.			55.515	48.071	-0.	0.63583	
	15.	300.	0.065	47.090	52.346	0.			52.346	47.090	-0.	0.62253	
	30.	300.	0.131	44.577	42.606	0.			42.606	44.577	-0.	0.58127	
	45.	300.	0.196	39.897	32.359	0.			32.359	39.897	-0.	0.51485	
	60.	300.	0.262	33.172	20.413	0.			20.413	33.172	-0.	0.43392	
	75.	300.	0.327	26.884	9.422	0.			9.422	26.884	-0.	0.35455	
	90.	300.	0.393	21.392	1.181	0.			1.181	21.392	-0.	0.27605	
	105.	300.	0.458	15.463	0.020	0.			0.020	15.463	-0.	0.19680	
	120.	300.	0.524	10.191	0.000	0.			0.000	10.191	-0.	0.12910	
	121.	300.	0.528	9.865	0.	0.			0.	9.865	-0.	0.12497	
SH	122.	300.	0.532	9.540	0.	0.			0.	9.540	-0.	0.12085	
SH	135.	300.	0.589	6.542	0.	0.			0.	6.542	-0.	0.08365	
SH	150.	300.	0.654	4.021	0.	0.			0.	4.021	-0.	0.05302	
SH	165.	300.	0.720	2.506	0.	0.			0.	2.506	-0.	0.03330	
SH	180.	300.	0.785	1.905	0.	0.			0.	1.905	-0.	0.02579	
SH	195.	300.	0.851	2.506	0.	0.			0.	2.506	-0.	0.03330	
SH	210.	300.	0.916	4.021	0.	0.			0.	4.021	-0.	0.05302	
SH	225.	300.	0.982	6.542	0.	0.			0.	6.542	-0.	0.08365	
SH	238.	300.	1.038	9.540	0.	0.			0.	9.540	-0.	0.12085	
	239.	300.	1.043	9.865	0.	0.			0.	9.865	-0.	0.12497	
	240.	300.	1.047	10.191	0.000	0.			0.000	10.191	-0.	0.12910	
	255.	300.	1.113	15.463	0.020	0.			0.020	15.463	-0.	0.19680	
	270.	300.	1.178	21.392	1.181	0.			1.181	21.392	-0.	0.27605	
	285.	300.	1.243	26.884	9.422	0.			9.422	26.884	-0.	0.35456	
	300.	300.	1.309	33.172	20.413	0.			20.413	33.172	-0.	0.43392	
	315.	300.	1.374	39.897	32.359	0.			32.359	39.897	-0.	0.51485	
	330.	300.	1.440	44.577	42.606	0.			42.606	44.577	-0.	0.58127	
	345.	300.	1.505	47.090	52.346	0.			52.346	47.090	-0.	0.62253	
	360.	300.	1.571	48.071	55.515	0.			55.515	48.071	-0.	0.63584	

TABLE 6-2 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 24. EXAMPLE 2, SIDE 4

ORBIT EARTH RADIUS = 3959. ORIENTATION INERT.

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
2	-15.000	30.000	0.	0.	315.000	0.	0.	15.000	300.	0.		

NON-ZERO CURVES PUNCHED 241 INERT. 242 INERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
	0.	300.	0.	2.032	2.551	453.696			456.247	2.032	-0.	0.02632	
	15.	300.	0.065	2.640	3.178	453.696			456.874	2.640	-0.	0.03429	
	30.	300.	0.131	4.023	4.463	453.696			458.158	4.023	-0.	0.05224	
	45.	300.	0.196	6.425	6.192	453.696			459.888	6.425	-0.	0.08299	
	60.	300.	0.262	10.081	7.824	453.696			461.519	10.081	-0.	0.13159	
	75.	300.	0.327	14.877	7.731	453.696			461.427	14.877	-0.	0.19612	
	90.	300.	0.393	21.158	3.751	453.696			457.446	21.158	-0.	0.27605	
	105.	300.	0.458	27.492	0.183	453.696			453.879	27.492	-0.	0.35388	
	120.	300.	0.524	34.377	0.000	453.696			453.696	34.377	-0.	0.43642	
	121.	300.	0.528	34.832	0.	453.696			453.696	34.832	-0.	0.44148	
SH	122.	300.	0.532	35.223	0.	0.			0.	35.223	-0.	0.44643	
SH	135.	300.	0.589	40.557	0.	0.			0.	40.557	-0.	0.51416	
SH	150.	300.	0.654	45.277	0.	0.			0.	45.277	-0.	0.58046	
SH	165.	300.	0.720	47.790	0.	0.			0.	47.790	-0.	0.62352	
SH	180.	300.	0.785	48.638	0.	0.			0.	48.638	-0.	0.63635	
SH	195.	300.	0.851	47.790	0.	0.			0.	47.790	-0.	0.62352	
SH	210.	300.	0.916	45.277	0.	0.			0.	45.277	-0.	0.58046	
SH	225.	300.	0.982	40.557	0.	0.			0.	40.557	-0.	0.51416	
SH	238.	300.	1.038	35.223	0.	0.			0.	35.223	-0.	0.44643	
	239.	300.	1.043	34.832	0.	453.696			453.696	34.832	-0.	0.44148	
	240.	300.	1.047	34.377	0.000	453.696			453.696	34.377	-0.	0.43642	
	255.	300.	1.113	27.492	0.183	453.696			453.879	27.492	-0.	0.35388	
	270.	300.	1.178	21.158	3.751	453.696			457.446	21.158	-0.	0.27605	
	285.	300.	1.243	14.877	7.731	453.696			461.427	14.877	-0.	0.19612	
	300.	300.	1.309	10.081	7.824	453.696			461.519	10.081	-0.	0.13159	
	315.	300.	1.374	6.425	6.192	453.696			459.888	6.425	-0.	0.08299	
	330.	300.	1.440	4.023	4.463	453.696			458.158	4.023	-0.	0.05224	
	345.	300.	1.505	2.640	3.178	453.696			456.874	2.640	-0.	0.03429	
	360.	300.	1.571	2.032	2.551	453.696			456.247	2.032	-0.	0.02633	

TABLE 6-3. PUNCHED CARD OUTPUT FOR EXAMPLES 1 AND 2

```
DEC    111                                          SOLAR SPEC   HORIZ.  11101
PER01 5654.1627                                                          11102
DEC02    0.          0.0006                                              11103
DEC02  235.5901      0.0006                                              11104
DEC02  471.1802      0.0005                                              11105
DEC02  706.7704      0.0004                                              11106
DEC02  942.3605      0.0002                                              11107
DEC02 1177.9506      0.0001                                              11108
DEC02 1413.5408      0.0000                                              11109
DEC02 1649.1309      0.                                                  11110
DEC02 1884.7210      0.                                                  11111
DEC02 1900.4267      0.                                                  11112
DEC02 1916.1327      0.                                                  11113
DEC02 2120.3111      0.                                                  11114
DEC02 2355.9012      0.                                                  11115
DEC02 2591.4914      0.                                                  11116
DEC02 2827.0817      0.                                                  11117
DEC02 3062.6717      0.                                                  11118
DEC02 3298.2618      0.                                                  11119
DEC02 3533.8519      0.                                                  11120
DEC02 3738.0299      0.                                                  11121
DEC02 3753.7360      0.                                                  11122
DEC02 3769.4420      0.                                                  11123
DEC02 4005.0321      0.                                                  11124
DEC02 4240.6221      0.0000                                              11125
DEC02 4476.2123      0.0001                                              11126
DEC02 4711.8024      0.0002                                              11127
DEC02 4947.3925      0.0004                                              11128
DEC02 5182.9825      0.0005                                              11129
DEC02 5418.5726      0.0006                                              11130
DEC02 5654.1627      0.0006                                              11131
DEC02        0.          0.                                              11132
DEC  - 111                                                               11133
DEC    112                                          INFRA-RED    HORIZ.  11201
PER01 5654.1627                                                          11202
DEC02    0.          0.0005                                              11203
DEC02  235.5901      0.0005                                              11204
DEC02  471.1802      0.0006                                              11205
DEC02  706.7704      0.0006                                              11206
DEC02  942.3605      0.0006                                              11207
DEC02 1177.9506      0.0006                                              11208
DEC02 1413.5408      0.0006                                              11209
DEC02 1649.1309      0.0006                                              11210
DEC02 1884.7210      0.0006                                              11211
DEC02 1900.4267      0.0006                                              11212
DEC02 1916.1327      0.0006                                              11213
DEC02 2120.3111      0.0006                                              11214
DEC02 2355.9012      0.0006                                              11215
DEC02 2591.4914      0.0006                                              11216
DEC02 2827.0817      0.0006                                              11217
DEC02 3062.6717      0.0006                                              11218
DEC02 3298.2618      0.0006                                              11219
DEC02 3533.8519      0.0006                                              11220
DEC02 3738.0299      0.0006                                              11221
DEC02 3753.7360      0.0006                                              11222
DEC02 3769.4420      0.0006                                              11223
DEC02 4005.0321      0.0006                                              11224
DEC02 4240.6221      0.0006                                              11225
DEC02 4476.2123      0.0006                                              11226
DEC02 4711.8024      0.0006                                              11227
DEC02 4947.3925      0.0006                                              11228
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TABLE 6-3 (CONTINUED)

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DEC02 5182.9825     0.0006                                    11229
DEC02 5418.5726     0.0005                                    11230
DEC02 5654.1627     0.0005                                    11231
DEC02        0.        0.                                    11232
DEC  - 112                                                    11233
DEC    121                                  SOLAR SPEC  HORIZ. 12101
PER01 5654.1627                                               12102
DEC02    0.         0.0156                                    12103
DEC02  235.5901     0.0149                                    12104
DEC02  471.1802     0.0123                                    12105
DEC02  706.7704     0.0096                                    12106
DEC02  942.3605     0.0068                                    12107
DEC02 1177.9506     0.0035                                    12108
DEC02 1413.5408     0.0003                                    12109
DEC02 1649.1309     0.0000                                    12110
DEC02 1884.7210     0.                                        12111
DEC02 1900.4267     0.                                        12112
DEC02 1916.1327     0.                                        12113
DEC02 2120.3111     0.                                        12114
DEC02 2355.9012     0.                                        12115
DEC02 2591.4914     0.                                        12116
DEC02 2827.0817     0.                                        12117
DEC02 3062.6717     0.                                        12118
DEC02 3298.2618     0.                                        12119
DEC02 3533.8519     0.                                        12120
DEC02 3738.0299     0.                                        12121
DEC02 3753.7360     0.                                        12122
DEC02 3769.4420     0.                                        12123
DEC02 4005.0321     0.0000                                    12124
DEC02 4240.6221     0.0003                                    12125
DEC02 4476.2123     0.0035                                    12126
DEC02 4711.8024     0.0068                                    12127
DEC02 4947.3925     0.0096                                    12128
DEC02 5182.9825     0.0123                                    12129
DEC02 5418.5726     0.0149                                    12130
DEC02 5654.1627     0.0156                                    12131
DEC02        0.        0.                                    12132
DEC  - 121                                                    12133
DEC    122                                  INFRA-RED   HORIZ. 12201
PER01 5654.1627                                               12202
DEC02    0.         0.0128                                    12203
DEC02  235.5901     0.0128                                    12204
DEC02  471.1802     0.0132                                    12205
DEC02  706.7704     0.0136                                    12206
DEC02  942.3605     0.0137                                    12207
DEC02 1177.9506     0.0135                                    12208
DEC02 1413.5408     0.0134                                    12209
DEC02 1649.1309     0.0136                                    12210
DEC02 1884.7210     0.0139                                    12211
DEC02 1900.4267     0.0139                                    12212
DEC02 1916.1327     0.0139                                    12213
DEC02 2120.3111     0.0140                                    12214
DEC02 2355.9012     0.0140                                    12215
DEC02 2591.4914     0.0139                                    12216
DEC02 2827.0817     0.0139                                    12217
DEC02 3062.6717     0.0139                                    12218
DEC02 3298.2618     0.0140                                    12219
DEC02 3533.8519     0.0140                                    12220
DEC02 3738.0299     0.0139                                    12221
DEC02 3753.7360     0.0139                                    12222
DEC02 3769.4420     0.0139                                    12223
```

TABLE 6-3 (CONTINUED)

```
DEC02 4005.0321    0.0136                                          12224
DEC02 4240.6221    0.0134                                          12225
DEC02 4476.2123    0.0135                                          12226
DEC02 4711.8024    0.0137                                          12227
DEC02 4947.3925    0.0136                                          12228
DEC02 5182.9825    0.0132                                          12229
DEC02 5418.5726    0.0128                                          12230
DEC02 5654.1627    0.0128                                          12231
DEC02        0.       0.                                          12232
DEC  - 122                                                        12233
DEC    131                                  SOLAR SPEC  HORIZ.    13101
PER01 5654.1627                                                   13102
DEC02    0.        0.0154                                         13103
DEC02  235.5901    0.0171                                         13104
DEC02  471.1802    0.0216                                         13105
DEC02  706.7704    0.0298                                         13106
DEC02  942.3605    0.0403                                         13107
DEC02 1177.9506    0.0521                                         13108
DEC02 1413.5408    0.0642                                         13109
DEC02 1649.1309    0.0794                                         13110
DEC02 1884.7210    0.0945                                         13111
DEC02 1900.4267    0.0955                                         13112
DEC02 1916.1327    0.                                             13113
DEC02 2120.3111    0.                                             13114
DEC02 2355.9012    0.                                             13115
DEC02 2591.4914    0.                                             13116
DEC02 2827.0817    0.                                             13117
DEC02 3062.6717    0.                                             13118
DEC02 3298.2618    0.                                             13119
DEC02 3533.8519    0.                                             13120
DEC02 3738.0299    0.                                             13121
DEC02 3753.7360    0.0955                                         13122
DEC02 3769.4420    0.0945                                         13123
DEC02 4005.0321    0.0794                                         13124
DEC02 4240.6221    0.0642                                         13125
DEC02 4476.2123    0.0521                                         13126
DEC02 4711.8024    0.0403                                         13127
DEC02 4947.3925    0.0298                                         13128
DEC02 5182.9825    0.0216                                         13129
DEC02 5418.5726    0.0171                                         13130
DEC02 5654.1627    0.0154                                         13131
DEC02        0.       0.                                          13132
DEC  - 131                                                        13133
DEC    132                                  INFRA-RED   HORIZ.    13201
PER01 5654.1627                                                   13202
DEC02    0.        0.0134                                         13203
DEC02  235.5901    0.0134                                         13204
DEC02  471.1802    0.0136                                         13205
DEC02  706.7704    0.0137                                         13206
DEC02  942.3605    0.0136                                         13207
DEC02 1177.9506    0.0134                                         13208
DEC02 1413.5408    0.0136                                         13209
DEC02 1649.1309    0.0138                                         13210
DEC02 1884.7210    0.0140                                         13211
DEC02 1900.4267    0.0140                                         13212
DEC02 1916.1327    0.0140                                         13213
DEC02 2120.3111    0.0140                                         13214
DEC02 2355.9012    0.0138                                         13215
DEC02 2591.4914    0.0136                                         13216
DEC02 2827.0817    0.0135                                         13217
DEC02 3062.6717    0.0136                                         13218
```

TABLE 6-3 (CONTINUED)

```
DEC02 3298.2618    0.0138                                    13219
DEC02 3533.8519    0.0140                                    13220
DEC02 3738.0299    0.0140                                    13221
DEC02 3753.7360    0.0140                                    13222
DEC02 3769.4420    0.0140                                    13223
DEC02 4005.0321    0.0138                                    13224
DEC02 4240.6221    0.0136                                    13225
DEC02 4476.2123    0.0134                                    13226
DEC02 4711.8024    0.0136                                    13227
DEC02 4947.3925    0.0137                                    13228
DEC02 5182.9825    0.0136                                    13229
DEC02 5418.5726    0.0134                                    13230
DEC02 5654.1627    0.0134                                    13231
DEC02        0.       0.                                    13232
DEC  - 132                                                   13233
DEC    141                              SOLAR SPEC  HORIZ.   14101
PER01 5654.1627                                              14102
DEC02    0.        0.1267                                    14103
DEC02  235.5901    0.1246                                    14104
DEC02  471.1802    0.1183                                    14105
DEC02  706.7704    0.1082                                    14106
DEC02  942.3605    0.0950                                    14107
DEC02 1177.9506    0.0797                                    14108
DEC02 1413.5408    0.0631                                    14109
DEC02 1649.1309    0.0467                                    14110
DEC02 1884.7210    0.0315                                    14111
DEC02 1900.4267    0.0306                                    14112
DEC02 1916.1327    0.                                        14113
DEC02 2120.3111    0.                                        14114
DEC02 2355.9012    0.                                        14115
DEC02 2591.4914    0.                                        14116
DEC02 2827.0817    0.                                        14117
DEC02 3062.6717    0.                                        14118
DEC02 3298.2618    0.                                        14119
DEC02 3533.8519    0.                                        14120
DEC02 3738.0299    0.                                        14121
DEC02 3753.7360    0.0306                                    14122
DEC02 3769.4420    0.0315                                    14123
DEC02 4005.0321    0.0467                                    14124
DEC02 4240.6221    0.0631                                    14125
DEC02 4476.2123    0.0797                                    14126
DEC02 4711.8024    0.0950                                    14127
DEC02 4947.3925    0.1082                                    14128
DEC02 5182.9825    0.1183                                    14129
DEC02 5418.5726    0.1246                                    14130
DEC02 5654.1627    0.1267                                    14131
DEC02        0.       0.                                    14132
DEC  - 141                                                   14133
DEC    142                              INFRA-RED   HORIZ.   14201
PER01 5654.1627                                              14202
DEC02    0.        0.0006                                    14203
DEC02  235.5901    0.0006                                    14204
DEC02  471.1802    0.0006                                    14205
DEC02  706.7704    0.0006                                    14206
DEC02  942.3605    0.0006                                    14207
DEC02 1177.9506    0.0006                                    14208
DEC02 1413.5408    0.0006                                    14209
DEC02 1649.1309    0.0006                                    14210
DEC02 1884.7210    0.0006                                    14211
DEC02 1900.4267    0.0006                                    14212
DEC02 1916.1327    0.0006                                    14213
```


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TABLE 6-3 (CONTINUED)

```
DEC02 2120.3111    0.0006                                  14214
DEC02 2355.9012    0.0006                                  14215
DEC02 2591.4914    0.0006                                  14216
DEC02 2827.0817    0.0005                                  14217
DEC02 3062.6717    0.0006                                  14218
DEC02 3298.2618    0.0006                                  14219
DEC02 3533.8519    0.0006                                  14220
DEC02 3738.0299    0.0006                                  14221
DEC02 3753.7360    0.0006                                  14222
DEC02 3769.4420    0.0006                                  14223
DEC02 4005.0321    0.0006                                  14224
DEC02 4240.6221    0.0006                                  14225
DEC02 4476.2123    0.0006                                  14226
DEC02 4711.8024    0.0006                                  14227
DEC02 4947.3925    0.0006                                  14228
DEC02 5182.9825    0.0006                                  14229
DEC02 5418.5726    0.0006                                  14230
DEC02 5654.1627    0.0006                                  14231
DEC02        0.       0.                                   14232
DEC  - 142                                                 14233
DEC    211                          SOLAR SPEC   INERT.    21101
PER01 5654.1627                                            21102
DEC02    0.        0.0006                                  21103
DEC02  235.5901    0.0007                                  21104
DEC02  471.1802    0.0011                                  21105
DEC02  706.7704    0.0013                                  21106
DEC02  942.3605    0.0014                                  21107
DEC02 1177.9506    0.0012                                  21108
DEC02 1413.5408    0.0003                                  21109
DEC02 1649.1309    0.0000                                  21110
DEC02 1884.7210    0.0000                                  21111
DEC02 1900.4267    0.0000                                  21112
DEC02 1916.1327    0.                                      21113
DEC02 2120.3111    0.                                      21114
DEC02 2355.9012    0.                                      21115
DEC02 2591.4914    0.                                      21116
DEC02 2827.0817    0.                                      21117
DEC02 3062.6717    0.                                      21118
DEC02 3298.2618    0.                                      21119
DEC02 3533.8519    0.                                      21120
DEC02 3738.0299    0.                                      21121
DEC02 3753.7360    0.0000                                  21122
DEC02 3769.4420    0.0000                                  21123
DEC02 4005.0321    0.0000                                  21124
DEC02 4240.6221    0.0003                                  21125
DEC02 4476.2123    0.0012                                  21126
DEC02 4711.8024    0.0014                                  21127
DEC02 4947.3925    0.0013                                  21128
DEC02 5182.9825    0.0011                                  21129
DEC02 5418.5726    0.0007                                  21130
DEC02 5654.1627    0.0006                                  21131
DEC02        0.       0.                                   21132
DEC  - 211                                                 21133
DEC    212                          INFRA-RED    INERT.    21201
PER01 5654.1627                                            21202
DEC02    0.        0.0005                                  21203
DEC02  235.5901    0.0007                                  21204
DEC02  471.1802    0.0011                                  21205
DEC02  706.7704    0.0017                                  21206
DEC02  942.3605    0.0028                                  21207
DEC02 1177.9506    0.0042                                  21208
```

TABLE 6-3 (CONTINUED)

```
DEC02 1413.5408     0.0058                                          21209
DEC02 1649.1309     0.0076                                          21210
DEC02 1884.7210     0.0094                                          21211
DEC02 1900.4267     0.0096                                          21212
DEC02 1916.1327     0.0097                                          21213
DEC02 2120.3111     0.0113                                          21214
DEC02 2355.9012     0.0128                                          21215
DEC02 2591.4914     0.0136                                          21216
DEC02 2827.0817     0.0139                                          21217
DEC02 3062.6717     0.0136                                          21218
DEC02 3298.2618     0.0128                                          21219
DEC02 3533.8519     0.0113                                          21220
DEC02 3738.0299     0.0097                                          21221
DEC02 3753.7360     0.0096                                          21222
DEC02 3769.4420     0.0094                                          21223
DEC02 4005.0321     0.0076                                          21224
DEC02 4240.6221     0.0058                                          21225
DEC02 4476.2123     0.0042                                          21226
DEC02 4711.8024     0.0028                                          21227
DEC02 4947.3925     0.0017                                          21228
DEC02 5182.9825     0.0011                                          21229
DEC02 5418.5726     0.0007                                          21230
DEC02 5654.1627     0.0005                                          21231
DEC02        0.        0.                                          21232
DEC  - 212                                                         21233
DEC    221                                SOLAR SPEC  INFRT.       22101
PER01 5654.1627                                                    22102
DEC02    0.         0.0156                                         22103
DEC02  235.5901     0.0145                                         22104
DEC02  471.1802     0.0110                                         22105
DEC02  706.7704     0.0074                                         22106
DEC02  942.3605     0.0042                                         22107
DEC02 1177.9506     0.0014                                         22108
DEC02 1413.5408     0.                                             22109
DEC02 1649.1309     0.                                             22110
DEC02 1884.7210     0.                                             22111
DEC02 1900.4267     0.                                             22112
DEC02 1916.1327     0.                                             22113
DEC02 2120.3111     0.                                             22114
DEC02 2355.9012     0.                                             22115
DEC02 2591.4914     0.                                             22116
DEC02 2827.0817     0.                                             22117
DEC02 3062.6717     0.                                             22118
DEC02 3298.2618     0.                                             22119
DEC02 3533.8519     0.                                             22120
DEC02 3738.0299     0.                                             22121
DEC02 3753.7360     0.                                             22122
DEC02 3769.4420     0.                                             22123
DEC02 4005.0321     0.                                             22124
DEC02 4240.6221     0.                                             22125
DEC02 4476.2123     0.0014                                         22126
DEC02 4711.8024     0.0042                                         22127
DEC02 4947.3925     0.0074                                         22128
DEC02 5182.9825     0.0110                                         22129
DEC02 5418.5726     0.0145                                         22130
DEC02 5654.1627     0.0156                                         22131
DEC02        0.        0.                                          22132
DEC  - 221                                                         22133
DEC    222                                INFRA-RED   INFRT.       22201
PER01 5654.1627                                                    22202
DEC02    0.         0.0128                                         22203
```

TABLE 6-3 (CONTINUED)

```
DEC02  235.5901    0.0126                                    22204
DEC02  471.1802    0.0121                                    22205
DEC02  706.7704    0.0109                                    22206
DEC02  942.3605    0.0094                                    22207
DEC02 1177.9506    0.0075                                    22208
DEC02 1413.5408    0.0058                                    22209
DEC02 1649.1309    0.0042                                    22210
DEC02 1884.7210    0.0029                                    22211
DEC02 1900.4267    0.0028                                    22212
DEC02 1916.1327    0.0027                                    22213
DEC02 2120.3111    0.0018                                    22214
DEC02 2355.9012    0.0011                                    22215
DEC02 2591.4914    0.0008                                    22216
DEC02 2827.0817    0.0006                                    22217
DEC02 3062.6717    0.0008                                    22218
DEC02 3298.2618    0.0011                                    22219
DEC02 3533.8519    0.0018                                    22220
DEC02 3738.0299    0.0027                                    22221
DEC02 3753.7360    0.0028                                    22222
DEC02 3769.4420    0.0029                                    22223
DEC02 4005.0321    0.0042                                    22224
DEC02 4240.6221    0.0058                                    22225
DEC02 4476.2123    0.0075                                    22226
DEC02 4711.8024    0.0094                                    22227
DEC02 4947.3925    0.0109                                    22228
DEC02 5182.9825    0.0121                                    22229
DEC02 5418.5726    0.0126                                    22230
DEC02 5654.1627    0.0128                                    22231
DEC02        0.        0.                                    22232
DEC  - 222                                                   22233
DEC    231                          SOLAR SPEC  INERT.       23101
PER01 5654.1627                                              23102
DEC02     0.       0.0154                                    23103
DEC02  235.5901    0.0145                                    23104
DEC02  471.1802    0.0118                                    23105
DEC02  706.7704    0.0090                                    23106
DEC02  942.3605    0.0057                                    23107
DEC02 1177.9506    0.0026                                    23108
DEC02 1413.5408    0.0003                                    23109
DEC02 1649.1309    0.0000                                    23110
DEC02 1884.7210    0.0000                                    23111
DEC02 1900.4267    0.                                        23112
DEC02 1916.1327    0.                                        23113
DEC02 2120.3111    0.                                        23114
DEC02 2355.9012    0.                                        23115
DEC02 2591.4914    0.                                        23116
DEC02 2827.0817    0.                                        23117
DEC02 3062.6717    0.                                        23118
DEC02 3298.2618    0.                                        23119
DEC02 3533.8519    0.                                        23120
DEC02 3738.0299    0.                                        23121
DEC02 3753.7360    0.                                        23122
DEC02 3769.4420    0.0000                                    23123
DEC02 4005.0321    0.0000                                    23124
DEC02 4240.6221    0.0003                                    23125
DEC02 4476.2123    0.0026                                    23126
DEC02 4711.8024    0.0057                                    23127
DEC02 4947.3925    0.0090                                    23128
DEC02 5182.9825    0.0118                                    23129
DEC02 5418.5726    0.0145                                    23130
DEC02 5654.1627    0.0154                                    23131
```

TABLE 6-3 (CONTINUED)

```
DEC02          0.          0.                                          23132
DEC  - 231                                                             23133
DEC    232                                  INFRA-RED   INERT.         23201
PER01 5654.1627                                                        23202
DEC02    0.          0.0134                                            23203
DEC02  235.5901      0.0131                                            23204
DEC02  471.1802      0.0124                                            23205
DEC02  706.7704      0.0111                                            23206
DEC02  942.3605      0.0092                                            23207
DEC02 1177.9506      0.0075                                            23208
DEC02 1413.5408      0.0059                                            23209
DEC02 1649.1309      0.0043                                            23210
DEC02 1884.7210      0.0028                                            23211
DEC02 1900.4267      0.0027                                            23212
DEC02 1916.1327      0.0026                                            23213
DEC02 2120.3111      0.0018                                            23214
DEC02 2355.9012      0.0011                                            23215
DEC02 2591.4914      0.0007                                            23216
DEC02 2827.0817      0.0005                                            23217
DEC02 3062.6717      0.0007                                            23218
DEC02 3298.2618      0.0011                                            23219
DEC02 3533.8519      0.0018                                            23220
DEC02 3738.0299      0.0026                                            23221
DEC02 3753.7360      0.0027                                            23222
DEC02 3769.4420      0.0028                                            23223
DEC02 4005.0321      0.0043                                            23224
DEC02 4240.6221      0.0059                                            23225
DEC02 4476.2123      0.0075                                            23226
DEC02 4711.8024      0.0092                                            23227
DEC02 4947.3925      0.0111                                            23228
DEC02 5182.9825      0.0124                                            23229
DEC02 5418.5726      0.0131                                            23230
DEC02 5654.1627      0.0134                                            23231
DEC02          0.          0.                                          23232
DEC  - 232                                                             23233
DEC    241                                  SOLAR SPEC  INERT.         24101
PER01 5654.1627                                                        24102
DEC02    0.          0.1267                                            24103
DEC02  235.5901      0.1269                                            24104
DEC02  471.1802      0.1273                                            24105
DEC02  706.7704      0.1277                                            24106
DEC02  942.3605      0.1282                                            24107
DEC02 1177.9506      0.1282                                            24108
DEC02 1413.5408      0.1271                                            24109
DEC02 1649.1309      0.1261                                            24110
DEC02 1884.7210      0.1260                                            24111
DEC02 1900.4267      0.1260                                            24112
DEC02 1916.1327      0.                                                24113
DEC02 2120.3111      0.                                                24114
DEC02 2355.9012      0.                                                24115
DEC02 2591.4914      0.                                                24116
DEC02 2827.0817      0.                                                24117
DEC02 3062.6717      0.                                                24118
DEC02 3298.2618      0.                                                24119
DEC02 3533.8519      0.                                                24120
DEC02 3738.0299      0.                                                24121
DEC02 3753.7360      0.1260                                            24122
DEC02 3769.4420      0.1260                                            24123
DEC02 4005.0321      0.1261                                            24124
DEC02 4240.6221      0.1271                                            24125
DEC02 4476.2123      0.1282                                            24126
```


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TABLE 6-3 (CONTINUED)

```
DEC02 4711.8024    0.1282                                          24127
DEC02 4947.3925    0.1277                                          24128
DEC02 5182.9825    0.1273                                          24129
DEC02 5418.5726    0.1269                                          24130
DEC02 5654.1627    0.1267                                          24131
DEC02        0.        0.                                         24132
DEC  - 241                                                        24133
DEC    242                                INFRA-RED   INERT.       24201
PER01 5654.1627                                                   24202
DEC02    0.        0.0006                                         24203
DEC02  235.5901    0.0007                                         24204
DEC02  471.1802    0.0011                                         24205
DEC02  706.7704    0.0018                                         24206
DEC02  942.3605    0.0028                                         24207
DEC02 1177.9506    0.0041                                         24208
DEC02 1413.5408    0.0059                                         24209
DEC02 1649.1309    0.0076                                         24210
DEC02 1884.7210    0.0095                                         24211
DEC02 1900.4267    0.0097                                         24212
DEC02 1916.1327    0.0098                                         24213
DEC02 2120.3111    0.0113                                         24214
DEC02 2355.9012    0.0126                                         24215
DEC02 2591.4914    0.0133                                         24216
DEC02 2827.0817    0.0135                                         24217
DEC02 3062.6717    0.0133                                         24218
DEC02 3298.2618    0.0126                                         24219
DEC02 3533.8519    0.0113                                         24220
DEC02 3738.0299    0.0098                                         24221
DEC02 3753.7360    0.0097                                         24222
DEC02 3769.4420    0.0095                                         24223
DEC02 4005.0321    0.0076                                         24224
DEC02 4240.6221    0.0059                                         24225
DEC02 4476.2123    0.0041                                         24226
DEC02 4711.8024    0.0028                                         24227
DEC02 4947.3925    0.0018                                         24228
DEC02 5182.9825    0.0011                                         24229
DEC02 5418.5726    0.0007                                         24230
DEC02 5654.1627    0.0006                                         24231
DEC02        0.        0.                                         24232
DEC  - 242                                                        24233
```

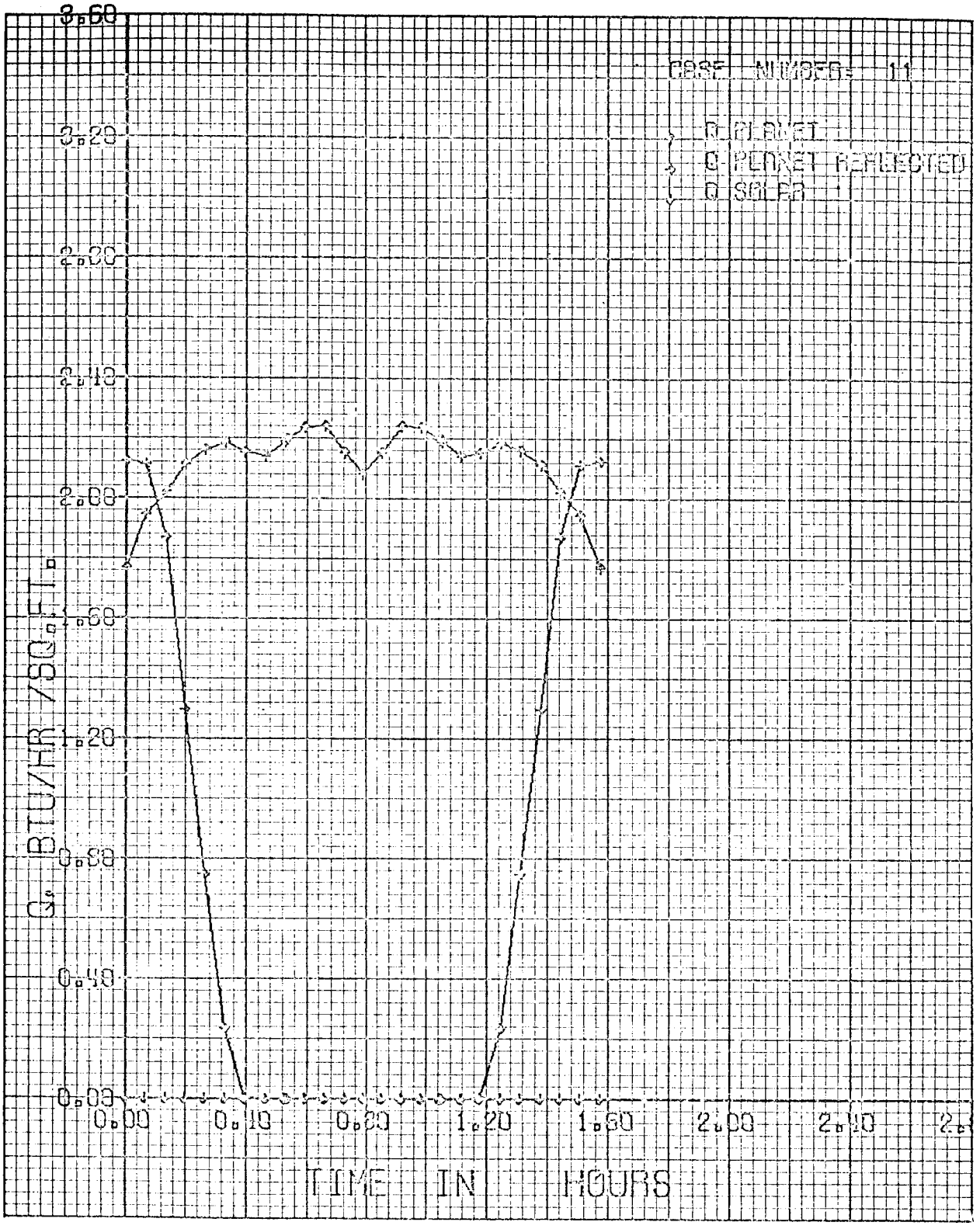

Figure 6-2. Plotted Output for Example 1, Side 1

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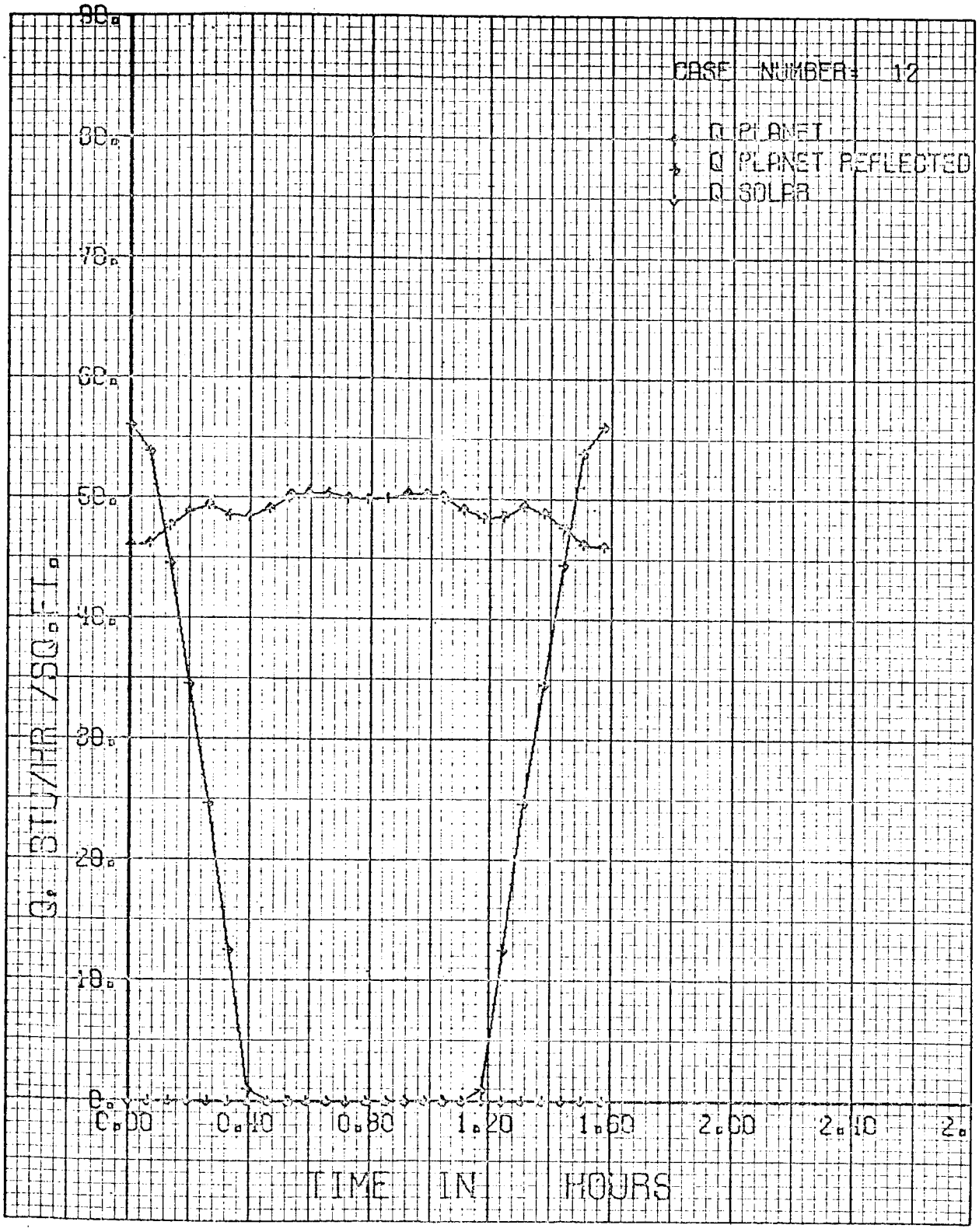

Figure 6-3. Plotted Output for Example 1, Side 2

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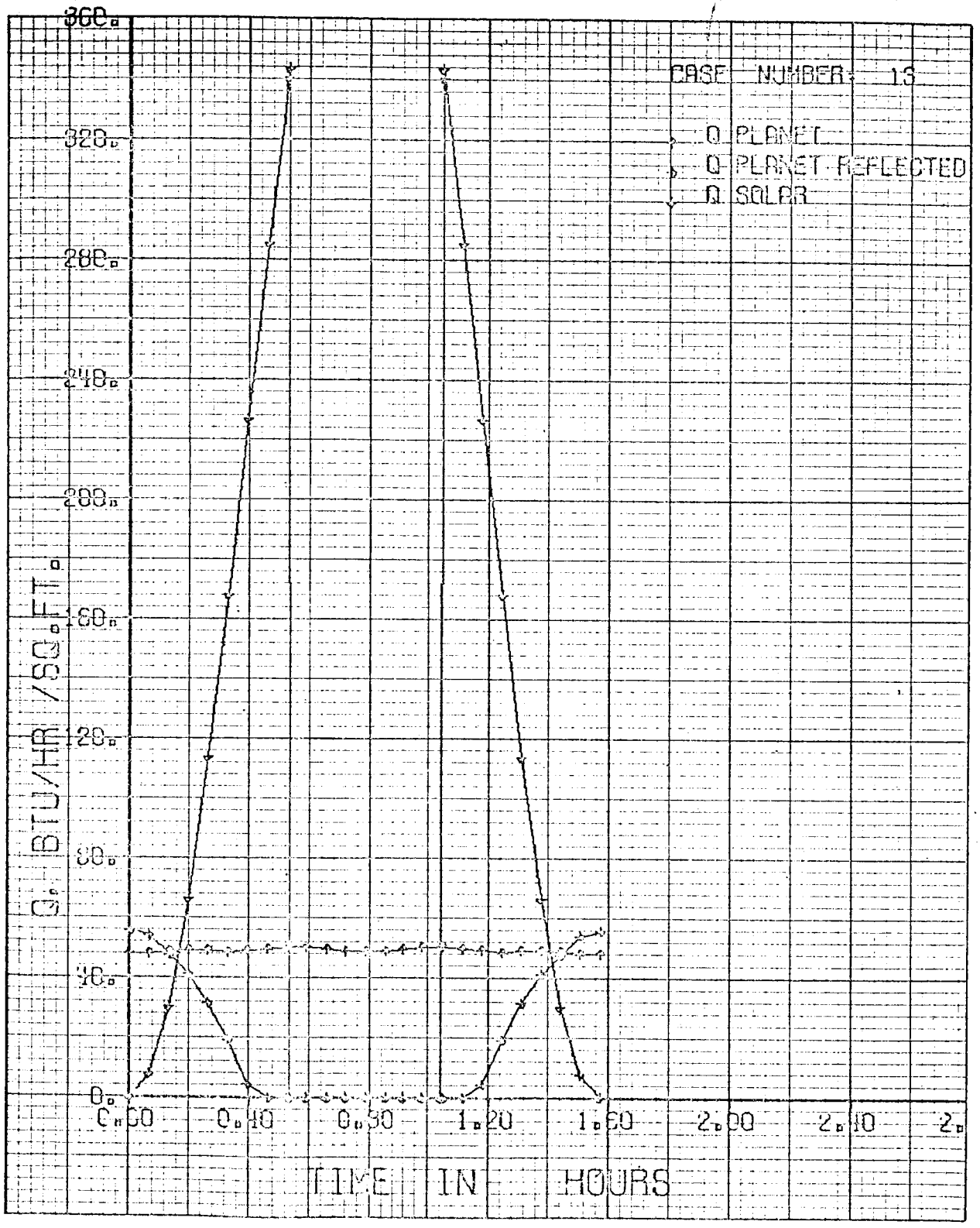

Figure 6-4. Plotted Output for Example 1, Side 3

LOCKHEED
CALIFORNIA COMPANY

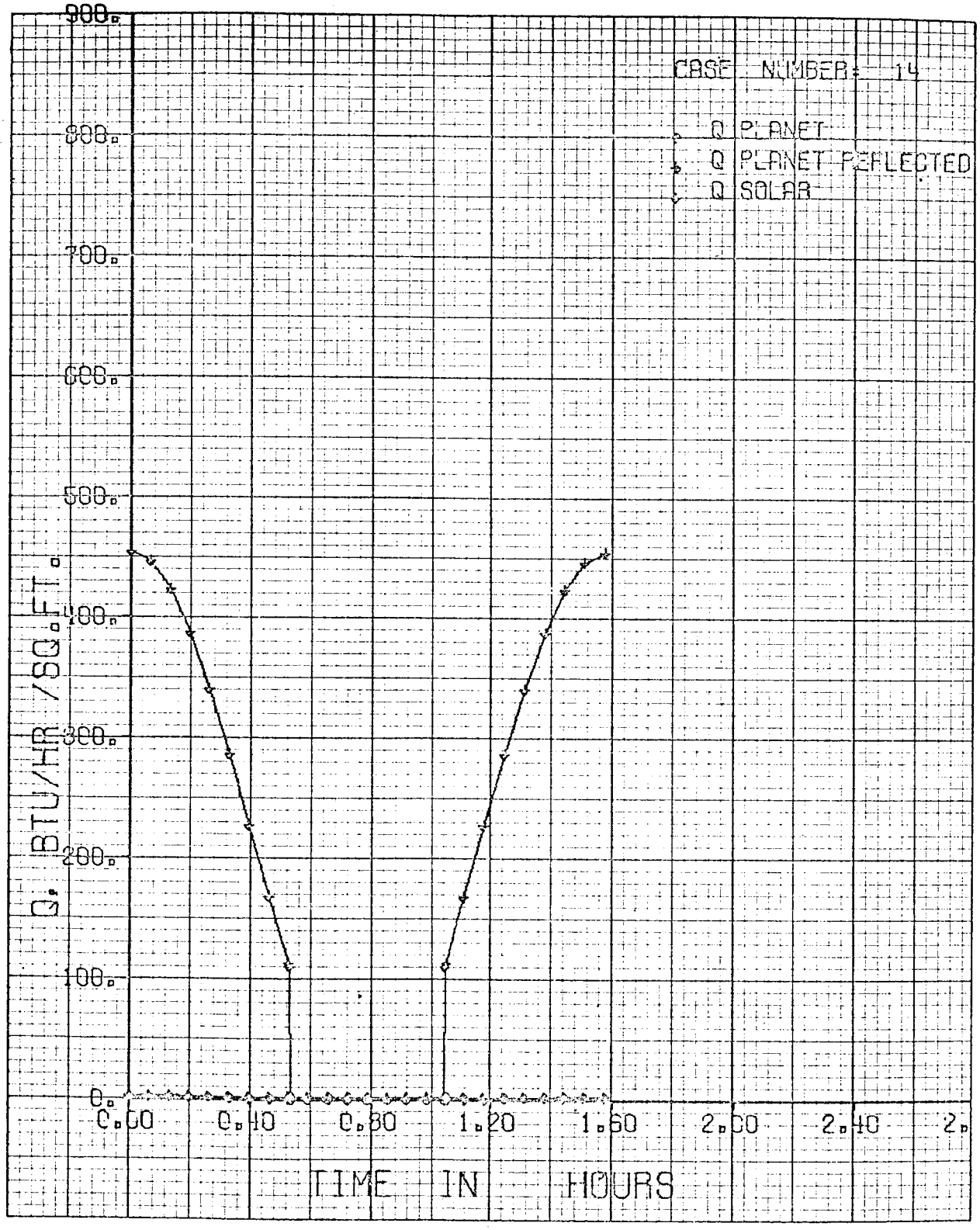

Figure 6-5. Plotted Output for Example 1, Side 4

LOCKHEED
CALIFORNIA COMPANY

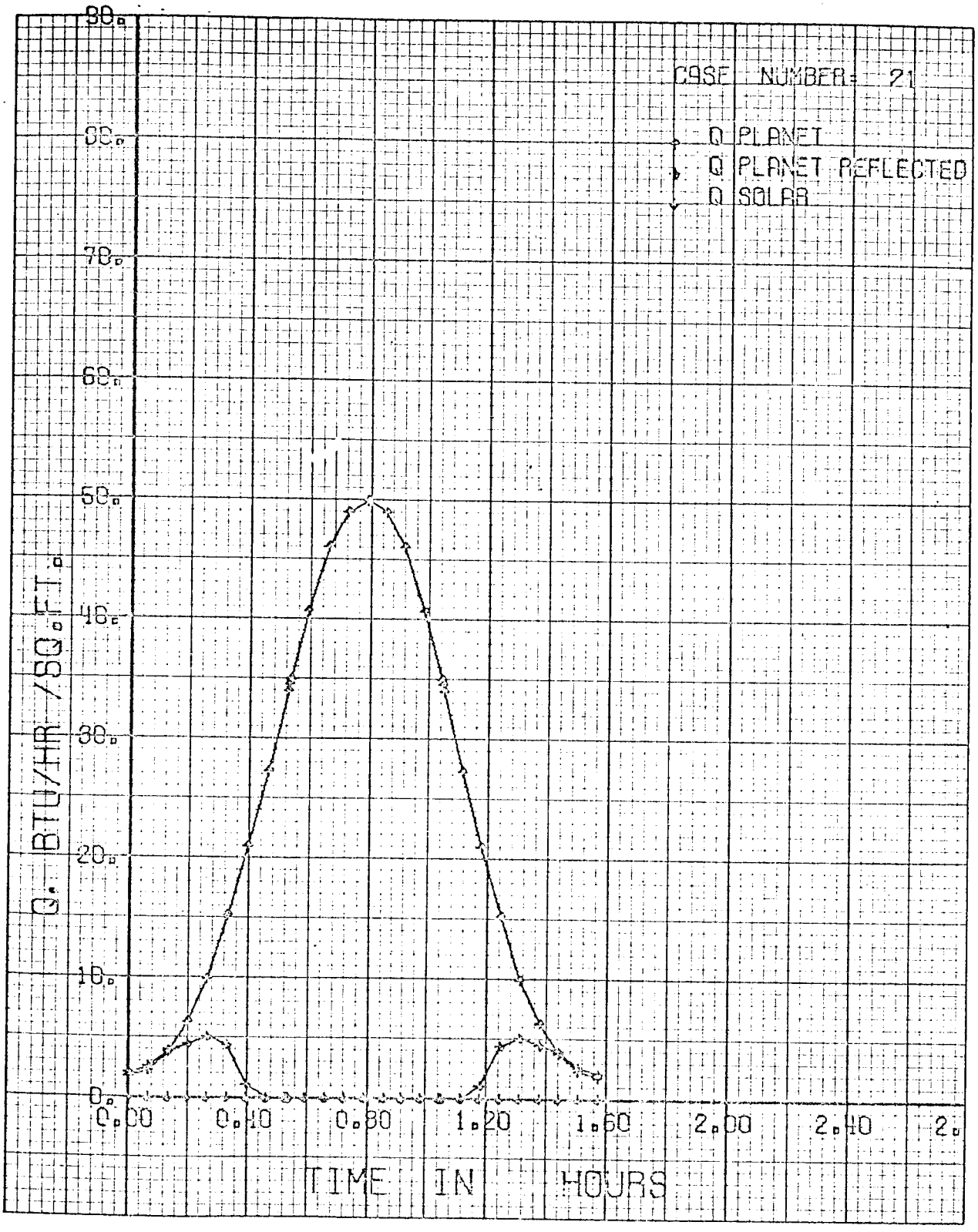

Figure 6-6. Plotted Output for Example 2, Side 1

LOCKHEED
CALIFORNIA COMPANY

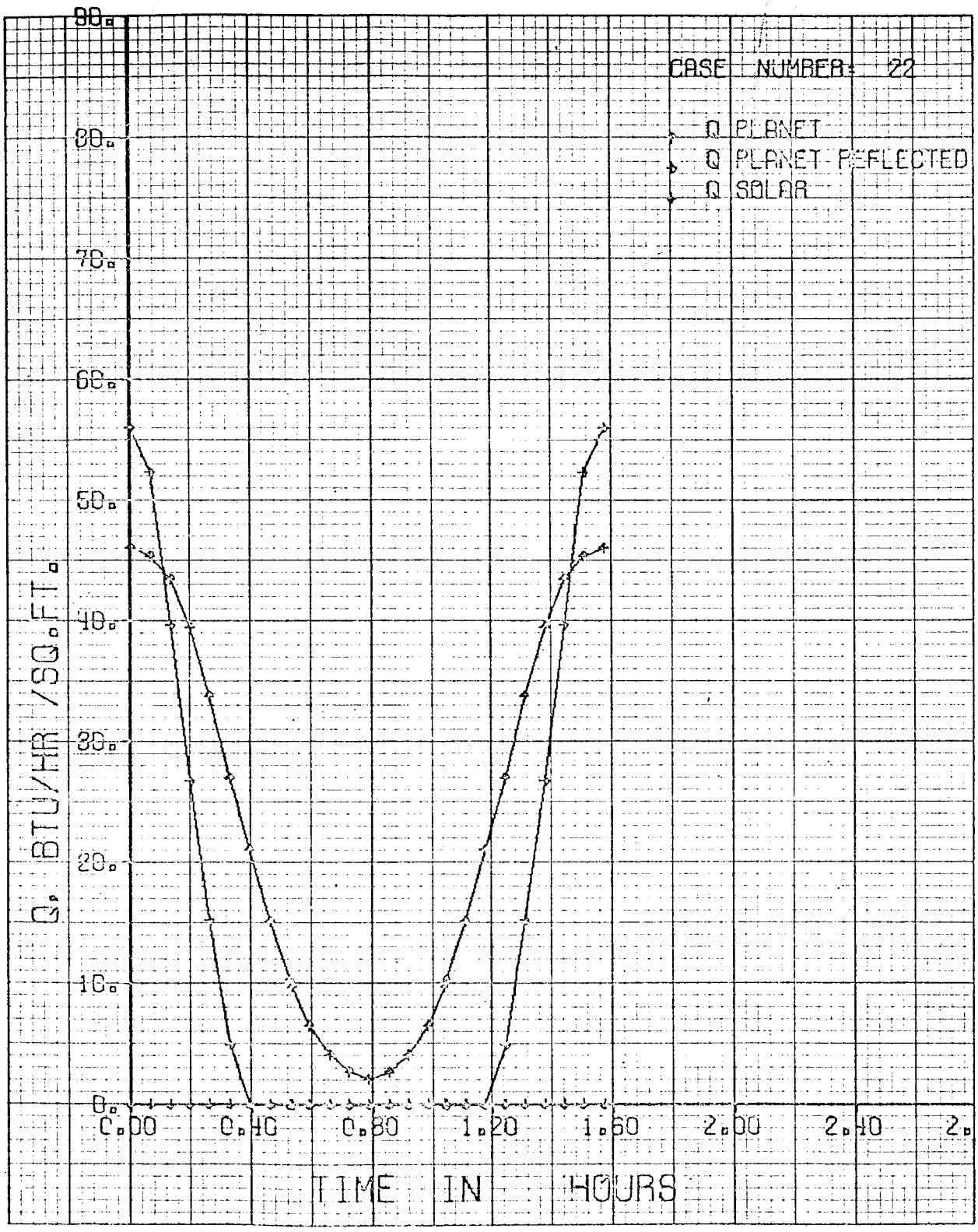

Figure 6-7. Plotted Output for Example 2, Side 2

LOCKHEED
CALIFORNIA COMPANY

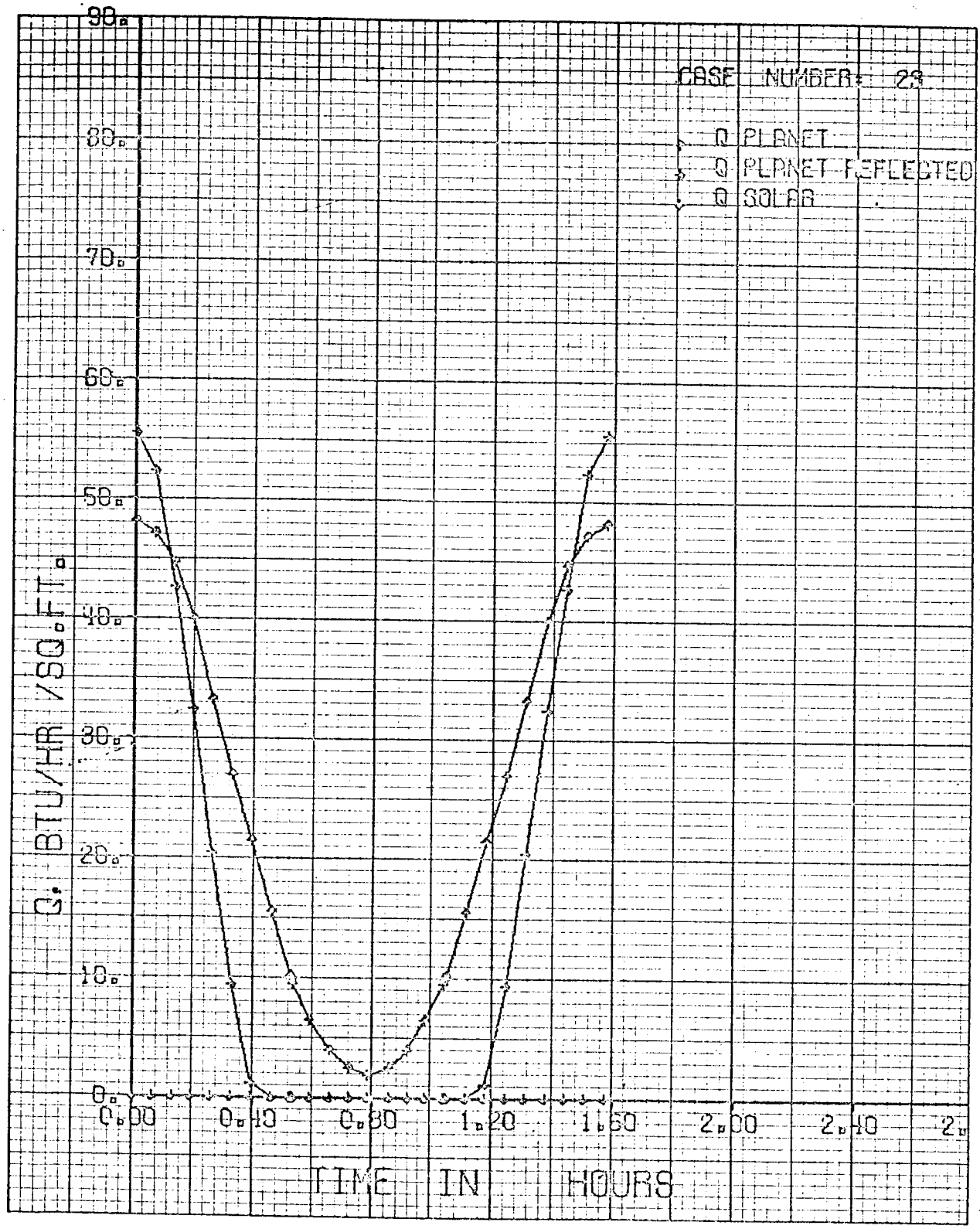

Figure 6-8. Plotted Output for Example 2, Side 3

LOCKHEED
CALIFORNIA COMPANY

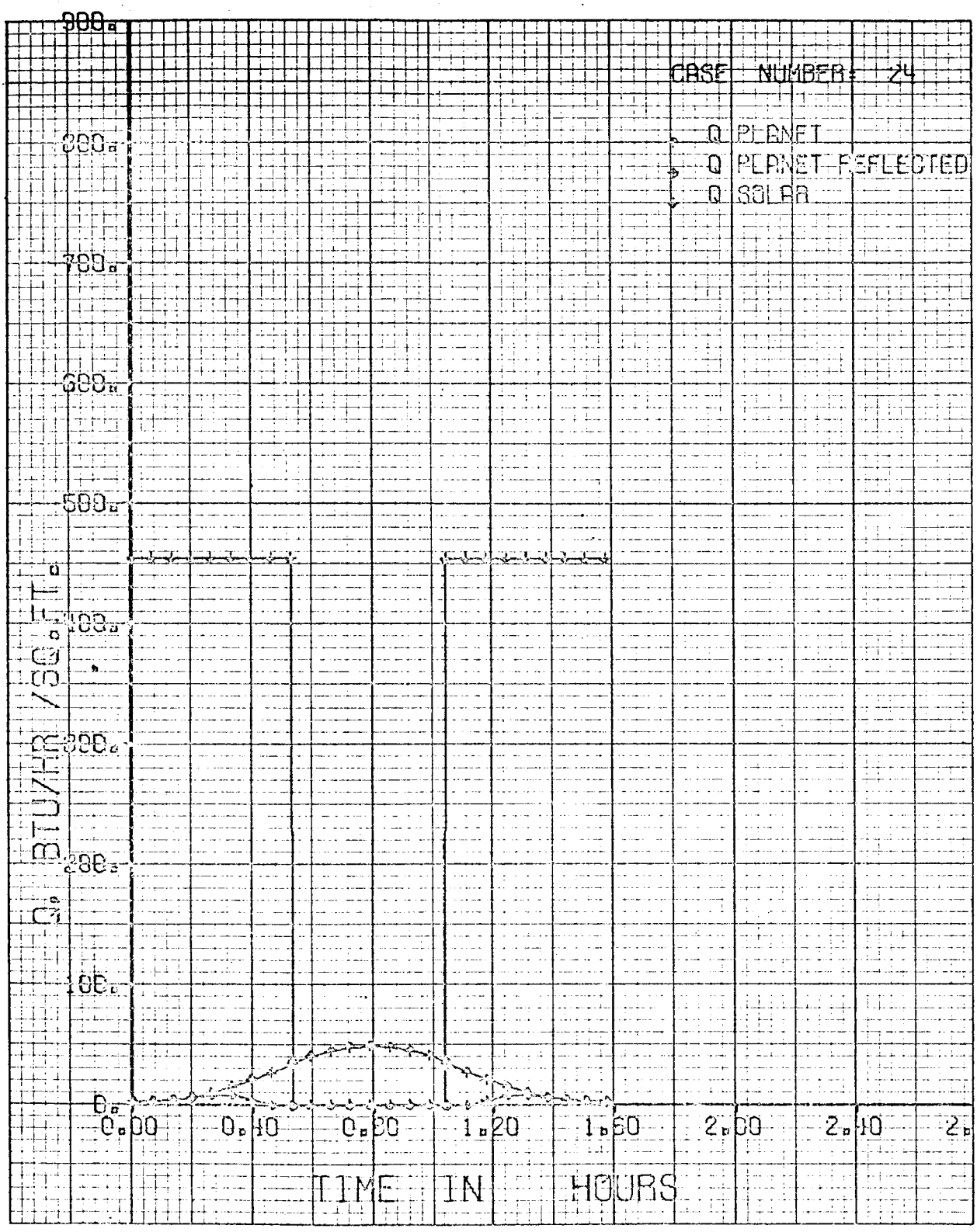

Figure 6-9. Plotted Output for Example 2, Side 4

LOCKHEED
CALIFORNIA COMPANY

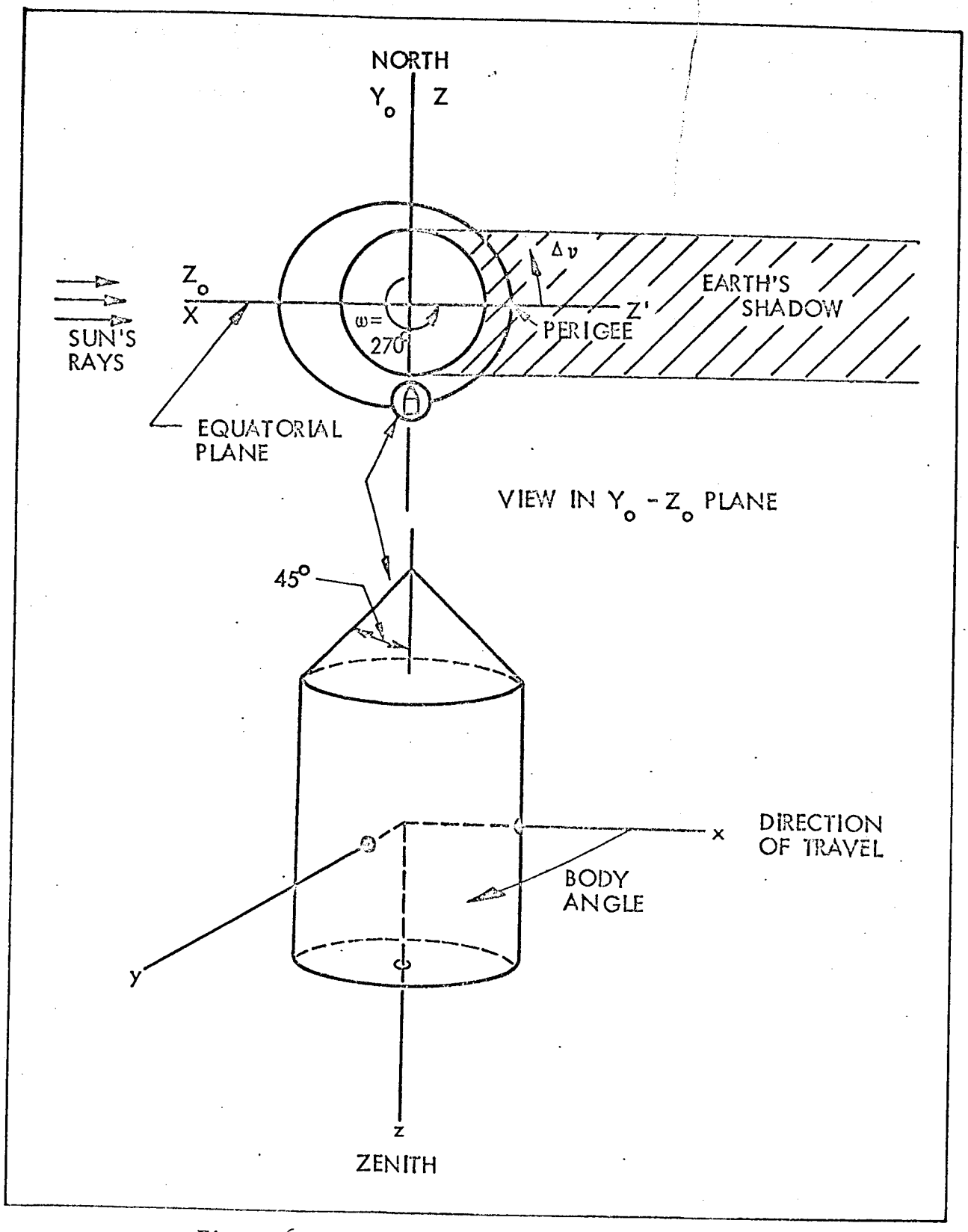

Figure 6-10. Geometry for Examples 3 and 4

LOCKHEED
CALIFORNIA COMPANY

TABLE 6-4

INPUT FOR EXAMPLES 3 AND 4

SEQ.											ID
77 80	1 5	10	15	20	25 30	35	40	45	50	55 60 65 70 72	73 76
3101	11231.	311	VERT.	312	VERT.					EXAMPLE 3, SIDE 1	
3102	03	0.	90.	270.	90.	0.	270.	1000.	.0915	0. 15.	
3103	10.	10.					111				
3201	11232.	321	VERT.	322	VERT.					EXAMPLE 3, SIDE 2	
3202	03	0.	90.	270.	90.	90.	270.	1000.	.0915	0. 15.	
	1 5	10	15	20	25 30	35	40	45	50	55 60 65 70	
3203	10.	10.					111				
3301	11233.	331	VERT.	332	VERT.					EXAMPLE 3, SIDE 3	
3302	03	0.	90.	270.	90.	180.	270.	1000.	.0915	0. 15.	
3303	10.	10.					111				
3401	11234.	341	VERT.	342	VERT.					EXAMPLE 3, SIDE 4	
	1 5	10	15	20	25 30	35	40	45	50	55 60 65 70	
3402	03	0.	90.	270.	90.	270.	270.	1000.	.0915	0. 15.	
3403	10.	10.					111				
4101	11241.	411	CØNE	412	CØNE					EXAMPLE 4, SIDE 1	
4102	03	0.	90.	270.	135.	0.	270.	1000.	.0915	0. 15.	
4103	10.	10.					111				
	1 5	10	15	20	25 30	35	40	45	50	55 60 65 70	
4201	11242.	421	CØNE	422	CØNE					EXAMPLE 4, SIDE 2	
4202	03	0.	90.	270.	180.	45.	270.	1000.	.0915	0. 15.	
4203	10.	10.					111				
4301	11243.	431	CØNE	432	CØNE					EXAMPLE 4, SIDE 3	
4302	03	0.	90.	270.	225.	0.	270.	1000.	.0915	0. 15.	
	1 5	10	15	20	25 30	35	40	45	50	55 60 65 70	
4303	10.	10.					111				
4401	11244.	441	CØNE	442	CØNE					EXAMPLE 4, SIDE 4	
4402	03	0.	90.	270.	180.	315.	270.	1000.	.0915	0. 15.	
4403	10.	10.					111				
4999	0.									END CARD	

TABLE 6-5. TABULAR OUTPUT FOR EXAMPLES 3 AND 4

ORBITAL RADIATION - 2374

CASE 31. EXAMPLE 3, SIDE 1

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	90.000	0.	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 311 VERT. 312 VERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	11.503	0.	0.			0.	11.503	-0.	0.15108	
SH	15.	1014.	0.079	11.409	0.	0.			0.	11.409	-0.	0.14930	
SH	30.	1056.	0.159	10.024	0.	0.			0.	10.024	-0.	0.14354	
SH	45.	1125.	0.240	8.552	0.	0.			0.	8.552	-0.	0.13150	
SH	50.	1153.	0.268	7.547	0.	0.			0.	7.547	-0.	0.12352	
	51.	1159.	0.273	8.070	0.	347.649			347.649	8.070	-0.	0.13295	
	60.	1217.	0.324	7.891	0.053	387.408			387.461	7.891	-0.	0.13693	
	75.	1329.	0.412	9.155	1.422	432.098			433.519	9.155	-0.	0.16790	
	90.	1454.	0.503	6.686	5.313	447.340			452.654	6.686	-0.	0.11723	
	105.	1585.	0.599	5.793	7.613	432.098			439.710	5.793	-0.	0.09221	
	120.	1713.	0.700	6.062	8.664	387.408			396.072	6.062	-0.	0.08800	
	135.	1828.	0.805	5.914	8.150	316.318			324.468	5.914	-0.	0.07877	
	150.	1920.	0.914	5.989	9.592	223.670			233.262	5.989	-0.	0.07824	
	165.	1978.	1.026	5.809	10.327	115.780			126.107	5.809	-0.	0.07590	
	180.	1999.	1.139	5.831	9.269	0.000			9.269	5.831	-0.	0.07510	
	195.	1978.	1.253	5.839	7.850	0.			7.850	5.839	-0.	0.07596	
	210.	1920.	1.365	5.578	8.033	0.			8.033	5.578	-0.	0.07808	
	225.	1828.	1.474	5.370	6.925	0.			6.925	5.370	-0.	0.07817	
	240.	1713.	1.579	5.509	5.116	0.			5.116	5.509	-0.	0.08925	
	255.	1585.	1.679	5.865	1.229	0.			1.229	5.865	-0.	0.09808	
	270.	1454.	1.775	6.340	0.	0.			0.	6.340	-0.	0.10262	
	285.	1329.	1.867	7.204	0.	0.			0.	7.204	-0.	0.10759	
	300.	1217.	1.955	8.927	0.	0.			0.	8.927	-0.	0.12487	
	309.	1159.	2.005	9.737	0.	0.			0.	9.737	-0.	0.13125	
SH	310.	1153.	2.011	9.786	0.	0.			0.	9.786	-0.	0.13195	
SH	315.	1125.	2.039	10.012	0.	0.			0.	10.012	-0.	0.13520	
SH	330.	1056.	2.120	11.218	0.	0.			0.	11.218	-0.	0.14362	
SH	345.	1014.	2.200	11.556	0.	0.			0.	11.556	-0.	0.14915	
SH	360.	1000.	2.279	11.503	0.	0.			0.	11.503	-0.	0.15108	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 32. EXAMPLE 3, SIDE 2

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	90.000	90.000	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 321 VERT. 322 VERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	11.549	0.	0.			0.	11.549	-0.	0.15074	
SH	15.	1014.	0.079	11.326	0.	0.			0.	11.326	-0.	0.14833	
SH	30.	1056.	0.159	10.486	0.	0.			0.	10.486	-0.	0.14126	
SH	45.	1125.	0.240	9.016	0.	0.			0.	9.016	-0.	0.12694	
SH	50.	1153.	0.268	7.994	0.	0.			0.	7.994	-0.	0.11957	
	51.	1159.	0.273	8.475	0.	0.000			0.000	8.475	-0.	0.12795	
	60.	1217.	0.324	7.697	0.005	0.000			0.005	7.697	-0.	0.12229	
	75.	1329.	0.412	6.919	0.250	0.000			0.250	6.919	-0.	0.11783	
	90.	1454.	0.503	7.202	1.702	0.000			1.702	7.202	-0.	0.12618	
	105.	1585.	0.599	5.862	4.427	0.000			4.427	5.862	-0.	0.09897	
	120.	1713.	0.700	5.613	6.477	0.000			6.477	5.613	-0.	0.08822	
	135.	1828.	0.805	5.684	7.450	0.000			7.450	5.684	-0.	0.08223	
	150.	1920.	0.914	5.773	7.921	0.000			7.921	5.773	-0.	0.07824	
	165.	1978.	1.026	5.733	8.647	0.000			8.647	5.733	-0.	0.07597	
	180.	1999.	1.139	5.763	9.580	0.000			9.580	5.763	-0.	0.07507	
	195.	1978.	1.253	5.858	9.317	0.000			9.317	5.858	-0.	0.07595	
	210.	1920.	1.365	5.935	8.282	0.000			8.283	5.935	-0.	0.07821	
	225.	1828.	1.474	6.006	7.428	0.000			7.428	6.006	-0.	0.08116	
	240.	1713.	1.579	5.967	7.560	0.000			7.560	5.967	-0.	0.08755	
	255.	1585.	1.679	6.022	5.323	0.000			5.323	6.022	-0.	0.09430	
	270.	1454.	1.775	6.335	2.004	0.000			2.004	6.335	-0.	0.10254	
	285.	1329.	1.867	7.074	0.285	0.000			0.285	7.074	-0.	0.11178	
	300.	1217.	1.955	8.236	0.005	0.000			0.005	8.236	-0.	0.12169	
	309.	1159.	2.005	8.371	0.	0.000			0.000	8.371	-0.	0.11787	
SH	310.	1153.	2.011	8.485	0.	0.			0.	8.485	-0.	0.11956	
SH	315.	1125.	2.039	8.981	0.	0.			0.	8.981	-0.	0.12693	
SH	330.	1056.	2.120	10.771	0.	0.			0.	10.771	-0.	0.14124	
SH	345.	1014.	2.200	11.509	0.	0.			0.	11.509	-0.	0.14830	
SH	360.	1000.	2.279	11.548	0.	0.			0.	11.548	-0.	0.15073	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 33. EXAMPLE 3, SIDE 3

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	90.000	180.000	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 331 VERT. 332 VERT. . -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	11.742	0.	0.			0.	11.742	-0.	0.15108	
SH	15.	1014.	0.079	11.397	0.	0.			0.	11.397	-0.	0.14915	
SH	30.	1056.	0.159	10.999	0.	0.			0.	10.999	-0.	0.14362	
SH	45.	1125.	0.240	10.155	0.	0.			0.	10.155	-0.	0.13520	
SH	50.	1153.	0.268	9.449	0.	0.			0.	9.449	-0.	0.13195	
	51.	1159.	0.273	9.355	0.	0.			0.	9.355	-0.	0.13130	
	60.	1217.	0.324	8.406	0.	0.			0.	8.406	-0.	0.12487	
	75.	1329.	0.412	6.688	0.	0.			0.	6.688	-0.	0.10759	
	90.	1454.	0.503	6.725	0.	0.			0.	6.725	-0.	0.11789	
	105.	1585.	0.599	7.592	1.125	0.			1.125	7.592	-0.	0.13845	
	120.	1713.	0.700	5.782	4.235	0.			4.235	5.782	-0.	0.10119	
	135.	1828.	0.805	4.901	6.007	0.			6.007	4.901	-0.	0.07975	
	150.	1920.	0.914	5.289	7.445	0.			7.445	5.289	-0.	0.07808	
	165.	1978.	1.026	5.454	7.958	0.			7.958	5.454	-0.	0.07596	
	180.	1999.	1.139	5.714	8.806	0.			8.806	5.714	-0.	0.07510	
	195.	1978.	1.253	5.793	10.157	115.780			125.937	5.793	-0.	0.07590	
	210.	1920.	1.365	6.079	10.055	223.670			233.725	6.079	-0.	0.07824	
	225.	1828.	1.474	6.376	8.917	316.317			325.234	6.376	-0.	0.08236	
	240.	1713.	1.579	6.378	9.291	387.406			396.699	6.378	-0.	0.08800	
	255.	1585.	1.679	6.233	9.305	432.098			441.402	6.233	-0.	0.09221	
	270.	1454.	1.775	6.387	6.275	447.340			453.615	6.387	-0.	0.10338	
	285.	1329.	1.867	6.827	1.584	432.098			433.682	6.827	-0.	0.11481	
	300.	1217.	1.955	7.786	0.058	387.408			387.467	7.786	-0.	0.12556	
	309.	1159.	2.005	8.056	0.	347.649			347.649	8.056	-0.	0.12152	
SH	310.	1153.	2.011	8.185	0.	0.			0.	8.185	-0.	0.12352	
SH	315.	1125.	2.039	8.698	0.	0.			0.	8.698	-0.	0.13150	
SH	330.	1056.	2.120	10.458	0.	0.			0.	10.458	-0.	0.14354	
SH	345.	1014.	2.200	11.380	0.	0.			0.	11.380	-0.	0.14930	
SH	360.	1000.	2.279	11.742	0.	0.			0.	11.742	-0.	0.15108	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 34. EXAMPLE 3, SIDE 4

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	90.000	270.000	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 341 VERT. 342 VERT. -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	11.559	0.	0.			0.	11.559	-0.	0.15087	
SH	15.	1014.	0.079	11.335	0.	0.			0.	11.335	-0.	0.14846	
SH	30.	1056.	0.159	10.496	0.	0.			0.	10.496	-0.	0.14139	
SH	45.	1125.	0.240	9.312	0.	0.			0.	9.312	-0.	0.13131	
SH	50.	1153.	0.268	8.430	0.	0.			0.	8.430	-0.	0.12632	
	51.	1159.	0.273	8.486	0.	0.			0.	8.486	-0.	0.12812	
	60.	1217.	0.324	7.707	0.005	0.			0.005	7.707	-0.	0.12246	
	75.	1329.	0.412	6.908	0.246	0.			0.246	6.908	-0.	0.11763	
	90.	1454.	0.503	6.738	1.698	0.			1.698	6.738	-0.	0.11821	
	105.	1585.	0.599	5.854	4.419	0.			4.419	5.854	-0.	0.09880	
	120.	1713.	0.700	5.603	6.463	0.			6.463	5.603	-0.	0.08805	
	135.	1828.	0.805	5.673	7.433	0.			7.433	5.673	-0.	0.08207	
	150.	1920.	0.914	5.739	7.884	0.			7.884	5.739	-0.	0.07775	
	165.	1978.	1.026	5.723	8.629	0.			8.629	5.723	-0.	0.07583	
	180.	1999.	1.139	5.755	9.564	0.			9.564	5.755	-0.	0.07496	
	195.	1978.	1.253	5.851	9.305	0.			9.305	5.851	-0.	0.07586	
	210.	1920.	1.365	5.904	8.251	0.			8.251	5.904	-0.	0.07779	
	225.	1828.	1.474	5.808	7.269	0.			7.269	5.808	-0.	0.07838	
	240.	1713.	1.579	5.960	7.546	0.			7.546	5.960	-0.	0.08743	
	255.	1585.	1.679	6.034	5.332	0.			5.332	6.034	-0.	0.09450	
	270.	1454.	1.775	6.894	2.067	0.			2.067	6.894	-0.	0.11160	
	285.	1329.	1.867	7.078	0.282	0.			0.282	7.078	-0.	0.11186	
	300.	1217.	1.955	8.246	0.005	0.			0.005	8.246	-0.	0.12184	
	309.	1159.	2.005	8.871	0.	0.			0.	8.871	-0.	0.12510	
SH	310.	1153.	2.011	8.952	0.	0.			0.	8.952	-0.	0.12632	
SH	315.	1125.	2.039	9.280	0.	0.			0.	9.280	-0.	0.13132	
SH	330.	1056.	2.120	10.784	0.	0.			0.	10.784	-0.	0.14141	
SH	345.	1014.	2.200	11.523	0.	0.			0.	11.523	-0.	0.14848	
SH	360.	1000.	2.279	11.560	0.	0.			0.	11.560	-0.	0.15088	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 41. EXAMPLE 4, SIDE 1

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SCLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
3	0.	90.000	270.000	135.000	0.	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 411 CONE 412 CONE -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	34.282	0.	0.			0.	34.282	-0.	0.44960	
SH	15.	1014.	0.079	34.191	0.	0.			0.	34.191	-0.	0.44779	
SH	30.	1056.	0.159	31.944	0.	0.			0.	31.944	-0.	0.44071	
SH	45.	1125.	0.240	28.853	0.	0.			0.	28.853	-0.	0.42256	
SH	50.	1153.	0.268	26.194	0.	0.			0.	26.194	-0.	0.40969	
	51.	1159.	0.273	26.991	0.	444.890			444.890	26.991	-0.	0.42564	
	60.	1217.	0.324	25.894	0.070	432.098			432.168	25.894	-0.	0.43055	
	75.	1329.	0.412	28.295	2.106	387.408			389.514	28.295	-0.	0.50555	
	90.	1454.	0.503	30.196	10.626	316.318			326.944	30.196	-0.	0.54501	
	105.	1585.	0.599	22.959	22.689	223.670			246.359	22.959	-0.	0.38707	
	120.	1713.	0.700	22.426	29.714	115.780			145.495	22.426	-0.	0.34580	
	135.	1828.	0.805	23.439	32.674	0.000			32.674	23.439	-0.	0.33121	
	150.	1920.	0.914	24.010	34.977	0.			34.977	24.010	-0.	0.32042	
	165.	1978.	1.026	23.926	38.416	0.			38.416	23.926	-0.	0.31443	
	180.	1999.	1.139	24.035	40.934	0.			40.934	24.035	-0.	0.31215	
	195.	1978.	1.253	24.271	37.717	0.			37.717	24.271	-0.	0.31452	
	210.	1920.	1.365	23.860	33.642	0.			33.642	23.860	-0.	0.32019	
	225.	1828.	1.474	23.229	29.770	0.			29.770	23.229	-0.	0.32265	
	240.	1713.	1.579	22.620	28.317	0.			28.317	22.620	-0.	0.34607	
	255.	1585.	1.679	22.712	15.788	0.			15.788	22.712	-0.	0.37081	
	270.	1454.	1.775	24.458	3.555	0.			3.555	24.458	-0.	0.40417	
	285.	1329.	1.867	25.312	0.130	0.			0.130	25.312	-0.	0.39758	
	300.	1217.	1.955	28.601	0.000	0.			0.000	28.601	-0.	0.41429	
	309.	1159.	2.005	30.309	0.	0.			0.	30.309	-0.	0.42001	
SH	310.	1153.	2.011	30.410	0.	0.			0.	30.410	-0.	0.42151	
SH	315.	1125.	2.039	30.835	0.	0.			0.	30.835	-0.	0.42785	
SH	330.	1056.	2.120	34.073	0.	0.			0.	34.073	-0.	0.44084	
SH	345.	1014.	2.200	34.832	0.	0.			0.	34.832	-0.	0.44755	
SH	360.	1000.	2.279	34.282	0.	0.			0.	34.282	-0.	0.44960	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 42. EXAMPLE 4, SIDE 2

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	180.000	45.000	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 421 CONE 422 CONE -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	34.442	0.	0.			0.	34.442	-0.	0.44952	
SH	15.	1014.	0.079	34.177	0.	0.			0.	34.177	-0.	0.44766	
SH	30.	1056.	0.159	32.630	0.	0.			0.	32.630	-0.	0.44071	
SH	45.	1125.	0.240	29.758	0.	0.			0.	29.758	-0.	0.42188	
SH	50.	1153.	0.268	27.216	0.	0.			0.	27.216	-0.	0.41075	
	51.	1159.	0.273	27.886	0.	199.065			199.065	27.886	-0.	0.42435	
	60.	1217.	0.324	26.242	0.033	158.159			158.192	26.242	-0.	0.42184	
	75.	1329.	0.412	26.557	1.104	81.869			82.973	26.557	-0.	0.46306	
	90.	1454.	0.503	30.551	6.872	0.000			6.872	30.551	-0.	0.55111	
	105.	1585.	0.599	24.236	18.108	0.			18.108	24.236	-0.	0.41989	
	120.	1713.	0.700	22.236	26.593	0.			26.593	22.236	-0.	0.35525	
	135.	1828.	0.805	22.730	31.171	0.			31.171	22.730	-0.	0.33201	
	150.	1920.	0.914	23.539	33.485	0.			33.485	23.539	-0.	0.32065	
	165.	1978.	1.026	23.682	36.754	0.			36.754	23.682	-0.	0.31457	
	180.	1999.	1.139	23.958	40.617	0.			40.617	23.958	-0.	0.31223	
	195.	1978.	1.253	24.243	39.357	0.			39.357	24.243	-0.	0.31454	
	210.	1920.	1.365	24.236	35.093	0.			35.093	24.236	-0.	0.32060	
	225.	1828.	1.474	24.080	31.291	0.			31.291	24.080	-0.	0.32759	
	240.	1713.	1.579	23.239	31.279	0.			31.279	23.239	-0.	0.34527	
	255.	1585.	1.679	22.963	21.491	0.			21.491	22.963	-0.	0.36651	
	270.	1454.	1.775	24.098	7.940	0.			7.940	24.098	-0.	0.39833	
	285.	1329.	1.867	25.041	1.231	81.869			83.100	25.041	-0.	0.40258	
	300.	1217.	1.955	27.783	0.036	158.159			158.195	27.783	-0.	0.41448	
	309.	1159.	2.005	28.776	0.	199.065			199.065	28.776	-0.	0.40802	
SH	310.	1153.	2.011	28.957	0.	0.			0.	28.957	-0.	0.41074	
SH	315.	1125.	2.039	29.690	0.	0.			0.	29.690	-0.	0.42187	
SH	330.	1056.	2.120	33.542	0.	0.			0.	33.542	-0.	0.44068	
SH	345.	1014.	2.200	34.717	0.	0.			0.	34.717	-0.	0.44762	
SH	360.	1000.	2.279	34.441	0.	0.			0.	34.441	-0.	0.44951	

TABLE 6-5 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 43. EXAMPLE 4, SIDE 3

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
3	0.	90.000	270.000	225.000	0.	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 431 CONE 432 CONE -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	34.616	0.	0.			0.	34.616	-0.	0.44960	
SH	15.	1014.	0.079	34.162	0.	0.			0.	34.162	-0.	0.44755	
SH	30.	1056.	0.159	33.305	0.	0.			0.	33.305	-0.	0.44084	
SH	45.	1125.	0.240	31.105	0.	0.			0.	31.105	-0.	0.42785	
SH	50.	1153.	0.268	28.860	0.	0.			0.	28.860	-0.	0.42151	
	51.	1159.	0.273	28.808	0.	0.			0.	28.808	-0.	0.42361	
	60.	1217.	0.324	26.652	0.000	0.			0.000	26.652	-0.	0.41429	
	75.	1329.	0.412	24.806	0.115	0.			0.115	24.806	-0.	0.42032	
	90.	1454.	0.503	30.251	3.118	0.			3.118	30.251	-0.	0.54594	
	105.	1585.	0.599	25.503	13.516	0.			13.516	25.503	-0.	0.45248	
	120.	1713.	0.700	22.031	23.450	0.			23.450	22.031	-0.	0.36446	
	135.	1828.	0.805	22.006	29.644	0.			29.644	22.006	-0.	0.33259	
	150.	1920.	0.914	23.021	31.940	0.			31.940	23.021	-0.	0.32019	
	165.	1978.	1.026	23.424	35.066	0.			35.066	23.424	-0.	0.31452	
	180.	1999.	1.139	23.869	40.279	0.			40.279	23.869	-0.	0.31215	
	195.	1978.	1.253	24.206	40.979	0.			40.979	24.206	-0.	0.31443	
	210.	1920.	1.365	24.569	36.501	0.			36.501	24.569	-0.	0.32042	
	225.	1828.	1.474	24.651	32.587	0.			32.587	24.651	-0.	0.32859	
	240.	1713.	1.579	23.847	34.222	115.780			150.002	23.847	-0.	0.34430	
	255.	1585.	1.679	23.232	27.208	223.670			250.878	23.232	-0.	0.36250	
	270.	1454.	1.775	24.525	12.420	316.317			328.733	24.525	-0.	0.40525	
	285.	1329.	1.867	24.778	2.348	387.408			389.757	24.778	-0.	0.40773	
	300.	1217.	1.955	26.992	0.077	432.098			432.175	26.992	-0.	0.41514	
	309.	1159.	2.005	27.955	0.	444.890			444.890	27.955	-0.	0.40637	
SH	310.	1153.	2.011	28.168	0.	0.			0.	28.168	-0.	0.40969	
SH	315.	1125.	2.039	28.993	0.	0.			0.	28.993	-0.	0.42256	
SH	330.	1056.	2.120	33.010	0.	0.			0.	33.010	-0.	0.44071	
SH	345.	1014.	2.200	34.594	0.	0.			0.	34.594	-0.	0.44779	
SH	360.	1000.	2.279	34.616	0.	0.			0.	34.616	-0.	0.44960	

TABLE 6-5 (CONTINUED

ORBITAL RADIATION - 2374 6-50

CASE 44. EXAMPLE 4, SIDE 4

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
3	0.	90.000	270.000	180.000	315.000	270.000	0.	15.000	1000.	0.091		

NON-ZERO CURVES PUNCHED 441 CONE 442 CONE -0 ALPHA= -0. EPSIL= -0.

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	0.	1000.	0.	34.456	0.	0.			0.	34.456	-0.	0.44970	
SH	15.	1014.	0.079	34.190	0.	0.			0.	34.190	-0.	0.44783	
SH	30.	1056.	0.159	32.643	0.	0.			0.	32.643	-0.	0.44088	
SH	45.	1125.	0.240	30.159	0.	0.			0.	30.159	-0.	0.42780	
SH	50.	1153.	0.268	27.811	0.	0.			0.	27.811	-0.	0.41999	
	51.	1159.	0.273	27.900	0.	199.065			199.065	27.900	-0.	0.42458	
	60.	1217.	0.324	26.255	0.033	158.159			158.192	26.255	-0.	0.42207	
	75.	1329.	0.412	26.542	1.098	81.869			82.967	26.542	-0.	0.46277	
	90.	1454.	0.503	29.898	6.867	0.000			6.867	29.898	-0.	0.53987	
	105.	1585.	0.599	24.224	18.097	0.			18.097	24.224	-0.	0.41966	
	120.	1713.	0.700	22.221	26.572	0.			26.572	22.221	-0.	0.35501	
	135.	1828.	0.805	22.715	31.147	0.			31.147	22.715	-0.	0.33179	
	150.	1920.	0.914	23.491	33.432	0.			33.432	23.491	-0.	0.31996	
	165.	1978.	1.026	23.668	36.728	0.			36.728	23.668	-0.	0.31438	
	180.	1999.	1.139	23.946	40.595	0.			40.595	23.946	-0.	0.31207	
	195.	1978.	1.253	24.233	39.339	0.			39.339	24.233	-0.	0.31441	
	210.	1920.	1.365	24.193	35.049	0.			35.049	24.193	-0.	0.32001	
	225.	1828.	1.474	23.800	31.065	0.			31.065	23.800	-0.	0.32366	
	240.	1713.	1.579	23.228	31.260	0.			31.260	23.228	-0.	0.34510	
	255.	1585.	1.679	22.980	21.504	0.			21.504	22.980	-0.	0.36679	
	270.	1454.	1.775	24.887	8.028	0.			8.028	24.887	-0.	0.41112	
	285.	1329.	1.867	25.047	1.226	81.869			83.095	25.047	-0.	0.40269	
	300.	1217.	1.955	27.797	0.036	158.159			158.195	27.797	-0.	0.41469	
	309.	1159.	2.005	29.460	0.	199.065			199.065	29.460	-0.	0.41791	
SH	310.	1153.	2.011	29.594	0.	0.			0.	29.594	-0.	0.41999	
SH	315.	1125.	2.039	30.094	0.	0.			0.	30.094	-0.	0.42781	
SH	330.	1056.	2.120	33.559	0.	0.			0.	33.559	-0.	0.44091	
SH	345.	1014.	2.200	34.736	0.	0.			0.	34.736	-0.	0.44787	
SH	360.	1000.	2.279	34.457	0.	0.			0.	34.457	-0.	0.44972	

TABLE 6-6. PUNCHED CARD OUTPUT FOR EXAMPLES 3 AND 4

```
DEC    311                                          SOLAR SPEC  VERT.   31101
PER01 8203.7683                                                         31102
DEC02    0.          0.                                                 31103
DEC02  283.8625      0.                                                 31104
DEC02  570.9663      0.                                                 31105
DEC02  864.4906      0.                                                 31106
DEC02  964.2891      0.                                                 31107
DEC02  984.3846      0.0966                                             31108
DEC02 1167.4669      0.1076                                             31109
DEC02 1482.6513      0.1204                                             31110
DEC02 1812.3383      0.1257                                             31111
DEC02 2158.1135      0.1221                                             31112
DEC02 2520.5663      0.1100                                             31113
DEC02 2899.0128      0.0901                                             31114
DEC02 3291.3107      0.0648                                             31115
DEC02 3693.8644      0.0350                                             31116
DEC02 4101.8846      0.0026                                             31117
DEC02 4509.9044      0.0022                                             31118
DEC02 4912.4579      0.0022                                             31119
DEC02 5304.7560      0.0019                                             31120
DEC02 5683.2024      0.0014                                             31121
DEC02 6045.6552      0.0003                                             31122
DEC02 6391.4304      0.                                                 31123
DEC02 6721.1173      0.                                                 31124
DEC02 7036.3017      0.                                                 31125
DEC02 7219.3837      0.                                                 31126
DEC02 7239.4792      0.                                                 31127
DEC02 7339.2781      0.                                                 31128
DEC02 7632.8022      0.                                                 31129
DEC02 7919.9061      0.                                                 31130
DEC02 8203.7683      0.                                                 31131
DEC02          0.          0.                                           31132
DEC  - 311                                                              31133
DEC    312                                          INFRA-RED   VERT.   31201
PER01 8203.7683                                                         31202
DEC02    0.          0.0032                                             31203
DEC02  283.8625      0.0032                                             31204
DEC02  570.9663      0.0028                                             31205
DEC02  864.4906      0.0024                                             31206
DEC02  964.2891      0.0021                                             31207
DEC02  984.3846      0.0022                                             31208
DEC02 1167.4669      0.0022                                             31209
DEC02 1482.6513      0.0025                                             31210
DEC02 1812.3383      0.0019                                             31211
DEC02 2158.1135      0.0016                                             31212
DEC02 2520.5663      0.0017                                             31213
DEC02 2899.0128      0.0016                                             31214
DEC02 3291.3107      0.0017                                             31215
DEC02 3693.8644      0.0016                                             31216
DEC02 4101.8846      0.0016                                             31217
DEC02 4509.9044      0.0016                                             31218
DEC02 4912.4579      0.0015                                             31219
DEC02 5304.7560      0.0015                                             31220
DEC02 5683.2024      0.0015                                             31221
DEC02 6045.6552      0.0016                                             31222
DEC02 6391.4304      0.0018                                             31223
DEC02 6721.1173      0.0020                                             31224
DEC02 7036.3017      0.0025                                             31225
DEC02 7219.3837      0.0027                                             31226
DEC02 7239.4792      0.0027                                             31227
DEC02 7339.2781      0.0028                                             31228
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TABLE 6-6 (CONTINUED)

```
DEC02 7632.8022    0.0031                                    31229
DEC02 7919.9061    0.0032                                    31230
DEC02 8203.7683    0.0032                                    31231
DEC02        0.        0.                                    31232
DEC  - 312                                                   31233
DEC    321                          SOLAR SPEC  VERT.        32101
PER01 8203.7683                                              32102
DEC02    0.        0.                                        32103
DEC02  283.8625    0.                                        32104
DEC02  570.9663    0.                                        32105
DEC02  864.4906    0.                                        32106
DEC02  964.2891    0.                                        32107
DEC02  984.3846    0.0000                                    32108
DEC02 1167.4669    0.0000                                    32109
DEC02 1482.6513    0.0001                                    32110
DEC02 1812.3383    0.0005                                    32111
DEC02 2158.1135    0.0012                                    32112
DEC02 2520.5663    0.0018                                    32113
DEC02 2899.0128    0.0021                                    32114
DEC02 3291.3107    0.0022                                    32115
DEC02 3693.8644    0.0024                                    32116
DEC02 4101.8846    0.0027                                    32117
DEC02 4509.9044    0.0026                                    32118
DEC02 4912.4579    0.0023                                    32119
DEC02 5304.7560    0.0021                                    32120
DEC02 5683.2024    0.0021                                    32121
DEC02 6045.6552    0.0015                                    32122
DEC02 6391.4304    0.0006                                    32123
DEC02 6721.1173    0.0001                                    32124
DEC02 7036.3017    0.0000                                    32125
DEC02 7219.3837    0.0000                                    32126
DEC02 7239.4792    0.                                        32127
DEC02 7339.2781    0.                                        32128
DEC02 7632.8022    0.                                        32129
DEC02 7919.9061    0.                                        32130
DEC02 8203.7683    0.                                        32131
DEC02        0.        0.                                    32132
DEC  - 321                                                   32133
DEC    322                          INFRA-RED   VERT.        32201
PER01 8203.7683                                              32202
DEC02    0.        0.0032                                    32203
DEC02  283.8625    0.0031                                    32204
DEC02  570.9663    0.0029                                    32205
DEC02  864.4906    0.0025                                    32206
DEC02  964.2891    0.0022                                    32207
DEC02  984.3846    0.0024                                    32208
DEC02 1167.4669    0.0021                                    32209
DEC02 1482.6513    0.0019                                    32210
DEC02 1812.3383    0.0020                                    32211
DEC02 2158.1135    0.0016                                    32212
DEC02 2520.5663    0.0016                                    32213
DEC02 2899.0128    0.0016                                    32214
DEC02 3291.3107    0.0016                                    32215
DEC02 3693.8644    0.0016                                    32216
DEC02 4101.8846    0.0016                                    32217
DEC02 4509.9044    0.0016                                    32218
DEC02 4912.4579    0.0016                                    32219
DEC02 5304.7560    0.0017                                    32220
DEC02 5683.2024    0.0017                                    32221
DEC02 6045.6552    0.0017                                    32222
DEC02 6391.4304    0.0018                                    32223
```

TABLE 6-6 (CONTINUED)

```
DEC02 6721.1173    0.0020                                    32224
DEC02 7036.3017    0.0023                                    32225
DEC02 7219.3837    0.0023                                    32226
DEC02 7239.4792    0.0024                                    32227
DEC02 7339.2781    0.0025                                    32228
DEC02 7632.8022    0.0030                                    32229
DEC02 7919.9061    0.0032                                    32230
DEC02 8203.7683    0.0032                                    32231
DEC02        0.        0.                                    32232
DEC  - 322                                                   32233
DEC    331                          SOLAR SPEC  VERT.        33101
PER01 8203.7683                                              33102
DEC02    0.        0.                                        33103
DEC02  283.8625    0.                                        33104
DEC02  570.9663    0.                                        33105
DEC02  864.4906    0.                                        33106
DEC02  964.2891    0.                                        33107
DEC02  984.3846    0.                                        33108
DEC02 1167.4669    0.                                        33109
DEC02 1482.6513    0.                                        33110
DEC02 1812.3383    0.                                        33111
DEC02 2158.1135    0.0003                                    33112
DEC02 2520.5663    0.0012                                    33113
DEC02 2899.0128    0.0017                                    33114
DEC02 3291.3107    0.0021                                    33115
DEC02 3693.8644    0.0022                                    33116
DEC02 4101.8846    0.0024                                    33117
DEC02 4509.9044    0.0350                                    33118
DEC02 4912.4579    0.0649                                    33119
DEC02 5304.7560    0.0903                                    33120
DEC02 5683.2024    0.1102                                    33121
DEC02 6045.6552    0.1226                                    33122
DEC02 6391.4304    0.1260                                    33123
DEC02 6721.1173    0.1205                                    33124
DEC02 7036.3017    0.1076                                    33125
DEC02 7219.3837    0.0966                                    33126
DEC02 7239.4792    0.                                        33127
DEC02 7339.2781    0.                                        33128
DEC02 7632.8022    0.                                        33129
DEC02 7919.9061    0.                                        33130
DEC02 8203.7683    0.                                        33131
DEC02        0.        0.                                    33132
DEC  - 331                                                   33133
DEC    332                          INFRA-RED   VERT.        33201
PER01 8203.7683                                              33202
DEC02    0.        0.0033                                    33203
DEC02  283.8625    0.0032                                    33204
DEC02  570.9663    0.0031                                    33205
DEC02  864.4906    0.0028                                    33206
DEC02  964.2891    0.0026                                    33207
DEC02  984.3846    0.0026                                    33208
DEC02 1167.4669    0.0023                                    33209
DEC02 1482.6513    0.0019                                    33210
DEC02 1812.3383    0.0019                                    33211
DEC02 2158.1135    0.0021                                    33212
DEC02 2520.5663    0.0016                                    33213
DEC02 2899.0128    0.0014                                    33214
DEC02 3291.3107    0.0015                                    33215
DEC02 3693.8644    0.0015                                    33216
DEC02 4101.8846    0.0016                                    33217
DEC02 4509.9044    0.0016                                    33218
```

TABLE 6-6 (CONTINUED)

```
DEC02 4912.4579    0.0017                                    33219
DEC02 5304.7560    0.0018                                    33220
DEC02 5683.2024    0.0018                                    33221
DEC02 6045.6552    0.0017                                    33222
DEC02 6391.4304    0.0018                                    33223
DEC02 6721.1173    0.0019                                    33224
DEC02 7036.3017    0.0022                                    33225
DEC02 7219.3837    0.0022                                    33226
DEC02 7239.4792    0.0023                                    33227
DEC02 7339.2781    0.0024                                    33228
DEC02 7632.8022    0.0029                                    33229
DEC02 7919.9061    0.0032                                    33230
DEC02 8203.7683    0.0033                                    33231
DEC02        0.        0.                                    33232
DEC  - 332                                                   33233
DEC    341                          SOLAR SPEC  VERT.        34101
PER01 8203.7683                                              34102
DEC02    0.        0.                                        34103
DEC02  283.8625    0.                                        34104
DEC02  570.9663    0.                                        34105
DEC02  864.4906    0.                                        34106
DEC02  964.2891    0.                                        34107
DEC02  984.3846    0.                                        34108
DEC02 1167.4669    0.0000                                    34109
DEC02 1482.6513    0.0001                                    34110
DEC02 1812.3383    0.0005                                    34111
DEC02 2158.1135    0.0012                                    34112
DEC02 2520.5663    0.0018                                    34113
DEC02 2899.0128    0.0021                                    34114
DEC02 3291.3107    0.0022                                    34115
DEC02 3693.8644    0.0024                                    34116
DEC02 4101.8846    0.0027                                    34117
DEC02 4509.9044    0.0026                                    34118
DEC02 4912.4579    0.0023                                    34119
DEC02 5304.7560    0.0020                                    34120
DEC02 5683.2024    0.0021                                    34121
DEC02 6045.6552    0.0015                                    34122
DEC02 6391.4304    0.0006                                    34123
DEC02 6721.1173    0.0001                                    34124
DEC02 7036.3017    0.0000                                    34125
DEC02 7219.3837    0.                                        34126
DEC02 7239.4792    0.                                        34127
DEC02 7339.2781    0.                                        34128
DEC02 7632.8022    0.                                        34129
DEC02 7919.9061    0.                                        34130
DEC02 8203.7683    0.                                        34131
DEC02        0.        0.                                    34132
DEC  - 341                                                   34133
DEC    342                          INFRA-RED   VERT.        34201
PER01 8203.7683                                              34202
DEC02    0.        0.0032                                    34203
DEC02  283.8625    0.0031                                    34204
DEC02  570.9663    0.0029                                    34205
DEC02  864.4906    0.0026                                    34206
DEC02  964.2891    0.0023                                    34207
DEC02  984.3846    0.0024                                    34208
DEC02 1167.4669    0.0021                                    34209
DEC02 1482.6513    0.0019                                    34210
DEC02 1812.3383    0.0019                                    34211
DEC02 2158.1135    0.0016                                    34212
DEC02 2520.5663    0.0016                                    34213
```

TABLE 6-6 (CONTINUED)

```
DEC02 2899.0128    0.0016                                    34214
DEC02 3291.3107    0.0016                                    34215
DEC02 3693.8644    0.0016                                    34216
DEC02 4101.8846    0.0016                                    34217
DEC02 4509.9044    0.0016                                    34218
DEC02 4912.4579    0.0016                                    34219
DEC02 5304.7560    0.0016                                    34220
DEC02 5683.2024    0.0017                                    34221
DEC02 6045.6552    0.0017                                    34222
DEC02 6391.4304    0.0019                                    34223
DEC02 6721.1173    0.0020                                    34224
DEC02 7036.3017    0.0023                                    34225
DEC02 7219.3837    0.0025                                    34226
DEC02 7239.4792    0.0025                                    34227
DEC02 7339.2781    0.0026                                    34228
DEC02 7632.8022    0.0030                                    34229
DEC02 7919.9061    0.0032                                    34230
DEC02 8203.7683    0.0032                                    34231
DEC02        0.        0.                                    34232
DEC  - 342                                                   34233
DEC    411                                   SOLAR SPEC  CONE 41101
PER01 8203.7683                                              41102
DEC02     0.        0.                                       41103
DEC02   283.8625    0.                                       41104
DEC02   570.9663    0.                                       41105
DEC02   864.4906    0.                                       41106
DEC02   964.2891    0.                                       41107
DEC02   984.3846    0.1236                                   41108
DEC02 1167.4669     0.1200                                   41109
DEC02 1482.6513     0.1082                                   41110
DEC02 1812.3383     0.0908                                   41111
DEC02 2158.1135     0.0684                                   41112
DEC02 2520.5663     0.0404                                   41113
DEC02 2899.0128     0.0091                                   41114
DEC02 3291.3107     0.0097                                   41115
DEC02 3693.8644     0.0107                                   41116
DEC02 4101.8846     0.0114                                   41117
DEC02 4509.9044     0.0105                                   41118
DEC02 4912.4579     0.0093                                   41119
DEC02 5304.7560     0.0083                                   41120
DEC02 5683.2024     0.0079                                   41121
DEC02 6045.6552     0.0044                                   41122
DEC02 6391.4304     0.0010                                   41123
DEC02 6721.1173     0.0000                                   41124
DEC02 7036.3017     0.0000                                   41125
DEC02 7219.3837     0.                                       41126
DEC02 7239.4792     0.                                       41127
DEC02 7339.2781     0.                                       41128
DEC02 7632.8022     0.                                       41129
DEC02 7919.9061     0.                                       41130
DEC02 8203.7683     0.                                       41131
DEC02        0.        0.                                    41132
DEC  - 411                                                   41133
DEC    412                                   INFRA-RED   CONE 41201
PER01 8203.7683                                              41202
DEC02     0.        0.0095                                   41203
DEC02   283.8625    0.0095                                   41204
DEC02   570.9663    0.0089                                   41205
DEC02   864.4906    0.0080                                   41206
DEC02   964.2891    0.0073                                   41207
DEC02   984.3846    0.0075                                   41208
```

TABLE 6-6 (CONTINUED)

```
DEC02 1167.4669    0.0072                                          41209
DEC02 1482.6513    0.0079                                          41210
DEC02 1812.3383    0.0084                                          41211
DEC02 2158.1135    0.0064                                          41212
DEC02 2520.5663    0.0062                                          41213
DEC02 2899.0128    0.0065                                          41214
DEC02 3291.3107    0.0067                                          41215
DEC02 3693.8644    0.0066                                          41216
DEC02 4101.8846    0.0067                                          41217
DEC02 4509.9044    0.0067                                          41218
DEC02 4912.4579    0.0066                                          41219
DEC02 5304.7560    0.0065                                          41220
DEC02 5683.2024    0.0063                                          41221
DEC02 6045.6552    0.0063                                          41222
DEC02 6391.4304    0.0068                                          41223
DEC02 6721.1173    0.0070                                          41224
DEC02 7036.3017    0.0079                                          41225
DEC02 7219.3837    0.0084                                          41226
DEC02 7239.4792    0.0084                                          41227
DEC02 7339.2781    0.0086                                          41228
DEC02 7632.8022    0.0095                                          41229
DEC02 7919.9061    0.0097                                          41230
DEC02 8203.7683    0.0095                                          41231
DEC02        0.        0.                                         41232
DEC  - 412                                                        41233
DEC    421                                SOLAR SPEC  CONE        42101
PER01 8203.7683                                                   42102
DEC02    0.        0.                                             42103
DEC02  283.8625    0.                                             42104
DEC02  570.9663    0.                                             42105
DEC02  864.4906    0.                                             42106
DEC02  964.2891    0.                                             42107
DEC02  984.3846    0.0553                                         42108
DEC02 1167.4669    0.0439                                         42109
DEC02 1482.6513    0.0230                                         42110
DEC02 1812.3383    0.0019                                         42111
DEC02 2158.1135    0.0050                                         42112
DEC02 2520.5663    0.0074                                         42113
DEC02 2899.0128    0.0087                                         42114
DEC02 3291.3107    0.0093                                         42115
DEC02 3693.8644    0.0102                                         42116
DEC02 4101.8846    0.0113                                         42117
DEC02 4509.9044    0.0109                                         42118
DEC02 4912.4579    0.0097                                         42119
DEC02 5304.7560    0.0087                                         42120
DEC02 5683.2024    0.0087                                         42121
DEC02 6045.6552    0.0060                                         42122
DEC02 6391.4304    0.0022                                         42123
DEC02 6721.1173    0.0231                                         42124
DEC02 7036.3017    0.0439                                         42125
DEC02 7219.3837    0.0553                                         42126
DEC02 7239.4792    0.                                             42127
DEC02 7339.2781    0.                                             42128
DEC02 7632.8022    0.                                             42129
DEC02 7919.9061    0.                                             42130
DEC02 8203.7683    0.                                             42131
DEC02        0.        0.                                         42132
DEC  - 421                                                        42133
DEC    422                                INFRA-RED   CONE        42201
PER01 8203.7683                                                   42202
DEC02    0.        0.0096                                         42203
```

TABLE 6-6 (CONTINUED)

DEC02	283.8625	0.0095		42204
DEC02	570.9663	0.0091		42205
DEC02	864.4906	0.0083		42206
DEC02	964.2891	0.0076		42207
DEC02	984.3846	0.0077		42208
DEC02	1167.4669	0.0073		42209
DEC02	1482.6513	0.0074		42210
DEC02	1812.3383	0.0085		42211
DEC02	2158.1135	0.0067		42212
DEC02	2520.5663	0.0062		42213
DEC02	2899.0128	0.0063		42214
DEC02	3291.3107	0.0065		42215
DEC02	3693.8644	0.0066		42216
DEC02	4101.8846	0.0067		42217
DEC02	4509.9044	0.0067		42218
DEC02	4912.4579	0.0067		42219
DEC02	5304.7560	0.0067		42220
DEC02	5683.2024	0.0065		42221
DEC02	6045.6552	0.0064		42222
DEC02	6391.4304	0.0067		42223
DEC02	6721.1173	0.0070		42224
DEC02	7036.3017	0.0077		42225
DEC02	7219.3837	0.0080		42226
DEC02	7239.4792	0.0080		42227
DEC02	7339.2781	0.0082		42228
DEC02	7632.8022	0.0093		42229
DEC02	7919.9061	0.0096		42230
DEC02	8203.7683	0.0096		42231
DEC02	0.	0.		42232
DEC	- 422			42233
DEC	431		SOLAR SPEC CONE	43101
PER01	8203.7683			43102
DEC02	0.	0.		43103
DEC02	283.8625	0.		43104
DEC02	570.9663	0.		43105
DEC02	864.4906	0.		43106
DEC02	964.2891	0.		43107
DEC02	984.3846	0.		43108
DEC02	1167.4669	0.0000		43109
DEC02	1482.6513	0.0000		43110
DEC02	1812.3383	0.0009		43111
DEC02	2158.1135	0.0038		43112
DEC02	2520.5663	0.0065		43113
DEC02	2899.0128	0.0082		43114
DEC02	3291.3107	0.0089		43115
DEC02	3693.8644	0.0097		43116
DEC02	4101.8846	0.0112		43117
DEC02	4509.9044	0.0114		43118
DEC02	4912.4579	0.0101		43119
DEC02	5304.7560	0.0091		43120
DEC02	5683.2024	0.0417		43121
DEC02	6045.6552	0.0697		43122
DEC02	6391.4304	0.0913		43123
DEC02	6721.1173	0.1083		43124
DEC02	7036.3017	0.1200		43125
DEC02	7219.3837	0.1236		43126
DEC02	7239.4792	0.		43127
DEC02	7339.2781	0.		43128
DEC02	7632.8022	0.		43129
DEC02	7919.9061	0.		43130
DEC02	8203.7683	0.		43131

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TABLE 6-6 (CONTINUED)

```
DEC02        0.        0.                                          43132
DEC  - 431                                                         43133
DEC    432                                  INFRA-RED   CONE       43201
PER01 8203.7683                                                    43202
DEC02    0.        0.0096                                          43203
DEC02  283.8625    0.0095                                          43204
DEC02  570.9663    0.0093                                          43205
DEC02  864.4906    0.0086                                          43206
DEC02  964.2891    0.0080                                          43207
DEC02  984.3846    0.0080                                          43208
DEC02 1167.4669    0.0074                                          43209
DEC02 1482.6513    0.0069                                          43210
DEC02 1812.3383    0.0084                                          43211
DEC02 2158.1135    0.0071                                          43212
DEC02 2520.5663    0.0061                                          43213
DEC02 2899.0128    0.0061                                          43214
DEC02 3291.3107    0.0064                                          43215
DEC02 3693.8644    0.0065                                          43216
DEC02 4101.8846    0.0066                                          43217
DEC02 4509.9044    0.0067                                          43218
DEC02 4912.4579    0.0068                                          43219
DEC02 5304.7560    0.0068                                          43220
DEC02 5683.2024    0.0066                                          43221
DEC02 6045.6552    0.0065                                          43222
DEC02 6391.4304    0.0068                                          43223
DEC02 6721.1173    0.0069                                          43224
DEC02 7036.3017    0.0075                                          43225
DEC02 7219.3837    0.0078                                          43226
DEC02 7239.4792    0.0078                                          43227
DEC02 7339.2781    0.0081                                          43228
DEC02 7632.8022    0.0092                                          43229
DEC02 7919.9061    0.0096                                          43230
DEC02 8203.7683    0.0096                                          43231
DEC02        0.        0.                                          43232
DEC  - 432                                                         43233
DEC    441                                  SOLAR SPEC  CONE       44101
PER01 8203.7683                                                    44102
DEC02    0.        0.                                              44103
DEC02  283.8625    0.                                              44104
DEC02  570.9663    0.                                              44105
DEC02  864.4906    0.                                              44106
DEC02  964.2891    0.                                              44107
DEC02  984.3846    0.0553                                          44108
DEC02 1167.4669    0.0439                                          44109
DEC02 1482.6513    0.0230                                          44110
DEC02 1812.3383    0.0019                                          44111
DEC02 2158.1135    0.0050                                          44112
DEC02 2520.5663    0.0074                                          44113
DEC02 2899.0128    0.0087                                          44114
DEC02 3291.3107    0.0093                                          44115
DEC02 3693.8644    0.0102                                          44116
DEC02 4101.8846    0.0113                                          44117
DEC02 4509.9044    0.0109                                          44118
DEC02 4912.4579    0.0097                                          44119
DEC02 5304.7560    0.0086                                          44120
DEC02 5683.2024    0.0087                                          44121
DEC02 6045.6552    0.0060                                          44122
DEC02 6391.4304    0.0022                                          44123
DEC02 6721.1173    0.0231                                          44124
DEC02 7036.3017    0.0439                                          44125
DEC02 7219.3837    0.0553                                          44126
```


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TABLE 6-6 (CONTINUED)

```
DEC02 7239.4792    0.                                          44127
DEC02 7339.2781    0.                                          44128
DEC02 7632.8022    0.                                          44129
DEC02 7919.9061    0.                                          44130
DEC02 8203.7683    0.                                          44131
DEC02        0.        0.                                     44132
DEC  - 441                                                     44133
DEC    442                                INFRA-RED   CONE     44201
PER01 8203.7683                                                44202
DEC02    0.        0.0096                                      44203
DEC02  283.8625    0.0095                                      44204
DEC02  570.9663    0.0091                                      44205
DEC02  864.4906    0.0084                                      44206
DEC02  964.2891    0.0077                                      44207
DEC02  984.3846    0.0078                                      44208
DEC02 1167.4669    0.0073                                      44209
DEC02 1482.6513    0.0074                                      44210
DEC02 1812.3383    0.0083                                      44211
DEC02 2158.1135    0.0067                                      44212
DEC02 2520.5663    0.0062                                      44213
DEC02 2899.0128    0.0063                                      44214
DEC02 3291.3107    0.0065                                      44215
DEC02 3693.8644    0.0066                                      44216
DEC02 4101.8846    0.0067                                      44217
DEC02 4509.9044    0.0067                                      44218
DEC02 4912.4579    0.0067                                      44219
DEC02 5304.7560    0.0066                                      44220
DEC02 5683.2024    0.0065                                      44221
DEC02 6045.6552    0.0064                                      44222
DEC02 6391.4304    0.0069                                      44223
DEC02 6721.1173    0.0070                                      44224
DEC02 7036.3017    0.0077                                      44225
DEC02 7219.3837    0.0082                                      44226
DEC02 7239.4792    0.0082                                      44227
DEC02 7339.2781    0.0084                                      44228
DEC02 7632.8022    0.0093                                      44229
DEC02 7919.9061    0.0096                                      44230
DEC02 8203.7683    0.0096                                      44231
DEC02        0.        0.                                     44232
DEC  - 442                                                     44233
```

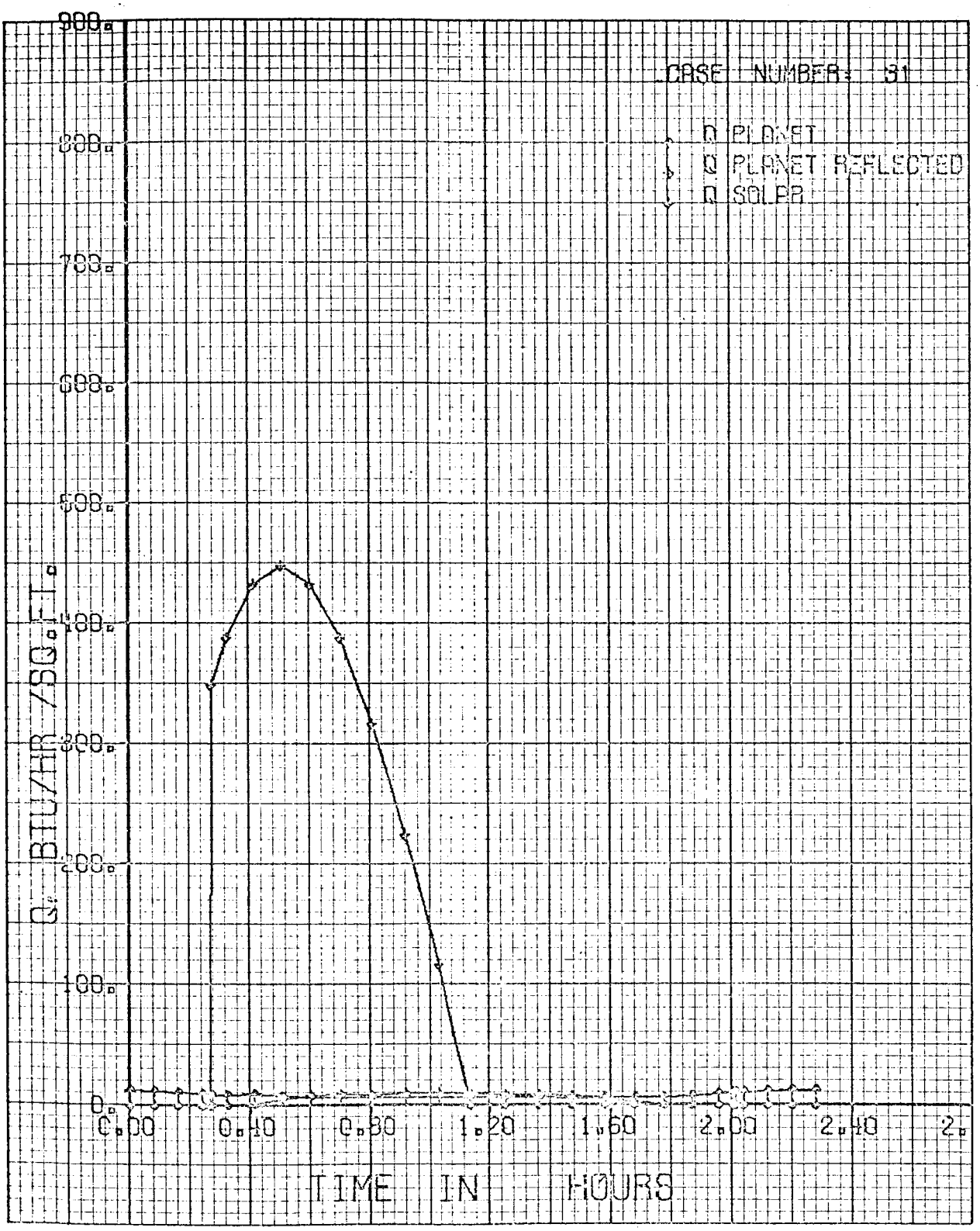

Figure 6-11. Plotted Output for Example 3, Side 1

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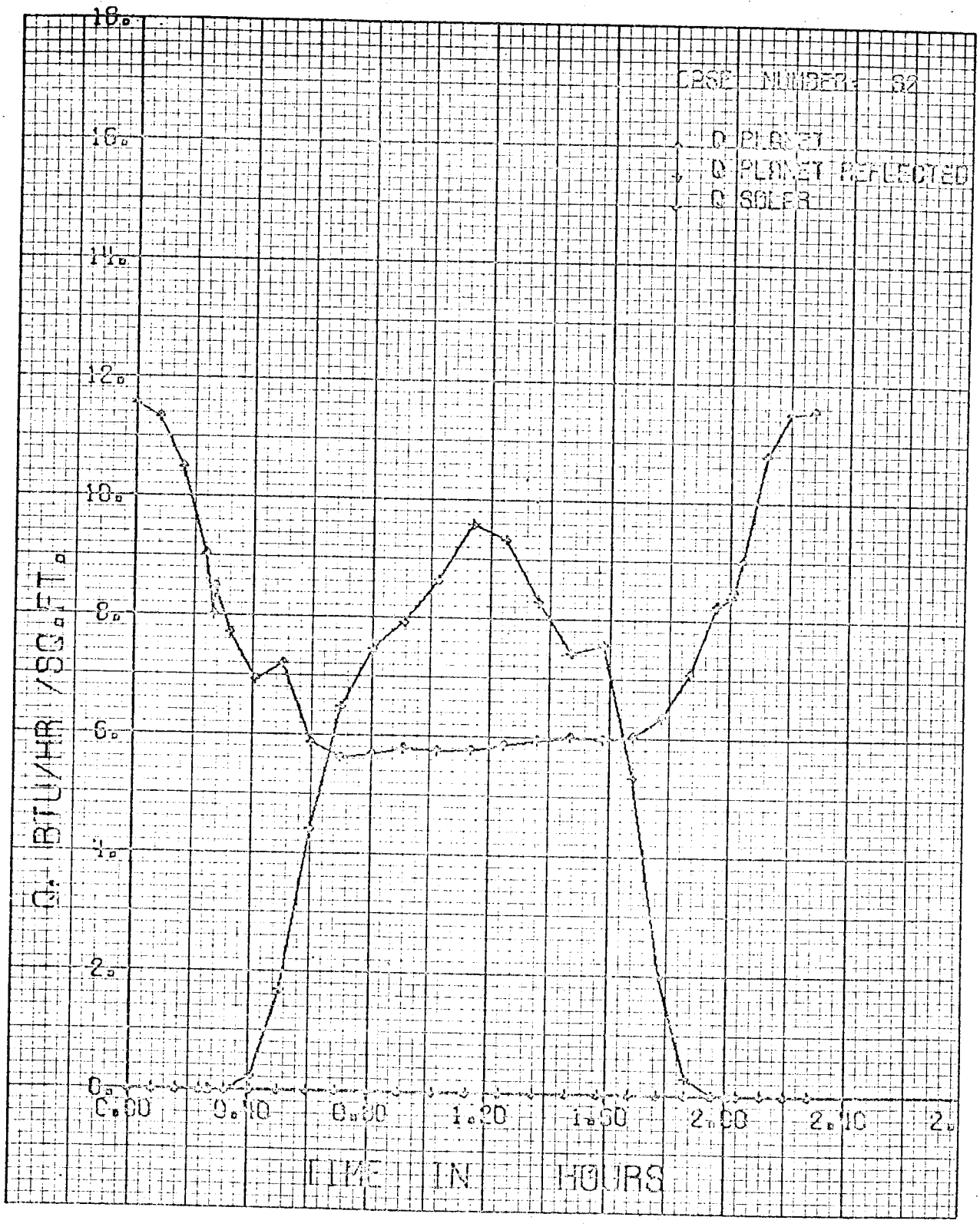

Figure 6-12. Plotted Output for Example 3, Side 2

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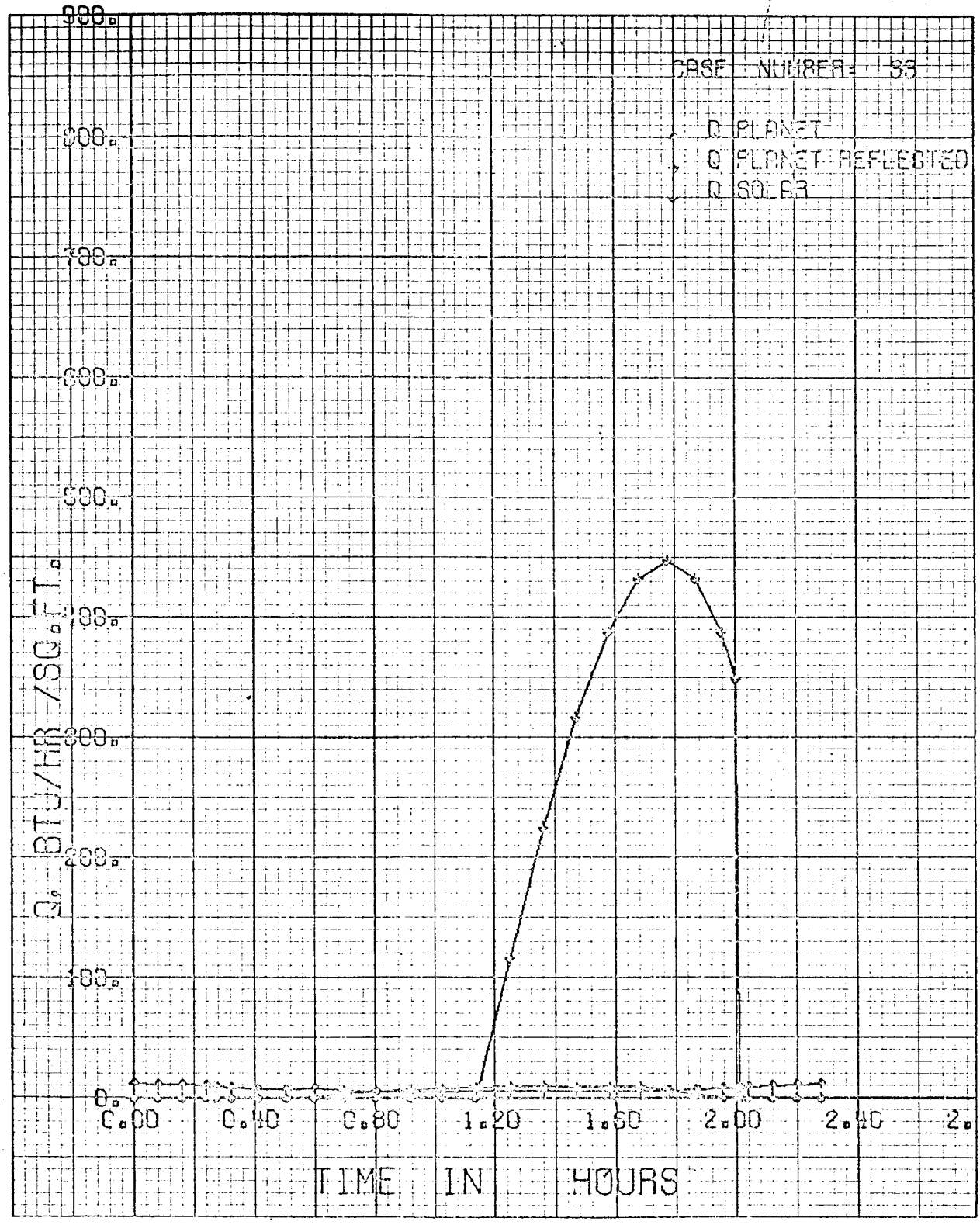

Figure 6-13. Plotted Output for Example 3, Side 3

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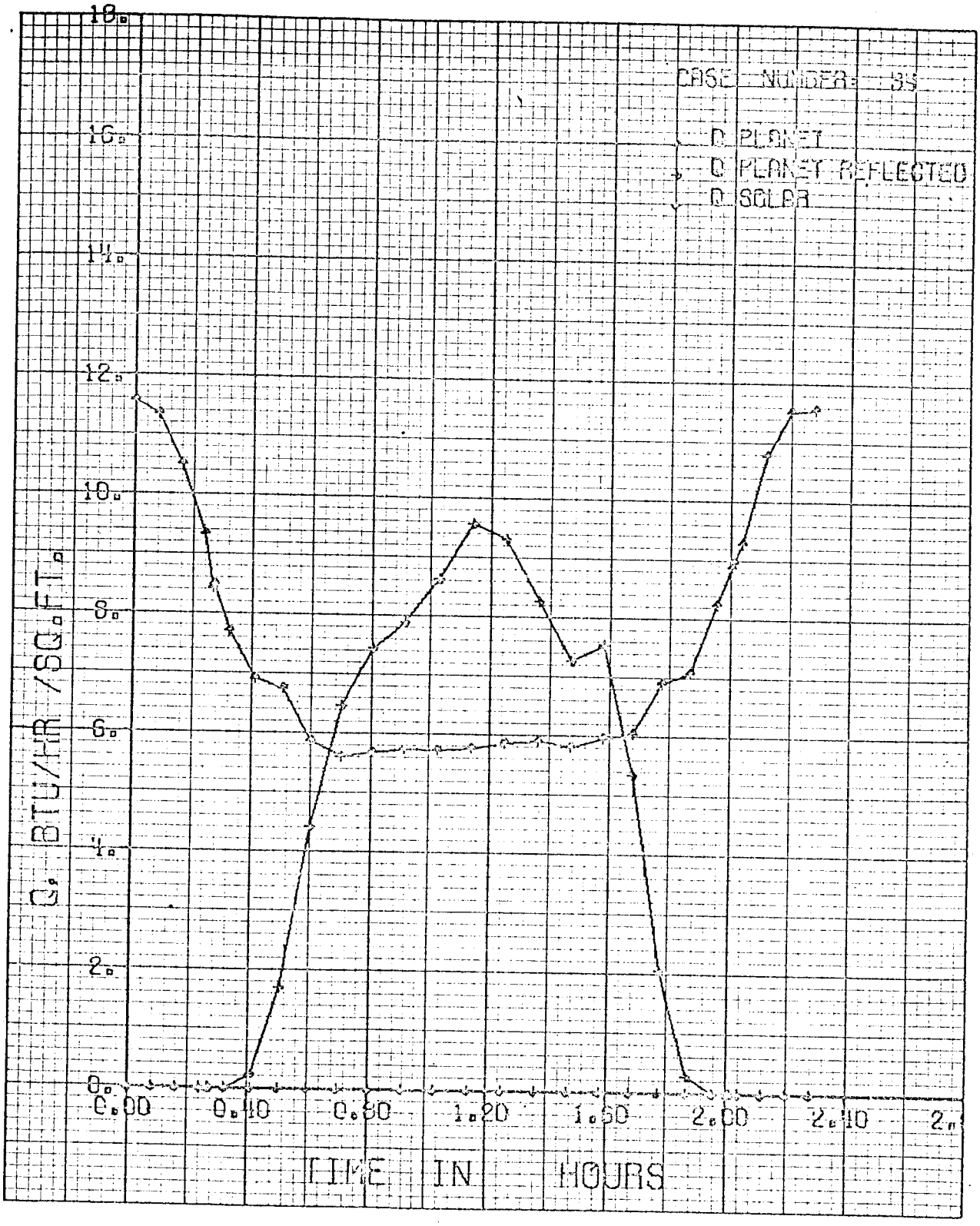

Figure 6-14. Plotted Output for Example 3, Side 4

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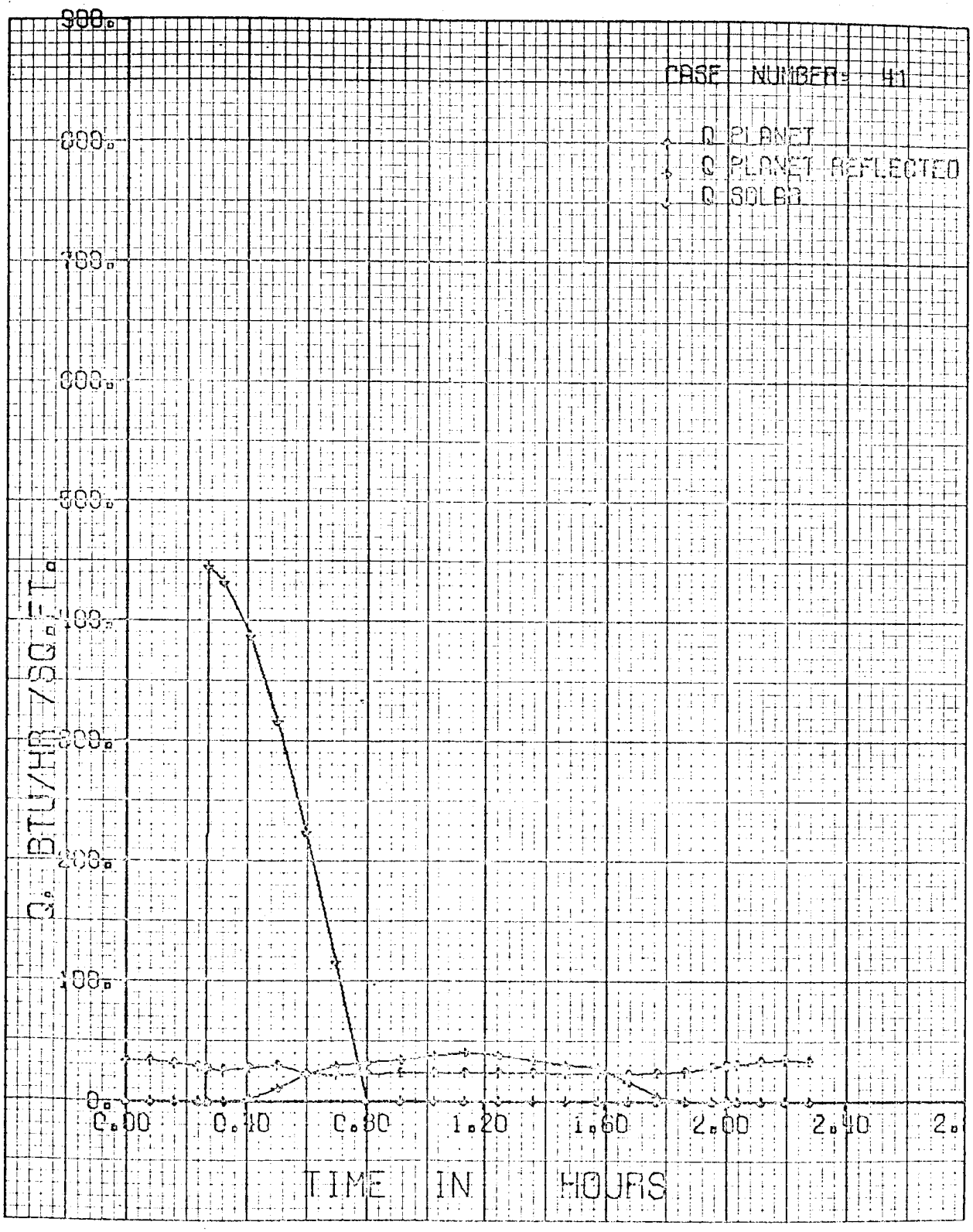

Figure 6-15. Plotted Output for Example 4, Side 1

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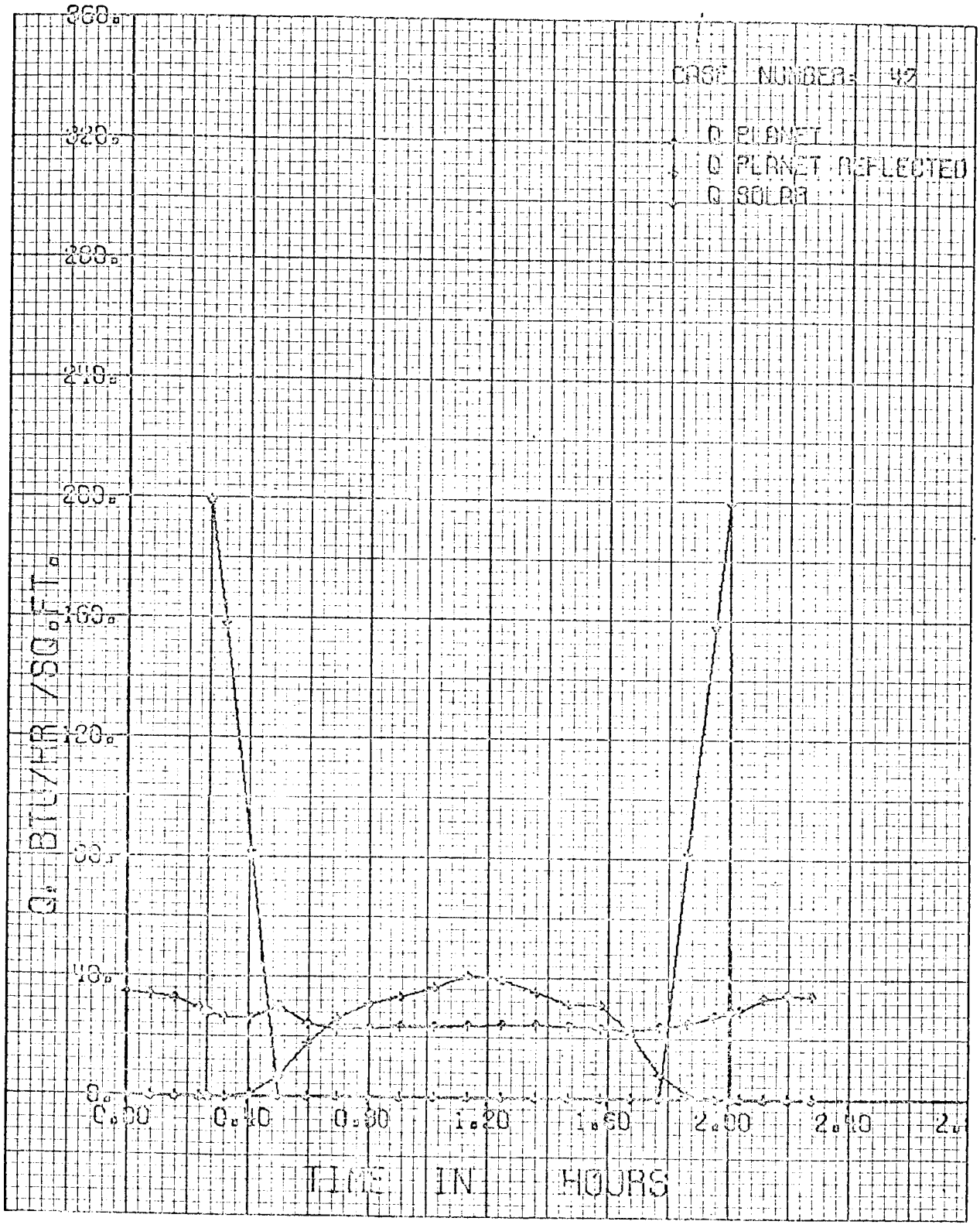

Figure 6-16. Plotted Output for Example 4, Side 2

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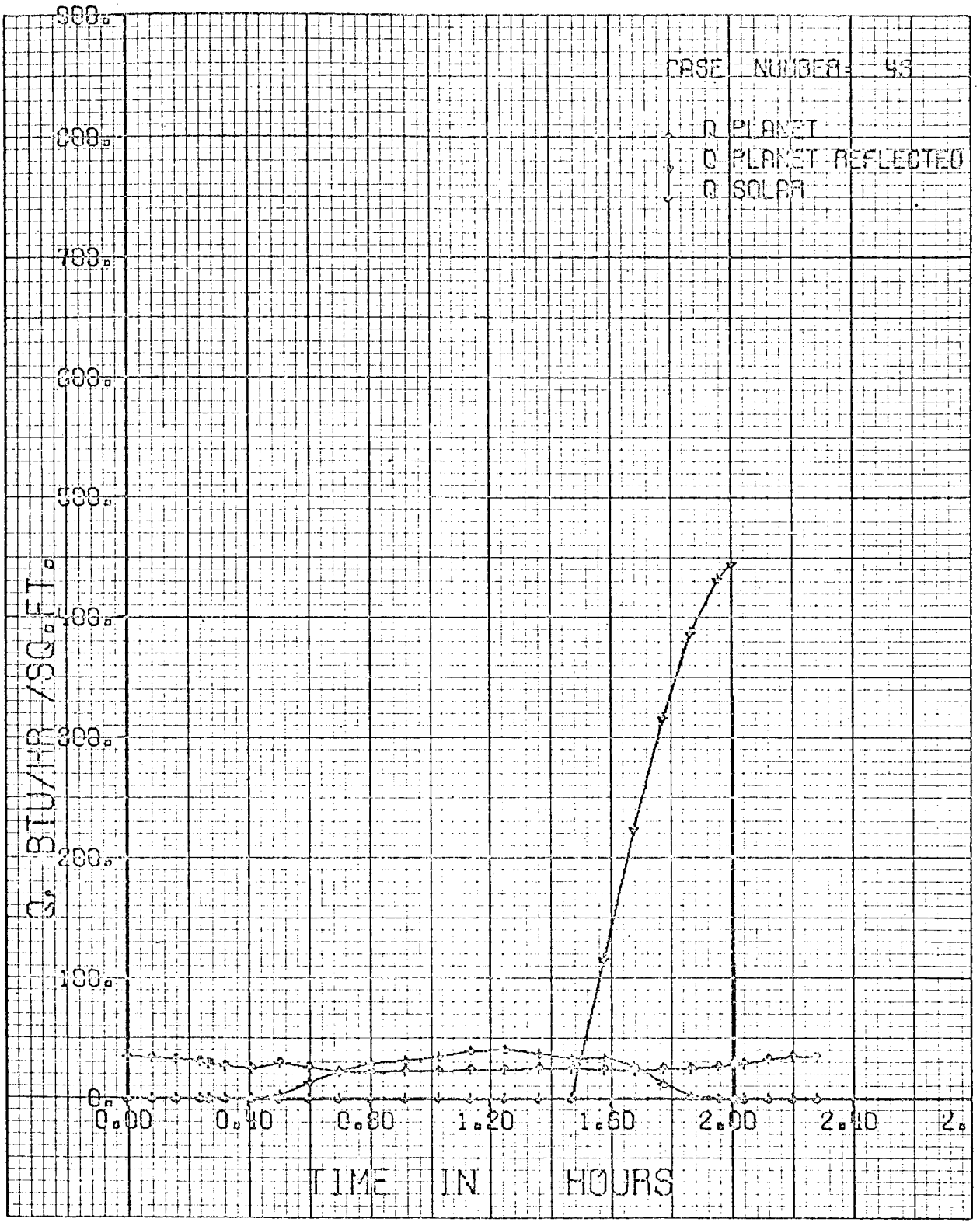

Figure 6-17. Plotted Output for Example 4, Side 3

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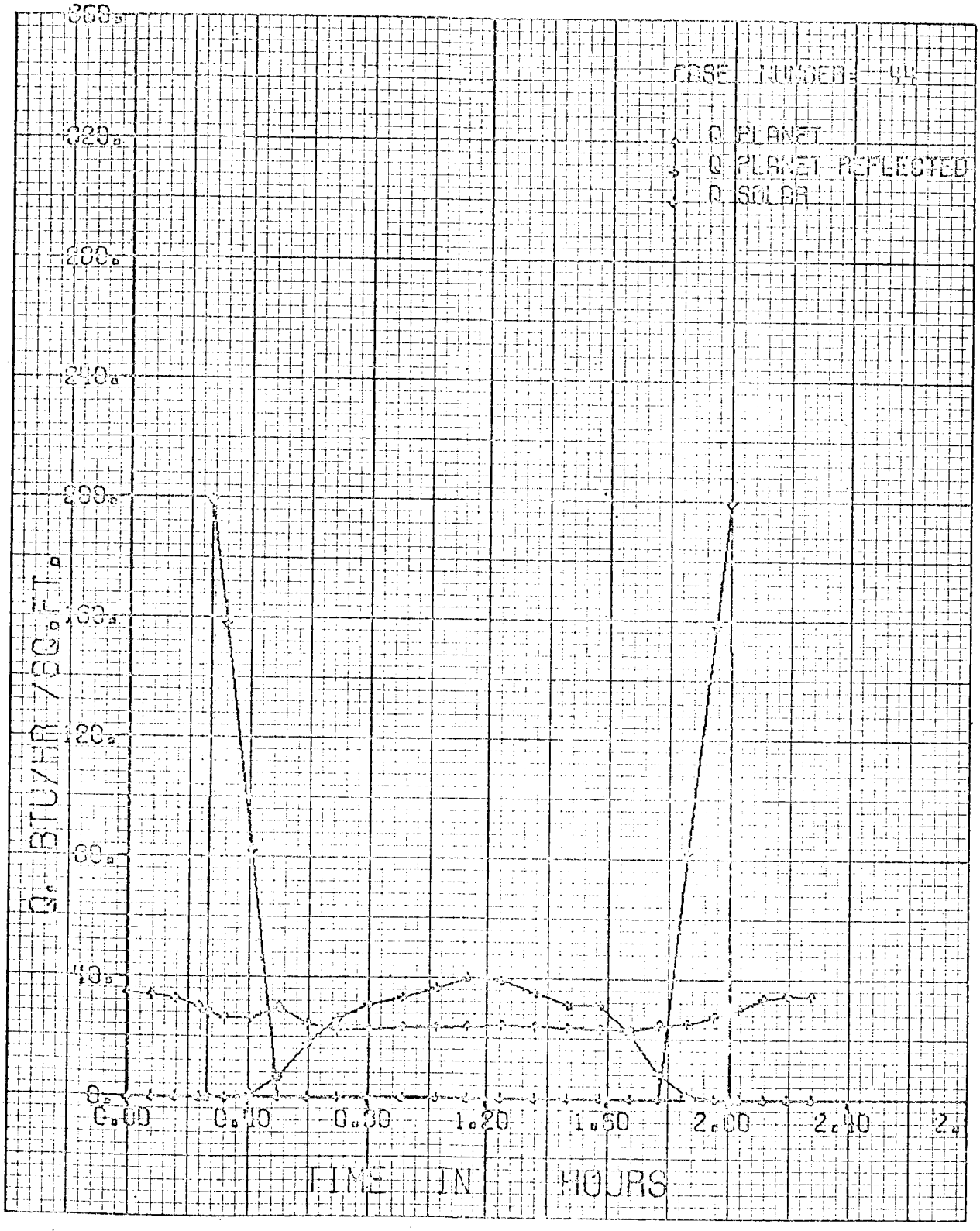

Figure 6-18. Plotted Output for Example 4, Side 4

LOCKHEED
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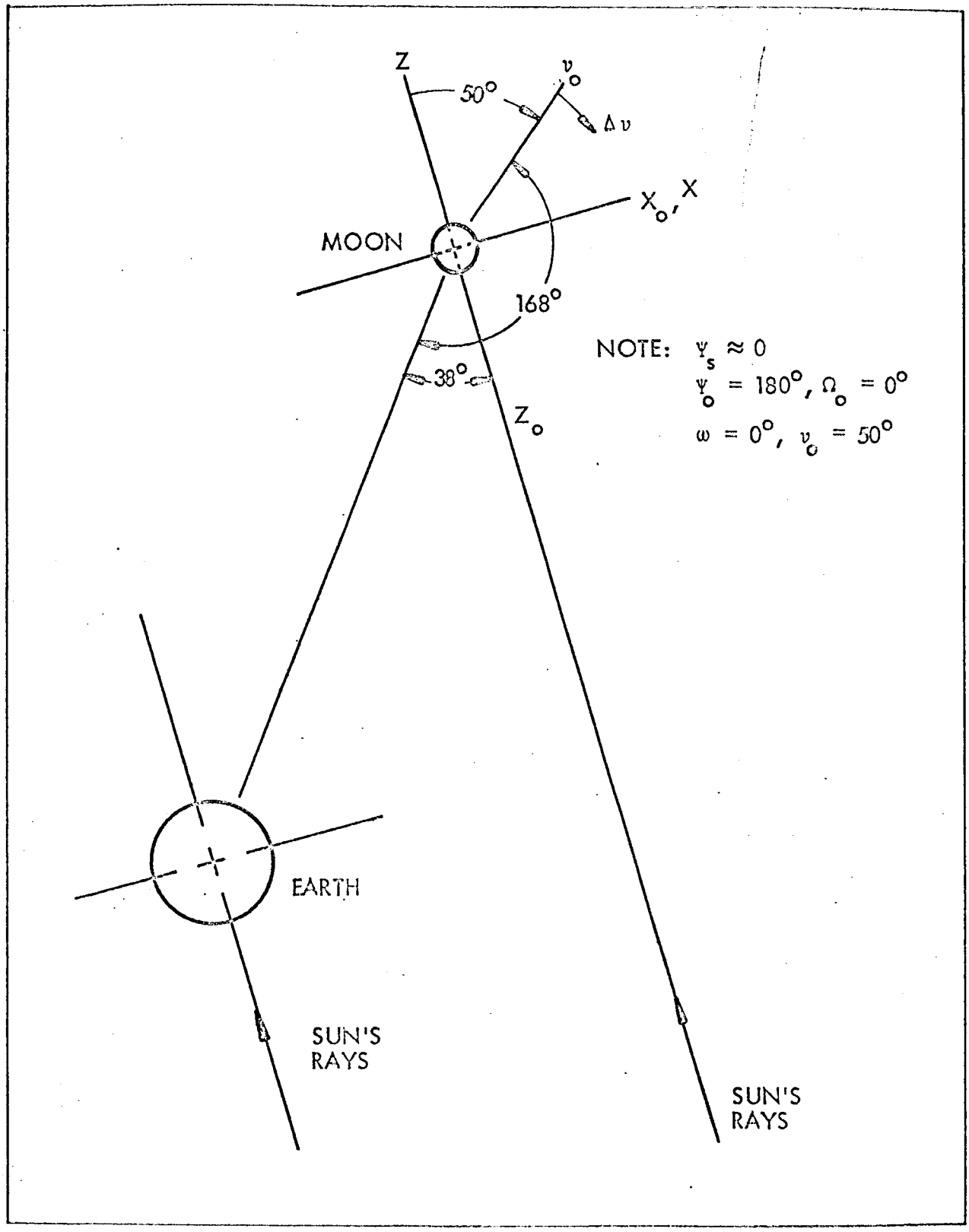

Figure 6-19. Lunar Orbit Parameters, Example 5

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TABLE 6-7

INPUT FOR EXAMPLE 5

SEQ.													ID
77 80	1 5	10	15	20	25	30	35	40	45	50	55 60	65 70	72 73 76
5101	21251.						513	LUNAR	.5	.5	EXAMPLE 5, SIDE 1		
5102	05	0.	180.	0.	90.		0.	0.	86.	0.	50.	15.	
5103	1.	1.						111	1				
5201	21252.						523	LUNAR	.5	.5	EXAMPLE 5, SIDE 2		
5202	05	0.	180.	0.	90.		90.	0.	86.	0.	50.	15.	
5203	1.	1.						111	1				
5301	21253.						533	LUNAR	.5	.5	EXAMPLE 5, SIDE 3		
5302	05	0.	180.	0.	90.		180.	0.	86.	0.	50.	15.	
5303	1.	1.						111	1				
5401	21254.						543	LUNAR	.5	.5	EXAMPLE 5, SIDE 4		
5402	05	0.	180.	0.	90.		270.	0.	86.	0.	50.	15.	
5403	1.	1.						111	1				
5999	0.										END CARD		

TABLE 6-8. TABULAR OUTPUT FOR EXAMPLE 5

ORBITAL RADIATION - 2374

CASE 51. EXAMPLE 5, SIDE 1

ORBIT MOON RADIUS = 1680. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
5	0.	180.000	0.	90.000	0.	0.	50.000	15.000	86.	0.		

NON-ZERO CURVES PUNCHED -0 -0 513 LUNAR ALPHA= 0.5000 EPSIL= 0.5000

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL) Q(ABSR)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	50.	86.	0.	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	65.	86.	0.084	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	67.	86.	0.096	0.995	0.	0.			0.	0.995	0.497	0.26680	
	68.	86.	0.101	0.995	0.	401.408			401.408	0.995	201.201	0.26680	
	80.	86.	0.169	2.530	0.056	426.355			426.411	2.530	214.471	0.26680	
	95.	86.	0.253	21.581	1.539	431.285			432.824	21.581	227.202	0.26680	
	110.	86.	0.338	45.971	3.620	406.823			410.443	45.971	228.207	0.26680	
	125.	86.	0.422	69.264	5.454	354.637			360.091	69.264	214.678	0.26679	
	140.	86.	0.506	87.837	6.917	278.283			285.200	87.837	186.518	0.26680	
	155.	86.	0.591	100.423	7.908	182.965			190.873	100.423	145.648	0.26680	
	170.	86.	0.675	106.166	8.360	75.178			83.538	106.166	94.852	0.26680	
	185.	86.	0.760	104.675	8.242	0.			8.242	104.675	56.459	0.26680	
	200.	86.	0.844	96.049	7.563	0.			7.563	96.049	51.806	0.26680	
	215.	86.	0.928	80.678	6.369	0.			6.369	80.678	43.623	0.26680	
	230.	86.	1.013	60.196	4.740	0.			4.740	60.196	32.468	0.26680	
	245.	86.	1.097	35.551	2.788	0.			2.788	35.551	19.170	0.26680	
	260.	86.	1.181	13.491	0.702	0.			0.702	13.491	7.097	0.26680	
	275.	86.	1.266	0.995	0.	0.			0.	0.995	0.497	0.26680	
	290.	86.	1.350	0.995	0.	0.			0.	0.995	0.497	0.26680	
	292.	86.	1.362	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	293.	86.	1.367	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	305.	86.	1.435	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	320.	86.	1.519	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	335.	86.	1.603	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	350.	86.	1.688	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	365.	86.	1.772	0.995	0.	0.			0.	0.995	0.497	0.26679	
SH	380.	86.	1.857	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	395.	86.	1.941	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	410.	86.	2.025	0.995	0.	0.			0.	0.995	0.497	0.26680	

TABLE 6-8 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 52. EXAMPLE 5, SIDE 2

ORBIT MOON RADIUS = 1080. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
5	0.	180.000	0.	90.000	90.000	0.	50.000	15.000	86.	0.		

NON-ZERO CURVES PUNCHED -0 -0 523 LUNAR ALPHA= 0.5000 EPSIL= 0.5000

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL) Q(ABSB)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	50.	86.	0.	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	65.	86.	0.084	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	67.	86.	0.096	0.995	0.	0.			0.	0.995	0.497	0.26680	
	68.	86.	0.101	0.995	0.	0.			0.	0.995	0.497	0.26680	
	80.	86.	0.169	1.285	0.009	0.			0.009	1.285	0.647	0.26680	
	95.	86.	0.253	14.335	0.783	0.			0.783	14.335	7.559	0.26680	
	110.	86.	0.338	36.398	2.854	0.			2.854	36.398	19.626	0.26680	
	125.	86.	0.422	60.788	4.787	0.			4.787	60.788	32.787	0.26680	
	140.	86.	0.506	81.186	6.393	0.			6.393	81.186	43.790	0.26680	
	155.	86.	0.591	96.051	7.563	0.			7.563	96.051	51.807	0.26680	
	170.	86.	0.675	104.371	8.219	0.			8.219	104.371	56.295	0.26680	
	185.	86.	0.760	105.578	8.314	0.			8.314	105.578	56.946	0.26680	
	200.	86.	0.844	99.590	7.842	0.			7.842	99.590	53.716	0.26680	
	215.	86.	0.928	86.815	6.836	0.			6.836	86.815	46.825	0.26680	
	230.	86.	1.013	68.123	5.364	0.			5.364	68.123	36.744	0.26680	
	245.	86.	1.097	44.813	3.527	0.			3.527	44.813	24.170	0.26680	
	260.	86.	1.181	20.817	1.459	0.			1.459	20.817	11.138	0.26680	
	275.	86.	1.266	2.490	0.056	0.			0.056	2.490	1.273	0.26680	
	290.	86.	1.350	0.995	0.000	0.			0.000	0.995	0.498	0.26680	
	292.	86.	1.362	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	293.	86.	1.367	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	305.	86.	1.435	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	320.	86.	1.519	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	335.	86.	1.603	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	350.	86.	1.688	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	365.	86.	1.772	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	380.	86.	1.857	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	395.	86.	1.941	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	410.	86.	2.025	0.995	0.	0.			0.	0.995	0.497	0.26680	

TABLE 6-8 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 53. EXAMPLE 5, SIDE 3

ORBIT MOON RADIUS = 1080. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
5	0.	180.000	0.	90.000	180.000	0.	50.000	15.000	86.	0.		

NON-ZERO CURVES PUNCHED -0 -0 533 LUNAR ALPHA= 0.5000 EPSIL= 0.5000

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL) Q(ABSB)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	50.	86.	0.	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	65.	86.	0.084	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	67.	86.	0.096	0.995	0.	0.			0.	0.995	0.497	0.26680	
	68.	86.	0.101	0.995	0.	0.			0.	0.995	0.497	0.26680	
	80.	86.	0.169	0.995	0.	0.			0.	0.995	0.497	0.26680	
	95.	86.	0.253	6.874	0.168	0.			0.168	6.874	3.521	0.26680	
	110.	86.	0.338	27.234	2.089	0.			2.089	27.234	14.661	0.26680	
	125.	86.	0.422	52.311	4.119	0.			4.119	52.311	28.215	0.26680	
	140.	86.	0.506	74.533	5.869	0.			5.869	74.533	40.201	0.26679	
	155.	86.	0.591	91.677	7.219	0.			7.219	91.677	49.448	0.26679	
	170.	86.	0.675	102.573	8.077	0.			8.077	102.573	55.325	0.26679	
	185.	86.	0.760	106.478	8.385	37.732			46.117	106.478	76.298	0.26680	
	200.	86.	0.844	103.128	8.121	148.071			156.192	103.128	129.660	0.26680	
	215.	86.	0.928	92.749	7.303	248.320			255.623	92.749	174.186	0.26680	
	230.	86.	1.013	76.050	5.988	331.645			337.634	76.050	206.842	0.26680	
	245.	86.	1.097	54.168	4.265	392.370			396.635	54.168	225.401	0.26680	
	260.	86.	1.181	28.931	2.252	426.355			428.607	28.931	228.769	0.26680	
	275.	86.	1.266	6.919	0.253	431.285			431.537	6.919	219.228	0.26680	
	290.	86.	1.350	1.004	0.000	406.823			406.823	1.004	203.914	0.26680	
	292.	86.	1.362	0.995	0.	401.408			401.408	0.995	201.201	0.26680	
SH	293.	86.	1.367	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	305.	86.	1.435	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	320.	86.	1.519	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	335.	86.	1.603	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	350.	86.	1.688	0.995	0.	0.			0.	0.995	0.497	0.26679	
SH	365.	86.	1.772	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	380.	86.	1.857	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	395.	86.	1.941	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	410.	86.	2.025	0.995	0.	0.			0.	0.995	0.497	0.26680	

LOCKHEED CALIFORNIA COMPANY

TABLE 6-8 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 54. EXAMPLE 5, SIDE 4

ORBIT MOON RADIUS = 1000. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE ORIENTATION)	TAU	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA (SATELLITE)
5	0.	180.000	0.	90.000	270.000	0.	50.000	15.000	86.	0.		

NON-ZERO CURVES PUNCHED -0 -0 543 LUNAR ALPHA= 0.5000 EPSIL= 0.5000

PLOTS REQUESTED FOR Q(P) Q(PR) Q(SOL) Q(ABSB)

	V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
					(ALL Q IN BTU/HR/SQ.FT.)								
SH	50.	86.	0.	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	65.	86.	0.084	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	67.	86.	0.096	0.995	0.	0.			0.	0.995	0.497	0.26680	
	68.	86.	0.101	0.995	0.	0.			0.	0.995	0.497	0.26680	
	80.	86.	0.169	1.285	0.009	0.			0.009	1.285	0.647	0.26680	
	95.	86.	0.253	14.335	0.783	0.			0.783	14.335	7.559	0.26680	
	110.	86.	0.338	36.398	2.854	0.			2.854	36.398	19.626	0.26680	
	125.	86.	0.422	60.788	4.787	0.			4.787	60.788	32.787	0.26680	
	140.	86.	0.506	81.186	6.393	0.			6.393	81.186	43.789	0.26680	
	155.	86.	0.591	96.051	7.563	0.000			7.563	96.051	51.807	0.26680	
	170.	86.	0.675	104.371	8.219	0.000			8.219	104.371	56.295	0.26680	
	185.	86.	0.760	105.578	8.314	0.000			8.314	105.578	56.946	0.26680	
	200.	86.	0.844	99.590	7.842	0.000			7.842	99.590	53.716	0.26680	
	215.	86.	0.928	86.815	6.836	0.000			6.836	86.815	46.825	0.26680	
	230.	86.	1.013	68.123	5.364	0.000			5.364	68.123	36.744	0.26680	
	245.	86.	1.097	44.813	3.527	0.000			3.527	44.813	24.170	0.26680	
	260.	86.	1.181	20.817	1.459	0.000			1.459	20.817	11.138	0.26680	
	275.	86.	1.266	2.490	0.056	0.000			0.056	2.490	1.273	0.26680	
	290.	86.	1.350	0.995	0.000	0.000			0.000	0.995	0.498	0.26680	
	292.	86.	1.362	0.995	0.	0.000			0.000	0.995	0.497	0.26680	
SH	293.	86.	1.367	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	305.	86.	1.435	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	320.	86.	1.519	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	335.	86.	1.603	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	350.	86.	1.688	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	365.	86.	1.772	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	380.	86.	1.857	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	395.	86.	1.941	0.995	0.	0.			0.	0.995	0.497	0.26680	
SH	410.	86.	2.025	0.995	0.	0.			0.	0.995	0.497	0.26680	

TABLE 6-9. PUNCHED CARD OUTPUT FOR EXAMPLE 5

```
DEC     513                                          Q ABSORBED  LUNAR   51301
PER01 7291.5015                                                          51302
DEC02     0.          0.0001                                             51303
DEC02   303.8126      0.0001                                             51304
DEC02   344.3208      0.0001                                             51305
DEC02   364.5750      0.0559                                             51306
DEC02   607.6251      0.0596                                             51307
DEC02   911.4377      0.0631                                             51308
DEC02  1215.2503      0.0634                                             51309
DEC02  1519.0629      0.0596                                             51310
DEC02  1822.8755      0.0518                                             51311
DEC02  2126.6880      0.0405                                             51312
DEC02  2430.5005      0.0263                                             51313
DEC02  2734.3132      0.0157                                             51314
DEC02  3038.1257      0.0144                                             51315
DEC02  3341.9384      0.0121                                             51316
DEC02  3645.7512      0.0090                                             51317
DEC02  3949.5636      0.0053                                             51318
DEC02  4253.3761      0.0020                                             51319
DEC02  4557.1887      0.0001                                             51320
DEC02  4861.0012      0.0001                                             51321
DEC02  4901.5092      0.0001                                             51322
DEC02  4921.7633      0.0001                                             51323
DEC02  5164.8137      0.0001                                             51324
DEC02  5468.6262      0.0001                                             51325
DEC02  5772.4387      0.0001                                             51326
DEC02  6076.2514      0.0001                                             51327
DEC02  6380.0638      0.0001                                             51328
DEC02  6683.8765      0.0001                                             51329
DEC02  6987.6890      0.0001                                             51330
DEC02  7291.5015      0.0001                                             51331
DEC02        0.          0.                                             51332
DEC   - 513                                                              51333
DEC     523                                          Q ABSORBED  LUNAR   52301
PER01 7291.5015                                                          52302
DEC02     0.          0.0001                                             52303
DEC02   303.8126      0.0001                                             52304
DEC02   344.3208      0.0001                                             52305
DEC02   364.5750      0.0001                                             52306
DEC02   607.6251      0.0002                                             52307
DEC02   911.4377      0.0021                                             52308
DEC02  1215.2503      0.0055                                             52309
DEC02  1519.0629      0.0091                                             52310
DEC02  1822.8755      0.0122                                             52311
DEC02  2126.6880      0.0144                                             52312
DEC02  2430.5005      0.0156                                             52313
DEC02  2734.3132      0.0158                                             52314
DEC02  3038.1257      0.0149                                             52315
DEC02  3341.9384      0.0130                                             52316
DEC02  3645.7512      0.0102                                             52317
DEC02  3949.5636      0.0067                                             52318
DEC02  4253.3761      0.0031                                             52319
DEC02  4557.1887      0.0004                                             52320
DEC02  4861.0012      0.0001                                             52321
DEC02  4901.5092      0.0001                                             52322
DEC02  4921.7633      0.0001                                             52323
DEC02  5164.8137      0.0001                                             52324
DEC02  5468.6262      0.0001                                             52325
DEC02  5772.4387      0.0001                                             52326
DEC02  6076.2514      0.0001                                             52327
DEC02  6380.0638      0.0001                                             52328
```

TABLE 6-9 (CONTINUED)

DEC02	6683.8765	0.0001		52329
DEC02	6987.6890	0.0001		52330
DEC02	7291.5015	0.0001		52331
DEC02	0.	0.		52332
DEC	- 523			52333
DEC	533		Q ABSORBED LUNAR	53301
PER01	7291.5015			53302
DEC02	0.	0.0001		53303
DEC02	303.8126	0.0001		53304
DEC02	344.3208	0.0001		53305
DEC02	364.5750	0.0001		53306
DEC02	607.6251	0.0001		53307
DEC02	911.4377	0.0010		53308
DEC02	1215.2503	0.0041		53309
DEC02	1519.0629	0.0078		53310
DEC02	1822.8755	0.0112		53311
DEC02	2126.6880	0.0137		53312
DEC02	2430.5005	0.0154		53313
DEC02	2734.3132	0.0212		53314
DEC02	3038.1257	0.0360		53315
DEC02	3341.9384	0.0484		53316
DEC02	3645.7512	0.0575		53317
DEC02	3949.5636	0.0626		53318
DEC02	4253.3761	0.0635		53319
DEC02	4557.1887	0.0609		53320
DEC02	4861.0012	0.0566		53321
DEC02	4901.5092	0.0559		53322
DEC02	4921.7633	0.0001		53323
DEC02	5164.8137	0.0001		53324
DEC02	5468.6262	0.0001		53325
DEC02	5772.4387	0.0001		53326
DEC02	6076.2514	0.0001		53327
DEC02	6380.0638	0.0001		53328
DEC02	6683.8765	0.0001		53329
DEC02	6987.6890	0.0001		53330
DEC02	7291.5015	0.0001		53331
DEC02	0.	0.		53332
DEC	- 533			53333
DEC	543		Q ABSORBED LUNAR	54301
PER01	7291.5015			54302
DEC02	0.	0.0001		54303
DEC02	303.8126	0.0001		54304
DEC02	344.3208	0.0001		54305
DEC02	364.5750	0.0001		54306
DEC02	607.6251	0.0002		54307
DEC02	911.4377	0.0021		54308
DEC02	1215.2503	0.0055		54309
DEC02	1519.0629	0.0091		54310
DEC02	1822.8755	0.0122		54311
DEC02	2126.6880	0.0144		54312
DEC02	2430.5005	0.0156		54313
DEC02	2734.3132	0.0158		54314
DEC02	3038.1257	0.0149		54315
DEC02	3341.9384	0.0130		54316
DEC02	3645.7512	0.0102		54317
DEC02	3949.5636	0.0067		54318
DEC02	4253.3761	0.0031		54319
DEC02	4557.1887	0.0004		54320
DEC02	4861.0012	0.0001		54321
DEC02	4901.5092	0.0001		54322
DEC02	4921.7633	0.0001		54323

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TABLE 6-9 (CONTINUED)

```
DECO2 5164.8137    0.0001                                    54324
DECO2 5468.6262    0.0001                                    54325
DECO2 5772.4387    0.0001                                    54326
DECO2 6076.2514    0.0001                                    54327
DECO2 6380.0639    0.0001                                    54328
DECO2 6683.8765    0.0001                                    54329
DECO2 6987.6890    0.0001                                    54330
DECO2 7291.5015    0.0001                                    54331
DECO2        0.         0.                                   54332
DEC  - 543                                                   54333
```

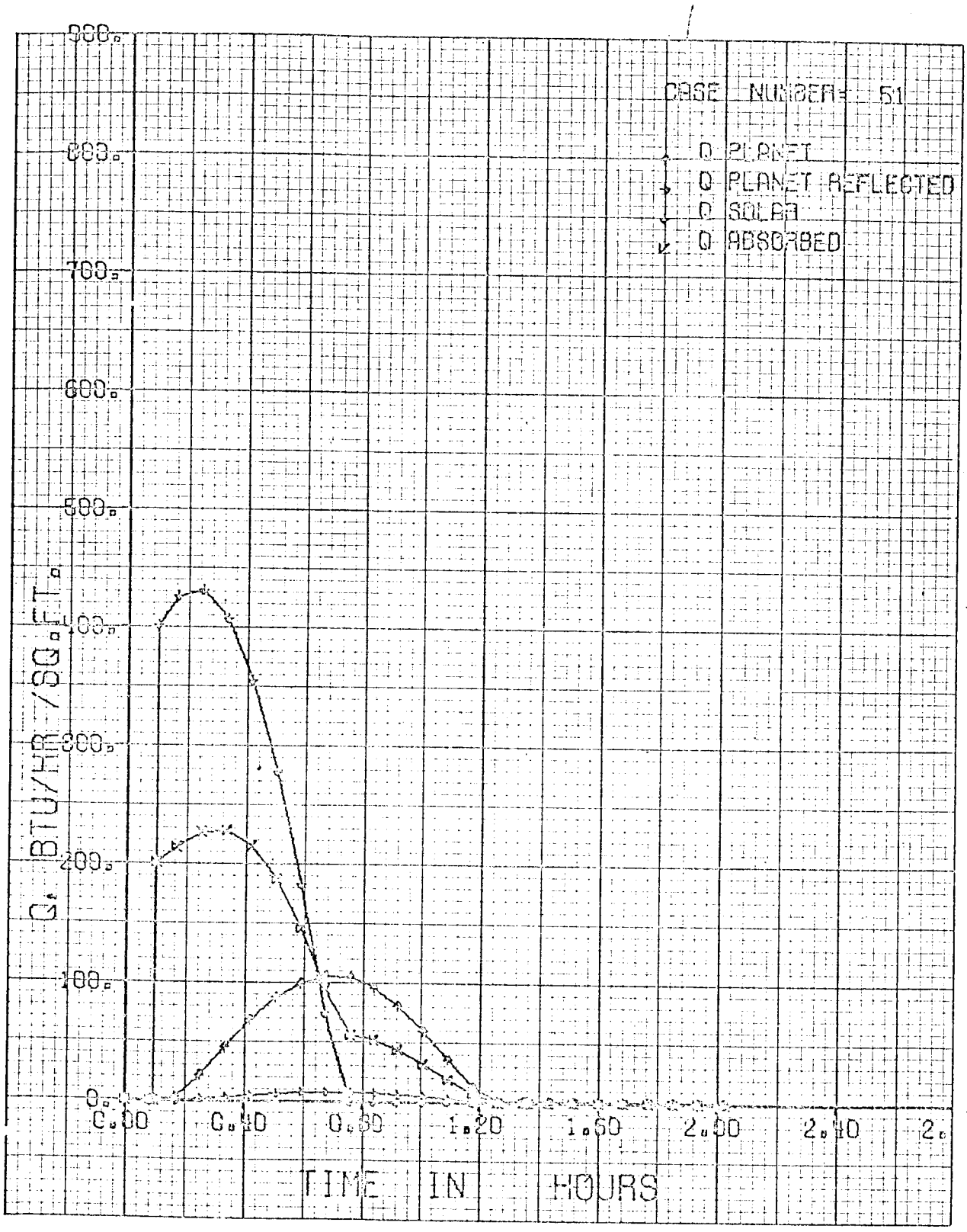

Figure 6-20. Plotted Output for Example 5, Side 1

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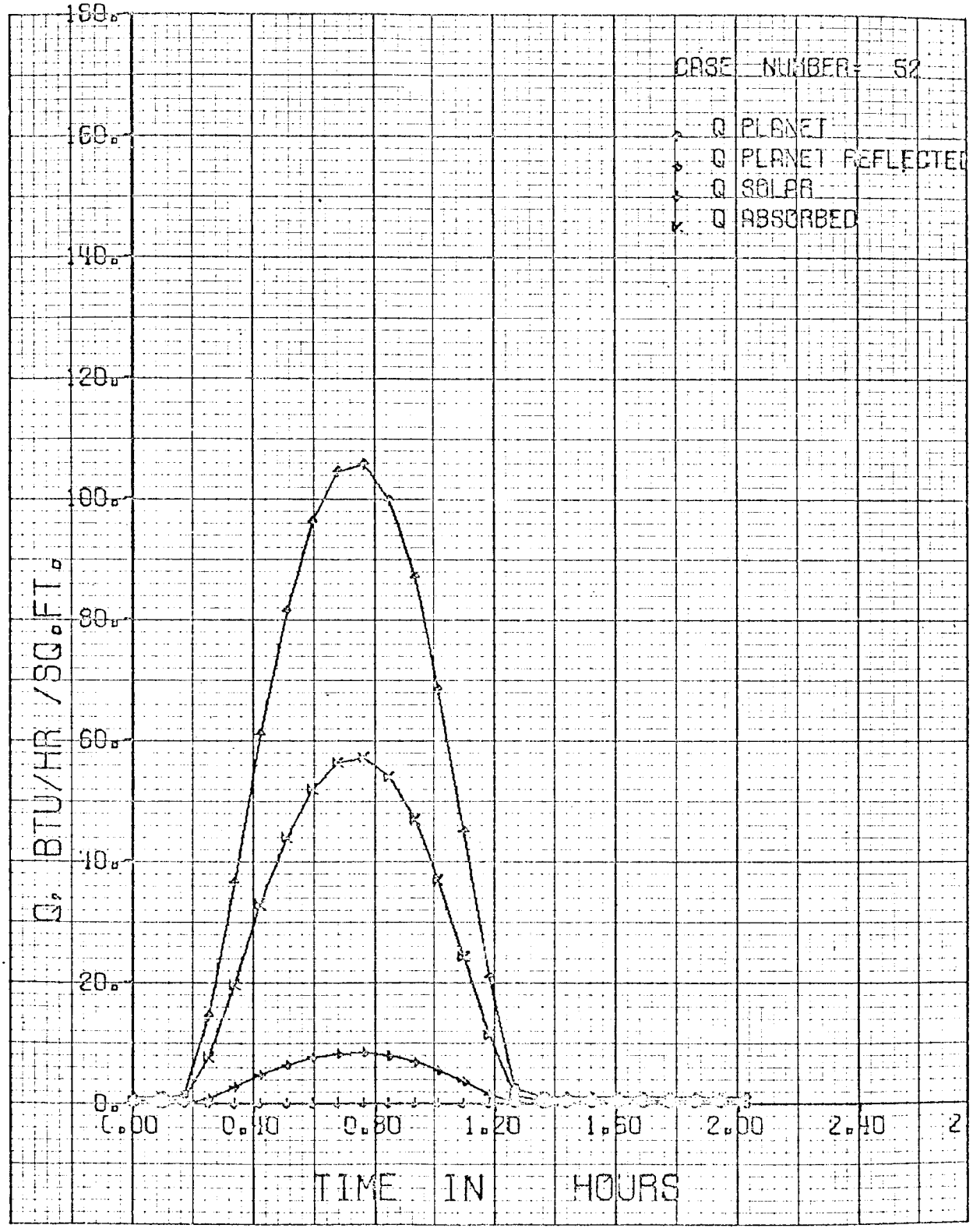

Figure 6-21. Plotted Output for Example 5, Side 2

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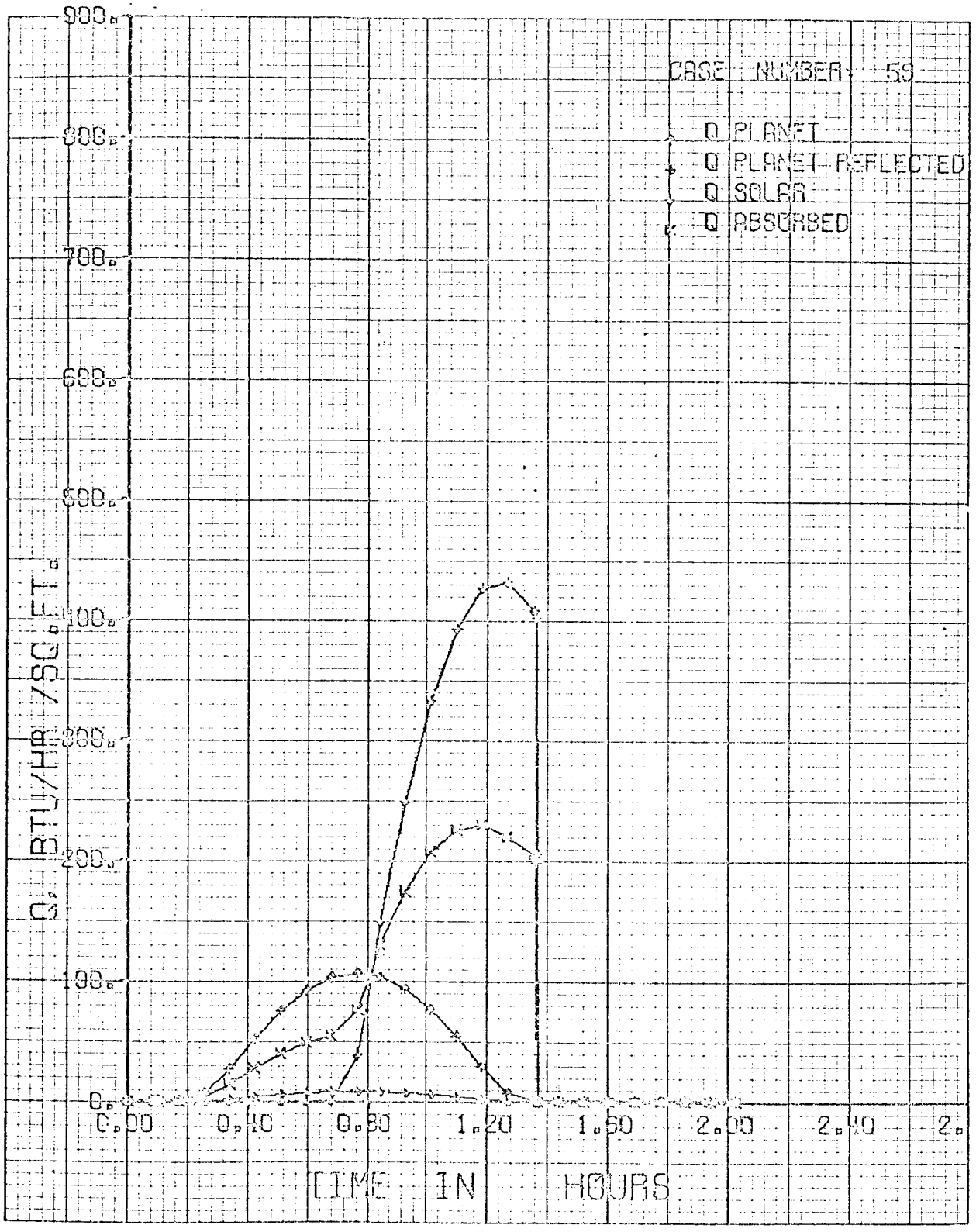

Figure 6-22. Plotted Output for Example 5, Side 3

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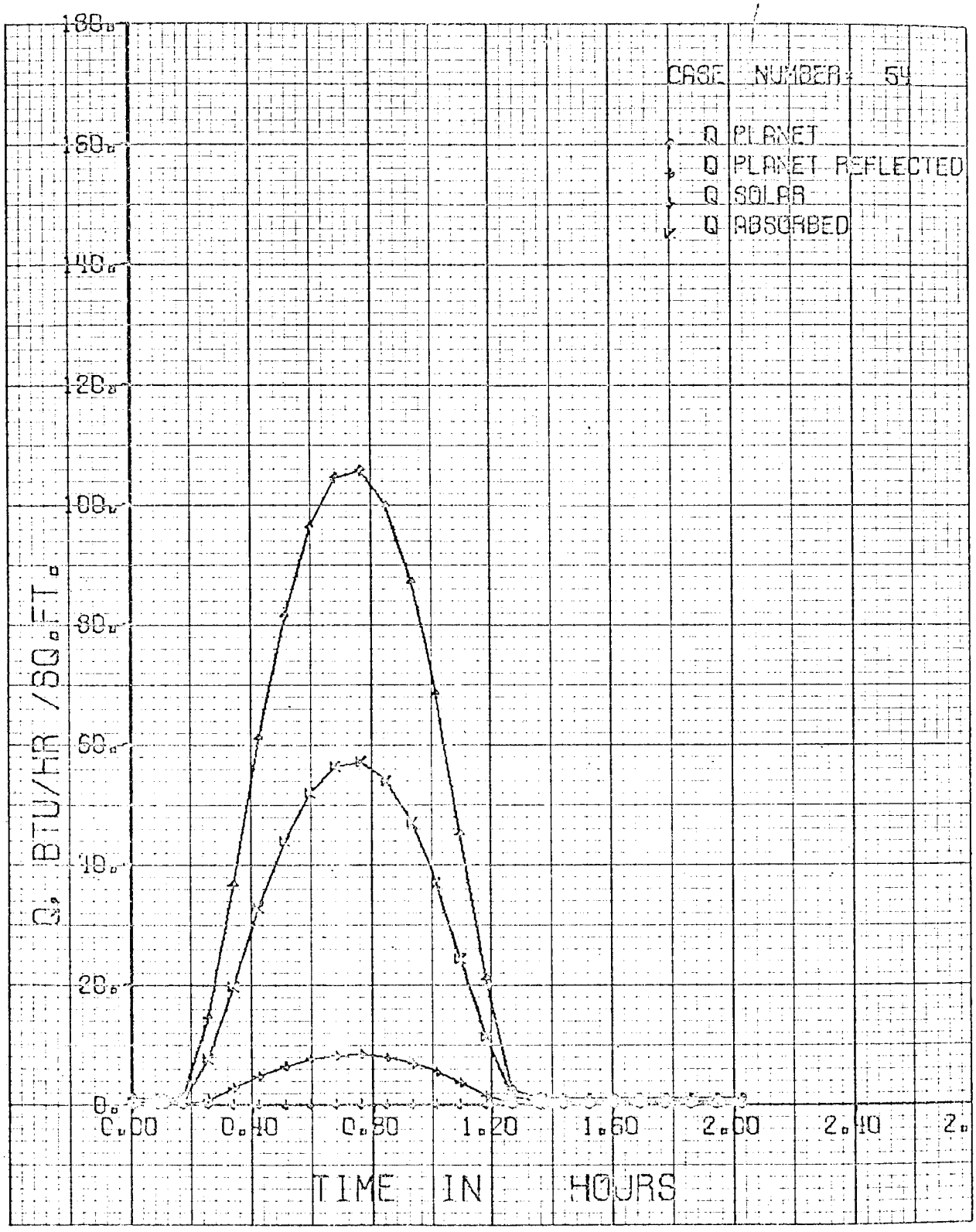

Figure 6-23. Plotted Output for Example 5, Side 4

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TABLE 6-10

INPUT FOR EXAMPLES 6 AND 7

SEQ.													ID
77 80	1 5	10	15	20	25 30	35	40	45	50	55 60	65	70 72	73 76
6101	1 1 7 6 1.									EXAMPLE 6.			
6102	1 2	-23.5	40.	90.	0.	180.	0.	1000.	0.	0.	0.		
6103	1 0.	1 0.											
7101	1 1 2 7 1.									EXAMPLE 7			
7102	0 2	-1 5.	3 0.	0.	0.	3 1 5.	0.	3 0 0.	0.	3 0.	0.		
7103	3.	3.											
7999	0.									END CARD			

TABLE 6-11. TABULAR OUTPUT FOR EXAMPLES 6 AND 7

ORBITAL RADIATION - 2374

CASE 61. EXAMPLE 6

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP	ALTITUDE SIZE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
12	-23.500	40.000	90.000	0.	180.000	0.	0.	0.	1000.	0.		

NON-ZERO CURVES PUNCHED -0 -0 -0 ALPHA= -0. EPSIL= -0.

V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR) (ALL Q IN BTU/HR/SQ.FT.)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
0.	1000.	0.	43.604	0.537	117.103			117.640	43.604	-0.	0.63390	

TABLE 6-11 (CONTINUED)

ORBITAL RADIATION - 2374

CASE 71. EXAMPLE 7

ORBIT EARTH RADIUS = 3959. ORIENTATION PLANET

MONTH	PSI SOLAR	PSI ORBIT	OMEGA ORBIT	SIGMA (VEHICLE	TAU ORIENTATION)	OMEGA PERIGEE	VO ENTRY	DEL V STEP SIZE	ALTITUDE SUBMITTED	ECCEN-TRICITY	PSI (SATELLITE)	OMEGA
2	-15.000	30.000	0.	0.	315.000	0.	30.000	0.	300.	0.		

NON-ZERO CURVES PUNCHED -0 -0 -0 ALPHA= -0. EPSIL= -0.

V DEG.	ALTITUDE MILES	TIME HRS.	Q(P)	Q(PR)	Q(SOL)	Q(SAT)	Q(SATR)	Q SOL.SPEC	Q INF.RED	Q ABSORB	F PLANET	F SATEL.
				(ALL Q IN BTU/HR/SQ.FT.)								
30.	300.	0.	2.199	2.503	423.304			425.807	2.199	-0.	0.02842	

VII GENERAL PROGRAM INFORMATION

ILLEGAL DATA HANDLING

Illegal characters in a data field will cause immediate termination of the program. An illegal character is defined as any character except numerals, decimal point, + and - signs, and E (for expression of an exponent) in the floating-point fields. An illegal character is anything except numerals and + and - signs in the integer fields. Only the dash (8-4 punch) is illegal in the Hollerith or "A" format fields.

Other types of data errors cannot so easily be checked. If a grid size parameter is entered as negative or zero, a diagnostic comment is printed and the case is deleted. If the case number is equal to zero or if the case number and the flags specifying planet and orientation are zero, the run is terminated. This can occur if the data cards are out of order so that the second or third card is read as the first card.

Provision has been made for extension of the program to other planets and orientations, but until appropriate data are entered into the program, requests for these are treated as illegal and the case is deleted with an appropriate comment.

ACCURACY OF INTEGRATION

The accuracy of the integration depends on the choice of the grid size. Normally, a value in degrees for $\Delta\psi$ and $\Delta\Omega$ is chosen equal to 1/100 of the value of the altitude in statute miles as a reasonable compromise between accuracy and speed. As altitude increases, the size of the grid may be increased. Figure 7-1 shows the relation between grid size, altitude, and accuracy for several representative Earth-orbiting cases. If desired, the user may select a finer grid size for increased accuracy, at the expense of increased computer time. Or, he may choose a coarser grid size for reduced computer time, at the expense of reduced accuracy.

EXECUTION TIME

For each orbit point calculated, execution time is a function of integration grid size, altitude, and orbit position. Time is inversely proportional

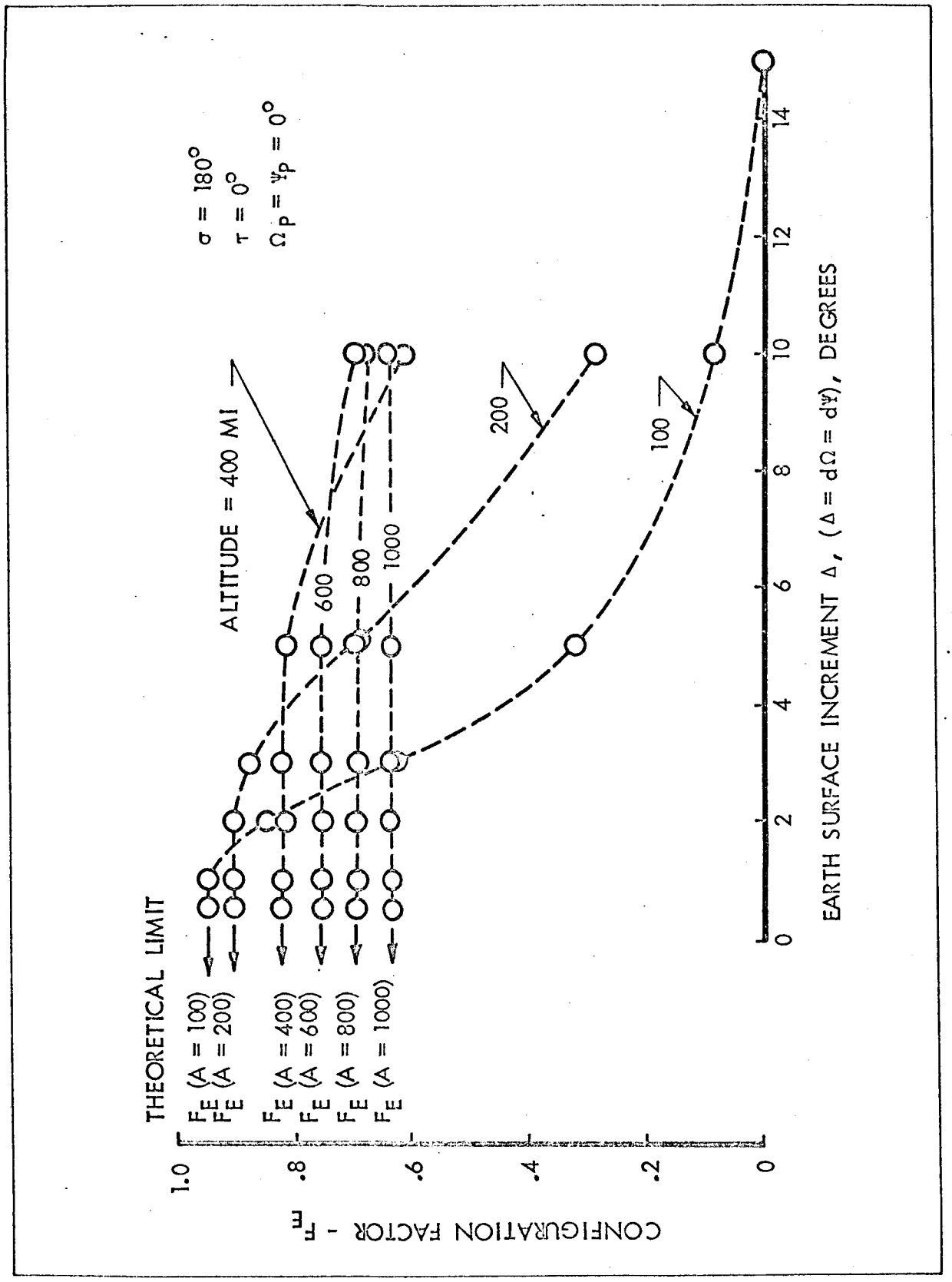

Figure 7-1. F_E vs Earth Surface Increment and Altitude

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to the grid size ($\Delta\psi_i \times \Delta\Omega_i$). The total area of the planet "seen" by the element is divided into differential areas for integration, and the basic part of the program is executed once for each differential area. Therefore, time of execution is inversely proportional to the differential area, $\Delta\psi_i \times \Delta\Omega_i$.

As altitude increases, the total area "seen" by the element increases, approaching a hemisphere as a limit:

$$\text{Area seen} = 2\pi R \left(\frac{R \times \text{Alt.}}{R + \text{Alt.}}\right) \qquad (7\text{-}1)$$

where R is the planet radius and Alt is the altitude of the element above the panel surface. It can be seen, therefore, that execution time is a direct, but non-linear function of altitude.

Execution time is a function of the orbit position because the area seen, mentioned above (eq. 7-1), can limit the integration only if the element does not see past one of the planetary poles. Therefore, a polar orbit will take more execution time than an equatorial orbit, and may take longer than an orbit between polar and equatorial, depending on the altitude.

As an approximation for estimating running time on the 7040/7094 (Mod I) DC, an average case with a 1° x 1° grid size takes about 3 seconds per point, or for an orbit calculated every 15°, 75 seconds.

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Appendix A

NOMENCLATURE

LATIN LETTERS

a	=	semi-major axis of elliptical orbit, statute miles
A	=	altitude above planet's surface, statute miles
A'	=	altitude above lunar surface, statute miles
A_o	=	altitude at perigee, statute miles
b	=	semi-minor axis of elliptical orbit, statute miles
C	=	conversion factor
C_F	=	eclipse factor
d	=	mean distance from center of Earth to center of moon, = 239,100 statute miles
E	=	$(1 - e)/(1 + e)$
e	=	eccentricity of elliptical orbit
F_E	=	total geometric view factor from the surface element to the Earth
F_M	=	total geometric view factor from the surface element to the moon
k	=	gravitational constant
ℓ_1, m_1, n_1	=	direction cosines, referenced to Earth
ℓ_1', m_1', n_1'	=	direction cosines, referenced to the moon
M	=	planet's mass
$\hat{n}_E$	=	local normal to surface of Earth
$\hat{n}_M$	=	local normal to surface of moon
$\hat{n}_P$	=	normal to surface element

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P	=	point P, location of surface element
p	=	orbit parameter, $= a\,(1 - e^2)$
q_E	=	irradiation of surface element due to Earth emissive power, Btu/hr-ft^2
q_{ER}	=	irradiation of surface element due to Earth reflective power, Btu/hr-ft^2
q_M	=	irradiation of surface element due to lunar emissive power, Btu/hr-ft^2
q_{MR}	=	irradiation of surface element due to lunar reflective power, Btu/hr-ft^2
q_S	=	irradiation of surface element due to solar radiation, Btu/hr-ft^2
R	=	mean radius of Earth (assumed to be a perfect sphere), = 3958.87 statute miles
R'	=	mean radius of moon, = 1081 statute miles
R_a	=	diffuse reflectance of Earth plus atmosphere system
r	=	distance between surface element and local point on Earth, statute miles
r'	=	distance between surface element and local point on moon, statute miles
$\vec{r}$	=	radius vector of Earth
S	=	irradiation on surface element normal to sun's rays due to solar radiation
S'	=	solar constant, = 2.00 calories/min-cm^2 ($\approx$ 443 Btu/hr-ft^2)
S_r	=	solar irradiation reflected and/or scattered by Earth-atmosphere system
S_ℓ	=	incident solar irradiation at a local point outside Earth's atmosphere
T	=	period of orbit, hours
T_M	=	temperature of lunar surface, °R
t	=	time, hours

W_E = outgoing radiant flux from Earth-atmosphere system, Btu/hr-ft^2

X, Y, Z = coordinate system for orbit plane

X', Y', Z' = coordinate system for orbit trajectory

X_o, Y_o, Z_o = basic coordinate system

x, y, z = local coordinate system at point P for surface element

GREEK LETTERS

α_S = solar absorptivity

ϵ_I = infrared emissivity

η = angle between sun's rays and line between planet and surface element

θ_E = angle between $\hat{n}_E$ and r

θ_M = angle between $\hat{n}_M$ and r'

θ_{M-S} = angle between sun's rays and $\hat{n}_M$

θ_P = angle between $\hat{n}_P$ and r

θ_P' = angle between $\hat{n}_P$ and r'

θ_S = angle between sun's rays and $\hat{n}_P$

ν = true anomaly of orbit (measured from perigee), degrees

ν_o = point of entry into orbit

ρ = polar length coordinate of orbit geometry

σ = Stefan-Boltzman constant, = 0.1713×10^{-8} Btu/hr-ft^2 - °R^4

σ, τ = local coordinates of normal to surface element, $\hat{n}_P$

ω = angle of rotation for translation of X - Y - Z axes to X' - Y' - Z' axes (angle between Z axis and major axis of orbit ellipse)

Ω, ψ = spherical coordinates for basic coordinate system

Ω', ψ' = spherical coordinates for lunar coordinate system

Ω_o, ψ_o = coordinates of orbit plane

Ω_M, ψ_M = coordinates of moon, referenced to Earth

Ω_P, ψ_P = coordinates of point P in basic coordinate system

Ω'_P, ψ'_P = coordinates of point P in lunar coordinate system

Ω_S, ψ_S = coordinates of sun

TERMINOLOGY

irradiation	- radiant flux density incident on the surface element
direct solar radiation	- radiation emanating directly from the sun
solar irradiation	- solar radiant flux density incident on the surface element
Earth emissive power	- radiant flux density in the infrared portion of the electromagnetic spectrum, and which is emitted directly from the Earth-atmosphere system to space at a result of its temperature
emissive irradiation	- radiant flux density incident on the surface element as a result of the emissive power of the Earth, or other planet
Earth reflective power	- flux density of solar radiation reflected and/or scattered from the Earth-atmosphere system to space
reflective irradiation	- radiant flux density incident on the surface element as a result of the reflective power of the Earth or other planet
radiosity	- total flux density of a planet's emissive and reflective radiation

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Appendix B

EQUATIONS EMPLOYED

As previously seen, the final solutions for the irradiation of the surface element were obtained as integral equations. Since these integral expressions cannot be solved in closed form, a solution by numerical techniques was necessitated. This was accomplished by finite differences on a digital computer (IBM 7094).

After algebraic rearrangement, the equations used in the digital computer program appear as follows:

EMISSIVE IRRADIATION FROM THE EARTH

$$q_E = \frac{C_1}{\pi} \int_{L_\psi}^{U_\psi} \int_{L_\Omega}^{U_\Omega} \frac{W_E \left[\max(\cos\theta_E, 0) \max(\cos\theta_P, 0)\right] \cos\psi \, d\Omega \, d\psi}{(r/R)^2} \tag{B-1}$$

where $C_1 = 0.1536$ (Btu/hr ft^2)/(cal/cm^2 day)

$$\left(\frac{r}{R}\right)^2 = \left(\frac{R+A}{R}\cos\psi_P \sin\Omega_P - \cos\psi \sin\Omega\right)^2 + \left(\frac{R+A}{R}\sin\psi_P - \sin\psi\right)^2 + \left(\frac{R+A}{R}\cos\psi_P \cos\Omega_P - \cos\psi\cos\Omega\right)^2 \tag{B-2}$$

$$\cos\theta_E = \frac{R}{r}\cos\psi \sin\Omega \left(\frac{R+A}{R}\cos\psi_P \sin\Omega_P - \cos\psi \sin\Omega\right) + \frac{R}{r}\sin\psi \left(\frac{R+A}{R}\sin\psi_P - \sin\psi\right) + \frac{R}{r}\cos\psi\cos\Omega \bullet \left(\frac{R+A}{R}\cos\psi_P \cos\Omega_P - \cos\psi\cos\Omega\right) \tag{B-3}$$

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$$\cos\theta_P = \frac{R}{r}\,\ell_1\left(\frac{R+A}{R}\cos\psi_P\sin\Omega_P - \cos\psi\sin\Omega\right)$$

$$+\frac{R}{r}\,m_1\left(\frac{R+A}{R}\sin\psi_P - \sin\psi\right) \qquad \text{(B-4)}$$

$$+\frac{R}{r}\,n_1\left(\frac{R+A}{R}\cos\psi_P\cos\Omega_P - \cos\psi\cos\Omega\right)$$

W_E = f (month, latitude), cal/cm^2 day

ℓ_1, m_1, n_1 are given by equation (4-3)

The integration limits, L and U, have been changed to encompass only that portion of the Earth which the surface element actually "see's." This reduces computer time by more than one half. The modified limits are:

$$L_\psi = \psi_P - (\delta + \text{increment});\quad U_\psi = \psi_P + \delta + \text{increment}$$

where $\delta = \cos^{-1}\left(\frac{R}{R+A}\right)$

$$L_\Omega = \Omega_P - \pi/2;\quad U_\Omega = \Omega_P + \pi/2$$

These limits also apply to the case of reflective irradiation, and similar limits are used for lunar emissive and reflective irradiation. The added increment insured that the entire "seen" area is used.

REFLECTIVE IRRADIATION FROM THE EARTH

$$q_{ER} = \frac{C_2}{\pi}\int_{L_\psi}^{U_\psi}\int_{L_\Omega}^{U_\Omega}\frac{\max(S_r,0)\,\max(\cos\theta_E,0)\,\max(\cos\theta_P,0)\,\cos\psi\, d\Omega\, d\psi}{(r/R)^2} \qquad \text{(B-5)}$$

where

$$C_2 = 221.25\ (\text{Btu/hr ft}^2)/(\text{cal/min cm}^2)$$

$$S_r = R_a\, S(\cos\Omega\cos\psi\cos\psi_S + \sin\psi\sin\psi_S) \qquad \text{(4-8,9)}$$

$$R_a = f\ (\text{month, latitude})$$

$$S = S'/(\vec{r})^2,\ \text{cal/min cm}^2 \qquad \text{(4-1)}$$

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$\vec{r}$ = f (month)

ψ_S = f (date)

Remainder of terms same as for equation (B-1).
The value of $\vec{r}$ are taken here as of the 15th of each month from the 1960 American Ephemeris and Nautical Almanac.

SOLAR IRRADIATION

$$q_S = C_3 \, C_F \, S \max \left[(M_1 \sin \psi_S + \eta_1 \cos \psi_S), \, 0 \right] \tag{B-6}$$

where $C_3 = 221.25$ (Btu/hr ft^2)/(cal/min cm^2)

$$\left.\begin{aligned} C_F &= 1, \ \cos \eta_P > -\sqrt{1-(R/\rho)^2} \\ C_F &= 0, \ \cos \eta_P \leq -\sqrt{1-(R/\rho)^2} \end{aligned}\right\} \tag{4-6}$$

Remainder of terms same as for equations (B-1) and (B-5).

LUNAR EMISSIVE IRRADIATION

$$q_M = \frac{\sigma \epsilon_I}{\pi} \int_{L_{\psi'}}^{U_{\psi'}} \int_{L_{\Omega'}}^{U_{\Omega'}} \frac{T_M^{\,4} \max (\cos \theta_M, 0) \max (\cos \theta_P', 0) \cos \psi' d\Omega' d\psi'}{(r'/R')^2} \tag{B-7}$$

where primed quantities refer to a lunar-based coordinate system

σ = Stefan-Boltzman constant

ϵ_I = lunar surface emissivity (assumed = 1.0)

T_M is defined by equation (4-11)

$(r'/R')^2$, $\cos \theta_M$, and $\cos \theta_P'$ are defined below:

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For lunar-referenced orbits (treating the moon as a planet):

$$\left(\frac{r'}{R'}\right)^2 = \left(\frac{R'+A'}{R} \cos \psi'_P \sin \Omega' - \cos \psi' \sin \Omega'\right)^2 + \left(\frac{R'+A'}{R'} \sin \psi'_P - \sin \psi'\right)^2$$

$$+ \left(\frac{R'+A'}{R'} \cos \psi'_P \cos \Omega'_P - \cos \psi' \cos \Omega'\right)^2 \qquad \text{(B-8)}$$

$$\cos \theta_M = \frac{R'}{r'} \cos \psi' \sin \Omega' \left(\frac{R'+A'}{R'} \cos \psi'_P \sin \Omega'_P - \cos \psi' \sin \Omega'\right)$$

$$+ \frac{R'}{r'} \sin \psi' \left(\frac{R'+A'}{R'} \sin \psi'_P - \sin \psi'\right) + \frac{R'}{r'} \cos \psi' \cos \Omega'$$

$$\cdot \left(\frac{R'+A'}{R'} \cos \psi'_P \cos \Omega'_P - \cos \psi' \cos \Omega'\right) \qquad \text{(B-9)}$$

$$\cos \theta'_P = \frac{R'}{r'} \ell'_1 \left(\frac{R'+A'}{R'} \cos \psi'_P \sin \Omega'_P - \cos \psi' \sin \Omega'\right)$$

$$+ \frac{R'}{r'} m'_1 \left(\frac{R'+A'}{R'} \sin \psi'_P - \sin \psi'\right)$$

$$+ \frac{R'}{r'} n'_1 \left(\frac{R'+A'}{R'} \cos \psi'_P \cos \Omega'_P - \cos \psi' \cos \Omega'\right) \qquad \text{(B-10)}$$

For Earth-referenced orbits (treating the moon as the Earth's satellite):

$$\left(\frac{r'}{R'}\right)^2 = \left(\frac{a_1'}{R} - \cos \psi' \sin \Omega'\right)^2 + \left(\frac{b_1'}{R'} - \sin \psi\right)^2$$

$$+ \left(\frac{c_1'}{R'} - \cos \psi' \cos \Omega'\right)^2 \qquad \text{(B-8a)}$$

$$a_1' = d \left(\frac{R+A}{d} \cos \psi_P \sin \Omega_P - \cos \psi_M \sin \Omega_M\right)$$

$$b_1' = d \left(\frac{R+A}{d} \sin \psi_P - \sin \psi_M\right)$$

$$c_1' = d \left(\frac{R+A}{d} \cos \psi_P \cos \Omega_P - \cos \psi_M \cos \Omega_M\right)$$

$$\cos \theta_M = \frac{R'}{r'} \cos \psi' \sin \Omega' \left(\frac{a_1'}{R'} - \cos \psi' \sin \Omega'\right)$$

$$+ \frac{R'}{r'} \sin \psi' \left(\frac{b_1'}{R'} - \sin \psi'\right) + \frac{R'}{r'} \cos \psi' \cos \Omega' \left(\frac{C_1'}{R'} - \cos \psi' \cos \Omega'\right) \qquad \text{(B-9a)}$$

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$$\cos\theta'_P = \frac{R'}{r'}\,\ell_1\left(\frac{a_1'}{R'} - \cos\psi'\sin\Omega'\right) + \frac{R'}{r'}\,m_1\left(\frac{b_1'}{R'} - \sin\psi'\right) + \frac{R'}{r'}\,n_1\left(\frac{c_1'}{R'} - \cos\psi'\cos\Omega'\right) \tag{B-10a}$$

LUNAR REFLECTIVE IRRADIATION

$$q_{MR} = \frac{C_5(1-\alpha_s)S}{\pi}\int_{L_{\psi'}}^{U_{\psi'}}\int_{L_{\Omega'}}^{U_{\Omega'}} \frac{\max(\cos\theta_S,0)\max(\cos\theta_M,0)\max(\cos\theta'_P,0)\cos\psi'\,d\Omega'\,d\psi'}{(r'/R')^2} \tag{B-11}$$

where $C_5 = 221.25$ (Btu/hr ft^2)/(cal/min cm^2)

$$\cos\theta_S = m_1\sin\psi_S + n_1\cos\psi_S \tag{4-4}$$

$(r'/R')^2$, $\cos\theta_M$, and $\cos\theta'_P$ were defined above for both Earth-referenced and lunar-referenced orbits.

ORBITAL GEOMETRY

$$\psi_P = \sin^{-1}\left[\sin\psi_o\,(\cos\nu\cos\omega - \sin\nu\sin\omega)\right] \tag{B-12}$$

$$\Omega_P = \cos^{-1}\left\{\left[\cos\Omega_o\,(\cos\nu\cos\omega - \sin\nu\sin\omega)\right] - \frac{\sin\Omega_o}{\cos\psi_o}\,(\sin\nu\cos\omega + \cos\nu\sin\omega)\right\} \tag{B-13}$$

$$(R+A) = (R+A_o)\,\frac{1-e^2}{1+e\cos\nu} \tag{B-14}$$

The parameters ψ_o, Ω_o, ω, A_o, and e are basic inputs to the computer as discussed in Sections III and V. The true anomaly, ν, is submitted as ν_o and $\Delta\nu$ (in degrees), and the computer calculates values of Ω_P and ψ_P for ν from

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ν_o to $\nu_o + 360^o$ in increments of $\Delta\nu$. A_o is the value of the altitude at perigee.

TIME

$$t = \frac{(R+A_o)^{3/2}}{k\, M_E^{1/2}} \left[2 \tan^{-1} \left(E^{1/2} \tan \frac{\nu}{2}\right) - \frac{e(1-e^2)^{1/2} \sin \nu}{1 + e\cos \nu} \right] \tag{B-15}$$

PLANETARY VIEW FACTORS

$$F_E = \frac{1}{\pi} \int_{L_\psi}^{U_\psi} \int_{L_\Omega}^{U_\Omega} \frac{\max(\cos \theta_E, 0) \max(\cos \theta_P, 0) \cos \psi \, d\Omega \, d\psi}{(r/R)^2} \tag{B-16}$$

$$F_M = \frac{1}{\pi} \int_{L_{\psi'}}^{U_{\psi'}} \int_{L_{\Omega'}}^{U_{\Omega'}} \frac{\max(\cos \theta_M, 0) \max(\cos \theta'_P, 0) \cos \psi' \, d\Omega' \, d\psi'}{(r'/R')^2} \tag{B-17}$$

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Appendix C

PROGRAM ARRANGEMENT AND LISTING

Proper use of the incident orbital radiant heat flux ("Orbital Radiation") program requires three program decks, associated control cards, a plotting subroutine package, and input data. For use with the Calcomp plotter, one set of plotting subroutines is required; for use with the SC-4020 plotter, a different set of plotting routines is required. Input data are supplied by the user in the format described in Section V. Figure C-1 shows the deck setup for use with the IBM 7040/7094-DC Computer and the Calcomp plotter.

The three basic program decks are:

1. The main deck, named ORAD, does all the required computations, reads the input, prints the output, and punches cards if requested.
2. Subroutine WSRA1 is a block data program containing tables of radiative heat loss of the Earth (calories/cm^2 day), by month and latitude, and diffuse reflectance of the Earth-atmosphere system (solar constant = 2.0 calories/cm^2 min) by month and latitude. These tables are entered into the main program by means of common storage block WSRA.
3. Subroutine QPLOT (deck name QPLT) receives computed data from the main program through common storage block QPX. These data are then plotted with each case on a separate graph. There may be as many as eight curves on a graph if all quantities are requested.
4. Plotting subroutine package. Subroutine QPLOT makes use of several system subroutines which draw axes, print titles, draw symbols and lines, and locate the points on the graph. The lists below give the subroutine names of the required subroutines.

Calcomp Plotter	SC 4020 Plotter
ASCALE	ASCALE
LINE	CAMRAV
NUMBER	GRIDIV
PLOT	POINTV
PLOTS	PRINTV
SYMBL 4	APRNTV
TRWEND	LINEV
XYAXIS	

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Figure C-2 is a simplified flow diagram, indicating the major branches and sections of the program. Table C-1 is a complete listing of the source program cards.

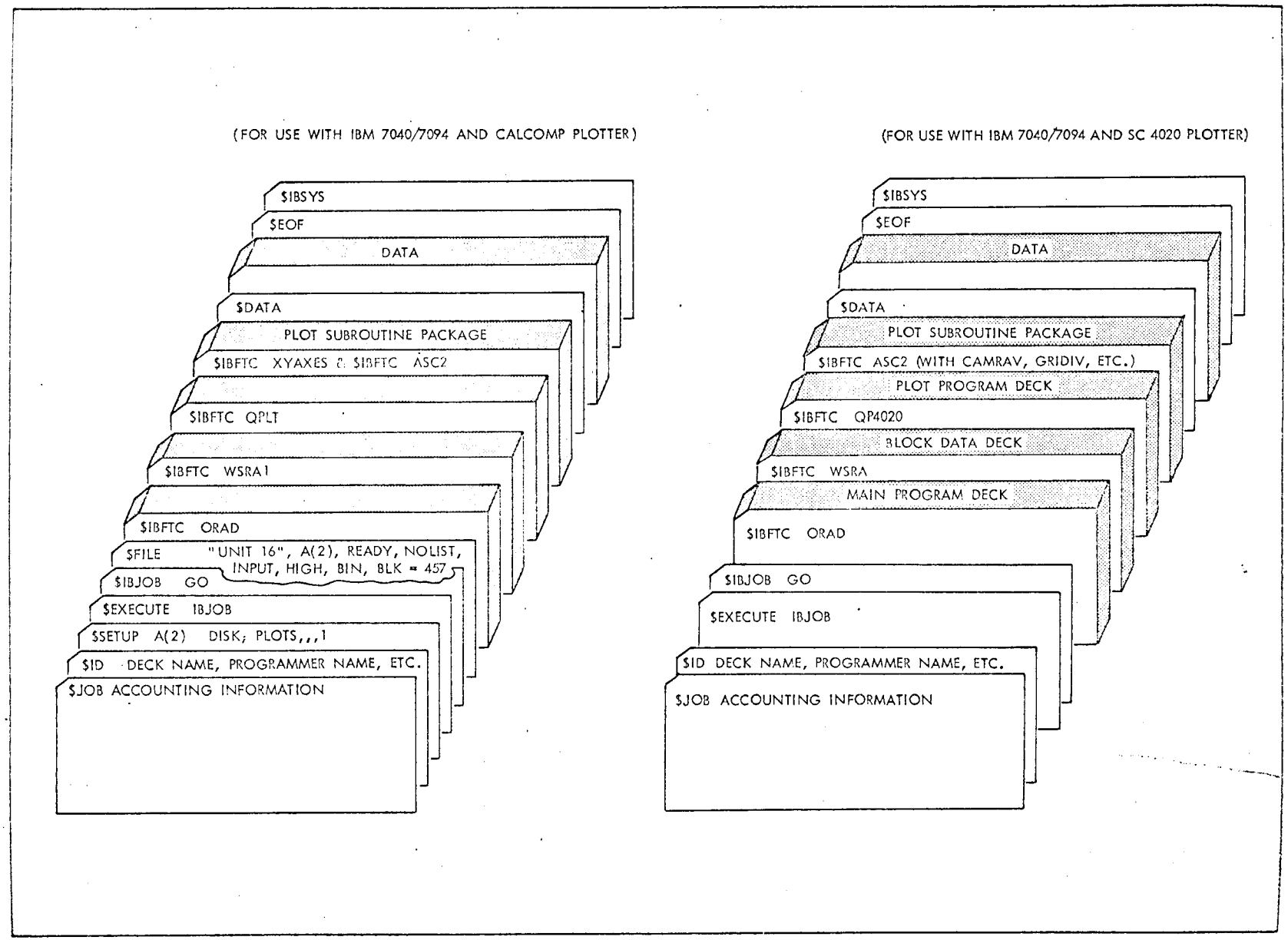

Figure C-1. FORTRAN IV Source Deck Set-up for Orbital Radiation Program

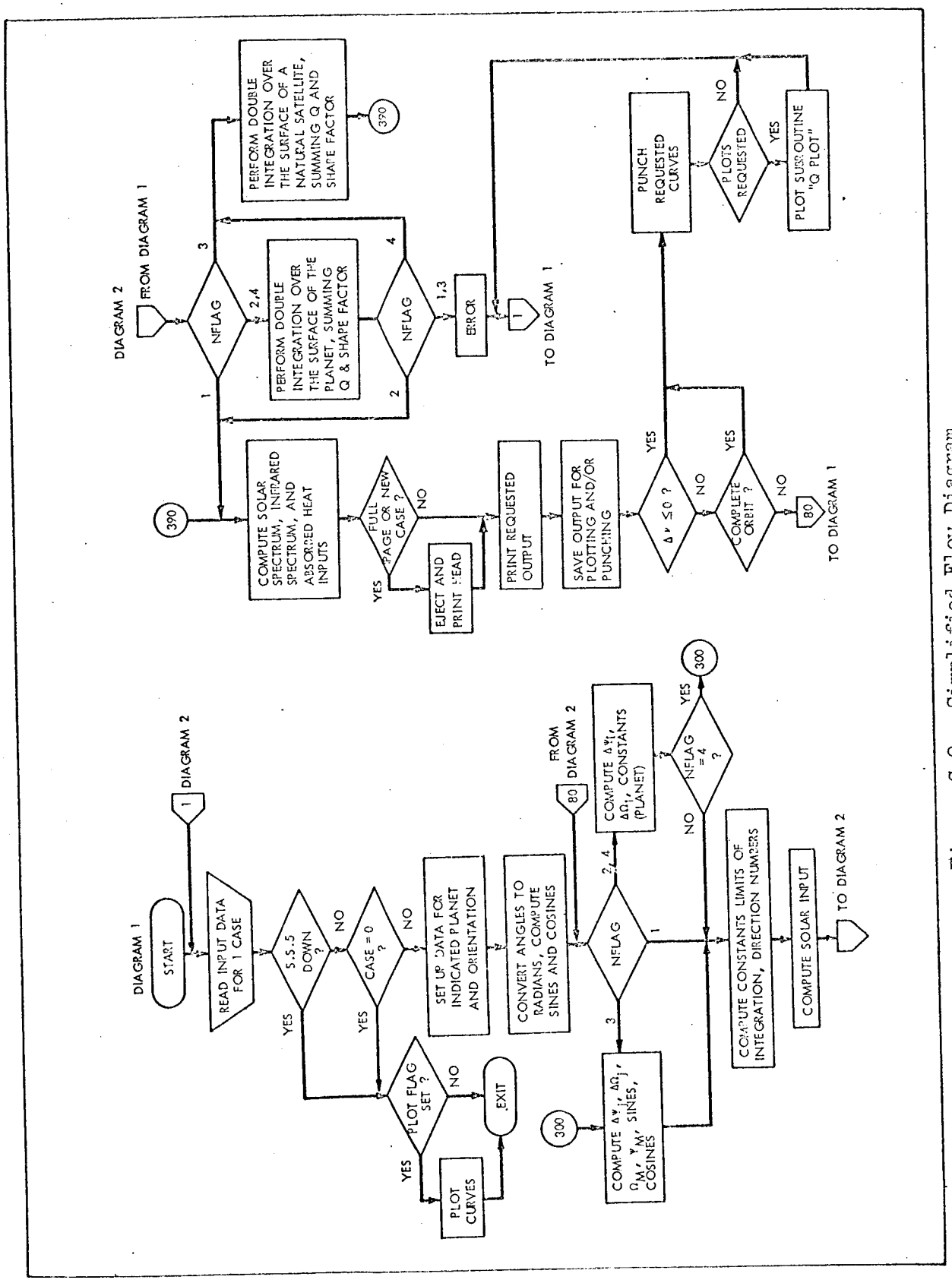

Figure C-2. Simplified Flow Diagram

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TABLE C-1. PROGRAM LISTING

```
$IBFTC ORAD    REF
      DIMENSION RBARM(12)                                               1289005
      DIMENSION XTIMP(360),YSOLP(360),YIRP(360),YABSP(360)              ORAD005
      DIMENSION ALBEDO(10),RATME(10)                                    1289005
      DIMENSION DFS(10),RADIUS(10)                                      1389005
      DIMENSION PLAN1(10),PLAN2(10),ORIEN(3),DATB(7)                    2374005
      DIMENSION DATE(6),VK(360),FM(360),FE(360),A(80)                   13890050
      DIMENSION DECLS(12)                                               2374005
      COMMON /WSRA/ WS1(12,19),RA1(12,19)                               13890060
      COMMON /QPX/PLT(8),XTIM(360),YQ1(360),YQ2(360),YQ3(360),YQ4(360), 23740061
     1 YQ5(360),YSOL(360),YIR(360),YABS(360),NPLTF,PNO                  23740062
C     9/3/64   PROGRAM CONSTANTS                                        13890067
C     DATA ORDER..EARTH(1),MOON(2),MERCURY(3),VENUS(4),MARS(5),         13890068
C     JUPITER(6),SATURN(7),URANUS(8),NEPTUNE(9),PLUTO(0)                13890069
      DATA (RADIUS(I),I=1,10)/3958.87,1080.,1500.,3800.,2100.,43500.,   13890071
     2 38000.,16000.,16500.,2000. /                                     13890072
      DATA (DFS(I),I=1,10) /1.,1.,.387,.72,1.516,5.25,10.75,19.35,      13890073
     1 30.0,39.6 /                                                      13890074
      DATA (RBARM(I),I=1,12)/.9835464,.9876141,.9946046,1.0034293,      13890075
     1 1.0110198,1.0156605,1.0164697,1.0127430,1.0055312,.9990161,      13890076
     2 .9890046,.9841658 /                                              13890077
      DATA (PLAN1(I),I=1,10)/6HEARTH ,6HMOON  ,6HMERCUR,6HVENUS ,       13890078
     1 6HMARS  ,6HJUPITE,6HSATURN,6HURANUS,6HNEPTUN,6HPLUTO /           13890079
      DATA (PLAN2(I),I=1,10) /6H    RA,6H    RA,6HY   RA,6H    RA,      2374008
     1 6H    RA,6HR   RA,6H    RA,6H    RA,6HE   RA,6H    RA/           23740081
      DATA (ORIEN(I),I=1,3)/6HPLANET,6HINERT.,6HFLIGHT/                 13890082
      DATA DATB(1),DATB(4),DATB(5),DATB(6)/6HORBIT ,6HDIUS =,6HORIENT,  23740083
     1 6HATION /                                                        23740083
      DATA (DECLS(I),I=1,12) / -.37242,-.22837,-.03870,.16911,.32836,   23740084
     1 .40667,.37636,.24656,.05441,-.14718,-.32166,-.40592 /            23740085
      DATA (ALBEDO(I),I=1,10)/.39,.073,.06,.76,.15,.51,.50,.66,.62,.16/ 23740086
      DATA (RATME(I),I=1,10)/1.,.01234,.054,.814,.108,318.35,95.28,     ORAD0087
     1 14.58,17.36,.8312/                                               23740088
      LOGICAL BACK1,BACK2,BACK3                                             012
      INTEGER PLT                                                       2374012
      NPLTF=0                                                           23740121
 1    READ (5,1005) NP,NOR,NF,CASE,KNO1,BS,KNO2,BI,KNO3,BA,ALFA,EPS,    23740122
     1 (DATE(I),I=1,3)                                                  23740123
      CALL SSWTCH (5,NOVT)                                              23740124
      GO TO (23,101),NOVT                                               23740125
 101  IF (CASE.EQ.0.) GO TO 23                                          23740126
      PNO=CASE                                                          2374013
      NPLAN=NP                                                          13890131
      NFLAG=NF                                                          13890131
      READ (5,1001) MONTH,PSIS,PSID,OMJ,SIG,TAU,OMEG,AS,ECCEN,VV,DELV   13890131
      READ (5,1000) DPSII,DOMI,PSIM,OMM,DPSIJ,DOMJ,PLT                  23740132
 11   IF (NP.EQ.0.AND.NOR.EQ.0.AND.CASE.EQ.0.) GO TO 23                 13890133
      IF (NPLAN.EQ.0) NPLAN=10                                          1389014
      IF (NOR.NE.3) GO TO 12                                            13890141
 990  FORMAT (47HONOR=3 TEMPORARILY ILLEGAL (FLIGHT ORIENTATION) )     13890142
      WRITE (6,990)                                                     13890143
      GO TO 1                                                           13890144
 23   NPLTF=1                                                           23740145
      IF (NPLT.GT.0) CALL QPLOT                                         23740145
      CALL EXIT                                                         13890145
      STOP                                                              13890145
 4    WRITE (6,2601)CASE                                                13890147
      GO TO 1                                                           13890148
 12   IF (NPLAN.LE.2) GO TO 13                                              015
      WRITE (6,991) NPLAN                                                   0151
```


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TABLE C-1 (CONTINUED)

```
      GO TO 1                                                           0152
991   FORMAT (7HONPLAN= I3, 24H IS TEMPORARILY ILLEGAL.  )              0153
13    NPLT=PLT(1)+PLT(2)+PLT(3)+PLT(4)+PLT(5)+PLT(6)+PLT(7)+PLT(8)     2374016
      DATB(2)=PLAN1(NPLAN)                                              1389017
      DATB(3)=PLAN2(NPLAN)                                              1389018
      DATB(7)=ORIEN(NOR)                                                2374019
      NEWCS=NOR                                                         1389020
3     RE= RADIUS(NPLAN)                                                 13890380
      KNTR=0                                                            1389039
      KOUNT=60                                                          1389040
      ISEQ1=0                                                           1389040
      ISEQ2=1                                                           1389041
      BACK1=.FALSE.                                                     0042
      BACK2=.FALSE.                                                     0043
      BACK3=.FALSE.                                                     0044
      SAVE=0.                                                           0045
      MFLAG = NFLAG                                                     13890490
      IK=1                                                              13890500
      E1=1.0                                                            13890510
      IF (NPLAN.EQ.1) RM=RADIUS(2)                                      1389052
      IF (NPLAN.EQ.2) RM=RADIUS(1)                                      1389052
      IF (NPLAN.LE.2) RBAR=RBARM(MONTH)                                 1389052
      IF (NPLAN.GT.2) RBAR=DFS(NPLAN)                                   1389052
      S = 2.0/RBAR**2                                                   13890521
      PI= 3.1415927                                                     13890530
      TWOPI = 2.0*PI                                                    13890540
      HAFPI = PI/2.0                                                    13890550
      D = 239100.0                                                      13890560
      ALPH=1.-ALBEDO(NPLAN)                                             2374057
      CKMASE=308.8539                                                   2374058
      T700=CKMASE*SQRT(RATME(NPLAN))                                    23740581
      CKME=T700                                                         2374059
      T435  = 5.0*PI/12.0                                               2374059
      T338 = (0.0334313* ALPH/E1     *S)**.25 *1000.0                   2374059
      T339 = 12.0/PI *(387.0-T338)                                      2374059
      T340 = 6.0*T338                                                   2374059
      PSIS1=PSIS                                                        13890601
      PSIS=PSIS/57.2957795                                              13890602
      IF (PSIS1.GT.360.) PSIS=DECLS(MONTH)                              23740603
5     TA1=TAU                                                           13890640
      SI1=SIG                                                           13890650
      OME1=OMEG                                                         13890660
      PSI1=PSIO                                                         13890670
      DEL1=DELV                                                         2374068
      OM1=OMO                                                           13890680
      PSIO=PSIO/57.2957795                                              13890690
      OMO=OMO  /57.2957795                                              13890700
      TAU=TAU  /57.2957795                                              13890710
      SIG=SIG  /57.2957795                                              13890720
      OMEG=OMEG/57.2957795                                              13890730
      DELV=DELV/57.2957795                                              13890740
      V = VV/57.2957795                                                 13890750
      CPSIO =COS(PSIO)                                                  13890760
      SPSIO =SIN(PSIO)                                                  13890770
      COMO  =COS(OMO  )                                                 13890780
      SOMO  =SIN(OMO  )                                                 13890790
      CTAU  =COS(TAU)                                                   13890800
      STAU  =SIN(TAU)                                                   13890810
      CSIG  =COS(SIG)                                                   13890820
      SSIG  =SIN(SIG)                                                   13890830
```

TABLE C-1 (CONTINUED)

```
      COMEG =COS(OMEG)                                                  13890840
      SOMEG =SIN(OMEG)                                                  13890850
      CPSIS =COS(PSIS)                                                  13890870
      SPSIS =SIN(PSIS)                                                  13890880
      TPSIS=SPSIS/CPSIS                                                 13890890
      FTPSI = SQRT(1.0+TPSIS**2)                                        13890900
      VK(1) = VV                                                        13890910
      E=ECCEN                                                           13890940
      T335= .061462*(1.0-ALPH)*S/PI                                     13890950
      T342 = .47583E-12*E1/PI                                           13890960
      T341 = 0.129168*ALPH *S /E1                                       13890970
      T701 = SQRT((1.0-E)/(1.0+E))                                      13890980
      T703 = E*SQRT(1.0-E*E)                                            13890990
      V0=V                                                              13891000
      T43S=COS(V)*COMEG -SIN(V)*SOMEG                                   13891010
      T44S=SIN(V)*COMEG+COS(V)*SOMEG                                    13891020
C     NFLAG =1 IMPLIES COMPUTE Q3 ONLY                                  13891030
C     NFLAG =2 IMPLIES COMPUTE Q1,Q2,Q3                                 13891040
C     NFLAG =3 IMPLIES COMPUTE Q3,Q4,Q5                                 13891050
C     NFLAG =4 IMPLIES COMPUTE Q1,Q2,Q3,Q4,Q5                           13891060
 80   GO TO ( 40,200,300,200),NFLAG                                     13891070
 40   CV = COS(V)                                                       13891080
      SV = SIN(V)                                                       13891090
      VV=V*57.2957795                                                       1091
      VK(IK)=VV                                                             1092
      Q1=0.0                                                            13891100
      Q2=0.0                                                            13891110
      Q3=0.0                                                            13891120
      Q4=0.0                                                            13891130
      Q5=0.0                                                            13891140
      Q14=0.0                                                           13891150
      Q225=0.0                                                          13891160
      DFL=0.0                                                           13891170
      FM1=0.0                                                           13891180
      T43 = CV *COMEG - SV* SOMEG                                       13891190
      T44 = SV*COMEG + CV*SOMEG                                         13891200
 50   SPSIP = SPSIO * T43                                               13891210
      PSIP = ASIN(SPSIP)                                                13891220
      CPSIP = COS(PSIP)                                                 13891230
      IF (ABS(PSIP - HAFPI) -.0001) 21,21,20                            13891240
 20   IF (ABS(PSIP + HAFPI) -.0001) 21,21,51                            13891250
 21   OMP = OMO + HAFPI                                                 13891260
      GO TO 72                                                          13891270
 51   XO = CPSIO * SOMO *T43 + COMO*T44                                 13891280
      ZO = COMO*T43*CPSIO - SOMO*T44                                    13891290
      COMP = ZO/CPSIP                                                   13891300
      OMP =  ACOS(COMP)                                                 13891310
      IF (XO) 71,72,72                                                  13891320
 71   OMP =  TWOPI -OMP                                                 13891330
 72   SOMP = SIN(OMP)                                                   13891340
      COMP = COS(OMP )                                                  13891350
 52   RPA =  (RE+AS)*(1.0+ECCEN    )/(1.0+ECCEN*CV)                     13891360
      ALT=RPA-RE                                                        13891361
      GO TO (66,41,59,41),NFLAG                                         13891370
 41   T42 = ACOS(RE /RPA )                                              13891380
 35   IF (ABS(SIG).LE.PI) GO TO 32                                      ORAD139
      IF (SIG.LT.-PI) SIG=SIG+TWOPI                                     ORAD140
      IF (SIG.GT.PI) SIG=SIG-TWOPI                                      ORAD141
      GO TO 35                                                          ORAD142
 32   CGAM = CTAU*CSIG                                                  13891450
```

TABLE C-1 (CONTINUED)

```
      GAM = ACOS(CGAM)                                                  13891450
      IF (T42.LE.GAM) GO TO 45                                          ORAD147
      GO TO (31,45),NEWCS                                               ORAD148
31    NFLAG = NFLAG - 1                                                 13891490
      GO TO 53                                                          13891500
45    BEGIN=0.                                                          ORAD151
47    IF (T42.LE.BEGIN) GO TO 48                                        ORAD152
      BEGIN=BEGIN+DPSII                                                 ORAD153
      GO TO 47                                                          ORAD154
48    XPSII = PSIP + BEGIN                                              13891570
      YPSII = PSIP - BEGIN +DPSII/2.0                                   13891580
      XOMI=OMP+BEGIN                                                    ORAD1581
      YOMI=OMP-BEGIN+DOMI/2.                                            ORAD1582
      IF (ABS(YPSII).LE.1.5707963.AND.ABS(XPSII).LE.1.5707963) GO TO 49 ORAD1583
      XPSII=1.5707963                                                   ORAD1584
      YPSII=-1.5707963+DPSII/2.                                         ORAD1585
      XOMI=OMP+PI                                                       ORAD1586
      YOMI=OMP-PI+DOMI/2.                                               ORAD1587
49    T209=RPA/RE                                                       ORAD159
      T210 = T209  *CPSIP                                               13891600
      T211 = T209  *SPSIP                                               13891610
      T212 = T210*COMP                                                  13891620
      T213 = T210*SOMP                                                  13891630
      PSII =YPSII                                                       13891640
      OMI  =YOMI                                                        13891650
53    IF (NFLAG - 3) 66,59,59                                           13891660
59    T300 = RPA/D                                                      13891670
      T301 = T300  *CPSIP                                               13891680
      T302 =(T300 * SPSIP - SPSIM)*D                                    13891690
      T303 =(T301 * SOMP  - CPSIM * SOMM)*D                             13891700
      T304 =(T301 * COMP - CPSIM*COMM)*D                                13891710
      T305 = SQRT(T302*T302+T303*T303+T304*T304)                        13891720
      PSIPJ = ASIN(T302/T305)                                           13891730
      CPSIPJ = COS(PSIPJ)                                               13891740
      IF (ABS(CPSIPJ) -0.001) 57,57,56                                  13891750
57    OMPJ = PI/2.0                                                     13891760
      GO TO 58                                                          13891770
56    OMPJ = -PI/2.0                                                    13891780
58    T306 = ACOS(RM/T305)                                              13891790
62    XOMJ = OMPJ + HAFPI                                               13891800
      YOMJ = OMPJ - HAFPI + DOMJ/2.0                                    13891810
      BEGIM =0.0                                                        13891820
63    IF (T306-BEGIM) 65,65,64                                          13891830
64    BEGIM = BEGIM + DPSIJ                                             13891840
      GO TO 63                                                          13891850
65    XPSIJ = PSIPJ + HAFPI                                             13891860
      YPSIJ = PSIPJ - HAFPI + DPSIJ/2.0                                 13891870
      PSIJ = YPSIJ                                                      13891880
      OMJ = YOMJ                                                        13891890
66    T702 = ATAN(T701 *SIN((V-V0)/2.0)/COS((V-V0)/2.0))                13891900
      IF (ABS(V-PI-V0) -0.001) 69,69,70                                 13891910
69    T702 = HAFPI                                                      13891920
      GO TO 68                                                          13891930
70    IF (V-PI-V0) 68,69,67                                             13891940
67    T702 = T702+PI                                                    13891950
68    T704 = T703*SIN(V-V0)/(1.0+E*COS(V-V0))                           13891960
      TIME = ((RE +AS)/(1.0-E))**1.5/(T700)*(2.0*T702 -T704)/3600.0     13891970
      A1 = CTAU * SSIG                                                  13891980
      A2 = CTAU * CSIG                                                  13891990
      B1 = CPSIO * SOMO                                                 13892000
```

TABLE C-1 (CONTINUED)

```
      B2 = CPSIO * COMO                                                 13892010
      GO TO (81,91),NEWCS                                               13892020
91    XL=A1*(COMO*T43S -B1*T44S )-STAU*SOMO*SPSIO+A2*(COMO*T44S +B1*T43S13892030
     1 )                                                                13892040
      XM=STAU*CPSIO+SPSIO*T43S *A2-A1*SPSIO*T44S                        13892050
      XN=A2*(B2*T43S -SOMO*T44S )-A1*(SOMO*T43S +B2*T44S )-STAU*SPSIO*CO13892060
     1MO                                                                13892070
      GO TO 100                                                         13892080
81    XL = A1 *(COMO *T43 -B1 *T44) -STAU *SOMO *SPSIO +A2*(COMO*T44+   13892090
     1 B1 * T43)                                                        13892100
      XM = STAU * CPSIO + SPSIO * T43 *A2 -A1 *SPSIO *T44               13892110
      XN = A2 *(B2*T43 - SOMO*T44) -A1*(SOMO*T43 + B2*T44) -STAU*SPSIO  13892120
     1 *COMO                                                            13892130
100   T1= SPSIS*SPSIP + CPSIS*CPSIP*COMP                                13892140
      T2= -SQRT(RPA**2-RE**2)/RPA                                       13892150
      IF (T1.LE.T2) GO TO 120                                               2160
      IF (SAVE.LT.0.) GO TO 140                                             2161
      IF (BACK3) GO TO 160                                                  2162
115   SAVE=T1-T2                                                            2170
      CF=0.061462                                                           2171
      T3=XM*SPSIS+XN*CPSIS                                                  2172
      IF (T3.LE.0.) GO TO 122                                               2173
      DQ3=S*T3*CF*3600.                                                     2174
      GO TO 125                                                             2175
120   IF (SAVE.GT.0.) GO TO 140                                             2180
      IF (BACK3) GO TO 160                                                  2181
121   SAVE=T1-T2                                                            2182
122   DQ3=0.                                                                2183
125   Q3=Q3+DQ3                                                             2184
      BACK1=.FALSE.                                                         2185
      GO TO (390,210,310,210),NFLAG                                         2186
140   IF (BACK1) GO TO 145                                                  2190
      IF (BACK2) GO TO 150                                                  2191
      VSAVE=V                                                               2192
      DVSAVE=DELV                                                           2193
      BACK1=.TRUE.                                                          2194
      DELV=1./57.2957795                                                    2195
145   V=V-DELV                                                              2200
      BACK2=.TRUE.                                                          2201
      GO TO 40                                                              2202
150   DELV=VSAVE-V                                                          2210
      BACK3=.TRUE.                                                          2211
      IF (DELV.GE.0.) GO TO 155                                         23742212
      DELV=0.                                                           23742213
      V=VSAVE                                                           23742213
      GO TO 40                                                          23742214
155   IF (T1.LE.T2) GO TO 121                                               2217
      GO TO 115                                                             2218
160   BACK2=.FALSE.                                                         2220
      BACK3=.FALSE.                                                         2221
      DELV=DVSAVE                                                           2222
      GO TO 155                                                             2223
200   IF (DPSII) 4,4,201                                                13892260
201   IF (DOMI) 4,4,202                                                 13892270
202   T201 = 0.1536                                                     13892310
      DPSII=DPSII/57.2957795                                            13892320
      DOMI=DOMI  /57.2957795                                            13892330
      IF (NFLAG.EQ.4) GO TO 300                                         13892331
      GO TO 40                                                          13892340
210   CPSII=COS(PSII)                                                   13892350
```

TABLE C-1 (CONTINUED)

```
      SPSII=SIN(PSII)                                                   13892360
      DEGR=90.                                                          1389237
      DO 2101 IWS=1,19                                                  13892371
      IF (PSII.GE.DEGR/57.2957795) GO TO 2102                           13892372
      DEGR=DEGR-10.                                                     13892373
 2101 CONTINUE                                                          13892374
      WRITE (6,2602) PSII,CASE                                          13892375
      GO TO 1                                                           13892376
 2102 WS=WS1(MONTH,IWS)                                                 13892377
      SA=RA1(MONTH,IWS)                                                 13892378
      WE= T201*WS                                                       13892380
      T230 = ABS(CPSII/PI*DPSII)                                        13892400
      T221 = T211 -SPSII                                                13892430
      T216 = SPSII*SPSIS                                                13892440
      T217 = CPSII*CPSIS                                                13892450
      T240 = -T216 / ABS( T217)                                         13892460
  220 COMI = COS(OMI)                                                   13892540
      SOMI = SIN(OMI)                                                   13892550
      T220 = T213 -CPSII*SOMI                                           13892560
      T222 = T212 - CPSII*COMI                                          13892570
      T223 = T220**2 +T221**2 +T222**2                                  13892580
      ROR = 1.0/SQRT(T223)                                              13892590
      CTHP=-ROR*(XL*T220+XM*T221+XN*T222)                               13892600
      IF ( CTHP ) 225,225,221                                           13892610
  221 T224= ROR*CPSII*SOMI*T220                                         13892620
      T225= ROR*SPSII*T221                                              13892630
      T226= ROR*CPSII*COMI*T222                                         13892640
      CTHE= T224+T225+T226                                              13892650
      IF (CTHE ) 225,225,222                                            13892660
  222 T231 = CTHE *CTHP *DOMI *T230 /T223                               13892670
      T214 = T216 +T217*COMI                                            23742671
      IF (NPLAN.EQ.1) GO TO 235                                         23742671
      CTHS=T214                                                         23742672
      THS=ACOS(CTHS)                                                    23742673
      IF (CTHS.LT.0.) TM=216.                                           23742674
      IF (CTHS.GE.0..AND.CTHS.LT..25882) TM=THS*T339+T340-1935.         23742674
      IF (CTHS.GE..25882) TM=(T341*CTHS)**.25*1000.                     23742674
      WE=TM**4*T342*3600.*PI                                            23742675
  235 DFE1 = T231                                                       13892680
      DQ1 = WE*T231                                                     13892690
      IF (NPLAN.EQ.2) GO TO 239                                         23742691
      IF (T214) 241,241,236                                             13892710
  236 SR = S*T214 *SA                                                   13892720
      IF(SR) 241,241,242                                                13892730
  241 DQ2=0.0                                                           13892740
      GO TO 240                                                         13892750
  239 IF (CTHS.LE.0.) GO TO 241                                         23740751
      SR=(1.-ALPHI)*S*CTHS                                              23740752
  242 DQ2 = SR*T231*221.25                                              13892760
  240 Q1= Q1+DQ1                                                        13892770
      Q2 = Q2 +DQ2                                                      13892780
      DFE=DFE+DFE1                                                      13892790
  225 IF (OMI -XOMI) 250,260,260                                        13892800
  250 OMI = OMI + DOMI                                                  13892810
      GO TO 220                                                         13892820
  260 OMI = YOMI                                                        13892830
      IF (PSII -XPSII ) 270,280,280                                     13892840
  270 PSII = PSII + DPSII                                               13892850
      GO TO 210                                                         13892860
  280 PSII = YPSII                                                      13892870
```

TABLE C-1 (CONTINUED)

```
      FE(IK)=DFE                                                        13892880
      GO TO (600,390,600,310),NFLAG                                     2374292
300   IF (DPSIJ) 4,4,301                                                13892940
301   IF (DOMJ) 4,4,302                                                 13892950
302   PSI2=PSIM                                                         13892960
      OM2=OMM                                                           13892970
      PSIM=PSIM  /57.2957795                                            13892980
      OMM=OMM    /57.2957795                                            13892990
      DPSIJ=DPSIJ/57.2957795                                            13893000
      DOMJ=DOMJ  /57.2957795                                            13893010
      SPSIM = SIN(PSIM)                                                 13893020
      CPSIM = COS(PSIM)                                                 13893030
      SOMM  = SIN(OMM)                                                  13893040
      COMM  = COS(OMM)                                                  13893050
      GO TO 40                                                          13893110
310   CPSIJ = COS(PSIJ)                                                 13893120
      SPSIJ = SIN(PSIJ)                                                 13893130
      T325 = SPSIS *SPSIJ                                               13893140
      T326 = CPSIS *CPSIJ                                               13893150
      T321 = (T302/RM -SPSIJ)                                           13893160
320   COMJ = COS(OMJ)                                                   13893170
      SOMJ = SIN(OMJ)                                                   13893180
      T320 = (T303/RM -CPSIJ*SOMJ)                                      13893190
      T322 = (T304/RM -CPSIJ*COMJ)                                      13893200
      T323 = T320**2 +T321**2 +T322**2                                  13893210
      T324 = SQRT(1.0/T323)                                             13893220
      CTHM =(CPSIJ*SOMJ*T320+SPSIJ*T321+CPSIJ*COMJ*T322)*T324           13893230
      IF (CTHM ) 348,348,325                                            13893240
325   CTHP=-(XL*T320 +XM*T321 +XN*T322)*T324                            13893270
      IF (CTHP ) 348,348,326                                            13893280
326   CTHS = T325 +T326 *COMJ                                           13893290
      THS = ACOS(CTHS)                                                  13893300
      IF (CTHS) 337,330,330                                             13893310
330   IF (CTHS -0.25882  ) 338,340,340                                  13893320
337   TM = 216.0                                                        13893330
      GO TO 344                                                         13893340
338   TM = THS *T339 +T340 -1935.0                                      13893350
      GO TO 344                                                         13893360
340   TM = (T341 *CTHS)**.25 *1000.0                                    13893370
      GO TO 344                                                         13893380
344   T334= CTHM*CTHP/T323*ABS(CPSIJ*DOMJ*DPSIJ                         13893390
      DQ4 = (T342 *TM**4 *T334) *3600.0                                 13893400
      DFM1=T334/PI                                                      13893410
      IF (CTHS) 345,345,346                                             13893420
345   DQ5 = 0.0                                                         13893430
      GO TO 347                                                         13893440
346   DQ5= T335 * CTHS* T334*3600.0                                     13893450
347   Q5 = Q5+DQ5                                                       13893460
      FM1=FM1+DFM1                                                      13893470
      Q4 = Q4+DQ4                                                       13893480
348   IF (OMJ-XOMJ ) 350,360,360                                        13893490
350   OMJ = OMJ + DOMJ                                                  13893500
      GO TO 320                                                         13893510
360   OMJ = YOMJ                                                        13893520
      IF (PSIJ - XPSIJ ) 370,380,380                                    13893530
370   PSIJ = PSIJ +DPSIJ                                                13893540
      GO TO 310                                                         13893550
380   PSIJ = YPSIJ                                                      13893560
      FM(IK)=FM1                                                        13893570
390   Q14=Q1+Q4                                                         13893580
```

TABLE C-1 (CONTINUED)

```
      Q235=Q2+Q3+Q5                                                     13893590
      QABS =Q235+ALFA+Q14*EPS                                           2374360
      GO TO 500                                                         13893610
  500 IF (KOUNT.GT.50) KATCH=1                                          1389372
      IF (KOUNT.GT.50) KOUNT=0                                          1389373
      GO TO (511,512),KATCH                                             1389375
  511 WRITE (6,2501) CASE,(DATE(I),I=1,3)                               2374376
      WRITE (6,2502) (DATB(I),I=1,4),RE,(DATB(I),I=5,7)                 23743761
      WRITE (6,2510)                                                    23743762
      WRITE (6,2511) MONTH,PSIS1,PSI1,OM1,SI1,TA1,OME1,VV,DEL1,AS,ECCEN 1389377
      IF (NFLAG.GT.2) WRITE (6,2521) PSI2,OM2                           1389378
      WRITE (6,2540) KNO1,BS,KNO2,BI,KNO3,BA,ALFA,EPS                   2374379
      IF (NPLT.EQ.0) GO TO 5115                                         ORAD380
      WRITE (6,2560)                                                    ORAD3801
      DO 5114 I=1,8                                                     ORAD3802
      IF (PLT(I).EQ.0) GO TO 5114                                       ORAD3803
      GO TO (5101,5102,5103,5104,5105,5106,5107,5108),I                 ORAD3804
 5101 WRITE (6,2561)                                                    ORAD3805
      GO TO 5114                                                        ORAD3806
 5102 WRITE (6,2562)                                                    ORAD3807
      GO TO 5114                                                        ORAD3808
 5103 WRITE (6,2563)                                                    ORAD3809
      GO TO 5114                                                        ORAD3810
 5104 WRITE (6,2564)                                                    ORAD3811
      GO TO 5114                                                        ORAD3812
 5105 WRITE (6,2565)                                                    ORAD3813
      GO TO 5114                                                        ORAD3814
 5106 WRITE (6,2566)                                                    ORAD3815
      GO TO 5114                                                        ORAD3816
 5107 WRITE (6,2567)                                                    ORAD3817
      GO TO 5114                                                        ORAD3818
 5108 WRITE (6,2568)                                                    ORAD3819
 5114 CONTINUE                                                          ORAD3820
 5115 WRITE (6,2512)                                                    1389386
  512 IF (T1.LT.T2) WRITE (6,2514) VV,ALT,TIME,Q3,Q235,QABS             2374387
      IF (T1.GE.T2) WRITE (6,2513) VV,ALT,TIME,Q3,Q235,QABS             2374388
      IF (NFLAG.EQ.2.OR.NFLAG.EQ.4) WRITE (6,2523) Q1,Q2,Q14,DFE        2374389
      IF (NFLAG.GT.2) WRITE (6,2533) Q4,Q5,FM1                          2374390
  525 KOUNT=KOUNT+1                                                     1389395
      KATCH=2                                                           1389396
      TIMP = TIME*3600.                                                 2374410
      Q235P=Q235/3600.                                                  2374411
      Q14P=Q14/3600.                                                    2374412
      QABSP=QABS/3600.                                                  23744121
      V=V+DELV                                                          1389413
      XTIM(IK)=TIME                                                     2374414
      YQ1(IK)=Q1                                                        23744141
      YSOL(IK)=Q235                                                     ORAD415
      YQ2(IK)=Q2                                                        23744161
      YQ3(IK)=Q3                                                        23744163
      YQ4(IK)=Q4                                                        23744164
      YQ5(IK)=Q5                                                        23744165
      XTIMP(IK)=TIMP                                                    ORAD417
      YSOLP(IK)=Q235P                                                   ORAD417
      YIRP(IK)=Q14P                                                     ORAD417
      YABSP(IK)=QABSP                                                   ORAD417
      YIR(IK)=Q14                                                       ORAD417
      YABS(IK)=QABS                                                     ORAD4172
      IK=IK+1                                                           1389418
      KNTR=KNTR+1                                                       1389419
```

TABLE C-1 (CONTINUED)

```
      IF (DELV.LE.0.) GO TO 552                                  1389435
      IF (V-VO.LE.TWOPI+.01) GO TO 40                            2374438
552   IK=IK-1                                                    1389440
      XTIM(IK+1)=0.                                              ORAD4401
      YQ1 (IK+1)=0.                                              ORAD4401
      YQ2 (IK+1)=0.                                              ORAD4401
      YQ3 (IK+1)=0.                                              ORAD4401
      YQ4 (IK+1)=0.                                              ORAD4401
      YQ5 (IK+1)=0.                                              ORAD4401
      YIR (IK+1)=0.                                              ORAD4401
      YSOL(IK+1)=0.                                              ORAD4401
      YABS(IK+1)=0.                                              ORAD4401
      PER=TIMP                                                   13894401
      IF (KNO1.LE.0) GO TO 570                                   13894402
560   ISEQ1=100*KNO1                                             1389441
      LSEQ=ISEQ1+1                                               13894411
      PUNCH 709,KNO1,BS,LSEQ                                     23744412
      LSEQ=ISEQ1+2                                               13894413
      IF (PER.LE.0.) GO TO 565                                   13894414
      PUNCH 702,PER,LSEQ                                         13894415
      DO 562 I=1,IK                                              13894416
      LSEQ=ISEQ1+2+I                                             13894417
      PUNCH 706,XTIMP(I),YSOLP(I),LSEQ                           ORAD442
562   CONTINUE                                                   1389443
      LSEQ=LSEQ+1                                                1389444
      PUNCH 703,LSEQ                                             1389445
      LSEQ=LSEQ+1                                                1389446
      PUNCH 707,KNO1,LSEQ                                        1389447
      GO TO 570                                                  1389448
565   PUNCH 708,PER,KNO1                                         1389449
570   IF (KNO2.LE.0) GO TO 580                                   2374451
      ISEQ2=100*KNO2                                             13894511
      LSEQ=ISEQ2+1                                               13894512
      PUNCH 701,KNO2,BI,LSEQ                                     23744513
      LSEQ=ISEQ2+2                                               13894514
      IF (PER.LE.0.) GO TO 575                                   13894515
      PUNCH 702,PER,LSEQ                                         13894516
      DO 572 I=1,IK                                              13894517
      LSEQ=ISEQ2+2+I                                             13894518
      PUNCH 706,XTIMP(I),YIRP (I),LSEQ                           ORAD452
572   CONTINUE                                                   1389453
      LSEQ=LSEQ+1                                                1389454
      PUNCH 703,LSEQ                                             1389455
      LSEQ=LSEQ+1                                                1389456
      PUNCH 707,KNO2,LSEQ                                        1389457
      GO TO 580                                                  2374458
575   PUNCH 708,PER,KNO2                                         2374459
580   IF (KNO3.LE.0) GO TO 590                                   2374460
      ISEQ3=100*KNO3                                             2374461
      LSEQ=ISEQ3+1                                               2374462
      PUNCH 710,KNO3,BA,LSEQ                                     2374463
      LSEQ=ISEQ3+2                                               2374464
      IF (PER.LE.0.) GO TO 585                                   2374465
      PUNCH 702,PER,LSEQ                                         2374466
      DO 582 I=1,IK                                              2374467
      LSEQ=ISEQ3+2+I                                             2374468
      PUNCH 706,XTIMP(I),YABSP(I),LSEQ                           ORAD469
582   CONTINUE                                                   2374470
      LSEQ=LSEQ+1                                                2374471
      PUNCH 703,LSEQ                                             2374472
```

TABLE C-1 (CONTINUED)

```
      LSEQ=LSEQ+1                                                       2374473
      PUNCH 707,KNO3,LSEQ                                               2374474
      GO TO 590                                                         2374475
585   PUNCH 708,PER,KNO3                                                23744751
590   IF (NPLT.GT.0) CALL QPLOT                                         23744771
      GO TO 1                                                           2374478
600   WRITE (6,2600)NFLAG                                               13894770
      GO TO 1                                                           13894780
1000  FORMAT(6F6.0,8I1)                                                 1389479
1001  FORMAT (I2,4X,11F6.0)                                             13894800
1005  FORMAT (3I1,F3.0,3(2X,I3,1X,A6),2F6.0,3A6)                        2374481
701   FORMAT (5HDEC  ,I5,37X,10HINFRA-RED ,2X,A6,2X,I5,8X)              2374482
702   FORMAT ( 5HPERO1,F10.4,52X,I5,8X)                                 2374483
703   FORMAT (5HDECO2,8X,2H0.,8X,2H0.,42X,I5,8X)                        2374484
706   FORMAT ( 5HDECO2,2F10.4,42X,I5,8X)                                2374485
707   FORMAT (6HDEC  -,I4,57X,I5,8X)                                    2374486
708   FORMAT (16H  ERROR, PERIOD=F10.3,11H FOR CURVE I5)                23744861
709   FORMAT (5HDEC  ,I5,37X,10HSOLAR SPEC,2X,A6,2X,I5,8X)              2374487
710   FORMAT ( 5HDEC  ,I5,37X,10HQ ABSORBED,2X,A6,2X,I5,8X)             2374488
2501  FORMAT(1H1,47(1H )24HORBITAL RADIATION - 2374 /10H      CASE     13894931
     1F5.0,3X,6A6)                                                      13894932
2502  FORMAT(1H0,4A6,F8.0,3X,3A6)                                       13894933
2510  FORMAT                                  ( 6HOMONTH,6X,3HPSI,7X,   1389494
     1 3HPSI,6X,5HOMEGA,5X,5HSIGMA,6X,3HTAU,6X,5HOMEGA,7X,2HV0,6X,      13894941
     2 5HDEL V,4X,8HALTITUDE,3X,6HECCEN-,5X,3HPSI,6X,5HOMEGA /          13894942
     3 12X,5HSOLAR,5X,5HORBIT,5X,5HORBIT,3X,29H(VEHICLE ORIENTATION) PER13894943
     4IGEE,3X,5HENTRY,3X,9HSTEP SIZE,2X,9HSUBMITTED,2X,7HTRICITY,6X,    13894944
     5 11H(SATELLITE) )                                                 13894945
2511  FORMAT (I6,4X,8F10.3,F10.0,F10.3)                                 1389495
2521  FORMAT (1H+,109X,2F9.3)                                           2374496
2540  FORMAT (25HONON-ZERO CURVES PUNCHED  3(I5,2X,A6,2X),              2374497
     1 6HALPHA=F8.4,8H  EPSIL=F8.4)                                     23744971
2512  FORMAT( 1H0,6X,1HV,5X,8HALTITUDE,4X,4HTIME,6X,4HQ(P),6X,5HQ(PR),  2374498
     1 4X,6HQ(SOL),4X,6HQ(SAT),3X,7HQ(SATR),6X,1HQ,9X,1HQ,9X,1HQ,9X,1HF,23744981
     2 9X,1HF /6X,4HDEG.,4X,5HMILES,6X,4HHRS.,16X,24H(ALL Q IN BTU/HR/SQ23744982
     3.FT.),13X,48HSOL.SPEC   INF.RED    ABSORB    PLANET    SATEL.)   23744983
2513  FORMAT(3X,F6.0,F10.0,F10.3,20X,F10.3,20X,F10.3,10X,F10.3)         2374499
2514  FORMAT(3H SH,F6.0,F10.0,F10.3,20X,F10.3,20X,F10.3,10X,F10.3)      2374500
2523  FORMAT (1H+,28X,2F10.3,40X,F10.3,10X,F10.5)                       2374501
2533  FORMAT (1H+,58X,2F10.3,40X,F10.5)                                 2374502
2560  FORMAT (1H0,19HPLOTS REQUESTED FOR )                              ORAD511
2561  FORMAT (1H+,34X,4HQ(P))                                           ORAD512
2562  FORMAT (1H+,44X,5HQ(PR))                                          ORAD513
2563  FORMAT (1H+,53X,6HQ(SOL))                                         ORAD514
2564  FORMAT (1H+,63X,6HQ(SAT))                                         ORAD515
2565  FORMAT (1H+,72X,7HQ(SATR))                                        ORAD516
2566  FORMAT (1H+,82X,7HQ(S.S.))                                        ORAD517
2567  FORMAT (1H+,92X,7HQ(I.R.))                                        ORAD518
2568  FORMAT (1H+,102X,7HQ(ABSB))                                       ORAD519
2550  FORMAT(1H1,5X,1HV,9X,2HFM,9X,2HFE /(1H 3F11.5))                   13895340
2600  FORMAT(8HOFLAG=  I2,26H SHOULD NOT GET HERE        )              13895350
2601   FORMAT(1H1,20HSOME DELTA FOR CASE F5.0,20H IS ZERO OR NEGATIVE / 13895360
     1 14HOCASE DELETED. )                                              13895370
2602  FORMAT (6HOPSII=F8.4,57H RADIANS IS NOT BETWEEN -90 AND +90 DEGREE13895371
     1S. CASE NUMBER F5.0)                                              13895372
      END                                                               13895380
```

TABLE C-1 (CONTINUED)

```
$IBFTC QPLT                                                          2266000
      SUBROUTINE QPLOT                                               2266001
C     SUBROUTINE FOR CAL-COMP PLOTTER                                2266002
C     FOR ORBITAL RADIATION ROUTINE                                  2266003
      COMMON /QPX/ PLT(8),XTIM(360),YQ1(360),YQ2(360),YQ3(360),YQ4(360),2266005
     1 YQ5(360),YSOL(360),YIR(360),YABS(360),LAST,PNO                2266006
      DIMENSION TKEY1(3),TKEY2(3),TKEY3(3),TKEY4(3),TKEY5(3)         QPLT0065
      DIMENSION TKEY6(3),TKEY7(3),TKEY8(3)                           QPLT0065
      DIMENSION BUFFER(914),XTITLE(3),YTITLE(3),TITLE(3),XR(2),YR(2), 2266007
     1 XP(360),YP(360),BCD(8)                                        2266008
      DATA (BCD(I),I=1,8)    /0150000000000,0160000000000,0170000000000, QPLT0081
     10320000000000,0350000000000,0360000000000,0370000000000,0560000000 2266009
     2000/                                                           22660091
      DATA (TKEY1(I),I=1,3)/6HQ PLAN,6HET     ,6H       /             QPLT010
      DATA (TKEY2(I),I=1,3)/6HQ PLAN,6HET REF,6HLECTED/               QPLT010
      DATA (TKEY3(I),I=1,3)/6HQ SOLA,6HR      ,6H       /             QPLT010
      DATA (TKEY4(I),I=1,3)/6HQ SATE,6HLITE   ,6H       /             QPLT010
      DATA (TKEY5(I),I=1,3)/6HQ SATE,6HL. REF,6HLECTED/               QPLT010
      DATA (TKEY6(I),I=1,3)/6HQ SOLA,6HR SPEC,6HTRUM  /               QPLT010
      DATA (TKEY7(I),I=1,3)/6HQ INFR,6HA RED',6HSPECT./               QPLT010
      DATA (TKEY8(I),I=1,3)/6HQ ABSO,6HRBED   ,6H       /             QPLT010
      DATA (XTITLE(I),I=1,3) /6HTIME  ,6HIN     ,6HHOURS /            QPLT010
      DATA (YTITLE(I),I=1,3) /6HQ, BTU,6H/HR /S,6HQ.FT. /             QPLT011
      DATA (TITLE(I) ,I=1,3) /6HCASE  ,6HNUMBER,6H=     /             QPLT012
      INTEGER PLT                                                    QPLT0121
      E=0.                                                           QPLT0121
      IF (PNO1.LE.0.) PNO1=0.                                        QPLT0121
      ND=360                                                         QPLT014
      XRANGE = 7.0                                                   QPLT014
      YRANGE = 9.0                                                   2266014
      YKEY=9.0                                                       QPLT0141
      XKEY=XRANGE/2.+2.                                              QPLT0141
      HT = .14                                                       QPLT0149
      H = .28                                                        QPLT015
C        LAST = 0 ,1ST CASE                                          2266017
C             =-1 ,MORE CASES TO FOLLOW                              2266018
C             = 1 ,FINAL CASE                                        2266019
      IA = LAST+2                                                    2266020
      GO TO (9,2,90),IA                                              2266021
    2 CALL PLOTS (BUFFER,914)                                        2266022
      LAST = -1                                                      2266023
C        SET-UP PROPER X,Y AXIS AND SCALES FOR CURVES                2266030
C        TIME IS SAME FOR ALL CURVES                                 2266031
    9 K = 0                                                          2266032
      PNO1= PNO1+1.                                                  QPLT0321
   15 K = K+1                                                        2266033
      IF (K.EQ.ND) GO TO 17                                          2266034
      IF (XTIM(K+1).GE.XTIM(K)) GO TO 15                             2266035
   17 NPTS = K                                                       2266036
      XR(1) = XTIM(1)                                                2266037
      XR(2) = XTIM(K)                                                2266038
      YR(1)=0.
      YR(2)=0.
C     DETERMINE MIN,MAX YSOL AND YIR                                 2266043
      DO 22 I=1,NPTS                                                 2266044
      IF (YQ1(I).GT.YR(2).AND.PLT(1).GT.0)  YR(2)=YQ1(I)             QPLT045
      IF (YQ2(I).GT.YR(2).AND.PLT(2).GT.0)  YR(2)=YQ2(I)             QPLT045
      IF (YQ3(I).GT.YR(2).AND.PLT(3).GT.0)  YR(2)=YQ3(I)             QPLT045
      IF (YQ4(I).GT.YR(2).AND.PLT(4).GT.0)  YR(2)=YQ4(I)             QPLT045
      IF (YQ5(I).GT.YR(2).AND.PLT(5).GT.0)  YR(2)=YQ5(I)             QPLT045
```

TABLE C-1 (CONTINUED)

```
      IF (YSOL(I).GT.YR(2).AND.PLT(6).GT.0)  YR(2)=YSOL(I)          QPLT045
      IF (YIR(I).GT.YR(2).AND.PLT(7).GT.0)  YR(2)=YIR(I)            QPLT045
      IF (YABS(I).GT.YR(2).AND.PLT(8).GT.0)  YR(2)=YABS(I)          QPLT045
   22 CONTINUE                                                      2266049
C        DETERMINE CURVES TO BE PLOTTED                              2266052
 26   CALLASCALE (XR,2,XRANGE,XMN,DX,1,EX)                          2266053
      CALLASCALE (YR,2,YRANGE,YMN,DY,1,EY)                          2266054
      DDX = XMN/DX                                                  2266055
      DDY = YMN/DY                                                  2266056
C  38 CALL AXIS (1.0,1.0,XTITLE   ,-18,XRANGE,0.0,XMN,DX)           2266061
C     CALL AXIS (1.0,1.0,YTITLE   ,+18, 8.0  ,90.,YMN,DY)           2266062
 38   CALL XYAXIS(1.,1.,XRANGE,1.,XMN,DX,2,2.5,0.2,.21,0.,XTITLE,18,0.)
      L=2.3-(EY-YMN )/10.
      IF (L.LT.0) L=0
      CALL XYAXIS(1.,1.,YRANGE,1.,YMN,DY,L,.4,2.5,.21,90.,YTITLE,18,90.)
      DO 40 J=1,NPTS                                                2266063
      XP(J) = XTIM(J)/DX+1. -DDX                                    QPLT064
   40 CONTINUE                                                      2266065
      DO 84 I=1,8                                                   2266066
      IF ( PLT(I))44,84,44                                          2266067
   44 GO TO (47,51,55,59,63,67,71,75),I                             2266068
   47 DO 49 J=1,NPTS                                                2266069
   49 YP(J) = YQ1(J)/DY+1.0-DDY                                     2266070
      B = BCD(1)                                                    2266071
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0711
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY1,0.,18)                      QPLT0712
      YKEY=YKEY-.25                                                 QPLT0713
      GO TO 80                                                      2266072
   51 DO 53 J=1,NPTS                                                2266073
   53 YP(J) = YQ2(J)/DY+1.0-DDY                                     2266074
      B = BCD(2)                                                    2266075
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0751
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY2,0.,18)                      QPLT0752
      YKEY=YKEY-.25                                                 QPLT0753
      GO TO 80                                                      2266076
   55 DO 57 J=1,NPTS                                                2266077
   57 YP(J) = YQ3(J)/DY+1.0-DDY                                     2266078
      B = BCD(3)                                                    2266079
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0791
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY3,0.,18)                      QPLT0792
      YKEY=YKEY-.25                                                 QPLT0793
      GO TO 80                                                      2266080
   59 DO 61 J=1,NPTS                                                2266081
   61 YP(J) = YQ4(J)/DY+1.0-DDY                                     2266082
      B = BCD(4)                                                    2266083
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0831
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY4,0.,18)                      QPLT0832
      YKEY=YKEY-.25                                                 QPLT0833
      GO TO 80                                                      2266084
   63 DO 65 J=1,NPTS                                                2266085
   65 YP(J) = YQ5(J)/DY+1.0-DDY                                     2266086
      B = BCD(5)                                                    2266087
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0871
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY5,0.,18)                      QPLT0872
      YKEY=YKEY-.25                                                 QPLT0873
      GO TO 80                                                      2266088
   67 DO 69 J=1,NPTS                                                2266089
   69 YP(J) = YSOL(J)/DY+1.0-DDY                                    2266090
      B = BCD(6)                                                    2266091
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                               QPLT0911
```

TABLE C-1 (CONTINUED)

```
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY6,0.,18)                          QPLT0912
      YKEY=YKEY-.25                                                     QPLT0913
      GO TO 80                                                          2266092
   71 DO 73 J=1,NPTS                                                    2266093
   73 YP(J) = YIR(J)/DY+1.0-DDY                                         2266094
      B = BCD(7)                                                        2266095
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                                   QPLT0951
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY7,0.,18)                          QPLT0952
      YKEY=YKEY-.25                                                     QPLT0953
      GO TO 80                                                          2266096
   75 DO 77 J=1,NPTS                                                    2266097
   77 YP(J) = YABS(J)/DY+1.0-DDY                                        2266098
      B = BCD(8)                                                        2266099
      CALL SYMBL4(XKEY,YKEY,H,B,0.,1)                                   QPLT0991
      CALL SYMBL4(XKEY+.3,YKEY,HT,TKEY8,0.,18)                          QPLT0992
      YKEY=YKEY-.25                                                     QPLT0993
   80 DO 82 J=1,NPTS                                                    2266100
      X = XP(J)                                                         2266101
      Y = YP(J)                                                         2266102
      CALL SYMBL4(X,Y,H,B,0.0,1)                                        2266103
   82 CONTINUE                                                          2266104
      CALL LINE(XP,YP,NPTS,1)                                           QPLT1041
   84 CONTINUE                                                          2266105
      X = XKEY                                                          2266106
      Y = 9.5                                                           QPLT107
      Z  = X+1.8                                                        22661001
      CALL SYMBL4(X,Y,HT,TITLE,0.0,18)                                  2266109
      CALL NUMBER(Z,Y,HT,PNO,0.0,-1)                                    22661091
90    XSPACE = XRANGE+5.0                                               2266110
      CALL PLOT (XSPACE,0.0,-3)                                         2266111
      GO TO (97,97,94),IA                                               2266112
   94 PRINT 222,PNO1                                                    QPLT113
  222 FORMAT (37H0 REMOVE PLOT TAPE AND MARK AS HAVING F5.0 ,6HPLOTS    2266114
      CALL TRWEND                                                       2266115
      PAUSE 55555                                                       2266116
      WRITE (6,222) PNO1                                                QPLT117
   97 RETURN                                                            2266118
      END                                                               2266119
```

TABLE C-1 (CONTINUED)

```
$IBFTC WSRA1   REF                                                      WSRA001
      BLOCK DATA                                                        WSRA002
      COMMON /WSRA/WS(12,19),RA(12,19)                                  WSRA003
      DATA ((WS(I,J),I=1,12),J=1,19)/                                   WSRA004
     A 328.,326.,343.,392.,420.,422.,430.,413.,395.,387.,375.,336.,     WSRA005
     B 330.,328.,348.,393.,425.,427.,435.,419.,402.,389.,376.,344.,     WSRA006
     C 345.,341.,366.,402.,436.,446.,452.,437.,424.,407.,382.,355.,     WSRA007
     D 376.,373.,390.,428.,457.,477.,478.,481.,453.,439.,408.,328.,     WSRA008
     E 399.,393.,409.,438.,463.,482.,483.,495.,477.,455.,415.,396.,     WSRA009
     F 431.,430.,441.,461.,482.,497.,508.,520.,500.,477.,440.,432.,     WSRA010
     G 466.,466.,475.,485.,502.,512.,515.,528.,514.,498.,479.,464.,     WSRA011
     H 494.,498.,497.,503.,510.,510.,506.,514.,510.,504.,501.,490.,     WSRA012
     I 500.,506.,503.,512.,505.,496.,500.,502.,497.,505.,502.,500.,     WSRA013
     J 484.,490.,490.,494.,487.,483.,486.,487.,488.,487.,487.,486.,     WSRA014
     K 501.,503.,503.,505.,498.,501.,497.,499.,503.,502.,502.,502.,     WSRA015
     L 506.,514.,509.,508.,500.,502.,486.,494.,504.,505.,505.,505.,     WSRA016
     M 514.,515.,510.,500.,489.,485.,479.,474.,487.,493.,497.,508.,     WSRA017
     N 493.,495.,487.,475.,471.,461.,462.,450.,465.,472.,480.,488.,     WSRA018
     O 472.,469.,465.,450.,445.,430.,427.,424.,439.,445.,456.,466.,     WSRA019
     P 456.,460.,450.,433.,425.,407.,407.,401.,418.,425.,438.,448.,     WSRA020
     Q 417.,416.,416.,388.,383.,379.,362.,360.,380.,394.,402.,409.,     WSRA021
     R 401.,393.,389.,346.,356.,349.,340.,336.,360.,377.,382.,384.,     WSRA022
     S 384.,386.,378.,327.,347.,327.,329.,321.,347.,363.,368.,364./     WSRA023
      DATA ((RA(I,J),I=1,12),J=1,19) /                                  WSRA024
     A 0.0,0.0,0.0,.67,.67,.67,.67,.67,.67,0.0,0.0,0.0,                 WSRA025
     B 0.0,0.0,.60,.60,.60,.62,.63,.58,.56,.60,0.0,0.0,                 WSRA026
     C 0.0,.65,.57,.46,.43,.44,.46,.51,.53,.55,.65,0.0,                 WSRA027
     D .51,.46,.40,.40,.40,.36,.39,.42,.47,.50,.50,.52,                 WSRA028
     E .42,.38,.37,.37,.38,.33,.33,.33,.36,.42,.46,.47,                 WSRA029
     F .42,.34,.34,.32,.32,.25,.24,.25,.31,.31,.33,.41,                 WSRA030
     G .30,.30,.28,.28,.26,.24,.24,.24,.27,.29,.32,.32,                 WSRA031
     H .29,.25,.25,.24,.24,.27,.27,.26,.30,.31,.31,.30,                 WSRA032
     I .29,.27,.28,.26,.28,.32,.34,.36,.34,.32,.32,.32,                 WSRA033
     J .33,.30,.33,.30,.34,.33,.32,.32,.34,.33,.34,.35,                 WSRA034
     K .34,.35,.34,.32,.32,.32,.29,.27,.28,.26,.28,.32,                 WSRA035
     L .27,.26,.30,.31,.31,.30,.29,.25,.25,.24,.24,.24,                 WSRA036
     M .24,.24,.27,.29,.32,.32,.30,.30,.28,.28,.26,.24,                 WSRA037
     N .24,.24,.27,.29,.32,.32,.30,.30,.28,.28,.26,.24,                 WSRA038
     O .33,.33,.36,.42,.46,.37,.42,.38,.37,.37,.38,.33,                 WSRA039
     P .39,.42,.46,.48,.48,.48,.48,.45,.40,.40,.40,.36,                 WSRA040
     Q .50,.52,.53,.60,.63,.0 ,.0 ,.63,.60,.57,.50,.50,                 WSRA041
     R .63,.60,.60,.0 ,.0 ,.0 ,.0 ,.0 ,.60,.60,.60,.62,                 WSRA042
     S .67,.67,.67,.0 ,.0 ,.0 ,.0 ,.0 ,.0 ,.67,.67,.67/                 WSRA043
      END                                                               WSRA044
```

TABLE C-1 (CONTINUED)

```
$IBFTC XYAXES                                                           XYAXS001
      SUBROUTINE XYAXIS(XORG,YORG,ALNGTH,SCDT,AMIN,DA,N,XLAB,
     1  YLAB,HLAB,ALAB,HEAD,NC,AXANG)
C                                                                       XYAXS004
C     XORG - X COORDINATE OF FIRST POINT ON AXIS                        XYAXS005
C     YORG - Y COORDINATE OF FIRST POINT ON AXIS                        XYAXS006
C     ALNGTH-LENGTH OF AXIS IN INCHES - TOTAL                           XYAXS007
C     SCDT  -LENGTH IN INCHES BETWEEN TICK MARKS                        XYAXS008
C     AMIN  -LABEL VALUE OF FIRST POINT ON AXIS                         XYAXS009
C     DA    -SCALE VALUE PER INCH OF LABEL VALUES                       XYAXS010
C     N     -NUMBER OF DECIMAL PLACES FOR AXIS LABEL VALUES             XYAXS011
C     XLAB  -X COORDINATE OF AXIS LABEL                                 XYAXS012
C     YLAB  -Y COORDINATE OF AXIS LABEL                                 XYAXS013
C     HLAB  -HEIGHTH OF AXIS LABEL                                      XYAXS014
C     ALAB  -ANGLE OF AXIS LABEL
C     HEAD  -AXIS LABEL                                                 XYAXS016
C     NC    -NUMBER OF CHARACTERS IN AXIS LABEL                         XYAXS017
C     AXANG -ANGLE OF AXIS
C                                                                       XYAXS018
      DIMENSION HEAD(3)                                                 XYAXS019
      DATA DATK, HNUM/0.07, 0.14/                                       XYAXS020
      DATA  PLUG/0.5E-07/
      XCON = 1.0                                                        XYAXS021
      YCON = HNUM/2.0                                                   XYAXS022
      IF ( AXANG .NE. 0.0 )  GO TO 50
      XCON = 2.0                                                        XYAXS024
      YCON = 0.25                                                       XYAXS025
 50   RLAB = AXANG * 0.01745329
      DELNUM = DA*SCDT                                                  XYAXS027
      SRSCDT = SIN(RLAB)*SCDT                                           XYAXS028
      CRSCDT = COS(RLAB)*SCDT                                           XYAXS029
      CR = COS(RLAB)                                                    XYAXS030
      SR = SIN(RLAB)                                                    XYAXS031
      WNUM = HNUM*6.0/7.0                                               XYAXS032
      ICNT = 0                                                          XYAXS033
      ANUM = AMIN                                                       XYAXS034
 100  NA = N + 3                                                        XYAXS035
      IF ( ANUM .EQ.  0.0)  ANUM = 0.0
      IF (ANUM .LT. 0.0) NA = NA + 1                                    XYAXS036
      I = 0                                                             XYAXS037
 105  I = I + 1                                                         XYAXS038
      IF (ABS(ANUM) .LT. 10.0**I) GO TO 115                             XYAXS039
      NA = NA + 1                                                       XYAXS040
      GO TO 105                                                         XYAXS041
 115  ADIST = FLOAT(ICNT)*SCDT                                          XYAXS042
      IF (ADIST .GT. ALNGTH) GO TO 200                                  XYAXS043
      XC = XORG + ADIST*CR - FLOAT(NA)*WNUM/XCON  + 0.05
      YC = YORG + ADIST*SR - YCON                                       XYAXS045
      IF (YC .GT. YLAB .AND. YLAB .GT. (YC - SRSCDT) .OR.  XC .GT. XLAB XYAXS046
     1  .AND. XLAB .GT. (XC - CRSCDT)) CALL SYMBL 4 (XLAB, YLAB, HLAB,  XYAXS047
     2  HEAD, ALAB, NC)                                                 XYAXS048
      XNUM = ANUM + PLUG
      CALL NUMBER (XC,YC,HNUM,XNUM,0.0,N)
      ICNT = ICNT + 1                                                   XYAXS050
      ANUM = ANUM + DELNUM                                              XYAXS051
      GO TO 100                                                         XYAXS052
 200  IF (YLAB .GE.(YORG+ALNGTH)) CALL SYMBL4(XLAB,YLAB,HLAB,HEAD ,
     1  ALAB,NC)
      I = 3                                                             XYA X053
 205  XC = XORG + FLOAT(ICNT - 1)*CRSCDT                                XYAXS054
```

TABLE C-1 (CONTINUED)

```
YC = YORG + FLOAT(ICNT - 1)*SRSCDT                    XYAXS055
CALL PLOT (XC, YC, I)                                 XYAXS056
I = I - 1                                             XYAXS057
IF (I .LT. 1) I = 1                                   XYAXS058
XC = XC - SR*DATK                                     XYAXS059
YC = YC - CR*DATK                                     XYAXS060
CALL PLOT (XC, YC, I)                                 XYAXS061
XC = XC + SR*DATK                                     XYAXS062
YC = YC + CR*DATK                                     XYAXS063
CALL PLOT (XC, YC, I)                                 XYAXS064
ICNT = ICNT - 1                                       XYAXS065
IF (ICNT .LE. 0) RETURN                               XYAXS066
GO TO 205                                             XYAXS067
END                                                   XYAXS068
```


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TABLE C-1 (CONTINUED)

```
$IBFTC ASC2                                                          ASCLE001
      SUBROUTINE ASCALE (X, N, S, YMIN, DY, K, YMAX)                 ASCLE002
C                                                                    ASCLE003
C     X - THE GIVEN ARRAY OF VALUES TO BE SCALED, AND THE OUTPUT     ASCLE004
C         SCALED VALUES                                              ASCLE005
C     N - NO. OF X VALUES                                            ASCLE006
C     S - NO. OF INCREMENTS                                          ASCLE007
C     YMIN - GENERATED MINIMUM X VALUE, ROUNDED DOWN                 ASCLE008
C     DY   - GENERATED INCREMENT                                     ASCLE009
C     K    - SPACING BETWEEN X VALUE STORAGES                        ASCLE010
C     YMAX = GENERATED MAXIMUN X VALUE, NOT ROUNDED                  ASCLE011
C                                                                    ASCLE012
      DIMENSION X(2)                                                 ASCLE013
      YMAX = X(1)                                                    ASCLE014
      YMIN = X(1)                                                    ASCLE015
      NP = N*K                                                       ASCLE016
      DO 6 I = K, NP, K                                              ASCLE017
      IF (YMAX .LT. X(I)) YMAX = X(I)                                ASCLE018
      IF (YMIN .GT. X(I)) YMIN = X(I)                                ASCLE019
 6    CONTINUE                                                       ASCLE020
      IF (YMIN .NE. YMAX) GO TO 20                                   ASCLE021
      DX = 1.0                                                       ASCLE022
      YMIN = YMIN - (S/2.0)*DX                                       ASCLE023
      GO TO 36                                                       ASCLE024
 20   DX = (YMAX - YMIN)/S                                           ASCLE025
      NA = 0                                                         ASCLE026
      IF (DX - 1.) 25, 36, 30                                        ASCLE027
 25   DX = DX*10.                                                    ASCLE028
      NA = NA - 1                                                    ASCLE029
      IF (DX .LT. 1. .OR. DX .GE. 10.) GO TO 25                      ASCLE030
      GO TO 35                                                       ASCLE031
 30   IF (DX .GE. 1. .AND. DX .LT. 10.) GO TO 35                     ASCLE032
      DX = DX/10.                                                    ASCLE033
      NA = NA + 1                                                    ASCLE034
      GO TO 30                                                       ASCLE035
 35   IF (DX .GT. 4.) DY = 10.**(NA + 1)                             ASCLE036
      IF (DX .LE. 4.) DY = 4.*10.**NA                                ASCLE037
      IF (DX .LE. 2.) DY = 2.*10.**NA                                ASCLE038
 36   RNDFTR = -0.9                                                  ASCLE039
      IYMIN = YMIN/DY + RNDFTR                                       ASCLE041
      YMIN = FLOAT(IYMIN)*DY                                         ASCLE042
      DO 40 I = 1, NP, K                                             ASCLE043
      X(I) = X(I)/DY                                                 ASCLE044
 40   CONTINUE                                                       ASCLE045
      RETURN                                                         ASCLE046
      END                                                            ASCLE047
```